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THEME:

FOOD SECURITY THROUGH INNOVATION: BRIDGING TECHNOLOGY WITH TRADITIONAL FARMING

BOOK OF PROCEEDINGS

FACULTY OF AGRICULTURE
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FOREWORD

1st Faculty of Agriculture International Annual Conference
The Faculty of Agriculture, University of Calabar, proudly presents its inaugural International Annual Conference, 2024. This landmark event provides a dynamic platform for academics, researchers, industry professionals, policymakers, and students to converge and engage in thought-provoking discussions, knowledge sharing, and collaborative innovation in the ever-evolving field of agriculture.

Themed **"Food Security Through Innovation: Bridging Technology with Traditional Farming,"** this conference aims to bring together a diverse array of stakeholders, including farmers, agronomists, animal scientists, chemists, agricultural economists, environmentalists, biotechnologists, food scientists, extension workers, soil scientists, crop protectionists, geographers, veterinarians, nutritionists, fisheries practitioners, poultry farmers, crop and livestock farmers, financiers, and representatives from academia, government agencies, and allied industries. By encompassing this wide spectrum, the conference endeavors to foster holistic solutions to contemporary agricultural challenges.

The conference will serve as a hub for presenting research findings, discussing critical issues, showcasing innovative products, and promoting impactful projects through sponsorship and collaboration. Participants will have the opportunity to explore cutting-edge technologies, deliberate on the integration of traditional and modern farming practices, and strengthen networks that drive sustainable agricultural development.

This **Book of Proceedings**, marking the beginning of what promises to be a series of impactful conferences, reflects the collective expertise and ingenuity of contributors from various fields of agriculture. It is our hope that these proceedings serve as a resourceful guide, sparking new ideas and encouraging groundbreaking advancements for the future of agriculture.

On behalf of the Faculty of Agriculture, University of Calabar, I extend my heartfelt gratitude to all participants, contributors, and sponsors for their unwavering support and commitment to this pioneering endeavor. Together, let us continue to champion agricultural innovation for the betterment of humanity.

Professor Susana Ben Ohen
Dean, Faculty of Agriculture
University of Calabar

RESOURCE USE EFFICIENCY IN SMALL-SCALE IRISH POTATO PRODUCTION IN JOS-SOUTH LOCAL GOVERNMENT AREA, PLATEAU STATE, NIGERIA

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ABSTRACT

The development of agriculture in Nigeria is not meeting the demand of its teeming population. Agriculture is practiced mainly where smallholder farmers dwell, yet they are still engrossed in abject poverty. These areas are characterized by low productivity, low income, large family size, continued use of crude technology etc. This study analysis the resource use efficiency of small-scale Irish potato farmers in Jos-South LGA of Plateau state. A simple random sampling technique was employed in selecting four districts in the study area. Data were collected from 135 respondents randomly selected from Vwang, Kuru and Du districts. It was collected using structured questionnaire and analyzed using descriptive statistics and farm budgeting analysis. The result revealed that 42.2% of the respondents were between 41 – 50 years of age with a mean of 45 years. In addition, the results indicated that 56.6% of the respondents were female and 79.3% were married with the mean family size of 8 persons. The result also revealed that 74.1% of the respondent sourced their capital from personal savings. The results shows that there is under-utilization of land in the study area as the marginal farm size was calculated to be ₦ 15.40, there is over- utilization of labour input and this is below the economic optimum in the study area. There is also under- utilization of chemical fertilizer and may be as a result of low nutrients status inherent in soils of the study area or the high cost of fertilizer. The study recommends optimizing input usage among farmers to enhance productivity and efficiency. Policy implications include targeted interventions to improve farmers' access to credit, technology and training.

Keywords: Agricultural productivity, Irish potato, Optimization, Resource use efficiency, Small-scale farming.

1.0 INTRODUCTION

The potato (Solanum tuberosum) belongs to the family Solanaceae, which includes tomato, eggplant and peppers (Noonari *et al.*, 2016). Potatoes family occupy a prominent position among vegetable planted in the world. Potatoes are an important food source, and consist of 205 solid matters and have 80% of the high-nutrient waters. Although it is ranked 4th after cassava, yam, sweet potato and cocoyam among the major tuber crops in Nigeria, it is by far the most efficient in the country in terms of tuber yield, and days of maturity (Okonkwo *et al.*, 1995b). The Nigerian agricultural sector has struggled to meet food security demands, particularly in potato production, despite its introduction by the miners in Jos- Plateau in the 19th century. The establishment of the Potato Research Centre at Kuru in 1976 marked a turning

point but productivity remains low (Lenka *et al.*, 2005). Small-scale farmers who dominate the sector face challenges in resource utilization, leading to suboptimal yields. Efficient resource use is critical to addressing food security concerns. Actual yields of potato differ significantly from potential yields, and this has been attributed to low resource productivity {Federal Ministry of Agriculture and Rural Development (FMARD) 2001}.

One of the many reasons usually adduced for the poor performance of the agricultural sector in Nigeria is the misallocation and poor utilisation of productive resources by small-scale farmers who dominate the Nigerian agricultural sector (Lenka *et al.*, 2005). Notable problems of Irish Potato production include inappropriate decision on how best to allocate resources, inadequate use/ high cost of production inputs, poor storage facilities, poor disease and pest management, and inadequate adoption of improved technologies by farmers (Ugonna, *et al.*,2013). Fakayode *et al.*, (2008) observed that the problem with Nigeria agriculture centers on the efficiency with which farmers use resources on their farms. Inefficiency of resource use according to Udoh and Etim (2008) can seriously jeopardize and hamper food production and availability. The consequences of resource under - utilization or over utilization either way translates into economic waste due to poor management of productive resources, thus farmers are likely to incur losses as a result of waste in resource over utilization or loss in revenue due to inability to optimize yield or output from production effort. Also farmers might use resources rationally but not at economic optimal level. All these contribute to inefficiency.

Effort aimed at increasing Irish potato output cannot be achieved unless the current level of inputs utilization is scaled up (Mohammed *et al.*, 2013). Most of the literature investigating the impact of improved agricultural input on farmers and the associated agro-based firms focuses on strategic assessment for agriculture and economic growth in potato producing regions, the dynamics of rural livelihoods, as well as commodity and market trends (Shabu, 2011). Increasingly, globalized markets are critically important for determining investment priorities for rural development. Nesbitt, (2003) observed that, planning and prioritizing potato research requires a deeper understanding of the people's access to use of natural resources and other forms of capital such as physical, financial and social capital, their interactions with government agencies, Non- Governmental Organizations, and other institutions that influence their livelihood strategies. It is critically important to understand the changes in farmers' practices that are currently taking place and drivers of such changes, including farmers' knowledge concerning their technological choice and how the components of livelihood systems and potato technologies interact. Such an understanding provides the scientific basis for improved farm input design, targets and delivery (Odusina, 2008). It is against this that study becomes crucial in examining the resource use efficiency of farmers in small-scale potato production in Jos-South Local Government Area of Plateau State.

2.0 METHODOLOGY

2.1 The Study Area

The study was conducted in Jos south Local Government Area, is one of the seventeen Local Government Areas (LGA) of Plateau State. It's headquarters is Bukuru located on latitudes 9 0 48'N and Longitudes 8 0 52E, it has an area of 510 square kilometer (km 2) and lies at an

altitude of about 1300m above sea level. It is surrounded by high plains with elevation of between 600m and 900mm above sea level. The LGA shares boundary with Jos north Local Government by the north, Riyom LGA to the east and Barkin ladi LGA to the west. The Local Government headquarters is Bukuru Town, which is 15 kilometres south of the state capital. The Local Government Area is divided into four districts namely Du, Bukuru, Kuru and Vom. The LGA has a population of about 311,392 (NPC, 2007).

Jos is generally known for its cool climatic condition and Jos-south is not an exception. This is due to the relief or altitude of the area above sea level. The area has two major seasons; these are the rainy and dry seasons. The rainy season normally starts around April and last till October with peak in August, while the dry season starts from November and ends in March. The minimum temperature of the area is 18 0 C while the maximum temperate of the area is 24 0 C. The vegetation of the area reflects integration between climate, soil type and human activities. However, Jos-south fells within Guinea savannah and is characterized by short trees shrubs and grasses.

The predominant human activity in the study area is farming. Other occupations carried out in the study area are mining, Civil servants, and few craftsmen. However, mining activities in Bukuru and environs took over the predominant activity of the people. As a result of the mining activities, the area became more attractive and more populated therefore it created high demand for food and other necessities of life and this gave rise to market spots and commercial activities in the area. The common crops grown in the study area includes: acha, Irish potatoes, millet, sweet potatoes, cocoyam, maize and vegetables such as cabbage, onions, carrots, tomatoes, lettuce, which are grown in the dry season.

2.2 Sampling Technique

The sample was drawn from the list of Irish potato famers without replacement. This involved the simple random sampling of three districts that is Vwang, Kuru and Du districts of Jos-south the Local Government Area because of their intensity in Irish potato production. A total of one hundred and fifty questionnaires/interview schedule was used and the questionnaires were distributed in proportionate order among the three districts. Of which one hundred and thirty five (135) were retrieved.

2.3 Data Analysis

Statistical tools used in analyzing the data were descriptive statistics, regression analysis, gross margin analysis, and marginal analysis

2.3.1 Net farm income (NFI)

Net farm income is the difference between gross margin (GM) and the total fixed cost (TFC) of production.

NFI= GM – TFC..... (1)

The fixed cost which is depreciated on farm tool, equipment's and land rent is calculated using declining balance method to arrive at the scrap value after which the straight line method is used to ascertain the annual depreciation rate.

2.3.2 Determining economic efficiency of resource use

The following ratios was used to estimate the relative efficiency of resource use (r) r = ... (2)

Where; r = Efficiency ratio MVP = marginal value product of a variable input and it is value added to output due to the use of an additional unit of input, calculated by multiplying marginal physical product by the price of output. MFC = Marginal factor cost (Price per unit input) and it is cost of additional unit of a particular resource Marginal value products (MVP) were estimated using the regression coefficient of each input and the price of the output as expressed in equation (9) (Sani ***et al***. 2010). The resources are said to be efficiently used if its MVP is equal to its acquisition unit price.

The MVP is calculated as; MVP = ... (3)

Where a1 = regression co-efficient of the variables Y and X = values of log Y and log X when they assume their means. The prevailing market price of inputs was used as the marginal factor cost (MFC) since the farmers were assumed to be operating under purely competitive inputs markets. On the basis of the economic theory, a firm maximizes profits with respect to resource use when the ratio of the marginal return to opportunity cost is one. The values were interpreted thus; a) if r 1, it shows that the resource was being under-utilized and increasing the rate of use will raise profit level. c) If r = 1 it means resource was being efficiently utilized.

Determining technical efficiency of resource use

The elasticity of production which is the percentage change in output as a ratio of a percentage change in input was used to calculate the rate of return to scale which is a measure of a firm's success in producing maximum output from a set of input.

EP..... (4)

Where:

EP = elasticity of production

MPP = marginal physical product

APP = average physical product

If

EP =1: constant return to scale

EP < 1: decreasing return to scale

EP > 1: increasing return to scale

3.0 RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics of the Respondents

The socio-economic characteristic of respondents gives an insight into the expected behaviour of farmers because it makes available the necessary information about the farmers. Some of the socio-economic variables considered were age, sex, marital status, household size, highest level of educational attainment, farm size source of finance and source of labour. The results of analysis are as presented on Table 1. These variables could be used as parameters for measuring the management capabilities of the farmer and as an important factor in decision making.

3.1.1 Age of the respondents

Table 3 showed the age distribution of the respondents. The results revealed that 42.2% of the respondents were within the age bracket 41-50years, 31.1% were within 31-40 years, 15.6% were within age bracket 51-60 years, while 10.3% were within 21-30 years age bracket and the mean age was 40.9 years. From the findings it can be deduced that majority of the respondents were in their productive age while 16.3% of the respondents were advanced in age (more than 50 years). This finding is in agreement with Ibrahim ***et al.***, (2008) in a study of rice farmers in Badegi, Niger State where he observed 69.7% were below 50years of age and Hassan (2010) observed that only 22.4% were above 50 years of age. In the same vein Adegboye (2011) observed that only 14.7% of rice farmers in Kwara State were older than 50 years and also in a study of ginger farmers in Kaduna State who observed that only 20% were above 50 years. The implication of these findings was that the high incidence of youth population will imply that new ideas and farm innovations will be readily and quickly adopted than the older people. It also constitutes the groups that are exposed and can take sound decisions as regards effective farm management.

Table 1: Socio-economic Characteristics of Small-Scale Irish Potato Farmers

Variable	Frequency	Percentage
Age		
21-30	14	10.3
31-40	42	31.5
41-50	57	42.2
51-60	21	15.6
61-70	1	0.7
Total	**135**	**100**
Sex		
Male	60	44.4
Female	75	56.6
Total	**135**	**100**
Marital status		
Single	7	5.2
Married	107	79.3
Divorced	13	9.6
Widow	8	5.9
Total	**135**	**100**
Family size (no)		
1-5	33	25.4
6-10	77	59.2
11-15	19	14.6
16-20	1	0.8
Total	**130**	**100**

Source: Field survey, 2022

3.2 Determination of Resource use Efficiency of Small-scale Irish Potato Production

The economic theory states that a farm maximizes its profits with respect to an input if the ratio of MVP to its MFC is equal to one or unity. A ratio of less than one shows that there is over utilization of that input while a ratio of greater than one indicates underutilization of that input. The marginal value product with respect to each input was obtained by taking first order partial derivatives of the total value product function, when other inputs were held at their geometric means. Similarly, the marginal factor cost with respect to each input was obtained by taking the first order derivatives of the total cost function with respect to each input (land, labour, seed, and fertilizer), when other inputs were held constant. From Table 2 farm size input has MVP of ₦ 16. This means that, if all other inputs are held constant, increasing the quantity of farm size by one hectare would increase the total value product by ₦ 16. However, the marginal factor cost of farm size in the study area was ₦ 15.40 and the ratio is 1.04. This indicates the under - utilization of land input below its economic optimum level in the study area. This agrees with Ibrahim ***et al.***, (2009) that seeds, fertilizer and farm size are under- utilized in sorghum enterprise. The above may be so due to low opportunity developed from fear for the season as a result of the emergence of diseases like leaf blight, lack of fertilizer or manure, drought etc. at the beginning of that rainy season.

Thus, profit can be increased by using more hectares of land. The MVP of labour input is ₦ 10.74. This means that increasing the labour input by 1.0-man day, if other inputs are held constant would increase the total value product by ₦ 10.74. Like farm size, the MFC of labour in the study area was ₦ 12.00. The ratio is 0.90 which means over- utilization of labour input and this is below the economic optimum in the study area. The above is so due to the utilization of family labour in production and/ or cheap 60 source of labour available. This is in agreement with Amos et al. (1993) and Olagoke (1990). Thus small-scale Irish potato farmers in the study area can make more profit by increasing the amount of labour used. Fertilizer input has a marginal value product of ₦ 81.50. This shows that, if other inputs are held constant at their geometric means, increasing the quantity of fertilizer by 1.0 kg would increase the total value product by ₦ 81.50. However, the marginal factor cost of fertilizer input in the study area was 67.40 and the ratio is 1.21. This indicates underutilization of chemical fertilizer and may be as a result of low nutrients status inherent in soils of the study area and/or the cost of fertilizer is high and farmers are force to use this input below the required quantity so that they can break-even at the end of the day. This result agrees with Haruna ***et a***l., (2009) who reported the under-utilization of fertilizer, labour and farm size in cotton production. Table 2: Shows the Marginal Value Product (MVP) the Marginal Factor Cost (MFC) and Resource use Efficiency.

Table 2: Determination of Resource use Efficiency of Small-scale Irish Potato Production

Variable input	MVP	MFC	MVP/MFC
Land X_1	16	15.40	1.04
Labour X_2	10.74	12.00	0.90
Fertilizer X_4	81.50	67.40	1.21

Source: Field survey, 2022

3.3: Problems of Small Scale Irish potato Production

The problems encountered during Irish potato production in the study area are present in table 3 below:

Table 3: Shows the Problems of Irish Potato Production in the Study Area

Problems	Frequency	Percentage	Ranking
High post-harvest losses	105	77.0	1st
High cost of inputs	95	70.0	2nd
Inadequate finance	94	69.0	3rd
Low price	79	58.5	4th
Transportation problem	71	52.6	5th
Poor pests and diseases control program	52	38.7	6th
Soil problem	32	23.7	7th

Source: Field Survey, 2014

***Multiple responses existed hence percentage greater than 100**

Post-harvest losses among farmers are the most production problem faced by Irish potato farmers in the study. This was ranked 1st (77%). This was because in the study area, most of the tubers were either stored in bags, basket or heaped on the floor of any convenient space in the farm stead because storage facilities are expensive. This leads to rottening of the 62 tubers as a result of heat generated. This finding agrees with Erhabor (2003) and NAERLS (1989). High cost of inputs was ranked 2nd (70%) among other problem that were identified as constraints of potato production in the study area. Most farmers in the study area complained of the accelerated prices of commercial seed and fertilizers. In terms of seeds, the lack of community seed programme made it difficult farmers to have access Lenka, ***et al.***, (2005) and Iwena, (2008) who reported that most potato varieties grown by farmers were imported about 25 years ago and their yield have declined. For even when they do the prices in the market is always higher thereby preventing them from acquiring the needed quantities.

Inadequate finance was ranked 3rd among the factors militating against Irish potato production in the study area. This is because to operate a potato enterprise, requires finances in order to make production more profitable. Moreover, acquiring loan from financial institutions which is supposed to help in curtailing this problem comes with high interest rate, requirement for collateral security, short duration of loan repayment and the conditions for obtaining loan from financial institutions are unattractive to farmers. Low price as indicated in table 3 above was ranked 4th (58.5%) of the problems confronting potato production in the study area. This always makes farmers sell the produce at give-away prices to exploitative middlemen in order to prevent losses due to the inadequate storage facilities which are already an existing problem. The table above revealed that poor transportation was 5th (52.6%) of the factors affecting potato enterprise in this study area. This production problem affects the supply and distribution of the produce. Because most rural roads are feeder roads which are characterized by frequent increases in transportation fare and bruises to the potato tubers. Pests and diseases are among the problems faced by farmers in the study area and is ranked 6th (38.5%). Pests and diseases

either attacks or affect the plant while in the field or they attack the crop during storage. This leads to either vegetative losses and/or tuber losses. Hence this factor limits the production of Irish potato in the study area. Soil fertility problem is last on the list and it was a constraint that led to increase rate of fertilizer application which in turn increased the cost of production. Consequently, the above discussed factors affected the potato farmers in the study area by reducing their efficiency, profit and optimality.

4.0 CONCLUSION AND RECOMMENDATION

Conclusion:

This study's findings indicate that small-scale Irish potato farmers in the study area can improve productivity and profitability by optimizing input use. The positive marginal value products of all inputs suggest that strategic resource adjustments can enhance total productivity. However, high post-production losses and costly inputs hinder farmers' productivity, emphasizing the need for targeted interventions.

Recommendations:

1. Farmers should be encouraged to adopt optimal resource use practices to maximize productivity and profits.
2. Establish linkages between farmers and input suppliers to reduce costs and enhance accessibility of quality inputs.
3. Policy initiatives should focus on reducing post-production losses through improved storage and marketing infrastructure.
4. Development programs should prioritize training and capacity building for farmers to optimize input use and improve productivity.
5. Further research should investigate innovative solutions to address high input costs and post-production losses in small-scale Irish potato production.

REFERENCES

Amos, T. T., Agbo, C. L., Ogunble, A.O. and Adebitan, S.A (1993). Labour Use and Farm Size in Maize Production under Current Improved Technology. The Nigerian Journal of Agricultural Extension. 8(1&2): 41-49.

Fakayode, S. B., Babatunde, R.O., Rasheed, A., (2008). Productivity Analysis of Cassava Based Production System in the Guinea Savannah. A case study of Kwara State, Nigeria. American Journal of Scientific Research. 3(1): 33-34

Federal Ministry of Agriculture and Rural Development. Crop, Area and Yield Survey, 2001.

Haruna, B; Kyiogwom, U. B, Senchi, I. D and Singh, A. (2009) Resource – Use Efficiency in Cotton Production in Selected L.G.A of Zamfara State, Nigeria. In Mohamed, I. Kyiogwom, U.B., Hassan, W.A, Ala, A.K., Singh, A. and Dogondaji, S.D. (ed) Sustaining Agricultural Growth to Meet National Economic Development Goal. Proceedings of 23rd Annual Conference of Farm Management Association of Nigeria.

Ibrahim, F. D., Alhassan, Z. S, Ibrahim, M and Ibrahim, P. A. (2009). Private Sector (Candel Company) and boasting Rice Production: a Case study of R – Box Technology Adoption in Badeggi, Bida l.G.A of Niger state. Proceedings of 10th Annual Conference of Nigeria Association of Agricultural Economics (NAAE) Held at Abuja. October 7th – 10th, Pp. 136 -144

Lenka, D. M. (2005). Temporal and Partial Pricing Efficiency in Potato Marketing in Bauchi and North Central Nigeria Annual Report. National Root Crops Research Institute Umudike Umuahia, Pp. 143 – 145.

Mohammed, A. B., Ayanlere, A. F., Ibrahim, U. and Muhammad, A, (2013). Economic Analysis of maize Production in Ogiri/Magongo L.G.A of Kogi State. Journal of Agricultural Economics and Development Vol 1(3)

National Population Commision, (2007). Preliminary 2006 Census figures. Retrieved 2007 from http//www.population.gov.ng/pop.figure.

Nesbitt, H. (2003). An Evaluation of the Economic, Social and Environmental Impacts of the Cooperation Research Centre for Sustainable Rice Production; Cooperative Research Centre for Sustainable Rice Production.

Noonari, S., Wigan, H., Memon, I. N., Ahmed, F., 2016. Economic Analysis of Potato Production in Sindh Pakistan. Journal of Economic Analysis, 6(5): 100-107. (https://www.researchgate.net).

Odusina, A. O. (2008) Urban Rice Demand Analysis: A case study of Ijebu Ode Township; Middle-East Journal of scientific research Vol. 3 No.2, IDOSI publication.

Okonkwo, J. C, Ene, L. S. and Okoli, O. O. (1995a) Potato Production in Nigeria. Publication of National Root Crop Research Institute, Umudike, Umuahia, Nigeria. 109pp.

Okonkwo, J. C, Ene, L. S. and Okoli, O. O. (1995b) Potato Production in Plateau State. National Root Crop Research Institute, Umudike, 34pp.

Olagoke, M. A. (1990) Efficiency of Resources Use in Rice Production Systems in Anambra State, Nigeria. African Royal Science Series, Winrok International Research Report. No, 7, 24pp.

Sani, A., Yakubu, A. A, and Bello, H. M (2010). Resource-Use Efficiency in Rice Production under Small-Scale Irrigation in Bunkure Local Government Area of Kano State. Nigerian Journal of Basic and Applied Science, 18(2),: 292-296

Shabu, T. (2011) Impact of Olam-out Grower Programme on Rice Farming in Kaamb District Guma Local Government Area, Benue State. (Unpublished) M.Sc. Dissertation; Benue State University, Makurdi.

Taha, Z., Sarahan, R., Farouk, A., Aziz, K., (2007). Effect of Potassium Fertilizer and Soil Cover in Three Cultivated Potatoes Categories in Basrah Governorate. Journal of Tikrit University for Agricultural Sciences, 41(2): 2224-9796.

Udoh E. J. and Etim., N. A (2008). Determinants of Technical Efficiency in Poultry Production: The case of urban broiler farmers in Nigeria. In Adeyemi D.A, Dada, A.O. Eniolorunda, O.O, Awojobi, H.A, Oke, D.B. and Agunbiade, J.A. (ed). Proceedings of 33rd Annual Conference of the Nigerian Society for Animal Production, Ogun State: College of Agricultural Sciences Olabisi Onabanjo University, Yewa Campus,Ayetoro Ogun State. Pp 320-323

Ugonna, C. U., Jolaosa, M. O., Onwualu, A. P. (2013). A Technical Apprisal of Potato Value Chain in Nigeria. International Research journal of Agricultural Science and Soil Science 3 (8), 291-301

ECONOMICS OF COCOYAM PRODUCTION IN ANAOCHA LOCAL GOVERNMENT AREA, ANAMBRA STATE, NIGERIA.

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ABSTRACT

The study analyzed the economics of cocoyam production in Anaocha Local Government Area, Anambra state, Nigeria. The study identified the varieties of cocoyam produced, estimated the cost and returns, analyzed the determinants of cocoyam production and identified the constraints to cocoyam production. A multistage sampling procedure was used in the selection of 138 respondents used for the study. Data were collected using a well-structured questionnaire. Data obtained were analyzed using both descriptive and inferential statistics and budgetary analysis. Results from the study showed that most of the respondents were female, with mean age of 45 years, were married and had attained secondary education, with a mean household size of 5 persons. A large proportion of the respondents not belonging to an association and not having contact with extension agents. The mean farming experience was 17 years and their mean farm size was 0.93 ha. The white cocoyam (Xanthosoma sagittifoluim) was predominantly produced in the study area. The total cost of production was ₦79, 298.55 while the total returns was ₦100, 820.29 per ha. The gross margin and net farm income were ₦43, 043.48 and ₦21, 521.74 respectively. The revenue-cost ratio was 1.27. The result for the factor influencing cocoyam production showed that the adjusted R^2 was 0.57. This implies that about 57% of the variation of the determinants of the factors influencing cocoyam output of respondents in the study area was explained by the explanatory variables. The key determinants of cocoyam production were farm size ($p<0.01$), household size ($p<0.1$), fertilizer rate ($p<0.05$), planting material ($p<0.05$), agrochemical application ($p<0.1$) and capital ($p<0.05$). The major constraints to cocoyam production identified included lack of good planting material, high cost of land and pest and diseases. The study therefore recommended that farmers should be encouraged pool their financial resources together to form cooperative as it will enable them access to low cost inputs, thereby taking advantage of economies of scale and size.

Keywords: Economics, Production, Cocoyam, Cost and Returns

Introduction

Cocoyam is an important tropical root crop grown purposely for its starchy corms or underground stem (Si, Zhang, Tang, Yang, Wen, wang & Zhou, 2018). It is one of the oldest world's food crops believed to have been first domesticated in Southeast Asia before its eventual spread to other parts of the world (Ramantatha, Matthews, Eyzaguire & Hunter 2010; Ubalua, Ewa & Okeagu, 2016). As early as 4000 BCE, cocoyam as food held a central role in the culinary traditions and cultural practices of diverse ethnic groups. Archaeologists discovered evidence of cocoyam cultivation in Nigeria dating back to as early as 4000 BCE (Ene-Obong *et al.*, 2019). Across different ethnic groups, including the Igbo, Yoruba, and Ibibio, cocoyam is not merely a dietary staple but a symbol of fertility, prosperity, and cultural

identity (Okoye *et al.*, 2021). Its usage extends beyond the confines of the kitchen, featuring prominently in traditional ceremonies, rituals, and festivities.

Cocoyam, historically, served as both sustenance and currency. Studies emphasize its role as a form of currency in trade and exchanges between communities (Okafor, 2020). The crop's versatility has allowed it to adapt to diverse agro-ecological zones in Nigeria, playing a vital role in ensuring food security. Cocoyam, particularly, continues to thrive as a resilient and sustainable crop, with farmers passing down cultivation practices from generation to generation. Okafor (2020) highlights its presence in ceremonies, underscoring its enduring importance in contemporary Nigerian society. While cocoyam has been a steadfast companion in times of plenty, it has gained renewed interest in recent years as a potential solution to contemporary challenges.

The Food and Agriculture Organisation (FAO), reported that, Nigeria is the highest global producer of cocoyam in 2019, with about 2.86 million tonnes and 27.14% share of world total production (Food and Agriculture Organization Statistics, (FAOSTAT), 2021). Cocoyam production is mostly used for human consumption and an important food security crop in times of failure or shortage of other crops (Acheampong *et al.*, 2014). Cocoyam production in particular, is differentiated along gender lines in most of Southeast Nigeria cropping systems (Ugboaja, Echebiri, Ogbodo, & Ebe, 2018). Cocoyam has been generally described as a woman's crop because of its low yield per hectare and its production that has remained at the subsistence level. Added to this, the nutritional and medicinal qualities as well as role of cocoyam in household food security were not quite known until recently. Men would want to engage in agricultural activities that yield more economic returns (Chukwu, 2015) and confer social and economic prestige. Most times their husbands only allow them to cultivate their cocoyam under their established oil palm, rubber, cocoa plantations and waste lands (Dike, 2016). Interestingly, recent research have shown that consumption of cocoyam is healthy as most rural people fine it most preferable to other staples especially those who are diabetic or pre diabetic.

Currently, cocoyam is highly produced in the southern part of the country. This region has high rainfall of about 1517 to 1799 mm (Ngene, *et al.*, 2018). However, the region lacks adequate field to cultivate the large quantity required for food security. Despite its wide adaptability as well as its nutritional and economical values, cocoyam output performance in the country has remained below expectation ranging between 5 and 7.5 tons per hectare (Otekunrin *et al.*, 2021). Unlike yam and cassava, the production of cocoyam has not been given necessary attention, farmers allocate resources to other food crops more than how they allocate to cocoyam (Anyiam *et al.*, 2023). This has seriously affected the production of cocoyam over time. Cocoyam would have been a major source of raw material for the production of essential vitamins as the crop is rich in essential vitamins and mineral nutrients, these vitamins and mineral nutrients remain untapped, neglecting the health benefits of the crop to improve the health relief of the people (Boakye *et al.*, 2018). Cocoyam can be used to improve rural and urban income and development in Nigeria if investments in the downstream sector of the industries are made more effective (Daud, Amao, Ganiyu & Adeniyi, 2015). Production of cocoyam has been neglected

in many countries probably because of its inability to contribute to the GDP through foreign exchange earnings and most of what is produced is consumed locally (Mbanaso and Enyinnaya, 1989; Abdulrahman *et al.*, 2015). Cocoyam production is faced with several challenges. Anaocha LGA, like many other agricultural regions, is susceptible to various risks, including adverse weather conditions, pests, and diseases. Smallholder cocoyam farmers in the study area often lack the resources and strategies to effectively mitigate these risks, leading to potential crop losses and decreased yields (Ojo *et al.*, 2022).

Several studies has been conducted in various agricultural contexts, studies on profit efficiency, profit efficiency of smallholder cocoyam based farmers, technical efficiency of cocoyam, economics of cocoyam production by (Abdulrahman, Yusuf and Suleiman, 2015; Afolami & Ogungbenro, 2018; Abdulrahman, Yusuf, Sanni & Ayinde, 2018; Anyiam, Uhuegbulem, Obi-Nwandikom, Ibegwa, Okwara, Eze & Nwokedimkpa 2023). Study of Ume *et al.*, (2016), discussed the allocative efficiency of scarce resources by cocoyam farmers and the profitability of cocoyam production in Anambra state. Enibe *et al.*, (2019), analyzed cocoyam market in the Anambra agricultural zone in Anambra state. It also examined the profitability of cocoyam market. There is dearth of comprehensive knowledge on the economics of cocoyam production in Anaocha LGA, Anambra State. This study will bridge the research gap that exists in the economics of cocoyam production in Anaocha Local Government Area, Anambra State, Nigeria. Based on the forgoing, it was necessary to conduct this research to identify the varieties of cocoyam produced in the study area, evaluate the cost and returns of cocoyam production, determine the factors influencing cocoyam production and examine the constraints to cocoyam production in the study area.

Materials and Methods

Study Area

This study was conducted in Anaocha LGA of Anambra State, Nigeria. Anaocha LGA lies between latitude 6° 4' 6" North of the equator and longitude 6° 59' 47" East of the meridian. Anaocha LGA is bordered by Awka North LGA to the north, Njikoka LGA to the east, Aguata LGA to the south, and Awka South LGA to the west. It has an area of 113.2 km² and an estimated population of 405,000 (National Population Commission of Nigeria, 2022). Anaocha LGA's average temperature is 27.5°C, with a humidity of 79%. The region has two significant seasons: the dry season, which runs from November to March, and the rainy season, which lasts from April to October. The people in the area are predominantly farmers with few traders. Anaocha LGA has a vibrant agricultural sector with crops such as cassava, yam, and cocoyam grown in substantial quantities as well as livestock like goat, sheep and poultry birds. Wood processing is another important economic activity in Anaocha LGA.

Sampling Procedure

A Multi-stage sampling technique was used to select the number of respondents for this study. Firstly, the purposive sampling technique was used to select six out of the ten autonomous communities in the study area due to the large concentration of cocoyam farmers in the area. Secondly, the random sampling technique was used to select five villages out of the six selected

autonomous communities in the study area. Lastly, the purposive sampling technique was used to select cocoyam based farmers in each of the selected villages.

The data collected were analyzed using descriptive statistics, budgetary analysis and the ordinary least square regression model.

The model for estimating cost and returns of cocoyam output is expressed as follows;

$GM = TR - VC$ ---------- (1)

The net farm income is expressed as follows

$NFI = GM - TFC$---------- (2)

Where; GM = Gross Margin of cocoyam farmers in naira (₦), TR= Total Revenue in naira (₦), which is = Price per unit x Total quantity produced, Price per unit = Average selling price of cocoyam in naira (₦), Total quantity produced in (Kg) = Total yield of cocoyam harvested, VC = Variable Costs in naira (₦) = Costs of variable inputs (seeds, fertilizers, rent, labor etc.). NFI = Net Farm Income, TFC = Total Fixed Cost

Rate of return per naira investment= NFI/TC

Profit margin = NFI/TR

Operating expense ratio = TVC/TR

The Ordinary Least Square regression model is expressed implicitly as follows;

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}, \varepsilon i)$

Where Y = Cocoyam output (kg),

X_1 = Farmers' age (years),
X_2 = Gender (1 = Male, 0 = Female),
X_3 = Farm size (ha),
X_4 = Household size (number of persons),
X_5 = Farming experience (years),
X_6 = Educational level (years of schooling),
X_7 = Labor (man-day),
X_8 = Fertilizer rate (kg),
X_9 - Quantity of planting materials (kg).
X_{10} = Membership to cooperative (1= Yes, 0= No),
X_{11} = Agrochemical use (liters),
X_{12} = Capital (the worth of various input in Naira).
e = error term

Four functional forms, linear, semi log, exponential, double log, the functional form were tried the one with the best fit was chosen as the lead equation.

Results and Discussion

Socio-economic characteristics of the respondents

The result in Table 1 revealed that majority of the respondents were female (59.4%) . This implies that female participated more actively in cocoyam production than male. The study agrees with the finding of Osahon and Odoemelam (2019). They reported that apart from yam, every other root and tuber crop is a woman's crop.

The result also revealed that the mean age of the respondents was 45 years. The result showed that the farmers were advanced in age. This finding agrees with that of Mukaila *et al.*, (2022). They reported that the farmers were advanced in age but still in their economic and active age.

The result also showed that 35.5% of the respondents were married, this implies that the study area was dominated by married individuals and they were relatively responsible, mature and financially stable to enable them carry out their farm business. The study agrees with the findings of Okoye *et al.,* (2015), which reported that marriage indicates some level of responsibility, commitment and stability.

The result showing the educational level indicates that 47.1% of the respondents had secondary education. This shows a high literacy in the study area. The high literacy level in the area would enhance their high involvement in cocoyam production and also enable farmers to be fast in the adoption of technologies. This finding is in line with that of Ezeano (2015), which reported that the high number of literate people among the respondents indicated that the majority of them are in a better position to adopt new technologies.

The household size distribution of respondents showed that the mean household size was 5 persons. The study showed that the respondents had large household size. The high number of persons per household may indicate the availability of family labour to carry out production activities. This will affect the size of land cultivated and also enhance the returns. The study agrees with the finding of Mukaila, Falola, & Ometesho (2020) they reported that the large household size will readily serves as source of labour.

This study revealed that most of the respondents (71.7%) did not belong to cooperative. The high proportion of respondents who did not belong to any cooperative may not be able to access credit easily, might limit their access to agricultural information on improved techniques of cocoyam production.

The result indicates that 69% of the respondents did not have contact with extension agents. This shows that cocoyam farmers in the study area may not be aware of the new innovation in cocoyam production and hence, may be implementing their production processes using local method which may likely not yield the desired results in terms expanding their techniques, intensifying crop yield per unit area, adopting new and improved innovation.

The result showed that the mean farming experience was 17 years. This revealed that many of the farmers are quite knowledgeable about cocoyam production in the study area and have been engage in cocoyam production for a long period. However, it is expected that with increasing years of farming, respondents would gain experiences in farming to the advantage of increasing agricultural productivity and technological ideas to tackle farm production problems. This finding is in line with that of Mukaila *et al.*, (2022). They reported that the farmers are experienced in cocoyam production activities as they have been in it for long. Thus the farming experience will greatly influence the farmer's production level and income as well.

In terms of income, 37% of the respondent earned within the range of ₦150,001- ₦200,000. This signifies the respondents are low income earners and this will have a negative effect on cocoyam production,

The study revealed that the mean farm size was 0.93ha. This implies that respondents in the area cultivated cocoyam on a small scale. It is expected that an increase in farm size should lead to an increase in cocoyam output. Cultivating in small scale implies that the farmers practices subsistence agriculture.

Table 1: Socio-economic characteristics of respondents

Variables	Frequency	Percentage
Gender		
Male	56	40.6
Female	82	59.4
Total	138	100
Age		
Less than 30	27	19.6
30-39	27	19.6
40-49	24	17.4
50-59	28	20.2
Above 59	32	23.2
Total	138	100
Mean	**45**	
Marital status		
Single	41	29.7
Married	49	35.5
Widowed	27	19.6
Divorced	21	15.2
Total	138	100
Educational level		
Primary education	38	27.5
Secondary education	65	47.1
Tertiary education	35	25.4
Total	138	100
Household size		
1-3	13	9.4
4-6	90	65.2
7-9	33	23.9
Above 9	2	1.4
Total	138	99.9
Mean	**5**	
Membership of Cooperative		
Yes	39	28.3
No	99	71.7
Total	138	100
Number of extension contact		
No contact	74	53.6
1-2	56	40.6
Above 2	8	5.8
Total	138	100
Farming experience		
1-10	49	35.5
11-20	41	29.7
21-30	31	22.5
Above 30	17	12.3
Total	138	100
Mean	**17**	
Annual income		
Less than ₦100,001	5	3.6
₦100,001- ₦150,000	33	23.9
₦150,001- ₦200,000	51	37
₦200,001- ₦250,000	12	8.7
Above ₦250,000	37	26.8

Total	138	100
Farm size		
0.5-1	102	73.9
1.1-1.6	32	23.2
1.7-2.2	3	2.2
Above 2.2	1	0.7
Total	138	100
Mean	**0.93**	

Source: Field survey, 2024

Varieties of cocoyam cultivated in the study area

The result in Table 2 indicates that the white cocoyam (*Xanthosoma sagittifolium)* which is also known as *tannia* and yellow cocoyam (*Colocasia esculenta)* otherwise known as *taro,* are the two types of cocoyam species produced in the study area. The result revealed that 52.2% of the cocoyam produced was white specie and 47.8% was yellow specie. This indicates the importance of *Xanthosoma sagittifolium* to human health benefit.

Table 2: Varieties of cocoyam produced in the study area

Variety	Frequency	Percentage (%)
White	72	52.2
Yellow	66	47.8
Total	138	100

Cost and returns of cocoyam production

The estimate of the cost and return per hectare of cocoyam farmers is presented in Table 2. The estimated cost and returns of cocoyam farmers was ₦79298.55 per ha and ₦100820.29 per ha respectively. The total variable cost of production was ₦ 57,776.81 per ha and constituted 72.86% of the total cost of production while the total fixed cost was ₦ 21,521.74.

The gross margin and net farm income was ₦ 43,043.48 and ₦ 21,521.74 respectively per hectare. The positive values of gross margin and net farm income implies that cocoyam production was profitable in the study area.

The result further revealed that the revenue-cost ratio was 1.27. This implies that for every one naira invested a profit of ₦0.27kobo was realized. Thus indicating that cocoyam production among cocoyam farmers was viable since they can pay for the factors of production and still make profit. The result obtained is in line with the findings of Abdulrahman *et al.,* (2015). They reported that return per naira investment was 1.69, indicating that for every ₦1 invested in cocoyam a profit of ₦0.69 kobo.

Table 3: shows the cost and return per hectare analysis for cocoyam production

Items/activities	Total cost (₦)	%Total cost
VARIABLE COST		
Planting materials	24,225	
Fertilizers	16,850.32	
Tillage/Ridges making	6500	

Harvesting	4,036.24	
Bush clearing	3,765.25	
Planting	2400	
Total variable cost	**57,776.81**	**72.86**
FIXED COST (Depreciated using straight line method)		
Wheelbarrow	9,740.31	
Machete	5,290	
Shovel	3,285	
Basin	2,097.20	
Weeding hoe	1,109.23	
Total fixed cost (TFC)	**21,521.74**	**27.14**
Total cost (TC)	**79,298.55**	
Revenue		
Unit price	337.54	
Quantity	**298.6913847248**	
Total revenue	**100,820. 29**	
Gross margin (GM) =TR-TVC	**43,043.48**	
Net farm income (NFI) = TR-TC	**21,521.74**	
Farm financial ratio		
Rate of return per naira investment (NFI/TC)	0.27	
Revenue-Cost ratio = TR/TC	1.27	
Profit margin = NFI/TR	0.2	
Operating expense ratio = TVC/TR	0.6	

Source: Data analysis, 2024.

Factors influencing Cocoyam production in the study area

Table 3 shows that the linear model was chosen as the lead equation. The adjusted R^2 and F-statistic value was 0.57 and 16.1317 respectively. This implies that about 57% of the variation of the determinants of the factors influencing cocoyam output of respondents was explained by the explanatory variables. Variables such as farm size ($p<0.01$), household size ($p<0.1$), fertilizer rate ($p<0.05$), planting material ($p<0.05$), agrochemical application ($p<0.1$) and capital ($p<0.05$). The F-statistic value of 16.1317 was significant at 5%. Implying that the joint effect of the regression analysis was significant.

The result revealed that farm size (9.024) was positive and significant at 1%. This implies that for every unit increase in farm size all things being equal the output increases by 9.024 kg/ha. The coefficient of household size (4.996) was significant at 10% and positive. This means an increase by one person will lead to an increase in output by 4.996kg/ha, this is because of the availability of farm labour. Furthermore, fertilizer rate and planting materials both has positive and significant relationship on output of cocoyam. The fertilizer coefficient (0.776) means that if the quantity of fertilizer increases by one unit (kg) the output of cocoyam increases by 0.776kg/ha. More so, if the quantity of planting materials increases by one unit (kg) the output increases by 35.615kg/ha. Both fertilizer rate and planting materials were significant at 5%. The result further revealed a positive and significant relationship between agrochemical

application and output. Agrochemical coefficient (7.256) means that if the quantity of agrochemicals applied increases by one unit (1litre) all things being equal, the quantity of cocoyam increases by 7.256kg/ha. More so, the coefficient of capital (0.002) has a positive and significant effect on cocoyam output. This implies that for every one naira increase all things being equal, the quantity of cocoyam increases by 0.002kg/ha. Since the F-calculated is greater than the F- tabulated, we reject the null hypothesis and conclude that these variables significantly affect output of cocoyam in the study area. This findings agreeds with the study of Nwafor *et al.*, (2016), they reported cocoyam output was positively influenced by credit, land farm size, farming experience, fertilizer and planting material.

Table 4: factors influencing cocoyam production

Variable	Linear(+)	Semi Log	Double Log	Exponential
Constant	31.476	-18.486	4.378	4.530
	(30.846)	(159.767)	(.796)	(0.161)
Age	0.327	5.030	-.075	-.001
	(0.4620	(18.821)	(.094)	(.002)
Sex	16.371	15.172	.066	.071
	(9.491)	(9.9360	(.049)	(.050)
Farm size	9.024	59.687	.212	.032
	(3.516)***	(17.403)***	(.087)***	(.017)**
House hold	4.996	35.713	.235	.033
size.	(2.924)*	(15.616)***	(.078)***	(.015)**
Farming	-1.058	-8.902	-.007	-.002
experience	(0.641)	(9.028)	(0.45)	(.003)*
Educational	0.529	7.306	.004	-.001
level	(1.371)	(13.726)	(.068)	(.007)
Labour	1.501	1.301	-.003	.007
	(1.535)	(9.1170)	(.045)	(.008)
Fertilizer	0.776	11.595	.037	.002
	(0.784)**	(12.080)**	(.060)*	(.004)
Planting	35.613	74.493	.377	.171
material	(5.654)**	(11.530)	(.057)*	(.030)***
Membership of	2.066	2.422	-.016	-.021
cooperative	(10.293)	(10.583)	(.053)	(.054)
Agrochemical	7.256	-16.641	-.080	-.032
	(3.944)*	(11.896)	(.059)**	9.021)
Capital	0.002	-2.570	.017	2.19
	(0.007)**	(19.294)	(.096)*	(.000)
R^2	0.608	0.572	0.533	0.529
Adj.R^2	0.570	0.531	0.489	0.483
Fcal	16.137**	13.922	11.913	11.677
SE	0.389109	54.71310	.27249	0.27395

Source: Data analysis computed from field survey, 2024. Note: Values in parenthesis are standard errors, *** =significant at 1%, ** =significant at 5% and * =significant at 10%. (+) = Lead equation.

Constraints to cocoyam production in the study area

The result showing the constraints to cocoyam production is presented in table 4. A weighted mean value of 3.00 was used as benchmark to rank items which describes the constraints to cocoyam production in the study area. A mean score of 3.00 and above indicates a severe constraint while a mean score of less than 3.00 indicate less severe constraints. The result showed that the severe constraints to cocoyam production by the farmers were; lack of good planting material (3.54), high cost of land (3.54), pest and diseases (3.48), insufficient capital (3.32), high cost of fertilizer (3.26), high cost of corm sett (3.25), unstable market price (3.11), lack of credit facility (3.01). Majority of the farmers cultivated cocoyam on a small scale due to high cost of land and availability of land. Farmers tend to use animal manure due to the high cost of N.P.K fertilizer. Cocoyam production was severely affected by lack of credit facility as the farmers' income was not enough to expand their production. This limits their production to small scale venture. Lack of storage facilities were severe constraint to farmers; this may lead to post harvest loss and forces cocoyam farmers to sell their products at a cheaper rate. Pest and diseases also affected cocoyam production severely. This is due to the high cost of pesticide to control them which resulted in low output and consequently low profit.

This finding is in line with that of Mukaila *et al.*, (2022). They identified high cost of inputs such as planting material, fertilizers, pesticides and herbicides, inadequate storage facilities, incidence of pest of diseases, high cost of hired labour to be severe constraints faced by cocoyam farmers.

Table 5: constraints to cocoyam production

Constraints	SA(5)	A(4)	UD(3)	D(2)	SD(1)	Mean	Rank
High cost of Land	50(250)	29(116)	20(60)	23(46)	16	3.54	1st
Lack of good planting material	39(195)	42(168)	21(63)	27(54)	9	3.54	1st
Pest and Diseases	36(180)	47(188)	21(63)	15(30)	19	3.48	3rd
Insufficient capital	41(205)	31(124)	21(63)	21(42)	24	3.32	4th
High cost of fertilizer	34(170)	35(140)	23(69)	25(50)	21	3.26	5th
High cost of corm setts	37(185)	31(124)	22(66)	26(52)	22	3.25	6th
Lack of storage facilities	28(140)	32(88)	28(84)	30(60)	20	3.13	7th
Unstable market price	28(140)	33(132)	29(87)	22(44)	26	3.11	8th
Lack of credit facility	23(115)	31(124)	30(90)	33(66)	21	3.01	9th
Low access to market	23(115)	33(132)	22(66)	24(48)	36	2.88	10th
Educational level of farmers	25(125)	27(108)	20(60)	35(70)	31	2.86	11th
Shortage of labour	25(125)	25(100)	26(78)	28(56)	34	2.85	12th

Transportation cost	20(100)	20(80)	38(114)	35(70)	25	2.82	13th
High cost of hired labour	23(115)	26(104)	24(72)	26(52)	39	2.77	14th
Gender of farmer	24(120)	28(112)	15(45)	33(66)	38	2.76	15th
Age of Farmer	17(85)	25(100)	24(72)	43(86)	29	2.70	16th

Source: Field survey, 2024. SA= strongly agreed, A=agreed, SD= strongly disagree, D= disagree, UD= undecided. Weighted mean= 3.00.

Conclusion

The study showed that majority of the cocoyam farmers were female, still in their active age, experienced with good level of education. Cocoyam production in the area was significantly influenced by farm size, household size, labour and good planting material. Despite the constraints faced by cocoyam farmers in the production of cocoyam, cocoyam farming was profitable in the area. The study therefore concludes that cocoyam production is a profitable and viable enterprise.

Recommendations

Based on the findings, the following recommendations were put forward:

1. There's need for the intensification through improved varieties. Seeing that majority of the farmers were female, so as to boost their output of cocoyam due to their small land size.
2. Farmers should be encouraged to pool their resources together to form cooperative associations to enable them interact with each other thereby taking advantage of economies of size and scale.
3. The government at the local level should send agricultural agents to farmers to bridge the need of the farmers.
4. Government should provide services like conducting free training programs for farmers to educate them on better control of pest and diseases.

References:

Abdulrahman, S., Yusuf, O. & Suleiman, A.D. (2015). Profit efficiency of cocoyam production in Kaduna State, Nigeria. *American Journal of Experimental Agriculture*. 7 (4), 231 -241.

Abdulrahman, S., Yusuf, O., Sanni, S. A., & Ayinde, T. B. (2018). Technical Efficiency of Cocoyam Production in Kaduna State, Nigeria: A Stochastic Production Frontier Approach. *Journal of Economics, Management and Trade*, *21*(11), 1–10. https://doi.org/10.9734/JEMT/2018/9964

Acheampong, P. P., Osei-Adu, J., Amengo, E., Sagoe, R. (2014). *Cocoyam value chain and benchmark study in Ghana.* A report submitted to West African Agricultural Productivity Project (WAAPP). Project Information Document. 7-11.

Afolami, C.A. & Ogungbemro, I.B. (2018). Profit efficiency of smallholder cocoyam farmers and it's determinant in Osun State, Nigeria. *Journal of agricultural science and Enviroment.* 18(1), 36-46. Anyiam, K.H., Uhuegbulem, I.J., Obi-Nwandikom, C.O., Ibeagwa, O.B., Okwara, M.O.,

Eze, J.A. & Nwokedimkpa, P.E. (2023). Economics of Cocoyam Production in Orsu Local Government Area, Imo State, Nigeria. *The International Journal of Agriculture, Management and Technology*. 7 (1), 557-565.

Boakye, A.A., Wireko-Manu, F.D., Oduro, I., Ellis, W.O., Gudjónsdóttir, M., Chronakis, I.S. (2018). Utilizing cocoyam (*Xanthosomasagittifolium*) for food and nutrition security: A review. *Food Science and Nutrition*. 6, 703–713.

Chukwu, G.O. (2015). Land Use for Cocoyam in Nigeria: Implication for Cocoyam Rebirth. *Journal of Hill Agriculture*. 6 (1), 1 – 7.

Chukwu, G. O., Okoye, B.C., Agugo, B.A.C., Amadi, C.O. and Madu, T.U. (2017). *Cocoyam rebirth: A structural transformation strategy to drive cocoyam value chain in Nigeria.* NRCRI book of readings in honour of Dr. J.C. Okonkwo's structural transformation in root and tuber research for value chain development and employment generation in Nigeria.

Daud S.A., Amao O., Ganiyu M.O. & Adeniyi B.A. (2015). Analysis of cassava production in Saki-West Local Government Area of Oyo State. *Journal of Biology, Agriculture and Healthcare*. 5(10), 51-59.

Dike, F. (2016). *Evaluation of Gender Participation in Cocoyam Production in Abia State*. Thesis, Michael Okpara University of Agriculture, Umudike, Nigeria.

Ene-Obong, H. N., et al. (2019). Cocoyam in Nigerian Culture: A Multifaceted Analysis. *Cultural Anthropology*. 16 (4), 321-336.

Enibe, D.O., Nwobodo, E.C., Nworji, M.J. & Okonkwo, C.A. (2019). Economic analysis of Cocoyam marketing in Anambra state, Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology*. 29(3), 1 – 10.

Ezeano, C.I. (2015). Analysis of the influence of personal and socio-economic characteristics of small scale farmers on sweetpotato production in South-East agro-ecological zone, Nigeria. *International Journal of Agricultural Bio-Science*, 4(2), 49-53.

FAOSTAT. (2021)Food and Agriculture Organisation of the United Nations Statistical Database; Statistical Division; FAO: Rome, Italy, 2021; http://www.fao.org/statistics/en

Mbanaso, E.N.A & Enyinnaya, A.M. (1989). *Cocoyam germplasm conservation*. NRCRI Annual Report: 60 Mukaila, R., Falola, A. & Ometesho, O. A. (2020). Food security status: its drivers and coping strategies among vegetable farming household. *Cercetari Agronomice In Moldova* 53(4): 414-425.

Mukaila, R., Falola, A., Awoyelu, F. E., Akanbi, S. U. O., Chiemela, C. J., Ukwuaba, I. C., & Erim, P. A. (2022). Profitability of cocoyam production and its determinants in Cross River State, Nigeria. *Jordan Journal of Agricultural Sciences*, 18(4), 279-292.

Ngene B. U., Jonah C. A., Imokhai T. T. and Gideon O. B. (2018). *Geography of Udi Cuesta Contribution to HydroMeteorological Pattern of the South Eastern Nigeria*. Nwafor, F.N.,

Anyaegbunam, H.N., Olojode, J.C. & Nzeakor, F.C. (2016). Assessment of factors influencing cocoyam production among farmers in Southeast zone of Nigeria. *Jordan Journal of Agriculture and Social Research (JASR).* 16(2), 32-39. Okafor, A. (2020). Cocoyam Symbolism in Traditional Ceremonies among the Igbo People. *African Cultural Studies.* 8(2), 189-205.

Okoye, B.C., Okoye, A.C., Okoroafor, O.N and Amaefula, A.B. (2015).Adoption analysis of improved cocoyam production process and storage technology across gender in Enugu North an agricultural zone of Enugu State. Proceedings of the 45th Annual Conference of the Agricultural Society of Nigeria, Abuja 2015". pp. 619 –623.

Okoye, P. U., et al. (2021). Cocoyam: Fertility Symbol and Cultural Identity among the Yoruba. *Journal of African Cultural Studies.* 12(3), 275-292.

Osahon, E.E. & Odoemelam, L.E. (2019). Extent of utilization of cocoyam value added technologies among rural households in South-east Nigeria. *Nigerian Agricultural Journal.* 50(2), 233-240.

Otekunrin, O.A., Sawicka, B., Adeyonu, A.G., Otekunrin, O.A., Racho'n, L. (2021). Cocoyam [*Colocasia esculenta* (L.) Schott]: Exploring the Production, Health and Trade Potentials in Sub-Saharan Africa. *Journal of Sustainability.* 13, 4483, 1 – 19.

Ramanatha, R. V., Matthews, P. J., Eyzaguirre, P. B., & Hunter, D. (2010). *The global diversity of taro: Ethnobotany and conservation.* Rome, Italy: Biodiversity International. Si, H., Zhang, N., Tang, X., Yang, J., Wen, Y., Wang, L. & Zhou, X., (2018). Transgenic research in tuber and root crops. *Genetic Engineering of Horticultural Crop*, 225 – 248.

Ubalua, A.O.; Ewa, F.; Okeagu, O.D. (2016). Potentials and challenges of sustainable taro (Colocasia esculenta) production in Nigeria. *J. Appl. Biol. Biotechnol.* 4, 053–059.

Ugboaja, C. I., Echebiri, R.N., Ogbodo, E.N. & Ebe, F. E., (2018). Gender differentiated household socioeconomics and relative participation in cocoyam pre-planting operations among smallholder farmers in Abia State, Nigeria. *Nigerian Agricultural Journal.* 49. (1), 23-31.

Ume, S. I., Ezeano C. I., Agu L. U. & Emma-Ajah, I. J. (2016). Resource Use Efficiency among Cocoyam Farmers in Anambra State of Nigeria. *Asian Research Journal of Arts & Social Sciences.* 1(3). DOI: 10.9734/ARJASS/2016/27424

ANALYSIS OF YOUTHS INVOLVEMENT IN YAM PRODUCTION IN OBUBRA LOCAL GOVERNMENT AREA, CROSS RIVER STATE, NIGERIA

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ABSTRACT

This study was carried out to analyze youths' involvement in yam production in Obubra Local Government Area, Cross River State, Nigeria. Specifically, the study described the socio-economic characteristics of youths in the study area, identified the farm activities carried out by youths' in yam production and ascertained the factors influencing youths' involvement in yam production. Multi-stage sampling procedure was used to select respondents for the study. Data was collected with the use of structured questionnaire and analyzed using both descriptive and inferential statistics. Results showed that 57.7% of the respondents were males while 42.3% were females, 38.7% were above 32 years of age, and majority (63.1%) were married. Only 29.7% had no formal education, 44.1% had farming experiences of between 7 to 10 years and mostly (48.6%) had farm sizes ranging between 2-4 hectares. Youths in the area were mostly involved in land tillage (99.1%), yam staking (97.3%), transportation of tubers (99.1%). The factors that determined youths' participation in yams cultivation were: market demand for yams, interest in yams production and availability of land.

Keywords: Analysis, youths, involvement, yams, production, activities.

Introduction

The agricultural sector accounts for approximately one-third of the total Gross Domestic Product (GDP) worldwide, Food and Agricultural Organization (FAO) (2020). Yam production is a vital component of Nigeria's agricultural sector according to Obong-Ema, Obidiegwu, Chilaka and Akpabio (2023), yam farming has led to the emergence of livelihood options in rural communities and a source of food supply, income generation and a source of planting material. Nigeria ranks as the leading producer of yams in the world accounting for 66% (about 50.1 million tons) of annual global production (Food and Agricultural Organization (FAO) (2015).

Despite the potential benefit of yam, the aging population of farmers and declining participation of youths in agriculture is threatening the sustainability of production making the involvement of youths in yam production imperative (Adejumo and Otunaiya 2019). Moreso, youths' involvement in yam production remains crucial for the sector's continuity and productivity.

Youths involvement in agriculture as opined by Eze (2020) stimulates economic growth, reduce unemployment and enhance food security. Obubra local government area is one of the local

government areas in Cross River State notable for yam cultivation due to the suitable soil and climate.

Yams and cassava stands out as the major root crops cultivated in Obubra local government area. Consequently, this study is designed to analyze youths' involvement in yam production in the study area with the following objectives.

1. Describe the socio-economic characteristics of youths in the study area.
2. Identify the activities carried out by youths in yam production
3. Ascertain factors influencing youths' involvement in yams production

Hypothesis

There is no significant relationship between youths' socio-economic characteristics and their participation yam production.

Materials and Methods

This study was conducted in Obubra Local Government Area of Cross River State, Nigeria. Obubra Local Government Area is bounded in the North by Ikom, south by Yakurr, East by Akamkpa Local Government Areas and bounded in the west by Ebonyi state. It lies between latitude $4^0 45'$ and $6^0 15'$ North of the equator and Longitude $8^0 12'$ East of the Greenwich meridian. It covers a land mass of 1115 km^2 and a population of 172,543 people (National Population Commission, 2006). It is located in Ikom Agricultural zone with its headquarters in Obubra Oban.

The population of the study consisted of all registered yam farmers in the study area and a multi-stage sampling technique was adopted in selecting the respondents.

Stage one involved the simple random selection of 6 wards out of the eleven wards that constitute the area. The selected wards include Ofat, Ofodua, Iyamoyong, Osopong 1, Ochon and Ofumbongha. Stage 2 involves the simple random selection of one cell each from the sampled wards. The cells include Onyadama, Ochikpor, Iyamitet, Echara-Osopong, Isabang and Imabana Itamtet. Stage three involve the simple random selection of respondents using 25% of the registered yam farmers from each of the cells giving a total sample size of 111 respondents. Data was collected with the use of questionnaire and analyzed using descriptive and inferential statistics.

Results and discussion

Socio-economic characteristics

Table 1: Distribution of respondents based on socio-economic characteristics

	Frequency	Percent
Sex		
Female	47	42.3
Male	64	57.7
Total	111	100.0
Age		

18-22	12	10.8
23-27	22	19.8
28-32	34	30.6
above 32	43	38.7
Total	111	100.0
Marital status		
Single	26	23.4
Married	70	63.1
Divorced	8	7.2
Widowed	7	6.3
Total	111	100.0
Educational qualification		
no formal education	33	29.7
FSLC	37	33.3
Waec	26	23.4
Tertiary education	15	13.5
Total	111	100.0
Farming experience		
<3years	19	17.1
3-6years	16	14.4
7-10years	49	44.1
Above 10 years	27	24.3
Total	111	100.0
Farm size		
less than 2	12	10.8
2-4	54	48.6
5-7	30	27.1
Above 7	15	13.5
Total	111	100.0
Household size		
less than 3	17	15.3
3-4	34	30.6
4-5	35	31.5
above 5	25	22.5
Total	111	100.0
Membership of association		
Yes	74	66.7
No	37	33.3
Total	111	100.0

Access to Credit

Yes	44	39.6
No	67	60.4
Total	111	100.0
Access to Extension		
Yes	53	47.7
No	58	52.3
Total	111	100.0

Source: Field survey data, 2024

The results on Table 1 reveals that majority (57.7%) of the participating youth were males while 42.3% were females. This result shows that there were more male youth respondents involves in yam production than females in the study area. This result is in line with the findings of Udemezue, Kanu, and Colley (201) whose results showed that in Anambra state, there were more men involved in yam production than the females making up 75% of the respondents. The findings also confirm the result of Donye (2012) which showed that more men were involved in yam production in Wukari than the women. Majority (38.7%) of the youths were above 32years of age, 30.6% were 28-32 years, 19.8% were between 23-27 years whereas 10.8% were between 18-22 years. Majority (63.1%) were married while 23.4% were single implying that they were more married youths than those who were single but falls within the youthful age. This result is in line with results of Udemezue *et al.,* (2012) which revealed that majority (61.1%) of the yam farmers were married. Furthermore, the result shows that majority (33.3%) of the respondents had first school leaving certificate, 29.7% had no formal education,23.4% had WAEC and 13.5% had obtained Tertiary education. The implication of this finding is that the youth in the study area had one form of education or the other.

Also, 44.1% had farming experience of between 7-10years while the least (14.4%) farming experience was 3-6years. Majority (48.6%) had farm size between 2-4ha, 27.1% had farm size of 5-7ha, 13.5% had Above 7ha while 10.8% had less than 2ha. Majority (31.5%) had household size of 4-5 persons while 15.3% had less than 3persons.

Majority (66.7%) of the farmers were members of farmers association while 33.3% do not belong to any association. Majority (60.0%) had no access to credit facilities, only 39.6% had access to credit facilities and 52.3% had no access to extension agents while 47.7% had no access to extension agents.

Table 2: Mean distribution of respondents based on yam production activities carried out by youths

	Yam production activities	Frequency	Percentage
1	Farm site selection	60	54.1
2	Land clearing	109	98.2
3	Bush burning	94	84.7
4	Gathering of debris	103	92.8
5	Land tillage	110	99.1
6	Transportation of yams to the farm	100	90.1
7	Yams minisett cutting	95	85.6
8	Planting	98	82.3
9	Weeding	30	27.0
10	Fertilizer application	69	62.2
11	Staking	108	97.3
12	Harvesting	103	92.8
13	Yam barn preparation	101	90.9
14	Transportation of tubers	110	99.1
15	Marketing	66	59.5

Source: Field survey, 2024

Results of the distribution of respondents based on yam production activities is presented in Table 2. From the table, there was no provision for multiple responses. 99.1% of respondents were involved in land tillage and transportation of tubers, 98.2% were involved in land clearing, 97.3% were involved in staking and 92.8% involved in harvesting and gathering of debris after burning. Others were; yam barn preparation (90.9%), transportation of seeds to the farm (90.1%), bush burning (84.7%) and minisetts cutting (85.6%). The results of this study implies that the youth are highly involved in yam production activities. In line with the findings of this study, Mbah et al (2016) observed in their study that the major roles performed in yam cultivation such as land clearing, tillage, bush burning, planting are carried out by youths.

Results also showed that other yam production activities included; fertilizer application (62.2%), marketing of yams (59.5) and site selection (54.1) showing that youths engage in a variety of activities in yams production. This study is consistent with the results of Michael (2021) who found that young people were involved in land preparation, crops planting and maintenance and post-harvest roles. Amengo *et al.*, (2016) study revealed six major activities of the youths in yam production to include land preparation, planting, weed control, fertilizer application, harvesting, packaging and marketing. Also, the findings of this study are in line with the results of Egwue and Anugwu which showed that youth in Ikole Ekiti local government area were involved in a variety of yam production activities such as land preparation, ridges making, planting of yam minisett, yams minisett cutting, fertilizer application, weeding etc.

Table 3: Mean distribution of respondents based on factors that determines youth participation in yam production activities

Factors	$\bar{x}$	Std	Rank
Household size	2.97*	1.29	8
Interest and passion in yam cultivation	1.71	.867	20
Family influence	2.48	1.077	13
Access to credit	3.59	.813	4
Gender	2.15	1.130	17
Interest in yams production	3.61*	.800	2
Social status	2.29	1.131	15
Farming experience	2.96*	1.061	9
Educational level	1.94	1.216	19
Perceived benefits from yam cultivation	3.10*	1.198	7
Cultural heritage	2.45	.871	14
Community influence	2.58*	1.049	12
Age	1.97	1.083	18
Availability of land	3.60*	.947	3
Gender	2.59*	.986	11
Availability of labour	3.32*	1.087	6
Availability of planting materials	3.46*	.892	5
Farm size	2.16	1.379	16
Market demand for yams	3.74*	.567	1
Knowledge of yams cultivation	2.95*	1.048	10

Source: Field survey data, 2024

*Mean $\geq$ 2.50 = determinants of youths' participation.

Factors that determine youth participation in yam production activities

Table 3 presents the distribution of respondents' based on factors that determines youth participation in yam production activities. The results show that the major determinants were; market demand for yams ($\bar{x}$ =3.74) ranked 1st, interest in yam production ($\bar{x}$ =3.61) ranked 2nd, availability of land ($\bar{x}$ =3.60) ranked 3rd, access to credit ($\bar{x}$ =3.59) ranked 4th, availability of planting materials ($\bar{x}$ =3.46) ranked 5th, availability of labour ($\bar{x}$ =3.32) ranked 6th, perceived benefit from yam cultivation ($\bar{x}$ =3.10) ranked 7th, household size ($\bar{x}$ =2.97) ranked 8th, farming experience ($\bar{x}$=2.96) ranked 9th, knowledge of yam cultivation ($\bar{x}$ =2.95) ranked 10th, gender ($\bar{x}$=2.59) ranked 11th, and community influence ($\bar{x}$=2.58) ranked 12th. Minor determinants ranked from 13 to 20 as indicated on the table and include family influence ($\bar{x}$=2.48), cultural heritage ($\bar{x}$=2.45), farming experience ($\bar{x}$=2.29) etc. This result is in line with the findings of Udemezue et al (2012) whose results showed that the socio-

economic determinants of yam production among small scale farmers in Anambra state include household size, access to credit and farm size. Also, Ayinde and Tomori (2014) had similar findings which showed that market demand for yams, land availability and interest in yam cultivation were determinant for youths' participation in yam cultivation. Onumadu and Nwaobiala (2012) study shows that age, farming experience and farm size were strong determinants of youths' participation in yam production.

The result of the relationship between relationship between socio-economic characteristics of youth and their participation in yam production is presented in Table 7. The Mac Fadden R-square is 0.79 and implies that all the explanatory variables included in the model jointly accounts for about 79% variation participation in yam production. The log-likelihood ratio (LR) test was 64.73 and significant at 5% implying that the model was adequate in explaining the relationship between explanatory variables and youth participation in yam production. The study reveals that out of the 9 explanatory variables, 6 variables (gender, marital status, education, Experience, farm size and Access to credit) had significant relationship with youth participation in yam production at 5%. However, gender, marital status, education, Experience, farm size and Access to extension indicates a positive relationship and an increase or a change in any of these variables leads to high level of youth participation while age, household size and Access to credit showed negative relationship, implying that there will likely be low participation of youth as these variables decreases. Therefore, the hypothesis that there is no significant relationship between socio-economic characteristics of youth and their participation in yam production was rejected and the study holds that there is a significant relationship between socio-economic characteristics of youth and their participation in yam production. Torimiro and Dinco-Adetayo (2024) study shows that age, level of education, marital status, membership of association and income have significant and positive relationship with participation, while sex had negative but significant relationship.

Conclusion

Youths were involved in a variety of yam production activities in the study area and they were driven into yams production by factors such as the high demand for yams, their interest in yam production, availability of land, etc. A strong relationship exists between their socio-economic characteristics and their participation in yams cultivation

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Yams cultivation was dominated by men in the study area, more women should be encouraged to go into yams production.

2. Programs should be developed by extension to increase the passion and interest of rural youth and make them go into yams production.

3. More male youths should be involved in farm weeding and the marketing of their yams.

References

Adejumo, E. O., & Otunalya, A. O. (2019). Youths participation in agricultural development: A case study of Oyo state. *Journal of Agricultural Extension* 24(1), 1-2.

Amengo, E. N., Harriet, Y., Fordjour, P. P., Achaempong, J. (2016). Gender analysis of yam production in Ghana. *International digital organization for scientific information,* 1(2), 9-10.

Ema, E. O., Obidiegwu, J. E., Chilaka, C. A., Akpabio, E. M. (2023). Indigenous food yam cultivation and livelihood practices in Cross River State, Nigeria. *World Journal of Sustainability.* 4(2), 314- 332.

Eze, C. C. (2020). Analysis of youths involvement in cassava production in Ebonyi state, Nigeria (unpublished masters thesis in the Department of crops production, Ebonyi state university.

Food and Agricultural Organization of the United Nations (FAO) (2020). Extension and advisory services at the frontline of the response to COVID-19 to ensure food security. Rome. Retrieved from https://doi.org/10.4060/ca871en.

Food and Agricultural Organization of the United Nations (FAO). The state of food security in the world. FAO. Rome: Available online in https://www.fao.org/3/14646e/1464e/.pdf (accessed on 19th November, 2024

Maku, M., Kitambo, E. & Mugonola, B. (2023). Drivers of youths participation in maize value addition in Gulu district, Uganda. *African Journal of Science, Technology, Innovation and Development.* 15(1), 45-48.

Michael, G. (2021). Youths participation in agriculture in the West Africa District of Ghana: benefits, challenges, and prospects.

National Population Commission (NPC) (2006).

Onumadu, F. N. & Nwaobiala, C. U. (2012). Assessment of youths' participation in yam minisett technology in Ivo LGA of Ebonyi state, Nigeria. *Journal off Economics and Sustainable Development.* 3(3), 46-48.

Torimira, D. O. & Dionco-Adetayo, E. A. (2012). Socioeconomic characteristics of rural youths' leadership development in south western Nigeria: Entrepreneurship implications. *Journal of social sciences,* 9(2), 131-136.

Anugwu, S. C., Egwue, O. L. (2024). Analysis of factors determining yam production in Ikole-Ekiti local government area. *Direct Research Journal of Agriculture and Food Science.* 12(2), 17-19.

Udemezue, J. C., Kanu, N. A. & Colley, M. (2017). Socio-economic determinants of yam production among small scale farmers in Anambra state. *Merit Research Journal of Agricultural Science and Social Science.* 5(12), 215-222.

ASSESSMENT OF E-BANKING SERVICE UTILIZATION AMONG DAY-OLD CHICK MARKETERS IN IBADAN SOUTH-WEST LOCAL GOVERNMENT, OYO STATE.

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Abstract
This study evaluates the impact of electronic banking (e-banking) services on customer satisfaction among day-old chick marketers in Ibadan South-West, Oyo State, Nigeria. It aims to understand the extent to which e-banking influences business operations and customer experiences within this niche market. Using a structured questionnaire, data were collected from 120 randomly selected marketers, focusing on their socio-economic characteristics, usage of e-banking services, satisfaction levels. Descriptive and inferential statistics, including chi-square tests, were employed for data analysis. The findings reveal that most marketers are young, educated, and predominantly male, with a high adoption of e-banking services such as ATMs and Internet banking. However, challenges like transaction failures and poor internet connectivity persist, affecting satisfaction levels. Despite these issues, e-banking services were found to contribute positively to business efficiency, income diversification, and operational cost reduction. The study recommends enhancing digital financial literacy, improving internet infrastructure, and expanding credit access through cooperative societies to boost the economic resilience of marketers. These insights are valuable for banks, policymakers, and consumer protection agencies aiming to improve service quality and customer satisfaction in Nigeria's banking sector. The research contributes to the academic discourse on e-banking and customer service in emerging markets.

Keywords: E-Banking, Customers Satisfaction, Day-Old Chicks

Introduction

Poultry encompasses all domesticated birds reared by humans for the production of eggs, meat, and other consumable products, including species such as chickens, ducks, turkeys, guinea fowl, and geese. The chicken industry, in particular, serves as a significant source of income and employment for many, owing to its rapid capital turnover (Boimah, et al. 2022). Day-old chicks (Gallus gallus), often referred to as DOCs, are newly hatched chicks kept in hatcheries before being transported to farms for rearing as layers, broilers, or breeding stock (Riber, et al. 2023). Their quality is critical to the success of the poultry industry, as it influences productivity and profitability.

Electronic banking (e-banking), including online and mobile banking, has emerged as a transformative force in the banking sector, providing customers with the ability to access a wide

range of financial services conveniently and efficiently. E-banking enables payments, investments, and bill settlements, contributing to improved service quality and reduced transaction costs (Alkhaibari et al., 2023). In Nigeria, the adoption of e-banking has accelerated, with technologies such as ATMs, POS terminals, and mobile banking apps being widely utilized (Isibor et al., 2018). Nevertheless, despite the potential benefits, the manual banking processes that once dominated often resulted in inefficiencies, delays, and customer dissatisfaction (Jenevive & Anyanwaokoro, 2017).

Customer satisfaction is essential for maintaining customer loyalty and improving a bank's image. It is influenced by customers' perceptions of service quality compared to their expectations (Hammoud, Bizri, & El Baba, 2018). As banking practices evolve, e-banking service quality has become a focal point for enhancing customer experiences, especially given the shift in banking behaviours during the COVID-19 pandemic (Oertli, 2020). However, despite the rapid growth in e-banking adoption, Nigerian banks still face significant challenges in satisfying customers' needs (KPMG, 2016). This gap is especially relevant in niche markets such as the day-old chick industry, where the quality of e-banking services can impact business operations.

While e-banking has contributed to reducing the time and inconvenience associated with traditional banking, various challenges persist, including transaction failures, uncredited payments, and poor internet connectivity. These issues raise questions about whether e-banking platforms are achieving their intended goals of providing efficient and reliable service delivery. Furthermore, studies indicate a high level of customer dissatisfaction in the banking sector across Africa, with many customers expressing concerns about service security and quality (KPMG, 2016). Given the importance of e-banking services to businesses, including day-old chick marketers, there is a need to understand how these services influence customer satisfaction and address the persistent service quality gaps in Nigeria.
This study seeks to: identify the socio-economic characteristics of day-old chick marketers, determine the commonly used e-banking services among them and assess the extent of satisfaction with these services. It will further find out if a significant relationship exists between the commonly used e-banking services and customer satisfaction among day-old chick marketers.

Materials and Method
This research was conducted in Ibadan South West Local Government Area (LGA), Oyo State, Nigeria. The area, predominantly urban, exhibits minimal agricultural activity, with most agricultural products processed within its confines. Notable companies and poultry farms, such as Zartech, Bronce, Avians, and Ajanla Farms, operate within the LGA. The LGA is divided into 12 wards, facilitating administrative and local governance.

The target population for this study comprises day-old chick (DOC) marketers within the Ibadan South West LGA of Oyo State, Nigeria. The study employed a simple random sampling technique to select participants. A sample of 120-day-old chick marketers was randomly chosen from a comprehensive list of marketers operating within the study area. This approach ensured equal representation and minimized selection bias.

Primary data were collected through a structured questionnaire designed to gather detailed information on respondents' experiences with e-banking services. The questionnaire covered various aspects of e-banking usage, satisfaction levels, and challenges faced. Data collection relied on a well-designed questionnaire to capture the necessary primary data. The instrument

was developed to ensure clarity, relevance, and comprehensiveness, enabling effective measurement of the variables.

Measurement of Variables

The dependent variable in this study is the level of satisfaction experienced by day-old chick marketers regarding e-banking services. Satisfaction was measured using a five-point Likert scale, with scores ranging from 0 (not satisfied) to 3 (very satisfied), capturing varying degrees of user satisfaction.

The independent variables include various e-banking service components:

- Internet Banking: Usage was categorized as "Used" (1) or "Not Used" (2).
- Unstructured Supplementary Service Data (USSD): Similarly measured as "Used" (1) or "Not Used" (2).
- Automated Teller Machine (ATM): Assessed with "Used" (1) or "Not Used" (2).
- Point of Sale (POS): Also measured as "Used" (1) or "Not Used" (2).

Data Analysis

Data analysis involved the use of descriptive and inferential statistics. Descriptive statistics, such as frequency distributions, means, and percentages, were employed to address the study's objectives. Inferential statistics, particularly the chi-square test, were used to examine the study's hypothesis, which assesses the relationship between commonly used e-banking services and customer satisfaction among day-old chick marketers.

This methodological framework provides a robust foundation for understanding the factors influencing the satisfaction levels of day-old chick marketers with e-banking services in Ibadan South West LGA, aiming to yield insights that can inform banking policies and service improvements.

Results and Discussion

Age Distribution

The age profile of the respondents, as shown in Table 1, indicates that 49.2% were aged 20-29 years, followed by 20.8% in the 30-39 age group, 15.8% aged 40-49, and 14.2% aged 50 years and above. The average age was 34 years, suggesting that most respondents were young adults in their prime working years. This demographic is likely to be more receptive to adopting e-banking services due to their familiarity with technology and active participation in economic activities. The finding aligns with Sowunmi et al. (2022) who observed similar age distribution patterns among chick marketers in Oyo State, with a concentration in the 21-40 age range.

Marital Status

The data in Table 1 also reveal that 51.7% of respondents were married, while 48.3% were single. The predominance of married individuals suggests a higher likelihood of embracing e-banking services to support their business operations and meet household financial obligations. This aligns with Taphone (2009), who found that married individuals often exhibit greater financial responsibility, which may drive their adoption of innovative banking solutions to enhance income opportunities.

Religious Affiliation

The religious composition of respondents showed that 50.8% were Muslims, 46.7% were Christians, and 2.5% practiced traditional religions. The diversity in religious affiliation reflects the multi-faith nature of the area, although Muslims slightly outnumbered other groups.

Gender Distribution

The survey indicated that 60.0% of respondents were male, while 40.0% were female, suggesting a male-dominated involvement in day-old chick marketing. This trend may be due to the demanding nature of poultry marketing, which often requires physical labor and extensive mobility, typically associated with male workers.

Educational Attainment

Educational levels among the respondents varied, with 46.7% having tertiary education, 45.0% having secondary education, 7.5% having primary education, and only 0.8% with no formal education. The high rate of formal education implies a substantial capacity for understanding and utilizing e-banking services. Education may enable respondents to leverage digital financial tools to optimize their business operations, consistent with findings by Abdul-Hanan et al. (2018), who noted a positive correlation between formal education and the adoption of e-banking services.

Household Size

The household size data indicate that 63.3% of respondents had 1-4 household members, 34.2% had 5-8 members, and 2.5% had more than 9 members, with an average household size of 4. This relatively large household size could provide an advantage in the form of family labor for business activities, supporting Subba-Reddy, Ram, Sastry, and Devi (2004), who found that household size often correlates with labor availability for agricultural and related business tasks. Effiong (2005) also noted that larger family sizes contribute to unpaid labor, especially in rural settings.

Secondary Occupations

Results from Table 1 show that 50.8% of respondents engaged in farming as a secondary occupation, while 31.7% were traders, 13.3% were artisans, and 4.2% had other occupations. This indicates a diversification in income sources, suggesting a strategy to augment earnings and meet economic responsibilities. Such diversification is crucial for cushioning income variability associated with marketing activities.

Membership in Cooperative Societies

The data show that 53.3% of respondents were members of cooperative societies, while 46.7% were not. Cooperative membership often facilitates access to credit and other financial resources, which could be used to procure tools for e-banking services. This finding underscores the role of cooperatives in enhancing business sustainability through improved access to financial services.

Marketing Experience

Most respondents (79.2%) had 1-10 years of experience in day-old chick marketing, with 16.6% having 11-20 years, and 4.2% with over 21 years. The average experience was 7 years, suggesting that the respondents were relatively experienced, which could positively influence their ability to navigate challenges in the business. This observation is in line with Mzycece (2011), who argued that longer business experience equips marketers with the skills and networks needed to exploit market opportunities effectively.

Access to Extension Services

The survey revealed that 59.2% of respondents had access to extension services, while 40.8% did not. Access to extension services can significantly enhance marketing strategies and profitability by providing up-to-date information on market trends and innovations. This

finding supports Idrisa and Ogunbameru (2012) and aligns with Swanson (2008) recommendations for extension services to foster the adoption of new technologies.

Annual Income

Income analysis indicated that 53.3% of respondents earned more than 500,001 naira annually, while 46.7% earned up to 500,000 naira. The relatively high-income levels among respondents may be attributed to the effective use of e-banking services, which could streamline financial transactions and reduce operational costs, thereby enhancing profitability.

Discussion

The socio-economic characteristics of the respondents suggest a youthful, educated, and relatively experienced demographic actively engaged in day-old chick marketing. The high adoption of secondary occupations and cooperative society memberships reflects a diversified livelihood approach aimed at income enhancement. Access to extension services and formal education appear to be key enablers of e-banking adoption, which may drive efficiency in business operations. The findings underscore the importance of promoting digital financial literacy and expanding access to credit through cooperative networks to further boost the economic resilience of chick marketers in the region.

Table 1: Socio-economic characteristics of the respondents

Variables	Frequency	Percentage	Mean
Age			
20-29	59	49.2	
30-39	25	20.8	34
40-49	19	15.8	
50 and above	17	14.2	
Marital status			
Single	58	48.3	
Married	62	51.7	
Religion			
Islam	61	50.8	
Christian	56	46.7	
Traditionalist	3	2.5	
Sex			
Male	72	60.0	
Female	48	40.0	
Educational status			
Primary	9	7.5	
Secondary	54	45.0	
Tertiary	56	46.7	
No formal education	1	0.8	
Household size			
1-4	76	63.3	4
5-8	41	34.2	
9 and above	3	2.5	
Secondary occupation			
Farming	61	50.8	
Trading	38	31.7	
Artisan	16	13.3	

Others	5	4.2	
Member of cooperative			
Yes	64	53.3	
No	56	46.7	
Experience in day-old-chick marketing			
1-10	95	79.2	7
11-20	20	16.6	
21 and above	5	4.2	
Access to extension service			
Yes	71	59.2	
No	49	40.8	
Annual income			
Less than 500,000	56	46.6	
500,0001 and above	64	53.3	

Source: Field survey, 2024

Adoption of E-Banking Services Among Day-Old Chick Marketers

The analysis presented in Table 2 highlights the most frequently utilized e-banking services by day-old chick marketers. The findings reveal a high adoption rate of Automated Teller Machines (ATMs), with 86.0% of respondents using this service, followed closely by internet banking at 85.0%, mobile banking at 80.0%, Unstructured Supplementary Service Data (USSD) at 77.5%, and Point of Sale (POS) services at 68.3%.

The prominence of ATMs, internet banking, and mobile banking suggests that these services are favoured due to their direct accessibility, user control, and enhanced security, which do not require third-party intermediaries. The relatively lower adoption of POS services may reflect concerns over potential fraud risks associated with third-party transactions.

The implications of these findings are significant, as the increasing availability and adoption of e-banking tools such as ATMs, mobile applications, and USSD codes are likely to drive a broader transition towards digital financial transactions. This shift could enhance transaction efficiency, improve financial transparency, and ultimately boost customer satisfaction among marketers.

These results are consistent with the observations of Takyi and Poku (2015), who found that the availability of electronic banking facilities—such as ATMs, POS, and mobile banking—positively influences customer patronage and satisfaction. As electronic banking infrastructure continues to expand, day-old chick marketers may experience even greater convenience and operational benefits, fostering a more dynamic and digitally inclusive market environment.

Table 2: Commonly used E-banking services among day-old-chicks marketers

Commonly used E-banking services	Used	Not used
Internet banking	102(85.0)	18(15.0)
Unstructured Supplementary Service Data (USSD)	93(77.5)	27(22.5)
Automobile Teller Machine (ATM)	104(86.7)	16(13.3)
Mobile banking	97(80.8)	23(19.2)
Point of Sales (POS)	82(68.3)	38(31.7)

Source: Field survey, 2024 **Multiple responses**

Figures in parentheses are in percentage

Assessing Satisfaction Levels Among Day-Old Chick Marketers with E-Banking Services
The analysis of satisfaction levels among day-old chick marketers using various e-banking services revealed several important insights (Table 3). The findings indicate that electronic banking is perceived as significantly more convenient than traditional banking (mean = 1.53), making it the top-rated benefit. Other aspects contributing to high satisfaction include overall satisfaction with bank services (mean = 1.38), the perception of enhanced security compared to manual banking (mean = 1.33), and meeting user expectations from Internet banking (mean = 1.33). The least influential factor was the desire to continue banking with the current institution (mean = 1.22), ranked fifth.

Regarding satisfaction with Unstructured Supplementary Service Data (USSD), the ability to check account balances without an internet connection emerged as the most highly rated feature (mean = 1.27). This was followed closely by the convenience of using any phone to initiate transactions and the intuitive, real-time interactive menu (mean = 1.18). Less impactful factors included cost-effectiveness (mean = 1.12) and speed in reducing operational costs (mean = 1.06).

For Automated Teller Machine (ATM) services, marketers expressed a preference for ATMs over other e-banking options (mean = 1.33). The cost reductions offered by ATM usage during off-hours and at off-site locations were also appreciated (mean = 1.24), alongside the accuracy of cash dispensation (mean = 1.23). Features like the global popularity of ATMs (mean = 1.16) and the user-friendliness of instructions (mean = 1.04) ranked lower in satisfaction.

Mobile banking services were evaluated as the most effective and secure e-banking option (mean = 1.35), tied with the perception of being risk-free compared to internet banking. The ability to easily manage personal finances (mean = 1.25) was also rated highly, while features like ordering a cheque book via a mobile app (mean = 1.18) were less emphasized.

Point-of-Sale (POS) machine services received positive feedback, with respondents expressing strong satisfaction with POS experiences and cost advantages over other e-banking services (mean = 1.28). POS's affordability in transaction fees and service delivery satisfaction (mean = 1.25) were ranked next. However, POS convenience compared to other e-banking services had the lowest mean score (mean = 1.02), ranking seventh.

These findings align with the work of Asiyanbi and Ishola (2018), who identified key factors driving customer satisfaction in e-banking, including the cashless nature of transactions, time savings from reduced bank visits, seamless processing, and reliable access to cash. The overall insights from this study suggest that day-old chick marketers experience high levels of satisfaction with e-banking, driven by convenience, security, and cost savings across different platforms. As e-banking adoption continues to expand, these factors are likely to sustain customer loyalty and enhance financial inclusion in the agricultural sector.

Table 3: Satisfaction of day-old chicks marketers on e-banking services

Satisfaction of day-old chicks marketers on e-banking services	Very satisfied	Satisfied	Not satisfied	Mean	Rank
Internet banking					
Electronic banking is more convenient than manual banking	71(59.2)	42(35.0)	7(5.8)	1.53	1

I am well satisfied with the services my bank delivered to me	56(46.7)	53(44.2)	11(9.2)	1.38	2
Electronic banking is safer than manual banking	54(45.0)	51(42.5)	15(12.5)	1.33	3
I would like to remain as a customer to my bank.	41(34.2)	64(53.3)	15(12.5)	1.22	5
My expectations before the use of Internet banking have been met with this current experience	58(48.3)	43(35.8)	19(15.8)	1.33	3
Unstructured Supplementary Service Data (USSD)					
Any type of phone can be used to initiate a transaction	36(30.0)	70(58.3)	14(11.7)	1.18	2
I can easily check my account balance without the internet	52(43.3)	48(40.0)	20(16.7)	1.27	1
It is faster and reduces operating cost	33(27.5)	61(50.8)	26(21.7)	1.06	5
Intuitive menu with real-time interactivity	46(38.3)	50(41.7)	24(20.0)	1.18	2
Very economical	36(30.0)	62(51.7)	22(18.3)	1.12	4
Automobile teller machine					
Utility of ATM's has gained worldwide popularity.	47(39.2)	45(37.5)	28(23.3)	1.16	5
Withdrawal of cash with ATM is more convenient than over-the-counter withdrawal.	35(29.2)	67(55.8)	18(15.0)	1.14	4
The reduction of cost in the off-time and off-store services is quite encouraging.	41(34.2)	67(55.8)	12(10.0)	1.24	2
ATM banking service is better than other electronic banking service.	50(41.7)	60(50.0)	10(8.3)	1.33	1
ATM dispenses money accurately	45(37.5)	58(48.3)	17(14.2)	1.23	3
I find the ATM banking instructions quite pleasant.	27(22.5)	71(59.2)	22(18.3)	1.04	6
Mobile banking system					
Mobile banking service is more effective than other electronic banking service.	57(47.5)	48(40.0)	15(12.5)	1.35	1
It is so easy to have control over my finance	45(47.5)	60(50.0)	15(12.5)	1.25	3
It is more secure/risk-free than online internet banking.	51(42.5)	60(50.0)	9(7.5)	1.35	1
Easy and fast in ordering for cheque book using your mobile app.	36(30.0)	70(58.3)	14(11.7)	1.18	4
POS Machine					
I am completely satisfied with the service of POS transactions.	52(43.3)	42(35.0)	26(21.7)	1.22	5

My experiences with POS are really encouraging.	45(37.5)	64(53.3)	11(9.2)	1.28	1
POS services cost less than other electronic banking	55(45.8)	43(35.8)	22(18.3)	1.28	1
POS banking service is more convenient than other electronic banking service.	27(22.5)	68(56.7)	25(20.8)	1.02	7
POS banking services charge me less fees	48(40.0)	54(45.0)	18(15.0)	1.25	3
I am completely satisfied with the usage of POS banking.	33(27.5)	67(55.8)	20(16.7)	1.11	6
Am satisfied the service delivery of E - banking via Mobile banking.	52(43.3)	46(38.3)	22(18.3)	1.25	3

Source: Field survey, 2024
Figures in parentheses are in percentage

Satisfaction Levels Among Day-Old Chick Marketers Regarding E-Banking Services

Figure 1 illustrates that a majority (59.2%) of day-old chick marketers reported a high level of satisfaction with e-banking services, while 35.0% expressed moderate satisfaction, and only a small proportion (5.8%) indicated low satisfaction. These findings suggest that e-banking services have gained widespread acceptance among respondents, with most experiencing a high degree of contentment.

The high satisfaction levels may be attributed to the ability of e-banking to enhance service delivery, making banking transactions faster, more accessible, and cost-effective. As Polatoglu and Ekin (2001) observed, e-banking has been instrumental in transforming traditional banking by offering customers the convenience of accessing essential banking products and services around the clock. It provides a platform for carrying out transactions online, enabling customers to manage their banking activities seamlessly, regardless of time or location.

The study highlights the significant role of e-banking in meeting the evolving needs of agricultural marketers, particularly in offering flexibility, efficiency, and ease of use. As the adoption of digital banking continues to grow, these aspects are likely to drive further improvements in customer satisfaction and strengthen the integration of e-banking into the agricultural business landscape.

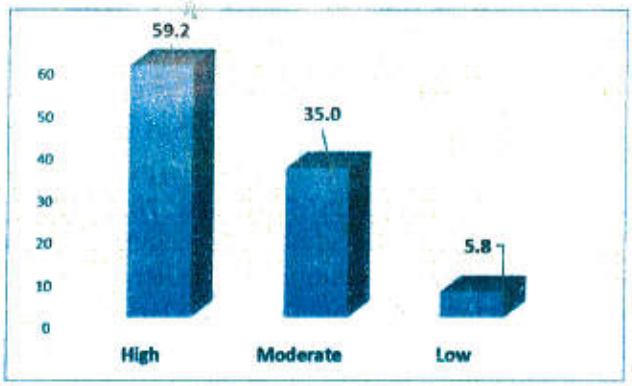

Fig: 1 Summary of satisfaction of day-old chick's marketers on e-banking services

Chi-Square Analysis of the Relationship Between Common E-Banking Services and Satisfaction Among Day-Old Chick Marketers

The chi-square analysis results in Table 4 demonstrate a statistically significant relationship between commonly used e-banking services and the satisfaction levels of day-old chick marketers. Specifically, significant associations were found for internet banking ($\chi^2 = 47.734$; $p = 0.002$), Unstructured Supplementary Service Data (USSD) ($\chi^2 = 1.834$; $p = 0.000$), Automated Teller Machine (ATM) ($\chi^2 = 1.889$; $p = 0.000$), mobile banking ($\chi^2 = 45.289$; $p = 0.004$), and Point of Sales (POS) ($\chi^2 = 54.258$; $p = 0.000$). With p-values below the 0.05 threshold, these findings indicate that each of these e-banking services significantly influences marketers' satisfaction levels.

The strong linkage between e-banking services and satisfaction reflects the role of digital banking in enhancing user experiences within agricultural marketing. As corroborated by Ozoji (2021), who found a positive and significant relationship between ATM usage and customer satisfaction in Nigeria, the availability of convenient and accessible banking options promotes higher satisfaction levels. Similarly, Danlami & Mayowa (2014) reported a positive impact of ATM usage on customer satisfaction in their empirical investigation, further underscoring the importance of e-banking services in driving user contentment.

These findings highlight the critical need for financial institutions to prioritize user-centric e-banking solutions, ensuring that they cater to the specific requirements of agricultural marketers. By addressing the preferences and pain points of day-old chick marketers, banks can enhance service satisfaction and foster the continued adoption of digital financial solutions within the agricultural sector.

Table 4: Chi-square analysis showing the significant relationship between the commonly used E-banking services among day-old chick's marketers and Satisfaction of day-old chicks marketers on e-banking services

Variables	χ^2	df	p-value	Decision
Internet banking	47.734	4	0.002	Significant
Unstructured Supplementary Service Data (USSD)	1.834	4	0.000	Significant
Automobile Teller Machine (ATM)	1.889	4	0.000	Significant
Mobile banking	45.289	4	0.004	Significant
Point of Sales (POS)	54.258	4	0.000	Significant

Source: Field survey, 2024

Conclusion and Recommendations

The study sheds light on the crucial role of e-banking services in enhancing the efficiency and customer satisfaction of day-old chick marketers in Ibadan South West, Oyo State, Nigeria. The findings reveal that socioeconomic factors such as age, education, and income levels significantly influence the adoption of digital banking tools, with Automated Teller Machines (ATMs), internet banking, and USSD services being the most commonly used. Marketers who embrace these technologies tend to streamline their financial transactions, reduce operational costs, and improve business outcomes. However, challenges persist, including transaction failures and poor internet connectivity, which hinder the full realization of the benefits of e-banking. Addressing these barriers is critical to sustaining the growth and profitability of the poultry sector and similar niche markets.

The insights gained underscore the importance of digital financial literacy and access to technology for enhancing the resilience of businesses in Nigeria's evolving economic landscape. As e-banking continues to reshape customer expectations, the banking sector must prioritize service quality to meet the specific needs of niche markets. By leveraging e-banking services, day-old chick marketers can unlock growth opportunities, ensuring a more dynamic and competitive agricultural sector.

Recommendations

1. **Enhance Digital Financial Literacy Programs:** Banks and financial institutions should implement targeted educational campaigns to increase digital financial literacy among poultry marketers. Training programs should focus on the effective use of e-banking services, cybersecurity, and troubleshooting common issues, which would empower users to fully utilize digital financial tools.

2. **Improve E-Banking Infrastructure:** To address the challenges of transaction failures and unreliable internet connectivity, banks should invest in robust e-banking infrastructure. This includes upgrading networks, expanding coverage, and ensuring system reliability to enhance the user experience and reduce transaction delays.

3. **Leverage Mobile Banking Innovations:** Given the increasing adoption of mobile banking, financial institutions should develop user-friendly mobile apps tailored to the needs of niche markets like the day-old chick industry. These apps could feature simplified interfaces and low-data modes to accommodate areas with poor internet connectivity.

4. **Strengthen Collaboration Between Banks and Agricultural Extension Services:** By working closely with agricultural extension agents, banks can better understand the unique challenges faced by poultry marketers and develop customized e-banking solutions. Extension agents can also play a role in disseminating information about new financial tools and services.

5. **Implement Feedback Mechanisms to Address Customer Concerns:** To enhance service quality, banks should establish effective feedback channels where users can report issues and provide suggestions. This will help identify recurring problems and facilitate prompt responses to customer needs, thereby improving satisfaction levels.

6. **Develop Incentive Programs for E-Banking Users:** Incentives such as reduced transaction fees, loyalty rewards, or cash-back programs for frequent users can encourage more day-old chick marketers to adopt and consistently use e-banking services. These programs can also serve as a tool for banks to differentiate themselves in a competitive market.

Implementing these recommendations will not only improve e-banking service delivery but also contribute to the economic resilience and growth of the poultry sector, reinforcing its role as a key income generator in Nigeria's agribusiness landscape.

References

Abdul-Hanan, A., Hananu, B., & Abdul-Rasheed, H. (2018). Beyond household characteristics: what influence adoption of banking innovations in Northern Ghana?. *International Journal of Electronic Banking*, *1*(2), 95-112.

Alkhaibari, M., Albarq, A., Elrayah, M., Moustafa, M., Ghaleb, M., & Abbas, A. (2023). The impact of e-banking service quality on the sustainable customer satisfaction: Evidence from the Saudi Arabia commercial banking sector. *International Journal of Data and Network Science*, *7*(3), 1153-1164.

Asiyanbi, H., & Ishola, A. (2018). E-banking services impact and customer satisfaction in selected bank branches in Ibadan metropolis, Oyo state, Nigeria. *Accounting*, *4*(4), 153-160.

Boimah, M., Chibanda, C., Schott, J., & Awuni, S. (2022). Doing it right to alleviate poverty: application of the sustainable food value chain development framework to Ghana's poultry sector. *International Journal of Agricultural Sustainability*, *20*(7), 1454-1469.

Danlami, M. I., & Mayowa, D. R. (2014). An empirical investigation of automated teller machines (ATMs) and customers' satisfaction in Nigeria: A case study of Ilorin, Kwara State. *Faculty of Social Sciences, Kogi State University, Anyigba, PMB*, *1008*.

Effiong E.O., (2005) Efficiency of Production in Selected Livestock Enterprises in Akwa Ibom State, *Unpublished Ph. D Dissertation*, Department of Agricultural Economics, Michael Okpara University of Agriculture (MOUA), Umudike, 51.

Hammoud, J., Bizri, R. M., & El Baba, I. (2018). The impact of e-banking service quality on customer satisfaction: Evidence from the Lebanese banking sector. *SAGE Open*, *8*(3). https://doi.org/10.1177/2158244018790633.

Idrisa, Y. L., Ogunbameru, B. O., & Madukwe, M. C. (2012). Logit and Tobit analyses of the determinants of likelihood of adoption and extent of adoption of improved soybean seed in Borno State, Nigeria. *Greener Journal of Agricultural Sciences*, *2*(2), 37-45.

Isibor, A. A., Omankhanlen, A. E., Okoye, L. U., Achugamonu, B. U., Adebayo, M. E., Afolabi, G. T., & Ayodeji, O. E. (2018). Impact of electronic banking technology on customers' satisfaction and economic growth in Nigeria. *International Journal of Civil Engineering and Technology*, *9*(12), 536–544.

Jenevive, O. C., & Anyanwaokoro, M. (2017). Electronic payment methods and profitability of banking firms in Nigeria: A panel data analysis. *International Journal of Finance and Accounting*, *6*(3), 67–74.

KPMG. (2016). *African banking industry report: Retail customer satisfaction survey*. Retrieved from http://www.kpmg.com

Mzycece, A. (2011). Factors influencing Cowpea producers' choice of marketing channels in Zambia.

Nui Polatoglu, V., & Ekin, S. (2001). An empirical investigation of the Turkish consumers' acceptance of Internet banking services. *International journal of bank marketing*, *19*(4), 156-165.

Oertli, K. (2020). How digital innovations helped banks adapt during Covid-19. *World Economic Forum*. Retrieved from https://www.weforum.org/agenda/2020/08/how-digital-innovations-helped-banks-adapt-during-covid-19/.

Ozoji, A.P, Iwara,O.E, Ezuwore-Obodoekwe,C.N , Inyada,S.J, Ezechukwu B.O, Ayem-Fella,T.F, Ezuma C.O, Ebisi L.N, Okoroiwu, K.L (2021). Insecurity of cash-less banking transactions: an empirical evidence from Nigerian banks. *Academy of Accounting and Financial Studies Journal.* 25(5), 1-23.

Riber, A. B., & de Jong, I. C. (2023). Are alternative hatching systems beneficial for chicken welfare In *Proceedings XI European Symposium on Poultry Welfare.* 61-61.

Sowunmi, F. A., Bello, A. A., Ogunniyi, A. I., & Omotayo, A. O. (2022). Delving deeper into market concentration of poultry feed and the driving factors for brand switching: evidence from commercial egg producers in Nigeria. *Sustainability*, *14*(13), 8030.

Subba Reddy, S., Raghu Ram, P., Neelakanta Sastry, T. V., & Bhavani Devi, I. (2004). Agricultural Economics. Published by Vijay Primlani for Oxford & IBH Publishing Co. Pvt. Ltd., S-155, Panchsheel Park, New Delhi 110 017.

Swanson, B. E. (2008). *Global review of good agricultural extension and advisory service practices* (Vol. 82). Rome: Food and Agriculture Organization of the United Nations.

Taphone B.G. (2009). Resource Productivity and Efficiency of Groundnut Farming in Northern Part of Taraba State, Nigeria. MSc. Thesis. Department of Agricultural Economics and Extension, Yola, Adamawa State. Federal University of Technology, Adamawa State.

EFFECT OF ACCESS TO ICT ON FOOD SECURITY STATUS OF FARMING HOUSEHOLDS IN ANAMBRA STATE, NIGERIA

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ABSTRACT

The study assessed the effect of ICT tools on the food security status of farming households in Anambra state, Nigeria. Employing a two-stage sampling technique, primary data was collected from 366 farming households in Anambra state, Nigeria and descriptive statistics, Food poverty line and logistic regression model were used to ascertain the level of access to ICT by farming households, assess the food security status of farming households and assess the effect of ICT access on food security status of farming households in the study area. Results show that while 52.5% of farming households in the study area were earmarked food secure, a whopping 47.5% were food insecure based on the poverty line of N1435.8 obtained. Furthermore, Radio, mobile phones and television were the 3 most accessed ICT tools by farmers in the study area and mobile phones, television, the internet as well as other socio-economic variables such as household size, income and educational qualification of the household head had significant effect on food security status of farming households in the study area

1.0 Introduction

Food security as a concept originated only in the mid-1970s in the discussion of international food problems, at a time of global crises (ODI, 1997), the initial focus, was primarily on food supply problems such as ensuring the availability and to some degree, price stability of basic foodstuff at the international and national levels (IFAD, 2013)). The final report of the 2016 Food and Agriculture Organization World Summit, redefined food security as "a situation that exists when all people at all times have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preference for an active and healthy life. This shuffled emphasis from food supply to consumption, demand and the issue of access by vulnerable people to food. In developing countries of the world, a wide variety of information sources are being used by farmers to get updated knowledge about farm practices to maximize farm profit thereby improving livelihoods (Ashraf *et al.,* 2015). These sources may be a face-to-face exchange of information between individuals or the use of Information and Communication Technologies (Namubiru *et al.,* 2018). Information and Communication Technologies according to Arokoyo (2015) are the technologies that facilitate communication and the processing of information by electronic means. This definition encompasses the full range of ICTs from radio and television to telephones (fixed and mobile), instant messaging, e-bulletins, computers and the internet which are the potential tools that could be used by arable crop farmers to improve their farm productivity (Arokoyo, 2015).

2.0 Problem Statement

Nigeria which was once food-sufficient currently spends $ 22 billion on food importation annually (Lokpobiri, 2016). This implies Nigeria is import-dependent which undermines agricultural growth and ultimately the ability of households to access safe and nutritious food in adequate quantities. Nigeria ranks 90th among 113 countries and 11th in Africa in the 2016 global food security index based on indices of availability, affordability, quality and safety of food, with farming households facing the worst-hit by food insecurity (Oluwatayo & Ojo, 2019). Information and communication are essential ingredients needed for the effective transfer of technologies that are designed to boost agricultural production and consequently, food security (Nwalieji *et al.*, 2019). Thus, ICT plays a key role in promoting information flow for market access to the rural population who lives in isolation, with limited access to information and advanced technologies (Mensink &Vranken, 2017). ICTs offer platforms for social economic transformation and enable farmers to be innovative, participate at all levels of the value chain, and empower themselves by getting access to information on production, market, and consumption (CTA, 2017). According to Olaniyi *et al.*, (2018), low access and adoption of ICT keep marginalized groups uninformed with low levels of household food security. Although the effect of ICT on food security has been demonstrated by several researchers worldwide, little attention has been put to understanding the effect of ICT on households' food security in Eastern Nigeria, specifically Anambra state.

3.0 Objectives of the Study

Consequently, the following objectives were put forward;

1. ascertain the level of access to ICT by farming households in the study area
2. Assess the food security status of farming households in the study area
3. Assess the effect of ICT access on the food security status of farming households in the study area

4.0 Sample and Sampling Technique

A two-stage sampling technique was used to select respondents. In stage one, 5 Local governments (Nnewi, Anambra West, Aguata, Awka South & Awka North) were purposively selected based on accessibility, from the 21 local governments that make up Anambra state. Stage 2 involved randomly selecting 366 households using the Taro Yamane sample size formulae (as shown in equation 1) from a sample frame of 4290 registered households obtained from the aforementioned local government councils whose household heads' main occupation was listed as farming.

$$n = \frac{N}{K + N(e)^2} \qquad (1)$$

$$\frac{4290}{1+4290(0.05)^2} = 366$$

Where N = population of study
K = constant
e = degree of error expected
n = sample size

5.0 Methodology

Primary data was gathered with the use of a well-structured questionnaire and analysed using descriptive statistics to achieve objective 1, the food poverty line to achieve objective 2 and a logit regression model was be employed to achieve objective 3.

5.1 Estimation of Food Poverty Line

Food Poverty Line (FPL)= $\frac{2}{3}$ × (MTPCFCEXP) (2)

MTPCFCEXP= TPCFCEXP ÷ Total number of households (3)

TPCFCEXP = $\sum PCFCEXP$ (4)

PCFCEXP= Food Consumption Expenditure ÷ Household Size (5)

Where,

MTPCFCEXP = Mean Total Per Capital Food Expenditure

TPCFCEXP = Total Per Capita Food Consumption Expenditure

PCFCEXP= Per Capita Food Consumption Expenditure

5.2 Logistic Regression Model

The logistic regressionmodel is empirically stated as:

$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e$ (6)

Where,

Y = Food Security Status (Dummy; 1= Food secure, and 0= Food Insecure)

X_1 = gender (1=Female, 0=Male)

X_2 = household size (number of persons)

X_3 = = income (Naira)

X_4 = educational level (years spent in school)

X_5 = Access to Radio (Yes=1, No=0)

X_6 = Access to Television (Yes=1, No=0)

X_7 = Access to Internet (Yes=1, No=0)

$\beta_1 - \beta_7$ = Regression coefficients

β_0 = Regression constant

e = error term.

6.0 Result & Discussion

- **Level of access to ICT for cassava production**

Results in Table 1 reveal the level of respondent's access to ICT tools for cassava production in the study area. Accessibility to any technology is a vital component for its efficient and effective use by the end users. Results on cassava farmers' access to ICT tools show that radio ($\bar{x}$=3.37), mobile phones ($\bar{x}$ =3.61), television ($\bar{x}$=3.07), social media ($\bar{x}$ =3.02), were the frequently accessed ICT tools (Table 4) and were ranked 1st, 2nd, 3rd, and 4th respectively. All the other ICT tools had a mean score of less than 2.5, which means that they were less accessible to farmers. This agrees with a study carried out by Omotayo, (2015), who asserted that farmers can easily have access to agricultural information provided through radio, television, and mobile phone but cannot easily have access to agricultural information provided through the projector, email, internet connected computer, cassette recorder etc. The results also reveal that respondents had a

very low access to digital camera, CD Rom, multimedia projector and internet connected computer as they all had a mean score of less than 2. This could be as a result of lack of interest in those facilities or the cost of purchasing them.

Table 1: Distribution of farmers according to their access to ICTs

ICT Tools	HAC	EAC	AC	NAC	Mean	Rank
Radio	156	24	02	08	3.73**	Ist
Mobile Phones?.	131	48	07	04	3.61**	2nd
Television	76	70	25	19	3.07**	3rd
Social Media	75	63	32	20	3.02	4th
Cassette R	29	46	66	49	2.29	5th
Internet	30	44	51	65	2.21	6th
Computer	29	37	50	74	2.11	7th
Email	29	39	43	79	2.09	8th
Internet C. C	16	18	71	85	1.81	9th
Mult. Proj.	18	24	49	99	1.80	10th
CD Rom	02	24	81	83	1.71	11th
Digital Cam	05	23	29	133	1.47	12th

Source: Field survey data, 2023.

HAC = Highly accessible, EAC = Easily accessible, AC = Accessible, NAC = Not accessible

- Estimation of Food Security Status of Farming Households

The Food Poverty line (FPL), derived from equation 2, was estimated at N1435 per month using two-thirds of the mean per capita food consumption (Onyemauwa, 2014). The result as seen in Table 2, shows that 52.5% of farming households in the study area fall on or above the poverty line and therefore are said to be food secure while 47.5% fall below the poverty line and therefore said to be food insecure. This shows that the majority of the farming households in the study area are food secure. Nevertheless, with just 5% difference in the number of food-secure and food-insecure households in the study area, it shows that the problem of food insecurity among farming households in the study has not been adequately addressed.

Table 2: Household Food Security Status

Food Security Status	Food poverty line	Frequency	Percentage
Food secure	**≥ 1435.8**	**192**	**52.5**
Food Insecure	**< 1435.8**	**174**	**47.5**
Total		**366**	**100.00**

Source, Field Survey, 2023

- **Effect of ICT access on Food security status**

Employing the Food security status of households as the dependent variable (0=food insecure & 1=food secure) and 8 independent variables, the result of the logistic regression as presented in Table 3 shows that as household size increases, food security decreases by 7.95%. however, as income and educational qualification of household head increases, food security increases by 4.77% and 9.211% respectively. On access to ICT tools, results show that there is a significant and positive relationship between access to mobile phones, television and internet

on food security among farming households in study area. Results as presented in Table 3 show that, as farming household have access to mobile phones, television and internet, the chances of being food secure Increases by 3.45%, 7.48%, and 8.11% respectively. This could be because farming households that have access to mobile phones, television and the internet will be exposed to agricultural information and technology, which will enhance productivity and improve household food security. This result agrees with Oluwatayo & Ojo, (2019).

Table 3: logistic Regression Result

Variable	Coefficient	t-statistics	Marginal Effect
Constant	-1.352931	0.250	0.0001
Gender of Household head	-0.4344402	0.395	0.0029
Household size	-0.05288	0.029**	0.0795
Income of Household head	0.3201589	0.028**	0.0477
Educational level of Household head	1.224838	0.031**	0.0921
Access to Radio	-0.2719754	0.512	0.0007
Access to mobile phone	0.331833	0.002**	0.0345
Access to Television	0.0997554	0.029**	0.0748
Access to Internet	0.0050582	0.017**	0.0811
LR Chi^2	11.27		
Psudo R^2	0.517		
Nos of Observations	366		

** = Significant at 5% level

7.0 Conclusion & Recommendation

The study has shown that while 52.5% of farming households in the study area were earmarked food secure, a whopping 47.5% were food insecure based on the poverty line of N1435.8 obtained. Furthermore, Radio, mobile phones and television were the 3 most accessed ICT tools by farmers in the study area and mobile phones, television, the internet as well as other socio-economic variables such as household size, income and educational qualification of household head had significant effect on food security status of farming households in the study area. Given these findings, the following recommendations were made:

1. Local Government Authorities should put forward programs that encourage Household heads to acquire more education to ensure better income and consequently food security

2. The Government should subsidize ICT tools such as mobile phones and Internet for farming households to improve food security

References

Arokoyo, T. (2015). ICTs in the transformation of agricultural extension: The case of Nigeria. Paper Presented at the 6th consultative expert meeting of CTA's observatory on ICTs. Wageningen, September, 2007. pp 23-25

Ashraf, S., Khan, G., Ali, S., Ahmed, S., &Iftikhar, M. (2015). Perceived effectiveness of information sources regarding improved practices among Citrus growers in Punjab.

Centre for Agriculture and Rural Cooperation (CTA) (2017). ICTs- transformation Agricultural extension and e-discussion.

Food and Agriculture Organization of the United Nations (2017). Information and Communication Technologies in Agriculture: Precision Agriculture (PA) is a whole-farm management approach using information technologies, satellite positioning (GNSS) data, remote sensing and proximal data gathering https://www.google.com/search?q=internet+world+statistics+2011&oq=internet+&gs_lcrp=&sourceid=chrome-mobile&ie=UTF-8#vhid=zephyr:0&vssid=atritem-https://www.itu.int/ITU-D/ict/facts/2011/material/ICTFactsFigures2011.pdf

International Fund for Agricultural Development (2013). Smallholders Food Security and the Environment. Issues and perspectives from a review of IOE evaluation reports and recent IFAD country strategies and project designs.) Rome: International Fund for Agricultural Development.

Lokpobiri, H. (2016). Nigeria's Food Imports Bill rises to N6.6 trillion a year. Available at https://shipsandports.com.ng/nigerias-food-imports-bill-rises-to-n6-6trilliona-year/.

Namubiru, M., Ngaka, W., & Picho, E. (2018). The Effect of ICT on Households' Food Security in Uganda. Evidence from Acholi Sub Region in Northern Uganda. International Journal of Technology and Management, 3(1), pp.10-19

Nwalieji, H. U., Ezeakunne, C. C., Enwelu, I. A., Okeke, M. G., Udemezue, J. C., & Uzuegbunam, C. (2019). Mass Media Utilization by Poultry Farmers in Anambra State, Nigeria. Journal of Agricultural Extension, 23(2), pp.91-99

Olaniyi, O. A., Adetumbi, S. I., & Adereti, M. A. (2018) Accessibility and Relevance of Journal Information and Communication Technologies (ICTs) Among Cassava Farmers in Nigeria. African Journal of Agricultural Research, 8(35), pp.4514-4522

Oluwatayo, I.B., & Ojo, A.O. (2019) Effect of access to ICT on food insecurity among farming households in Nigeria. The Journal of Developing Areas, 53 (2), pp. 155-168

Onyemauwa, C.S., Orebiyi, J.S., Onyeagocha, S.U.O., Ehirim, N.C., Nwosu, F.O. & Ben-Chendo, N.G. (2018). Risk Aversion among Farmers of the National Program for Food Security in Imo State Southeast Nigeria. Journal of Economics and Sustainable Development, 4(10), pp. 131-137

OPTIMIZATION AND PERFORMANCE ANALYSIS OF A CANVAS BELT THRESHER FOR COWPEA IN SMALL-SCALE AGRICULTURE

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ABSTRACT

This study evaluates the performance of a canvas belt thresher designed specifically for cowpea, addressing post-harvest challenges in threshing efficiency, seed damage, and grain loss. Traditional threshers often lack precision for cowpea, leading to reduced yield and high labor demands. The constructed canvas belt thresher was tested at various drum speeds (200–1200 rpm) and moisture contents (10–14%) to determine its impact on threshing recovery, efficiency, cleaning ability, and seed integrity. Comparative performance was also assessed against a spike-tooth thresher, revealing the canvas belt thresher's enhanced threshing efficiency (93.98%) and lower unthreshed grain percentage (6.02%) at optimal conditions. While the canvas belt thresher showed reduced throughput (91.33 kg/h) compared to the spike-tooth (181.89 kg/h), it minimized grain damage (3.83% vs. 11.54%) and achieved a higher threshing recovery rate (89.62%). Overall, the canvas belt thresher demonstrated effective threshing and cleaning for cowpea, although certain design refinements, such as covering the belt edges to reduce seed loss, could further enhance its efficiency and yield. This study highlights the potential of a canvas belt thresher for cowpea to support post-harvest processing, reduce losses, and improve yield quality in regions reliant on cowpea as a staple crop. Future research could investigate adjustments in belt configuration and speed control for further optimization.

Keywords: Cowpea threshing, Canvas belt thresher, Seed damage reduction, Agricultural mechanization, Post-harvest processing, Threshing efficiency.

1.0 Introduction

Cowpea (Vigna unguiculata) is a vital legume crop, particularly for smallholder farmers in Africa and Asia, providing a critical source of protein, income, and soil-enriching nitrogen (Omoigui et al., 2018). Despite its significance, traditional cowpea post-harvest processing remains labor-intensive, especially threshing, which is predominantly done manually. Manual threshing often results in inconsistent threshing, higher labor costs, seed breakage, and inefficiency, directly impacting farmers' income and market access (Food and Agriculture Organization of the United Nations [FAO], 2004). In addressing these challenges, effective mechanical threshing methods can enhance productivity, reduce post-harvest losses, and provide a more consistent product.

Existing threshing machines, designed for cereals like wheat and maize, are unsuitable for cowpea due to the legume's fragile structure and sensitivity to damage. Cowpea seeds are more delicate than cereal grains, and conventional threshers often cause excessive seed breakage and loss, diminishing their market and nutritional value (Fernández et al., 2022; Kamara et al., 2020). Cowpea's lower hardness and tendency to crack require gentler processing (Refaay et

al., 2023). Standard threshers also overlook cowpea's unique aerodynamic properties, with spike-tooth types causing damage due to high-impact forces (Dessye & Fetene, 2021; Bello, 2020).

The limitations of current threshing machines underscore the need for a cowpea-specific solution that balances efficiency with the gentleness required to preserve cowpea seeds. Advances in agricultural engineering have led to threshers designed with lower impact forces and controlled environments, such as a cowpea thresher with a canvas belt mechanism that shows promise in reducing seed damage while achieving high efficiency (Shalaby et al., 2023). Performance evaluations indicate that these specialized threshers can significantly reduce damage, achieving up to 96.75% efficiency with minimal seed loss, a notable improvement over conventional machines, which often damage over 10% of seeds (Appah, 2017). By focusing on low-impact designs tailored to cowpea's unique properties, these innovations support the crop's economic and sustainable production (Bello, 2020; Dessye & Fetene, 2021).

This study introduces a novel canvas belt cowpea thresher to address the limitations of traditional threshing machinery for cowpea processing. Utilizing the friction-rubbing principle, it employs controlled belt speed and positioning to gently separate seeds from pods, aiming to reduce damage and enhance recovery (Mohsenin, 1970; Mohsenin, 1986; Nowosad et al., 2023). Rigorous performance testing at varying drum speeds and moisture levels evaluates its efficiency, grain damage, seed loss, and recovery, with a comparison to spike-tooth threshers revealing unique operational strengths (Ozguven & Kubilay, 2004). The research supports agricultural mechanization with implications for food security and economic stability (PwC Nigeria, 2021; Sasu, 2024; Voice of Nigeria, 2022; Zhang et al., 2021).

2.0 Materials and Methods

2.1 Description of the Canvas Belt Cowpea Thresher

The thresher (plate I) was constructed at the Centre for Industrial Studies (CIS), Abubakar Tafawa Balewa University (ATBU), Bauchi, leveraging available tools and equipment. Components such as angle irons, shafts, and sheet metal were cut to specification, joined by welding or bolting, and assembled with belts and pulleys to complete the design. Key units include the feeding, threshing, blower, unloading, power transmission, and support frame.

The thresher operates on a friction-rubbing principle. Powered by a gasoline engine, it uses two conveyor belts with varying speeds to thresh cowpea pods. Contact between belts causes threshing, with a blower separating chaff from grain; grains are collected in a trough while chaff exits via an airflow outlet.

Plate I. The canvas belt cowpea thresher: The constructed isometric view of the canvas belt cowpea thresher (L), Test operation and setting of the thresher prior to testing (R)

2.2 Method

2.2.1 Canvas belt cowpea thresher

Performance tests were conducted on the thresher to evaluate its feed rate, threshing recovery, threshing efficiency, cleaning efficiency, percentage grain damage, and grain loss. A total of 100 kg of unthreshed cowpea (*Kanannado variety*) was used for the tests. The cowpea was sundried for 24 hours, and its moisture content was determined using a G-7 grain moisture meter. The cowpea was then conditioned to three levels of moisture content. The rewetting method described by Singh and Goswami (1996) was adopted, and equation (1) was used to estimate the amount of water needed for each moisture level. For each test, 1 kg of unthreshed cowpea was used at moisture contents of 10.0%, 12.0%, and 14.0%, with the machine operating at five different speeds: 200 rpm, 400 rpm, 600 rpm, 900 rpm, and 1200 rpm. The speed was measured using a hand-held digital laser tachometer (Model: DT-209X, accuracy ±1 rpm for 6 - 8,300 rpm). The time required to process 1 kg was recorded from the start to when the last grain exited the threshing unit. Grains from all outlets were collected and weighed separately.

$$Q = \frac{W_i(M_f - M_i)}{100 - M_f} \quad (1)$$

Where; Q is the mass of water to be added in g; W_i is the initial mass of sample to be conditioned in g; M_f is the final or desired moisture content and M_i is the initial moisture content.

The following parameters and performance metrics were evaluated:
A: Total grain input per unit time, where A = B + C + D.
B: Weight of threshed grain at the main outlet.
C: Threshed grain weight at other outlets.
D: Unthreshed grain weight at all outlets.

Performance parameters (based on NSAE/NCAM/SON, 1995):

1. Damaged grain, $\% = \frac{E}{A} \times 100\%$ (E: damaged grain at all outlets)
2. Blown grain, $\% = \frac{F}{A} \times 100\%$ (F: whole grain at chaff outlet)
3. Grain loss, $\% = \frac{G}{A} \times 100\%$ (G: all grain losses)

4. Unthreshed grain % $= \frac{H}{A} \times 100\%$ (H: unthreshed grain)
5. Threshing efficiency = 100 - unthreshed grain %
6. Cleaning efficiency, % $= \frac{I}{J} \times 100\%$ (I: whole grain at main outlet; J: total material at main outlet)
7. Threshing recovery, % $= \frac{B}{A} \times 100\%$

2.2.2 Comparative Performance Evaluation with a Commonly Used Cowpea Thresher

A spike-tooth multi-crop thresher was evaluated alongside the canvas belt cowpea thresher to compare their performance. The spike-tooth thresher consists of several key units: the feeding unit, threshing unit, delivery unit, power transmission unit, and the frame (see Plate II).

The machines were tested at moisture contents of 10% and 14%, operating at a speed of 600 rpm. For each test, 1.3 kg of cowpea was fed into the machine, and the duration of the threshing process was recorded from the start until the last grain exited the thresher. The threshed material was then separated into whole seeds, unthreshed pods, broken seeds, chaff, and loss materials. These data were used to calculate key performance metrics, including feed rate, performance efficiency, percentage of unthreshed pods, threshing efficiency, percentage grain damage, threshing recovery, and seed loss. The results are summarized in Table 4.

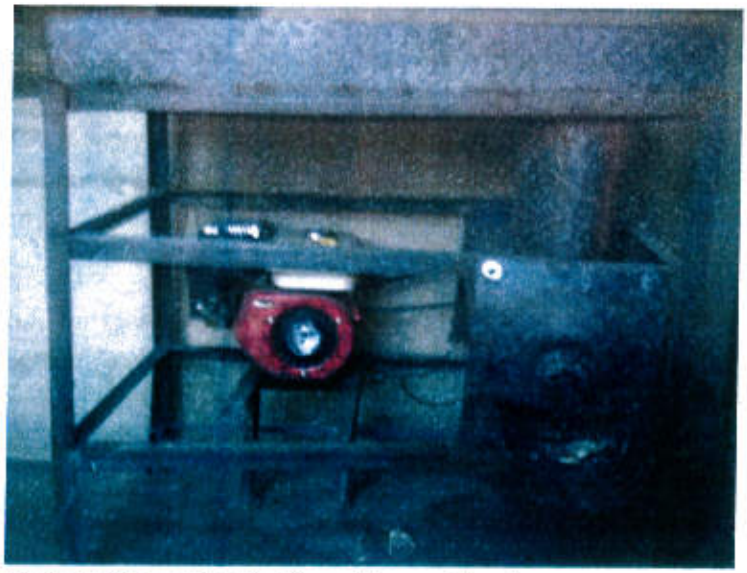

Plate II. The spike tooth multi-crop thresher

2.3 Experimental design

The experiment was laid on a factorial design, where 2 independent variables (drum speed and moisture content) were combined at levels of 3 and 5 to obtain 15 treatments replicated thrice in a randomized block design (RBD). Descriptive statistics, regression analysis and the mean analysis of variance (ANOVA) were statistical tools used to analyse the results and how it affects the dependent variables of threshing recovery, performance efficiency, threshing efficiency, percentage unthreshed, cleaning efficiency, grain damage, seed loss, blown away seeds, material capacity and throughput capacity.

3.0 Results and Discussion

3.1 Canvas Belt Cowpea Thresher Test

The testing of the constructed canvas belt cowpea thresher was conducted with three replications, and the results are summarized in Tables 1 and 2. Table 1 presents the mean performance of the thresher at drum speeds of 200 rpm, 400 rpm, 600 rpm, 900 rpm, and 1200 rpm, alongside moisture content levels of 10.0%, 12.0%, and 14.0%. This table includes the grand mean, standard deviation, and least significant difference of the parameters assessed as influenced by drum speeds and moisture contents. The summarized results provide a comprehensive overview of the performance across the various conditions tested.

Table 2 details the analysis of variance (ANOVA) for the thresher's performance. The optimal throughput capacity was achieved at a moisture content of 10.0% and a drum speed of 1200 rpm, attributed to the increased speed of the thresher belt that facilitates quicker product processing, as well as the lower moisture content allowing for smoother flow. The ANOVA results indicate that drum speed, moisture content, and their interaction significantly affected the feed rate at a 5% significance level. The thresher achieved a percentage of unthreshed grain of 6.02% at a drum speed of 900 rpm and moisture contents of 10.0% and 12.0%, demonstrating a decrease in unthreshed grain with increasing drum speed until 900 rpm, after which it began to increase.

The thresher exhibited a threshing efficiency of 93.98% at 900 rpm and moisture contents of 10.0% and 12.0%. This efficiency aligns with previous studies, with Ahaneku et al. (2003) and Irtwange (2009) reporting efficiencies of 99% and 96.39%, respectively, for cowpea. The ANOVA showed significant differences in all tested parameters affecting threshing efficiency. The data indicated that threshing efficiency improved with increased drum speed, peaking at 900 rpm, before declining with higher moisture content. This observation supports Zaalouk (2009), but contrasts with Umogbai et al. (2014), who found that increased moisture content solely affected efficiency.

Cleaning efficiency reached its highest performance at 92.42% when operating at 900 rpm and 12.0% moisture content. The analysis highlighted that the interaction between moisture content and drum speed significantly influenced cleaning efficiency, although drum speed alone had no effect at a 5% significance level. Additionally, the testing indicated that the lowest percentage of grain damage occurred at 1200 rpm and 14.0% moisture content, revealing that moisture content significantly impacts grain damage more than speed. The test for blown-away seeds revealed an optimal result of 0.33% at 200 rpm and 14.0% moisture content, demonstrating that thresher drum speed correlates with fan speed, which can increase blown-away seeds. The seed loss recorded a minimal figure of 1.96% at 200 rpm and 14.0% moisture, better than the findings of Ahaneku et al. (2003) and Irtwange (2009). Overall, the machine achieved an optimal threshing recovery of 89.62% at a drum speed of 900 rpm and moisture content of 10.0%, with the analysis of variance confirming significant effects of both parameters on recovery. More of the trend can be visualized in the Figure 1. The regression model and coefficient of determination for the thresher parameters, shown in Table 3, indicate high predictability for throughput capacity (R^2 = 99.14%) and less predictability for grain breakage (R^2 = 93.75%).

Table 1. Mean Values and Least Significant Difference of Parameters as Influenced by the Effects of Drum Speeds at 10%, 12% and 14% Moisture Contents

Drum Speed, rpm	% Moisture Content			LSD	Grand Mean	Standard Deviation
	10	12	14			
Percentage Unthreshed, %						
200	7.14	7.21	7.53			
400	6.33	6.38	6.71			
600	6.21	6.23	6.366			
900	6.02	6.02	6.07	MC=0.052		
1200	6.33	6.46	6.65	DS=0.067	6.5096	0.457
Threshing Efficiency, %						
200	92.86	92.79	92.47			
400	93.67	93.62	93.29			
600	93.79	93.77	93.63			
900	93.98	93.98	93.93	MC=0.052		
1200	93.67	93.54	93.35	DS=0.067	93.4904	0.457
Cleaning Efficiency, %						
200	64.17	63.00	62.49			
400	62.13	63.21	62.69			
600	72.41	71.47	74.65			
900	92.21	92.42	90.58	MC=0.33		
1200	85.74	85.71	85.52	DS=0.43	75.2259	12.175
Grain break, %						
200	4.46	4.406	4.32			
400	4.074	4.04	3.972			
600	4.18	4.054	3.926			
900	4.074	4.02	3.834	MC=0.054		
1200	3.834	3.814	3.734	DS=0.069	4.0495	0.217
Blown away seed, %						
200	0.37	0.33	0.33			
400	0.37	0.4	0.37			
600	0.8	0.83	0.86			
900	1.58	1.43	1.51	MC=0.053		
1200	2.88	2.27	2.45	DS=0.681	1.1187	0.860
Seed loss, %						
200	2.1	2.022	1.962			
400	2.262	2.22	2.178			
600	2.934	2.916	2.838			
900	3.714	3.774	3.474	MC=0.05		
1200	3.822	3.9	4.122	DS=0.064	2.949	0.791

MC = moisture content (%); DS = drum speed (rpm)

Table 1. Mean Values and Least Significant Difference of Parameters as Influenced by the Effects of Drum Speeds at 10.0%, 12.0% and 14.0% Moisture Contents. Cont'd

Drum speed, rpm	% Moisture content 10.0	12.0	14.0	LSD	Grand mean	Std dev.
Throughput capacity, kg/hr						
200	52.22	50.56	49.50			
400	59.38	56.06	55.49			
600	72.36	72.2	69.44			
900	91.33	87.44	86.82	MC=0.065		
1200	105.28	103.87	100.13	DS= 0.084	74.14	9.76
Performance Eff, %						
200	96.87	96.97	97.03			
400	96.63	96.70	96.70			
600	96.16	95.94	96.18			
900	95.62	95.15	95.73	MC=0.099		
1200	96.26	95.94	95.35	DS= 0.127	96.21	0.620
Material capacity, kg/hr						
200	14.4	14.19	13.88			
400	19.67	18.7	18.44			
600	24.02	24.67	23.61			
900	32.54	31.28	31.58	MC=0.057		
1200	34.78	34.24	32.71	DS= 0.073	24.58	7.589

MC = moisture content (%); DS = drum speed (rpm)

Table 2. ANOVA for the Canvas Belt Cowpea Thresher Performance

		F-Cal								
	df	Percentage Unthreshed	Threshing Efficiency	Cleaning Efficiency	Grain Breakage	BAS	Seed loss	Throughput capacity	Performance Efficiency	Material Capacity
Replica	2									
Drum speed (A)	4	18.23***	15.67***	22.89***	12.34**	30.67***	19.45***	44.78***	13.56**	27.89***
Moisture Content (B)	2	5.67*	4.54*	8.03**	3.88	9.23**	6.12*	11.56**	4.78*	10.12**
(A*B)	8	2.34	3.22	5.41*	1.45	6.78**	4.01*	7.22**	2.98	5.67**
Error	30									
Total	44									

* for $p<0.05$ (significant); ** for $p<0.01$ (highly sig.); *** for $p<0.001$ (very highly sig.)

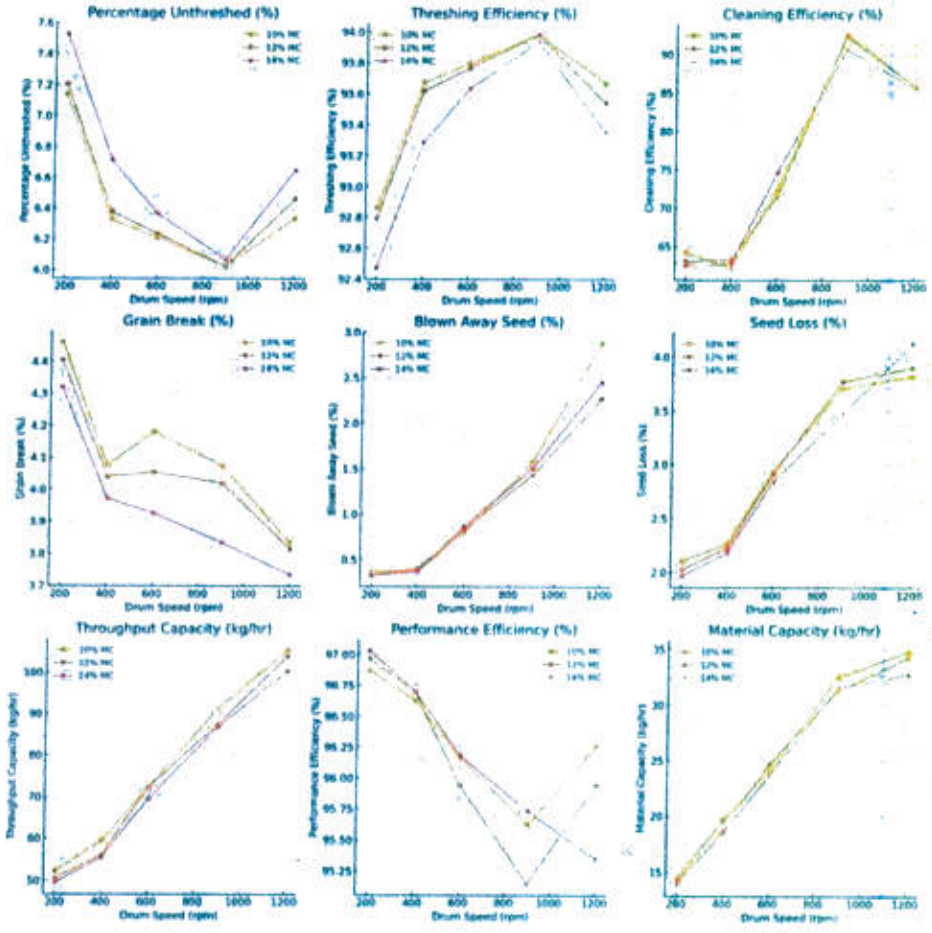

Figure 1. Canvas belt cowpea thresher parameter results at combine drum speed and moisture content settings

Table 3. Regression model showing the interaction between drum speed and moisture content on the threshing parameters

S/N	Parameter	Linear model	R^2
1	Percentage Unthreshed	0.0035*DS + 0.1535*MC + 5.9635	0.9789
2	Threshing Efficiency	-0.0011*DS - 0.0412*MC + 94.0385	0.9641
3	Cleaning Efficiency	0.0119*DS - 0.0462*MC + 62.0817	0.9563
4	Grain Breakage	-0.0007*DS - 0.0325*MC + 4.6705	0.9375
5	Blown away seed	0.0019*DS + 0.0003*MC + 0.0083	0.9876
6	Seed loss	0.0017*DS + 0.0281*MC + 1.6595	0.9721
7	Performance Efficiency	-0.0001*DS - 0.0286*MC + 96.8389	0.9234
8	Material Capacity	0.0135*DS - 0.1827*MC + 11.9485	0.9897
9	Throughput Capacity	0.0545*DS - 0.9595*MC + 49.6513	0.9914

DS = Drum speed (rpm); MC = Moisture content (%)

.2 Spike tooth multi-crop thresher test

Table 4 is the mean results of the canvas belt cowpea thresher performance at drum speed of 600rpm and moisture content levels of 10.0%, and 14.0%. It also comprises, the grand mean and the standard deviation of the parameters assessed as influenced by drum speeds and moisture contents.

The results presented in Table 4 showed that whole seeds collected and the seed loss were not affected by change in moisture content. It further showed that there was a decrease in performance with respect to threshing efficiency, grain damage, threshing recovery, material capacity, performance efficiency and throughput capacity as moisture content increased from 10.0% to 14.0%. Meanwhile, the percentage unthreshed increased at increasing moisture content of the crop. The machines throughput capacity at 10.0% moisture content which was 181.89kg/hr is better compared to the 110.86kg/hr by Irtwange (2009). The machine has a performance efficiency of 98.46%, that is to say it is more effective when compared to the 81.21% performance efficiency by Ojo *et al.* (2010) at almost the same moisture content of cowpea tested.

Table 4. Mean values of spike-tooth multi-crop thresher performance parameters as influenced by levels of Moisture content at drum speed of 600rpm.

	% Moisture content			
Performance Parameter	10.0	14.0	Grand Mean	SD
Throughput capacity, kg/hr	181.89	177.05	179.47	1.56
Unthreshed, %	24.62	26.15	25.39	0.87
Threshing Efficiency, %	75.38	73.85	74.62	0.87
Grain damage, %	13.08	11.54	12.31	0.88
Seed loss, %	1.54	1.54	1.54	0
Threshing recovery, %	59.23	57.7	58.47	0.87
Material capacity, kg/hr	83.95	82.35	83.15	0.89
Performance Efficiency, %	98.46	97.69	98.08	0.62

3.3 Comparison of the Prototype Canvas Belt and the Spike-Tooth Thresher

The canvas belt cowpea thresher was compared with a spike-tooth multi-crop thresher, using the same engine power and cowpea variety, as shown in Table 5. Tests used optimal settings: 600 rpm for the spike-tooth and 900 rpm for the canvas belt. The spike-tooth thresher achieved higher throughput (181.89 kg/h at 10% MC) than the canvas belt (91.33 kg/h). Increasing the speed beyond 900 rpm caused stability issues in the canvas belt.

Table 5. Comparison between the Spike-tooth thresher and the Canvas belt thresher

Parameters	Spike-tooth Thresher		Canvas belt thresher	
Moisture content, %	***10.0***	***14.0***	***10.0***	***14.0***
Throughput capacity, kg/hr	181.89	177.05	91.33	86.82
Unthreshed, %	24.62	26.15	6.02	6.07
Threshing Efficiency, %	75.38	73.85	93.98	93.93
Grain damage, %	13.08	11.54	4.074	3.834
Seed loss, %	1.54	1.54	3.714	3.474
Threshing recovery, %	59.23	57.7	86.74	89.62
Material capacity, kg/hr	83.95	82.35	32.54	31.58
Performance Efficiency, %	98.46	97.69	95.62	95.73

The canvas belt thresher showed a lower unthreshed percentage (6.02%) compared to 24.62% for the spike-tooth. Threshing efficiency was higher for the canvas belt (93.98%) than the spike-tooth (75.38%). Grain damage was 3.83% for the canvas belt and 11.54% for the spike-tooth at 14% MC. Seed loss was higher for the canvas belt (3.47% at 14% MC) than for the spike-tooth (1.54% at 10% MC). Threshing recovery differ, with 89.62% for the canvas belt and 59.23% for the spike-tooth, although wear and tear on the spike-tooth caused several openings.

The spike-tooth showed better overall efficiency (98.46% vs. 95.73% for the canvas belt). However, improvements to the canvas belt, such as covering the sides to reduce seed spillage, could enhance performance. Additionally, the canvas belt's integrated cleaning mechanism, absent in the spike-tooth, makes its threshing process more complete.

4.0 Conclusions

The study evaluated the canvas belt cowpea thresher's performance and compared it with a spike-tooth thresher. The results indicate that the canvas belt thresher, with optimal performance at 900 rpm and 10% moisture content, achieved higher threshing efficiency (93.98%) and lower unthreshed percentage (6.02%) compared to the spike-tooth thresher. However, its throughput was lower, and seed loss was slightly higher at higher moisture levels. Suggested improvements to reduce seed spillage, combined with its effective cleaning mechanism, could enhance its suitability for smallholder cowpea farmers, offering a viable alternative to conventional methods.

5.0 Recommendations

Based on the findings, future studies could consider testing alternative belt materials that are durable and friction-effective to enhance belt efficiency and lifespan. Additionally, optimizing belt design and speed by adjusting speeds, widths, and textures could improve seed handling, reduce spillage, and increase throughput. Enhancing the blower airflow design to better separate chaff and grain, especially in higher moisture conditions, would also be beneficial. These recommendations aim to refine the thresher's design, improve operational efficiency, and address specific challenges faced in different farming conditions.

Reference

Ahaneku, I. E., Kamal, A. R., & Ogunjirin, O. A. (2003). Design, construction, and performance evaluation of a multipurpose crop thresher. *Journal of Agricultural Engineering and Technology*, 11, 17–23.

Appah, S. (2017). Effect of open-air drying duration on seed moisture and the threshing quality of cowpea. *Journal of Advances in Agriculture*.

Bello, R. S. (2020). Design, construction, and performance evaluation of cowpea thresher. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*, 3(2).

Dauda, A. (2001). Design, construction, and performance evaluation of a manually operated cowpea thresher for small-scale farmers in northern Nigeria. *Agricultural Mechanization in Asia, Africa, and Latin America (AMA)*, 32(2), 47–49.

Dessye, B., & Fetene, M. (2021). The effect of moisture content on the performance of Melkassa multicrop thresher in some cereal crops. *Journal of Agricultural Science and Technology*.

Fernández, J. A., Messina, C. D., Salinas, A., Prasad, P. V. V., Nippert, J. B., & Ciampitti, I. A. (2022). Kernel weight contribution to yield genetic gain of maize: A global review and US case studies. *Journal of Experimental Botany*, 73(11), 3597–3609. https://doi.org/10.1093/jxb/erac103

Food and Agriculture Organization of the United Nations (FAO). (2004). Post-harvest compendium: Cowpeas. Retrieved from https://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_-_Cowpeas.pdf

Irtwange, S. V. (2009). Design, fabrication, and performance of a motorized cowpea thresher for Nigerian small-scale farmers. *African Journal of Agricultural Research*, 4(12), 1383–1391.

Kamara, A. Y., Kamai, N., Omoigui, L. O., Togola, A., Ekeleme, F., & Onyibe, J. E. (2020). *Guide to maize production in northern Nigeria*. Ibadan, Nigeria: International Institute of Tropical Agriculture.

Mohsenin, N. N. (1970). *Physical properties of plant and animal materials*. New York: Gordon and Breach Science Publishers.

Mohsenin, N. N. (1986). *Physical properties of plant and animal materials*. New York: Garden and Breach Science Publishers.

Nowosad, K., Bocianowski, J., Kianersi, F., & Pour-Aboughadareh, A. (2023). Analysis of linkage on interaction of main aspects (genotype by environment interaction, stability, and genetic parameters) of 1000 kernels in maize (Zea mays L.). *Agriculture*, 13(10), 2005. https://doi.org/10.3390/agriculture13102005

NSAE/NCAM/SON. (1995). *Nigeria standard test code for grain and seed cleaners, grain harvesters, and maize sheller*. Nigeria Agricultural Engineering Standards for the Nigerian Society of Agricultural Engineers. Sponsored by the National Centre for Agricultural Mechanization and Standards Organization of Nigeria.

Ojo, M. O., Ale, M. O., & Olajide, O. G. (2010). Development and performance evaluation of a cowpea harvester. *Journal of Engineering and Applied Sciences*, 5(10), 5–10.

Omoigui, L. O., Kamara, A. Y., Batieno, J., Iorlamen, T., Kouyate, Z., Yirzagla, J., Diallo, S., & Garba, U. (2018). *Guide to cowpea production in West Africa*. Ibadan, Nigeria: International Institute of Tropical Agriculture. https://www.iita.org/wp-content/uploads/2020/05/Cowpea-manualENGLISH.pdf

Ozguven, F., & Kubilay, V. (2004). Some physical, mechanical, and aerodynamic properties of pine (Pinus pinea) nuts. *Journal of Food Engineering*, 68, 191–196.

PwC Nigeria. (2021, September). Positioning Nigeria as Africa's leader in maize production for AfCFTA. Retrieved November 2, 2024, from https://www.pwc.com/ng/en/assets/pdf/positioning-nigeria-as-africa-leader-in-maize-production-for-afcfta.pdf

Refaay, M. M. S., El-Sayed, A. S., & Awad, M. C. A. (2023). Development of a cowpea threshing machine. *Turkish Journal of Agricultural Engineering Research*, 4(1), 46–60. https://doi.org/10.46592/turkager.1267961

Sasu, D. D. (2024, September 30). Production of maize in Nigeria from 2010 to 2021. *Statista*. Retrieved November 2, 2024, from https://www.statista.com/statistics/1300743/production-volume-of-maize-in-nigeria/

Shalaby, M. M., El-Sayed, A. S., & Awad, M. C. A. (2023). Development and performance evaluation of a cowpea threshing machine. *ResearchGate*. https://www.researchgate.net/publication/364927657_Development_and_performance_evaluation_of_a_cowpea_threshing_machine/fulltext/6360406496e83c26eb6ed17f/Development-and-performance-evaluation-of-a-cowpea-threshing-machine.pdf

Singh, K. K., & Goswami, T. K. (1996). Physical properties of cumin seed. *Journal of Agricultural Engineering Research*, 6(4), 93–98.

Umogbai, V. I., & Shehu, A. (2009). Development and performance evaluation of a manually operated cowpea thresher. In A. O. Akii-Ibhadode, I. A. Igbafe, & B. U. Anyata (Eds.), *Advanced Materials Research: Advances in Materials and Systems Technologies II*, 62(64), 239–246.

Umogbai, V. I., Fulani, A. U., & Obetta, S. E. (2014). Development and evaluation of a powered cowpea thresher. *International Journal of Engineering Science and Technology (IJEST)*, 6(6), 359–369.

Voice of Nigeria. (2022, March 15). Nigeria's maize production at highest level since independence – USDA. Retrieved November 2, 2024, from https://von.gov.ng/nigerias-maize-production-at-highest-level-since-independence-usda/

Zaalouk, A. K. (2009). Evaluation of local machine performance for threshing bean. *Misrata Journal of Agricultural Engineering*, 26(4), 1696–1709.

Zhang, H., Lu, Y., Ma, Y., et al. (2021). Genetic and molecular control of grain yield in maize. *Molecular Breeding*, 41(18). https://doi.org/10.1007/s11032-021-01214-3

ECONOMIC ANALYSIS OF ADOPTERS AND NON-ADOPTERS OF RICE PRODUCTION TECHNOLOGY IN IKWO LOCAL GOVERNMENT AREA EBONYI STATE, NIGERIA

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ABSTRACT

A study was carried out on economic analysis of adopters and non-adopters of rice production technology in Ikwo Local Government Area Ebonyi State, Nigeria. Gross margin, net farm income and Ordinary Least squares regression model was used for analyses. The profitability analysis indicated that for every naira earned as revenue by non-rice technology adopters, 41 kobo was returned to the rice farmer as net income; hence, rice production for non-rice technology adopters was profitable in the area. For rice technology adopters, 79 kobo was returned to the rice farmer as net income for every naira earned as revenue. Therefore, rice production for rice technology adopters was also profitable, but higher than for non-rice technology adopters. The result of regression analysis of factors influencing the profitability of rice production in the area shows that the coefficient for farm size, labour input, quantity of seed, educational attainment and access to credit were significant, while the coefficients of quantity of fertilizer and farming experience were not significant to influence the profitability of rice production in the area. Based on the result of the analysis, the following recommendations were proffered: rice farmers in the area should be encouraged to access and adopt technologies in rice production as the profitability index is higher among adopters and variables like farm size, labour input, quantity of seed, educational attainment and access to credit should be improved upon to boost the profit margins of rice production in the area.

Key words: adopters, non-adopters, rice, production technology, costs and returns, regression analyses

1. Introduction

The development and dissemination of novel agricultural technologies is seen as a way of enhancing productivity (Chukwu *et. al.*, 2022). Onyeneke (2022) noted that governments and development organizations have long been promoting agricultural technologies as effective ways to increase farm productivity and reduce poverty. Nonetheless, adoption of many seemingly beneficial technologies remains low. Widespread adoption of a new technology is a necessary (though not sufficient) condition for achieving impactful agricultural development. Agricultural technology is a broad term that is used here to describe equipment, genetic materials, farming techniques, and agricultural inputs that have been developed to improve the effectiveness of agriculture (Umeh, 2022).

According to Nwakpu *et. al.,* (2021), agricultural technologies that concern natural resource management are technologies that have been developed to deal with and mitigate environmental stresses, such as land degradation and nutrient depletion. Those for improved varieties include new crop varieties that are developed to exhibit favourable characteristics, such as increased yields, pest resistance, drought tolerance, shorter growing periods, higher nutritional value, etc. Chemical inputs agricultural technologies on the other hand, would include agrochemical inputs intended to increase yields or reduce losses to pests. Mechanization and infrastructure agricultural technologies are any of a variety of technologies requiring significant investment in physical equipment. Agricultural technology adoption theory is a multi-disciplinary field that combines elements of decision theory and diffusion of innovations theory in an attempt to explain why some farmers adopt new technologies and others do not (Ladebo 2020).

Rice (*oriza sativa*) is an annual crop which belongs to the graminae family (Agu, 2017). It is the second most widely grown cereal crop and the staple food for more than half the world's population. According to Girei, Usman and Onuk (2016) rice is the fourth major cereal crop in Nigeria after sorghum, millet and maize in terms of output and cultivated land area. Rice is a staple in the diets of the majority of people and has become a rapidly growing food source in Nigeria, with consumption rate increasing significantly, at an estimated 6 million metric tonnes annually (Food and Agricultural Organization (FAO), 2022). The importance of rice in Nigeria is no longer the question but rather, how can we meet the growing demand, reduce imports and be self-sufficient in production. The use of rice production technologies is therefore necessary as a way out of this quagmire.

Domestic supply accounts for about 37% of this demand, a phenomenon attributed to the non-adoption of rice production technologies, while the remaining is bridged through importation (Ndaghu, *et. al.*, 2021). The demand for rice consumption in Nigeria has risen tremendously to about 10% per annum since the mid-1970s due to an increase in population growth, increased income levels, rapid urbanization and changing consumer preferences (FAO, 2022). This however requires a change in the production technologies, if output is to be increased and sustained to march with the heightened demand. The demand for rice has been increasing at a much faster rate in Nigeria than in other West African countries. For instance, during the 1960s Nigeria had the lowest per-capita annual consumption of rice in the West Africa sub-region with an annual average of 3kg. Since then, Nigeria's per-capita consumption levels have grown significantly at 7.3% per annum. Consequently, per-capita consumption during 1980 increased to an average of 18kg and reached 22kg per person between 1995 and 1999 (Federal Ministry of Agriculture and Rural Development (FMARD), 2023).

According to Ogechi (2023), the average Nigerian now consumes 24.8kg of rice per year, representing 9% of total caloric intake. Nigeria's rice consumption is forecasted to reach 36 million tonnes by 2050 if it continues to grow at the current rate of 6 – 7% per annum (FAO 2023). Even though most Nigerians living in rural areas consume limited quantities of rice, it forms an important diet for the majority of urban dwellers. The annual consumption is increasing at a rate of 7% as compared to 4% for wheat and 1% for maize, which is the main

staple food (International Institute for Tropical Agriculture (IITA) (2019)). This is attributed to progressive changes in eating habits, changes in income and urbanization.

Promotion of the adoption of technologies in rice production would improve domestic rice production and marketing, consequently improve food security, increase the income of actors, contribute to employment creation and reduce the huge rice import bill (Agu, 2017). As a result of the high consumption rate in the face of low output occasioned by the non-adoption of technologies in its production, domestic production has never been able to meet demand thereby leading to considerable importation of milled rice to bridge the gap between domestic demand and supply. The study is predicated on this assertion and is designed to achieve the following objectives:

i. estimates the profitability of rice production among adopters and non-adopters of rice technologies in the area,

ii. determine the factors influencing the profitability of rice production in the area.

2. METHODOLOGY

2.1 Area of study

The study was carried out in Ikwo Local Government Area of Ebonyi State, Nigeria. The area was purposively chosen for this study because of two reasons: The peculiarity of this research problem in the area and the familiarity of the researchers to the area, factors which facilitated data generation. What is now Ebonyi State was part of Anambra State, South-Eastern until 1987, (Ebonyi Agricultural Development Programme, (EBADEP), 2022). The study area is located in Southeast Nigeria and lies in the humid tropical agro-ecological zone of Nigeria within longitudes 70' 30'E and 80' 30'E and latitudes 50' 40'N and 60' 45'N (Ebonyi State Ministry of Agriculture and Water Resources, 2022). It has a land area of 5,935 km2 with a projected population of 2,853,140 persons in 2023 using a growth rate of 3.5% (National Population Commission, 2006). The State shares boundaries on the North by Benue State, to the West by Enugu State, to the East by Cross River State and to the South by Imo and Abia State (EBADEP, 2022). Ebonyi State has a climate characterized by two distinct seasons- the dry and wet seasons. The dry season spans from November to late March, while the rainy season spans from April to October with a short spell in August called "August break" (Umeh, 2022). The climate of the State is that of a humid tropical climatic region, with a mean annual temperature standing at 31'C and an average rainfall of 1200mm - 2500mm, including a luxuriant vegetation of tropical rainforest (EBADEP, 2022). The soil of Ebonyi State is basically clayey and loamy, the claycy swampy soil is suitable for rice farming.

2.2 Sampling Procedure and Sample Size

The population for this study comprised of rice farmers from Ikwo Local Government Area (LGA) of Ebonyi State, Nigeria. Multi-stage random sampling techniques was adopted to select respondents for the study. In the first stage, 3 villages were purposively selected from the ten villages making up the LGA based on the prevalence of rice farmers in those villages. The second stage involved the random selection of two communities from each of the selected villages, because of similar reasons, making it six communities in the sample. At the last stage, a list comprising all the registered rice farmers from these selected villages was compiled with the help of resident extension agents. This formed the sampling frame from which the sample

was drawn. A total of sixteen rice farmers were randomly selected from each of the communities earlier selected, giving a total sample size of ninety-six respondents.

2.3 Method of Data Collection

Data required for this study were generated from primary sources and collected using a set of pre-tested structured questionnaires. The questionnaires were administered by well-trained enumerators (farmers), who were conversant with the selected locality. Primary data were also obtained through personal contact, oral interviews, etc. Questions related to rice production formed part one of the questionnaire. Part two on the other hand dealt with questions related to technology adoption by rice farmers. The last section of the questionnaire asked questions related to technology non-adoption by rice farmers. A pilot study was conducted where key informants, including ADP extension agents, IFAD staff, Executives of the Ikwo Rice Mill Industry and focus group discussions were used for pre-testing of the questionnaire. This was to triangulate information provided by households.

2.3 Analytical Procedure

Data were analyzed using descriptive and inferential statistics. Farm budgeting techniques such as Gross Margin and Net farm income (NFI) were used to estimate the costs and returns among technology adopters and non-adopters, while the Ordinary least squares regression model was used to analyze the factors influencing the output of the rice farmers.

Model specification

The Gross Margin (GM)

The Gross Margin (GM) is expressed as GM= TR – TVC (i)

where GM= Gross Margin TR=Total Revenue TVC=Total Variable Cost.

On the other hand, Net Farm Income (NFI) is expressed as NFI=Revenue – Total cost (ii)

NFI= TVP – (TVC+ TFC) (iii)

Where NFI= Net Farm Income. TVP=Total value of production

The profit/ profitability index was derived from the total cost of rice production less the revenue derived from the sale of rice

Multiple Regression

Model specification for Cobb- Douglas function for both adopters and non-adopters of rice production technologies.

$Y = b_0 + X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + ei$ (iv)

Where Y= profit of rice (naira)

X_1= farm size (hectares)

X_2= labour input (man days)

X_3 = quantity of seeds planted (kg)

X_4 = quantity of fertilizer (kg)

X_5 = educational attainment (years)

, X_6 = access to credit (1 = yes, 0 = no)

X_7 = farming experience (years)

e_i = Error term.

3.0 Result and Discussion

3.1 Cost and returns of non-rice technology adopters

Table 1 Cost and Returns of Rice Production per hectare

Items	Total value ₦	Percentage to total cost
A Total value of production	215,000	
B Variable costs		
Cost of labour (man-days)	45,608.00	36.01%
Cost of Fertilizer (bags)	18,100.00	14.29%
Cost of seeds (naira)	8,200.00	6.48%
Cost of agrochemicals (litres)	4,320.00	3.41%
C Total variable cost	76,228.00	60.19%
D Fixed costs		
Depreciation on land	45,000.00	35.50%
Depreciation on fixed assets	5,412.00	4.27%
E Total fixed cost	50,412.00	39.81%
F Total cost	126,640.00	100.00%
G Net farm income	88,360.00	
Gross margin	138,772.00	

Gross margin = ₦138,772, Operating ratio (C/F) = 0.60 and Profitability Index (G/A) = 0.41

The results of the cost and returns of non-rice technology adopters are presented in Table 1. The table showed that the total revenue (sales) from rice production of non-rice technology adopters per hectare was ₦215,000. The table also revealed that the variable costs constituted the highest share of costs of production representing 60.19%, while the fixed cost represented 39.81% of the total costs of production. The average gross margin income of the respondents and net farm incomes of the respondents were ₦138,772.00 and ₦86,360.00 respectively. This result corroborates that of Ohaka, Adiaha and Amanze (2013) who found that greater gross margin leads to profit maximization which is the central objective of producers. The profitability index (PI) was 0.41 implying that for every naira earned as revenue, 41 kobo was returned to the rice farmer as net income; the decision rule for a firm or business to be profitable, is that the profitability index should be greater than zero, thus rice production for non-rice technology adopters is profitable in the area.

3.2 Cost and Returns of Rice Technology Adopters

Table 2 Cost and Returns of Rice Production per hectare

Items	Total value ₦	Percentage to total cost
A Total value of production	403,100	
B Variable costs		
Cost of labour (man-days)	37,654.00	23.87%
Cost of Fertilizer (bags)	32,320.00	20.49%
Cost of seeds (naira)	14, 500.00	9.19%
Cost of agrochemicals (litres)	9, 420.00	5.97%
C. Total variable cost	83, 894.00	59. 52%
D. Fixed costs		
Depreciation on land	51,000.00	32.32%
Depreciation on fixed assets	12,876.00	8.16%
E. Total fixed cost	63, 876.00	40.48%
F Total cost	147, 770.00	100.00%
G Net farm income	245, 330.00	
Gross margin	319, 206	

Gross margin = ₦319, 206, Operating ratio (C/F) = 0.532 and Profitability Index (G/A) = 0.792

The results of the cost and returns of rice technology adopters are presented in Table 2. According to the table, the total revenue from rice production of technology adopters per hectare was ₦403,100. In the same way, the variable costs constituted the highest share of costs of production representing 59. 52%, while the fixed cost represented 40.48%. The average gross margin and net farm incomes of the respondents were ₦319, 206 and ₦245, 330.00 respectively. The profitability index (PI) was 0.792 implying that for every naira earned as revenue, 79 kobo was returned to the rice farmer as net income. Rice production for technology adopters is also profitable in the area, but higher than for non-rice technology adopters. This result conforms with that of Chukwu *et. al.*, (2022) in their work "determinants of adoption of improved rice production technologies among rice farmers in Ebonyi State, Nigeria: A Logit Regression Model Approach".

3.3 Factors influencing the profitability of rice production in the area

Table 3: Multiple regression results of factors influencing the profitability of rice production in the area

Variables	Linear form	Double log form	Semi log form	Exponential form
Farm size (X_1)	0.6550	0.9450	0.9340	0.6620
	(6.488)**	(9.350**	(6.080)**	(4.831)**
Labour input (X_2)	-0.1190	0.2150	0.0600	-0.0430
	(-0.398)	(1.116)*	(0.859)	(-0.668)
Qnty of seed (X_3)	0.4300	0.2000	0.4100	0.2410
	(4.800)**	(3.836)**	(5.165)**	(1.984)**
Qnty of fertilizer (X_4)	-0.0130	0.0390	0.0430	-0.1200
	(-0.134)	(0.751)	(-0.543)	(-0.937)
Educational level (X_5)	0.0450	0.0700	0.1980	-0.1200

	(1.043)*	(1.629)**	(3.018)***	(-0.375)
Access to credit (X_6)	0.0370	0.0510	0.0000	0.0790
	(0.885)	(1.231)*	(-0.0060)	(1.375)*
Farming experience (X_7)	-0.0560	-0.0760	-0.0050	-0.0300
	(-0.8930)	(1.072)	(-0.420)	(-0.350)
R^2	0.9030	0.9260	0.8290	0.8590
F-ratio	4.2264	2.9185	16.1218***	6.3358
Constant	18.2908	15.4209	38.9126	29.0422** = significant

at 1%, **= significant at 5%, *= significant at 10%

According to Table 3, the double log functional form produced the best fit and hence it was chosen as the lead equation. This is based on the fact that it has the highest value of the coefficient of multiple determination (R^2), the highest number of significant variables and conformity to *apriori* expectation. The F-ratio was statistically significant at 1%, implying that the sample data fit the model and that the independent variables are important explanatory factors of the variation in the dependent variable. The R^2 was 0.926, meaning that about 93% of the total variation in the dependent variable was accounted for by the independent variable. The table also shows that the coefficient for farm size, labour input, quantity of seed, educational attainment and access to credit were significant, while the coefficients of quantity of fertilizer and farming experience were not significant.

The coefficient of farm size was positive and significant at 1% level, implying that there is a direct relationship between farm size and the profit of rice farmers and that an increase in the hectare of farmland, would invariably lead to an increase in the profit of rice farmers. The coefficient of labour input was also positive and significant at 5%level, implying that an increase in labour input would invariably lead to an increase in the output of farmers, hence profit. The quantity of rice seed was positive and significant at 1% level, showing that an increase in the quantity of rice seeds cultivated would invariably lead to an increase in the output of farmers and by extension profit. Educational attainment was also positive and significant at 1% level, this indicates that the higher the level of educational attainment of the farmer, the higher his profit level. This is because the adoption and non-adoption of technology in rice production is influenced by the educational level of farmers. The coefficient of access to credit was also positive and significant at 5% level, implying that an increase in credit accessibility will invariably lead to an increase in the profit of rice production, this is so because technology use and non-use depend on funds availability, which is influenced by access to credit. This result conforms with that of Ben-Cheno (2017) in his study of the cost and returns of paddy rice production in Kaduna State

Conclusion and policy recommendations

Promotion of adoption of technologies in rice production would improve domestic rice production and marketing, consequently improving food security, and increase the income of actors. Adoption of many seemingly beneficial technologies remains low in the study area. Profitability analysis indicated that for every naira earned as revenue by non-rice technology adopters, 41 kobo was returned to the rice farmer as net income; thus, rice production for non-rice technology adopters is profitable in the area. While for rice technology adopters 79 kobo

was returned to the rice farmer as net income for every naira earned as revenue. Therefore, rice production for rice technology adopters is also profitable, but higher than for non-rice technology adopters. Farm size, labour input, quantity of seed, educational attainment and access to credit influences significantly the profitability of rice production in the area, while the coefficients of the quantity of fertilizer and farming experience were not. Based on the result of the analysis, the following recommendations were proffered: rice farmers in the area should be encouraged to access and adopt technologies in rice production as the profitability index is higher among adopters and variables like farm size, labour input, quantity of seed, educational attainment and access to credit should be improved upon to boost the profit margins of rice production in the area.

References

Agu, I. K. S. (2017) "Rice in the Economy of Abakaliki, Southeast Nigeria,1940-2011" *PhD Dissertation Submitted to the Department of History and International Studies*, Nnamdi Azikwe University Awka.December.

Ben-Chendo, G. N., Lawal N. and M. N. Osuji (2017). Cost and returns of paddy rice production in Kaduna State; *European Journal of Agriculture and forestry Research*; 5 (3); 41-48, 2017.

Chukwu, Victor A, Eze, Anayochukwu, V. and Osuafor, O. O. (2022). Socio-Economic Determinants of Adoption of Improved Rice Production Technologies among Rice Farmers in Ebonyi State, Nigeria: A Logit Regression Model Approach; *Elixir Agriculture*; 3 (2); 39900-39908

Ebonyi State Ministry of Agriculture and Water Resources, (2022). Ministry of culture and tourism, Abakaliki, Ebonyi State, Nigeria. Pp. 10-18.

Ebonyi Agricultural Development Programme, (EBADEP), 2022). Annual publication of tourism potentials of Ebonyi State government; 2018. Abakaliki, Nigeria Pp. 12-16

Federal Ministry of Agriculture and Rural Development (FMARD) (2022) "National Agriculture and Food Security Strategy, 2010-2020," Abuja, Nigeria, 25th August, 2010

Food and Agricultural Organisation, (2022).The state of Nigeria agriculture. *African regional review*, Nigeria pp17-28.

Girei, A., Usman, I. S. and E. G. Onuk (2016). Profitability investigation of rice production in Fufore Local Government Area of Adamawa State, Nigeria, *European Journal of Academic*; 3 (3).137- 140.

International Institute for Tropical Agriculture (IITA) (2019). Agricultural yearly report of selected crops in Nigeria. IITA yearly publication 2011, Ibadan, Nigeria.

Ladebo, O.J. (2020). Determinants Of Adoption of New Technology Among Rice Farmers In

Ifo Local Govt. Area Of Ogun State, Nigeria. *Acta Universities Agriculture Et Silviculturae Mendelinae Brunensis* 48 (5); 58-60

Ndaghu N. N, Zakari A, Shehu A. And Tahirou A. (2021). Socio-Economic Factors Affecting Adoption Of Early Maturing Maize Varieties By Small Scale Farmers In Safana Local Government Area Of Katsina State, Nigeria. *Journal of Development and Agricultural Economics*. 5(6): 562-567

National population commission, (2016). Census enumeration survey N. P. C. Abuja, Nigeria. *2*, 6-8. Nigeria.

Nwakpu, C. C. (2021). Socio-Economic Determinants Of Adoption Of Recommended Rice Technologies Among Smallholder Farmers In Ebonyi State, Nigeria; *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS);* 17 (2); 29-35

Nwobiala, C. U., & Adesope, O. M. (2013). Economic analysis of small holder rice production systems in Ebonyi State, Southeast,Nigeria. *Russian Journal of Agricultural and Socio Economic Sciences*, 11(23), 4-11

Ogechi C. N. (2021). Analysis of The Cost and Economic Returns in Rice Production in Ebonyi State, Nigeria; *Indonesian Journal of Agricultural Research;* 3 (3), 205 – 214.

Ohaka, C.C, Adiaha, M.M, Amanze, P.C (2013) Economic Analysis of small-scale Rice Production in Ihitte Uboma Local Government Area, of Imo State. *Nigeria Journal of Agriculture, Food and Environment*. 9(2): 37-41

Onyeneke, R. U. (2022). Determinants of Adoption of Improved Technologies in Rice Production in Imo State, Nigeria; *African Journal of agricultural Research*; 12 (11); 23-32

Umeh G, N (2022). Determinants of Adoption of Improved Rice Production technologies in Ebonyi State of Nigeria; *Journal of Biology, Agriculture and Healthcare;* 5 (7); 56-66

RESOURCE OPTIMIZATION AMONG SMALLHOLDER RICE FARMERS IN OBUBRA LOCAL GOVERNMENT AREA CROSS RIVER STATE, NIGERIA

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ABSTRACT
This study aimed to determine the optimal use of resources among smallholder rice farmers in Obubra Local Government Area of Cross River State, Nigeria. One hundred (100) smallholder rice farmers were selected for the study. Data on input and output including some rice farmer's socio-economic characteristics were collected using questionnaires. Marginal Physical Product (MPP) was used to measure farmers' level of resource allocation, while regression analysis was carried out to evaluate the determinants of rice production. Findings showed that resources were not optimally allocated by the rice farmers. This is because some resources were over-utilized, while others were under-utilized. Therefore, the study recommends that farmers should use less of the over-utilized and more of the under-utilized productive resources for increased rice output in the study area.

Keywords : Marginal physical product, optimum, resource use

INTRODUCTION
Nigeria is blessed with varied climatic zones, and enormous resources, with potentials to produce different agricultural commodities for domestic consumption and export. Unfortunately, agricultural productivity has declined over the years. This is partly due to inefficiency in the use of resources. Hence, her inability to attain self-sufficiency in food production. Udoh, (2019) note that in Nigeria, rice is one of the few food items whose consumption has no cultural, religious, ethnic or geographical boundary. However, its production has been dwindling, leading to importation. The ban on rice importation by the previous administration was to encourage local production and make Nigeria self-sufficient in rice production. Unfortunately, Nigeria still relies on rice importation to meet her food needs, as domestic production is inadequate to bridge the increasing demand-supply gap. The inability of the rice sector to match domestic demand has led the country to expend billions of Naira on rice importation. According to FAO, (2018), the amount expended on rice importation in Nigeria averaged USD 300 million between years 2000 and 2006. Between 2006 and 2008, rice importation expenditure increased from USD 300 million to USD 800million, an increase of about 37.5%. Osawe *et al.*, (2019) note that, this trend has continued over the years. To stem this ugly tide in the face of dwindling foreign reserves in the country, the government has been putting together plans to ensure that there is increased productivity in rice through improving yield and increasing land acreage put into rice production.

Studies have shown that rice production requires efficient use of resources to increase productivity. Idiong, (2016) reported that the extent to which rice productivity can be enhanced

by input factors depends on how the inputs are maximally utilized. This means that low productivity in rice production may be as a result of resources not being maximally utilized, among other factors. Diego (2016) posits that misallocation of inputs can result in low productivity in agriculture. Osawe *et al.,* (2019) also note that misallocation of resources results in losses of aggregate agricultural productivity. Low productivity in rice production due to resource misallocation means that more resources are devoted to production in order to produce a given minimum level of output per capita, implying lower average operational scales. Resource allocation and utilization most effectively and efficiently minimizes costs and maximize productivity. Umoh and Yusuf, (2019) suggest that efficient allocation of resources in production that is the allocation that maximizes output in crop production will minimize cost. Several studies on resource use in rice production have shown that resources are often inefficiently used, over-utilized or under-utilized. Xing, *et al.,* (2022) in the study of improvement of resource efficiency versus mitigation of environmental impacts in rice production of Fujian province, China, found that efficiency for a resource like herbicides was lower, while capital was higher. Kaman, *et al.,* (2020) in the investigation of resource use efficiency among rice farmers around fragile ecosystems in Tanzania, reported that fertilizer was not optimally used by farmers. Thus, they recommended that farmers should be up to date with the optimal use of fertilizer. Gama, *et al.,* (2022) analyzing resource-use efficiency of rice production in Kura Local Government Area of Kano State, Nigeria, found that farm size, agrochemicals, seed quantity and labour were under-utilized. Similarly, Madaki *et al.,* (2022) and Sanusi, *et al.,* (2022) also found in their various studies that efficiency of resource use was greatly influenced by farmers' educational level, experience, age, farm size. The studies concluded that the probability of resource use efficiency of inputs used by farmers increased with these variables.

The ever-increasing population pressure and environmental degradation followed by declining soil fertility and expansion of marginal agricultural lands have aggravated the problem of low productivity in rice production in Obubra LGA, a major rice-producing area in Cross River State, Nigeria. Thus, farmers are left with no other option than to use modern farm technologies or efficient use of resources to maximize output in the area. Therefore, it is imperative to investigate the level of resource use among smallholder rice farmers in Obubra, to determine whether or not resources are optimally used. This can be achieved by determining the allocative efficiency of resource use by rice farmers, evaluate the determinants of rice production and examine the resource elasticities in the study area.

METHODOLOGY

Study area

The study was conducted in Obubra Local Government Area, Cross River State, Nigeria. The area lies between longitude $6^0 5^{"}$ and $8^0 20^{"}$ E and latitude $5^0 4^{"}$ and $6^0 10^{"}$ N of the equator. The area occupies a land mass of 1,115 km² and a population of 172,444 (NPC, 2006). The climate is characterized by two distinct wet and dry seasons. It consists of tropical rainforest and small stretched of derived savannah. The temperature is fairly uniform with a mean monthly average of about 27^0 C (Tiku *et al.*, 2010). The mean annual rainfall is between 2000 mm to 2250 mm, while the relative humidity varies from 60% to 70% in January and 70% to 80% in July. The

area is in the heart of the rain forest zone in Cross River State and is endowed with natural resources with fertile soil. The primary economic activities are farming and crops grown in the area include Cassava, yam, rice, maize, vegetables, plantain, banana, fruits and tree crops. Other economic activities include palm wine tapping, processing of wild palm fruits, tailoring, carpentry, welding, trading, and processing of cassava into *garri* and *fufu* for sale.

Method of Data collection

A total number of 100 smallholder rice farmers were sampled for the study. A multistage sampling technique was used in choosing the sample. Obubra was purposively selected because it is a major rice producing area in Cross River State. Two villages were purposively selected based on the concentration of rice farmers. From each of the chosen villages, 3 blocks were randomly selected from which 6 ADP cycles were randomly chosen. Twenty (20) rice farmers were randomly selected from each of the cycle using simple random sampling method making a total of 120, but 100 rice farmers fully filled and returned their questionnaires which were used for the study. Data were obtained through structured questionnaires. Data obtained include; farm size, labour, seeds, fertilizer, herbicides and output of rice, including information on socio-economic characteristics such as educational level and farming experience of the farmers. Prices of inputs and output were also obtained based on the current market prices in the study area during the 2024 production season.

The prices were taken as follows;

- Land rent at ₦25,000.00 per hectare
- Labour wage rate at ₦7,000.00 per man-day
- Cost of seeds at ₦300.00 per kg
- Cost of fertilizer at ₦900.00 per kg
- Cost of herbicides at ₦450.00 per litre
- Output price at ₦1,700.00 per kg of rice

Analytical technique

The allocative efficiency model was used to determine the efficiency of resource use in rice production. The model is a framework used to analyze and optimize resource allocation in various economic systems. It is a measure of how an enterprise uses production resources optimally in the right combination to maximize profits (Inoni, 2017). Thus, the allocative efficient level of production is where the farm operates at the least-cost combination of inputs. Allocative efficiency denoted by 'r' is first derived by computing the Average Physical Product (APP), Marginal Physical Product (MPP), Marginal Value Product (MVP), Marginal Factor Cost (MFC) and elasticities of the resource.

The Average Physical Product (APP) is given;

$$APP_i = \frac{Y}{X} \qquad 1$$

Where Y and X are the mean of the output and inputs respectively

Marginal Physical Product (MPP) is given as;

$$MPPxi = b_i. \qquad 2$$

Where b_i is the elasticity of the inputs used

Marginal Value Product (MVP) is given as:

$MVP = MPPx_i . PY_i$ 3

Where;

PY is the output price of rice

Px_i is the price per unit of resource input used

Marginal Factor Cost (MFC) is the price for each inputs used estimated as average acquisition cost. Therefore, allocative efficiency is given as;

$$\text{Allocative Efficiency (A.E)} = \frac{MVP}{MFC} \quad 4$$

Since farmers are price takers in the input market, the marginal cost of input *i* approximates the price of the factor i, (P_{xi})

Hence, efficiency is attained if:

$MVP = MFC$ 5

It follows that if AE =1, resources are efficiently utilized. AE < 1 (MVP>MFC), means that resources are over-utilized and to raise farm profits its use should be reduced. AE > 1 (MVP < MFC), implies that resources are under-utilized and farm profit can be raised by increasing the use of this input. The relative percentage change in MVP adjustment of each resource required to obtain optimal allocation of resources, i.e MVP =MFC is obtain by;

$$D = \left(1 - \frac{MFC}{MVP}\right) X100 \quad 6$$

Where:

D = is absolute value of percentage change in MVP of each resource.

Economic optimum occurs where MVP=MFC, and if $r \neq 1$, it suggests that resources are not efficiently or optimally utilized. Adjustments could therefore be done in the quantity of inputs employed and costs in the production process to restore r = 1.

Model specification

Multiple Regression model

The Ordinary least square (OLS) regression was employed to determine factors influencing production and resource use of rice farmers. Explicitly, the model is stated as;

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, e)$ 7

Where,

Y = Output of rice harvested (kg/ha)

X_1 = Farm size (ha)

X_2 = Labour in man-days

X_3 = Herbicide (liters/ha)

X_4 = Fertilizer (kg/ha)

X_5 = Quantity of seed (kg/ha)

X_6 = Educational level (years)

X_7 = Farming experience (years)

e = error term.

The explicit form of Cobb-Douglas function was used and is stated as;

$$LnY = \beta_0+\beta_1LnX_1+\beta_2LnX_2+\beta_3LnX_3+\beta_4LnX_4 + \beta_5LnX_5+\beta_6LnX_6+\beta_7LnX_7 + ei \quad 8$$

Where,

β_0 = Regression constant

$\beta_1 - \beta_7$ = Regression coefficients to be estimated and ei is the error term.

X_1 - X_7 are as earlier defined.

RESULTS AND DISCUSSION

Allocative efficiency of resource use

The level of allocative efficiency of rice farmers in the study area is shown in Table 1. MPP was used to measure what and how farmers allocate a resource. From the estimated results, the values of the MPP show that the farmers were efficient in the use of labour, rice seed and land, at the efficiency levels of 2.745, 5.876 and 164.86, respectively. This suggests that if additional units of labour, seed and land were available and accessible, it would lead to an increase in rice output given the efficiency levels of each of the inputs. This implies that the farmers were allocatively efficient in the use of labour, seed and land inputs. This result is at variance with that of Gama *et al.,* (2022) and Oniah *et al.,* (2008), who found that farm size, agrochemicals, seed quantity and labour were under-utilized, and farmers were generally inefficient in the allocation of their resources in swamp rice production in the study area respectively. There was inefficiency in the use of herbicides and fertilizer with the least MPP values of 0.00145 and 0.0517, respectively given the level of technology and input prices. The result agrees with that of Kama *et al.,* (2020), who found that fertilizer was under-utilized. The result further reveals that the ratios of the MVP to the MFC were greater than unity (>1) for farm size and quantity of seeds. This is an indication that farm size and quantity of seed were over-utilized, while labour, herbicide and fertilizer were under-utilized (<1). This means that rice output and revenue were likely to increase if more fertilizer, herbicide and labour had been used.

The adjustment in the MVPs for optimal resource used indicated that for optimum allocation of resources, it will require labour to be increased by 9.02 man-days, herbicides by ₦3,035.45 and fertilize by 466.99 kg. On the other hand, land and seed were over-utilized and require about 92.5% and 96.6% reduction, respectively. Therefore, since the use of labour, herbicdes and fertilizer were under-utilized, farmers could increase the utilization of these resources to improve their allocative efficiency. However, the fact that the MVPs of the resources were positive means that rice farmers were using these resources within the economically rational stage even though they were not optimally used. The result is in line with Tiku *et al.* (2019) who found that resources were not optimally used, since farm size and seed were over utilized, while fertilizer was under-utilized.

Table 1: Allocative efficiency of resource use in rice farming

Variables	APP	MPP	MVP(MPP*Py)	MFC(Px)	r =MVP/MFC	Divergence (D)
Farm size	225.093	164.86	56,894.73	4252	13.38	0.925
Labour	39.942	2.745	969.228	9,712.66	0.0998	-9.02
Herbicide	0.0731	0.00145	0.438	1329.53	0.000329	-3,035.45
Fertilizer	7.419	0.0517	17.265	8,080	0.00214	-466.99
Quantity of seed	24.049	5.876	2,288.346	76.86	29.77	0.966

Source: Field data, 2024

Note: Px = Input unit prices, Py= Output selling price (N1,700 /kg),
MVP= Marginal value product, r= Efficiency level

Determinants of rice production

Table 2 present the result of Cobb-Douglass production analysis using Ordinary Least Square (OLS) method. The R^2 estimated shows that 80.2% of variations in total rice output were explained by the explanatory variables with the remaining 19.8% due to error term or uncontrollable factors in the model. The estimated F-value was 60.82 and was significant at 1% level. This implies that the model has a good fit. The production estimates had positive signs and conformed to *a priori* expectations. Farm size, labour, herbicides, fertilizer, the quantity of seed, as well as educational level and farming experience had influence on rice output. The regression coefficient of all the variables was positive, indicating that a unit increase in any of the variable *ceteris paribus* will lead to a unit increase in the output of rice. The coefficient of farm size, level of education and farming experience were statistically significant at the 1% level, labour was significant at the 10% level and quantity of seed was significant at the 5% level. It follows that these variables are the major determinants of rice production in the study area. This is true because increased farm size enhances economies of scale through reduced production costs per unit, increased efficiency and productivity. Rice production is labour-intensive from cultivation to harvesting, thus, an increase in labour at reduced cost will enhance output. On the other hand, a higher seed rate would result in higher output, except where there is overcrowding leading to competition for available nutrient which will consequently lead to lower output. The result conforms to Adedoyin *et al.,* (2016). Furthermore, the level of education of farmers enhances their awareness; hence, farmers' educational level contributes to increased output of rice production. The result agrees with that of Sanusi *et al.,* (2022). The longer the number of years farmers have been in farming, the more knowledge they will acquire to enable them adopt different techniques and methods to increase productivity.

Table 2: Multiple regression estimates of rice production

Variables	Parameters	Coefficient	Standard error	t-statistic
Constant	β_0	4.257	0.505	8.433
Ln Farm size (ha)	β_1	0.773	0.114	6.779***
Ln Labour (man-days	β_2	0.0074	0.043	1.708*
Ln Herbicides (kg)	β_3	0.0184	0.0283	0.650
Ln Fertilizer (Kg)	β_4	0.0071	0.0545	0.131
Ln Quantity of seed (kg)	β_5	0.291	0.139	2.089**
Ln Educational level (years)	β_6	0.053	0.015	0.000***
Ln Experience (years)	β_7	0.020	0.003	0.000***
R^2	0.815			
Adj R^2	0.802			
F-statistic	60.82***			
S.E	0.19			

Source: Computed from field survey result, 2024

***, **,*significant at 1%, 5% and 10 % level respectively

Elasticity of rice production and Returns to Scale (RTS)

The estimated coefficients for the specified function are explained as the elasticities of the explanatory variables. The elasticity of production for Cobb Douglas was obtained from the coefficients of each variable. The analysis shows that a 10% increase in farm size, labour, herbicides, fertilizer and seed will lead to a 7.73%, 0.074%, 0.18%, 0.071% and 2.91 % increase in rice output (Table 3). The value of the returns to scale (RTS = 1.164) shows that the farmers were producing at the increasing return to scale (Stage I). This implies that on average the rice farms have increasing return to scale which is the characteristics of stage one of the production function. It means if the rice farm increased all inputs by 1%, production will give 1.164%. This result suggests that there is every possibility to increase production by improving the use of these inputs. Adedeji *et al.,* (2014), Kadiri *et al.,* (2014) and Oniah *et al.,* (2008) also reported return to scale production elasticities of 9.621, 2.1826 and 1.236 respectively.

Table 3: Elasticities of rice production

Variable	Elasticity
Farm size	0.773
Labour	0.0742
Fertilizer	0.0071
Quantity of seed	0.291
RTS	1.164

Source: Field data, 2024

CONCLUSION AND RECOMMENDATION

The study concludes that resources were not optimally allocated for rice production in the study area. While some resources; farm size and quantity of seeds were over-utilized, labour, herbicides and fertilizer were under-utilized. Therefore, it is recommended that rice farmers should allocate less of the productive resources that were over-utilized and more of those that were under-utilized for increased rice production.

Farmers are advised to employ resources up to the point where the values of marginal products (MVPs) equate to their factor prices (i.e. MVPs = P_{xs}).

REFERENCES

Adedeji, I. A., Ajetomobi, J. O., Bamiro, O. M., Ifegwu, K. U., & Ogunjobi, J. O. (2014). Estimating production function with economic content using data envelopment analysis as a complement to marginal analysis in rice production of Kwara State, Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology*, 3(3), 189-205.

Diego, R. (2016). Resource allocation and productivity in agriculture: Proceedings of conference on economic development in Africa organized by the Center for the study of African Economies (CSAE) at the University of Oxford in March, 2015.

Food and Agricultural Organisation FAO, (2018). FAO Rice Information 2, Rome.

Gama, E.N., Umah, M. & Djomo. C.F. (2022). Resource –use efficiency of rice production in Kura Local Government Area of Kano State, Nigeria. FUDMA *Journal of Agriculture and Agricultural Technology,* 8(1).

Idiong, I. C. (2016). Estimation of Farm Level Technical Efficiency in Small scale Swamp Rice Production in Cross River State of Nigeria: A Stochastic Frontier Approach. *World Journal of Agricultural Sciences*, 3(5), 653-658..

Inoni, O.E. (2007). Allocative efficiency in pond fish production in Delta State, Nigeria: A Production Function Approach. *AgriculturaTropica Et Subtropica,* 40(4), 23-41.

Kadiri, F. A., Eze, C.C., Orebiyi, J. S., Lemchi, J. I., Ohajianya, D. O. & Nwaiwu, I. U.(2014). Technical efficiency in paddy rice production in Niger Delta region of Nigeria.*Global Journal of Agricultural Research,* 2(2), 33-43.

Kaman, P., Willey, D. & Ngare, L. (2020). Resource use efficiency among rice farmers around fragile ecosystems: Evidence from Kilombero Wetland, Tanzania. Applied Studies in Agribusiness and Commerce, AGRIMA 14(3-4).

Madaki, M.J., Abba, I.Y., Ismaila, M. & Mujaheed, A.M. (2022). Resource used efficiency of rice production in Bade Local Government Area of Yobe State, Nigeria. *The International Journal of Science & Technology,* 10(2). https://doi.org/10.24940/theijst/2022/v.10/i12/ST2212-001

National Population Commission, Census 2006..

Oniah, M.O., Kuye, O.O., &Idiong, I.C., (2008). Efficiency of resource use in small scale swamp rice production in Obubra Local Government Area of Cross River State, Nigeria. *Middle-East Journal of Scientific Research*, 3 (3), 145-148.

Osawe, O.W., Akinyosoye, V.O., Omonona, B.T., Okoruwa, V.O. & Salman, K.K. (2017). Productivity Differentials in Rice Production Systems: Evidence from Rice Farmers in Five Agroecological Zones in Nigeria. *J. Nutraceutical Food Science.*2 (3):18

Sanusi, S.O., Alabi, O.O. & Ebukiba, E.S. (2022). Analysis of resource use efficiency of smallholder's rice production farmers in Federal Capital Territory of Nigeria: Probit Model Approach. *Agrotech Food Science, Technology and Environment,* 1(1).

Tiku, N.E., Simonya, J.B., Agbogo, E. A. &Iibor, G.(2019). The efficiency of inputs utilization on rice production in Obubra Local Government Area of Cross River State, Nigeria.*Journal of Agriculture and Social Sciences,* 11(2), 86-92.

Udoh, E.J. (2019). Land management resources, use efficiency among farmers in South Eastern Nigeria, unpublished Ph.D thesis, Department of Agricultural Economics, University of Ibadan.

Umoh, G.S. and Yusuf, S.A. (2019). An empirical analysis of the poverty status and productivity of rural farmers in Obubra, Cross River State, Nigeria. *Nigerian Journal of Economics and Social Studies, 41(2):259-273.*

Xing, J., Shi, W., Deng, X., Lu, C. Zuo, L., Wang, S., Wang, M., Wang, X & Yan, B. (2022). Improvement of resource efficiency versus mitigation of environmental impacts in rice Production of Fujian Province, China. *Journal of Cleaner Production.* 368.

FACTORS INFLUENCING FARMERS' INVOLVEMENT IN MAIZE PRODUCTION IN ODUKPANI LOCAL GOVERNMENT AREA, CROSS RIVER STATE

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ABSTRACT

This study assessed factors influencing farmers' involvement in maize production in Odukpani Local Government Area, Cross River State, Nigeria. The specific objectives were to describe the socio-economic characteristics of maize farmers, identify the key activities performed in maize production, determine sources of information used, and ascertain factors driving farmers' participation. A simple random sampling technique was used to select 100 maize farmers, with data collected through a structured questionnaire. Data was analysed using descriptive statistics. Results revealed that 50% of respondents were aged 40-49, with 54% being female, and 72% were married with an average household size of 5 members. Most farmers (68%) had secondary education, and 52% had farm sizes ranging from 5-10 hectares. Results on activities performed by farmers in maize production revealed that high percentages of farmers are engaged in weed control and disease management. The data showed that agricultural extension services are the most utilized information source, followed by government publications and reports It is recommended that stakeholders provide targeted training and promote gender equality to enhance maize production and ensure food security.

Introduction

Maize (Zea mays L.) remains a cornerstone of food security and agricultural productivity in sub-Saharan Africa, including Nigeria, where it serves as a staple food and critical cash crop for both smallholder and commercial farmers. The prominence of maize production in Nigeria is influenced by its adaptability to various agro-ecological zones, making it one of the most widely grown crops across the country (Lasisi, 2019). However, maize farmers in regions such as Odukpani face a range of challenges including limited access to critical agricultural resources, low extension service coverage, and socio-economic constraints that affect their productivity and market access (Eta,*et al.*, 2023).Understanding the socio-economic characteristics of farmers, including their age, education level (Etim, *et al.*, 2022), and farm size, is crucial for developing targeted agricultural interventions that can enhance productivity and sustainability (Elemi, Eta, and Eremi, 2023). Socio-economic factors directly influence farmers' access to inputs, decision-making capacity, and resilience to agricultural shocks, which in turn determine their level of involvement and investment in maize production. Information sources such as extension services, research institutions, and peer networks are essential for transferring knowledge on best practices in maize production (Etim *et al.*, 2021). However, a significant gender gap in access to these resources often restricts the involvement of women

farmers, thereby limiting their productivity and contributions to household food security (Elemi, *et al.*, 2023).One core element that affects farmers' involvement in maize production is the availability and management of resources, especially land and capital. Lasisi (2019) found that limited access to financial resources and inputs hinders maize productivity, while capital investment in tools and machinery has shown to boost yield and engagement in farming activities. Another study by Eta, Oyedeji, and Ginini (2022) emphasized the importance of conservation agriculture and how sustainable practices—such as reduced tillage and improved soil management—have shown promise in improving maize yield and attracting farmers' sustained interest in maize cultivation. Access to agricultural extension services and timely information is another crucial factor; extension services play a significant role in disseminating best practices and innovations, which have shown to positively impact productivity and encourage farmer participation (Idiku, *et al.*, (2021); Etim,*et al.*, (2023)).This study examines the socio-economic characteristics of maize farmers, identifies key maize production activities, determines sources of information used by farmers, and ascertains the factors driving their involvement in maize production.

Methodology

Odukpani is a local government area in Cross River State, south south Nigeria. It lies between latitude 5^0.4'52.46''N and longitude 8^0 20'59.7''E and has an elevation of approximately 413ft above sea level (Cross River State government,2020). It shares a boundary with Calabar (the state capital) and is largely populated by the Efik people. Settlements in Odukpani includes; Akpapokoyong, Eki,Eniongabatim, Ito, Idere, Ukwalkom, Creek town, Inuakpa Okoyong, Okurikang. The local government area has a population of approximately 257,800 persons (National Population Commission, 2020). The climate of Odukpani is tropical humid with wet and dry seasons, Annual rainfall is between 1300 and 3000mm. This area is characterized by high temperature. The population of the study comprised of all registered maize farmers residing in Odukpani local government area. The simple random sampling technique was used to select 5 cells out of the 9 cells that make up Odukpaniagricultural block, and to sample 10% of registered maize farmers in each of the selected cells. The list of registered maize farmers was obtained from CRADP (Cross River Agricultural Development Programme). Primary data was collected mainly from the structured questionnaires. Variables were measured using descriptive statistics.

Table 1. Sampling procedure

Agricultural block	Number of cells in the block	Number selected cells	Number registered maize farmers selected	Numbers of registered maize farmers selected (10%)
	AkpabOkoyong	Okurikang	200	20
	Eki	Creek Town	150	15
	EniongAbatim	EniongAbatim	250	25
ODUKPANI	Ito	AkpabOkoyong	170	17
	Idere	Eki	230	23
	Ukwa Ibom			

	Creek Town		
	Inuakpa Okoyong		
	Okurikang		
Total		1000	100

Field Survey, 2024

RESULTS AND DISCUSSION

1. Socio-economic characteristics of the respondents

The following socio-economic characteristics of respondents were highlighted in the study, as depicted in Table 2.

Age:

Half (50.0%) of the respondents were between the age range of 40 -49 years, while 28.0% were between the age range of 30–39. Only 11.0% of the respondents were between the age range of 20 – 29 years. This implies that most of the farmers were in their mid and active age. According to Surry (1997), when one is young and agile, individual's efficiency tends to be high and activities are approached with vigor and seriousness.

Sex:

A high proportion (54.0%) of the respondents were females, while 46% were males. This implies that maize production is dominated by females in the study location.

Marital Status:

A greater proportion (72.0%) of the respondents were married, while about (25,0%) were single. This implies that most of the farmers were married with family to fend for. Ifeanyi-obi (2017) reported that most cocoyam farmers were married in Delta State, Nigeria.

Educational Level:

Most (68%) of the respondent had secondary School education, while 14.0% % and 9.0% of the respondents had tertiary and secondary education respectively. The finding implies that most of the farmers were literate, having attended formal schooling. Nwalieji and Ojike (2018) was of the view that education enhances technology adoption and ability of farmers to plan and take risks.

Household size:

A greater proportion (65.0%) of the respondents had household size range of 5 - 10 members, while 35.0% had household size range of less than 5 members. The mean household size was 5 members. The result implies that the maize farmers had a relatively high household size. Ajani (2012) reported that large family size constitutes the family labour, which most farmers rely upon in carrying out farm operations.

Farm size:

A greater proportion (52.0%) of the respondents had farm size range of 5 -10hectares, while 48.0% had farm size range of less than 5 hectares. The finding implies that majority of the respondents are smallholder farmers. The result agrees with the view of Ajayi and Solomon (2010) who reported that small farm holdings constitute more than 70.0% of all farming activities in Nigeria.

Main occupation:

The majority (88.0%) of the respondents' main occupation was farming, while only 12.0% combined farming with trading. Combining farming with business is very crucial for farmers. This is because it improved their livelihoods; by generating higher more income, farmers can improve living standards and contribute to local economic growth.

Monthly income:

Most (49.0) %) of the respondents had a monthly income range of between N101,000.00 – 150,000.00, about 29.0% had a monthly income range of N50,000.00 – 100,000.00. This implies that the respondents had a relatively moderate income. However, low income of farmers may hinder adoption of innovations, as farmers may not have adequate fund to access and use such innovations.

Contact with extension:

Almost all (93.0%) the respondents never had contact with extension agent in the past one year. The finding implies almost all the maize farmers had not been visited by extension agents in the past one year. This reveals that there is a disproportionate extension agent to farm family ratio. Agbogidi&Ofuoku, (2009) noted that the disproportionate ratio of extension agent to farm family prevalent in developing countries has led to a situation in which many rural dwellers or farmers do not benefit from the available services.

Table 2: Distribution of the respondents based on socioeconomic characteristics

Variables	Frequency	Percentage	Mean
Age (years)			
20 – 29	11	11.0	
30 – 39	28	28.0	
40 – 49	54	54.0	
50 & above	7	7.0	
Total	100	100.0	
Sex			
Male	46	46.0	
Female	54	54.0	
Total	100	100.0	
Marital status			
Single	**25**	**25.0**	
Married	72	72.0	
Widowed	3	3.0	

Total	100	100.0	
Educational level			
No formal education	9	9.0	
Primary school	9	9.0	
Secondary school	68	68.0	
Tertiary education	14	14.0	
Total	100	100.0	
Household size			
Less than 5	35	35.0	
5 -10	65	65.0	5
Total	100	100.0	
Farm Size (Ha)			
Less than 5	48	48.0	
5 -10	52	52.0	
Total	100	100.0	
Main Occupation			
Farming	88	88.0	
Farming & trading	12	12.0	
Total	100	100.0	
Monthly Income (Naira #)			
Less than 50,000.00	8	8.0	
50, 000.00 – 100, 000.00	29	29.0	
101,000.00 – 150,000.00	49	49.0	
151,000.00 & above	14	14.0	
Total	100	100.0	
Farm Experience (years)			
Less than 5	8	8.0	
5 – 10	51	51.0	
11 – 20	41	41.0	
Total	100	100.o	
Extension contact			
Yes	93	93.0	
No	7	98.3	
Total	**100**	**100.0**	

Source: Field Survey, 2024

2. Activities performed in maize production by farmers

The result on activities performed by farmers in maize production as displayed in Table 3 revealed that high percentages of farmers are engaged in weed control (76%) and disease management (86%), suggesting a strong emphasis on these areas, which are crucial for maintaining crop health and maximizing yield. Seed selection is also a commonly practiced activity, with 72% of farmers involved, indicating an awareness of the importance of using quality seeds for successful crop establishment. On the other hand, lower engagement is observed in fertilizer application (48%) and irrigation (46%), which may reflect limited access

to these resources or challenges in affordability. The relatively lower rate of land preparation (56%) could be due to constraints in labor or equipment availability, which are critical for effective land management.

The findings of this study on farmers' activities in maize production align with the insights provided by Ogunlela and Mukhtar (2019) and Mukhtar (2019). According to Ogunlela and Mukhtar, variations in planting methods—such as row spacing, planting density, and planting depth—are influenced by farmers' local knowledge and resource availability. These factors are essential to achieving optimal maize yields and ensuring food security.

To collaborate the findings of this study as they highlight that farmers focus on key areas such as disease management (86%) and weed control (76%), Mukhtar (2019) emphasized the importance of understanding specific activities in maize production to improve productivity, enhance efficiency, and promote sustainable practices. That disease management and weed control are practices critical for effective crop health management. These activities reflect an alignment with the practices identified by Nwanga (2020), who found that farmers utilize diverse weed control methods, including manual weeding, herbicide application, and intercropping with legumes.

Table 3: Activities performed in maize production by farmers (n =100)

Activities	Yes (%)	No (%)
Land preparation	56	44
Selection of seeds	72	28
Fertilizer application	48	52
Weed control	76	24
Disease management	86	14
Irrigation	46	54

Source; Field survey, (2024)

3. Sources of information on maize production by farmers

The findings in Table 4 present insights into the sources of information that farmers rely on for maize production. The data showed that agricultural extension services (92%) are the most utilized information source, followed by government publications and reports (67%) and social media platforms such as Facebook, WhatsApp, and Telegram (59%). On the other hand, information from research institutions (42%) and online sources (45%) is accessed by a lower percentage of farmers, suggesting variability in access or preferences among different information channels. These findings highlight the critical role of agricultural extension services in providing reliable and up-to-date guidance to farmers. Abdalla (2020) supported this findings, emphasizing that agricultural extension services are essential for delivering information on various aspects of crop production, including land preparation, seed selection, fertilization, pest management, and market access. The high use of extension services could be linked to farmers' understanding of these services as reliable and accessible resources, often regarded as the official source of agricultural knowledge and practical support. This aligns with

the idea that extension agents bridge the gap between research institutions and the farming community, translating technical knowledge into practical advice. Government publications and reports (67%) also play a significant role in informing farmers, likely due to their structured dissemination of region-specific agricultural practices and policies. Meanwhile, Stalker (2018) noted that online resources such as agricultural forums, digital platforms, and websites have grown as valuable tools for farmers. Although only 45% of farmers in this study use online sources, digital platforms increasingly offer a wealth of information on various aspects of maize production, complementing more traditional sources. Interestingly, social media platforms (59%) are a substantial source of information, showing a trend toward the digital and social sharing of agricultural knowledge. The lower usage of research institutions (42%) and online sources (45%) suggests potential gaps in accessibility or familiarity with these resources highlighting areas for further outreach and education to ensure broader access to reliable agricultural information.

Table 4. Sources of information on Maize production by farmers (n = 100)

Sources of information	Yes (%)	No (%)
Agric extension services	92	8
Government publication and reports	67	33
Research institution e.g. Universities	42	58
Online sources	45	55
Social media: Facebook, WhatsApp, telegram	59	41

Source; Field Survey, (2024)

4. Factors influencing farmers' involvement in maize production

Based on the weight of the mean scores, the result displayed in Table 5 reveals that Food security ($\bar{x}$ = 4.0) ranked as the topmost factor influencing farmers' involvement in maize production. This is followed by Profit/economic gain ($\bar{x}$ = 3.9), Cost of living ($\bar{x}$ = 3.8), and Market demands for maize ($\bar{x}$ = 3.5) accordingly. The least ranked factor was Family tradition /cultural significant ($\bar{x}$= 2.7).

The implication of the finding is that the involvement male and female farmers in maize production is dependent on a number of factors, such as food security, cost of living, profit, market demands of maize and family tradition/cultural significant. Women, by their cultural role at the family front, prioritize food security more than the male counterpart, therefore, their involvement in maize production will be based on the derived gains. FAO (2018) mentioned that women prioritize maize production for household consumption and food security. Also, Lutomia, *et al.*, (2019) found that women use maize sales to supplement household income and support children's education,

Table 5. Factors influencing farmers' involvement in maize production (n= 100)

Factors	SA	A	DA	SD	Std.dev	Mean	Rank
Food Security	100.0	-	-	-	0.00	4.0	1st

Cost of living	67.0	13.0	-	-	0.33	3.8	3rd
Profits/economic gain	91.0	9.0	-	-	0.28	3.9	2nd
Market demands for maize	50.0	50.0	-	-	0.50	3.5	4th
Family tradition/cultural significant	6.0	60.0	34.0	-	0.56	2.7	5th

Source; Field survey, (2024)

CONCLUSION

The study found a high performance of agronomic activities in maize production among maize farmers in Odukpani Local Government Area. Specifically, all the farmers were involved in the performance of maize production activities, such as land preparation, selection of seeds, Fertilizer application, weed control, among others. The farmers maximally used extension agents, research institutes, the print media and online sources, and minimally used social media to source for information on maize production.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made:

1. Given the high proportion of farmers aged 40-49 and the significant number of female farmers (54%), targeted training programs should be developed to support both older and female farmers in enhancing their agricultural productivity, with a focus on age- and gender-specific challenges. Also, since 93% of the farmers reported no contact with extension agents in the past year, there is a need for increased outreach by extension services, ensuring that more farmers, especially those in rural areas, can access agricultural advisory services.

2. Agricultural extension services and research institutions take the lead in providing targeted support and training to farmers. By offering guidance on best practices in planting methods, such as row spacing and density, and effective weed control techniques, these organizations can help farmers optimize yields and enhance sustainable maize production.

3. Extension providers should strengthen the accessibility and reach of digital platforms and research institution resources for farmers. Expanding training on how to effectively use online sources and research publications could enhance farmers' knowledge, particularly for those less familiar with these channels. Additionally, leveraging social media platforms as supplementary information sources can further support farmers in accessing timely and diverse insights into maize production practices

4. Since food security and economic gain are key motivators for maize production, government and stakeholders should provide incentives, subsidies, and support programs to further enhance farmers' productivity and ensure sustainable income generation. Also, efforts should be made to improve market access for maize farmers by establishing better infrastructure and market linkages, which will address the high demand and ensure stable pricing, enhancing farmers' profitability.

REFERENCES

Agbogidi, O. M., &Ofuoku, A. U. (2009). Forestry extension: Implications for forest protection. *International Journal of Biodiversity and Conservation, 1*(5), 98-104. http://www.academicjournals.org/ijbc

Ajani, E. N., Onwubuya, E. A., &Nwalieji, H. U. (2012). Assessment of oil palm production and processing among rural women in Enugu North agricultural zone of Enugu State, Nigeria. *International Journal of Agricultural Sciences, 2*(12), 322-329. http://www.internationalscholarsjournals.org

Ajayi, M. T., & Solomon, O. (2010). Influence of extension contact and farmers' socio-economic characteristics on adoption of oil palm techniques in Aniocha North Local Government Delta State. *Journal of Agricultural Science and Technology (JAGST), 12*(2), 35-46.

Cross River State Government. (2020). *Agricultural development strategy for Cross River State.* Calabar, Nigeria: Cross River State Government.

Elemi, G., Eta, H., &Eremi, E. (2023). Influence of gender on land tenure rights and participation among rice farmers in Cross River State, Nigeria. *Global Journal of Pure and Applied Sciences, 29*(1), 127-131.

Eta, H. C., Idiku, F. O., & Elemi, G. F. (2023). Crop farmers' access to e-information for climate-smart agriculture production in Cross River State, Nigeria. *Journal of Agricultural Extension.* https://www.academia.edu/111912127/Crop_Farmers_Access_to_E_information_for_Climate_Smart_Agriculture_Production_in_Cross_River_State_Nigeria?uc-sb-sw=15829531

Eta, H. C., Oyedeji, T. Y., & Elemi, G. F. (2022). Perceived capacities of public extension personnel for climate information dissemination to farmers in Cross River State, Nigeria. *Journal of Agricultural Extension, 26*(2), 44-52. https://journal.aesonnigeria.org/index.php/jae/article/view/3119

Etim, O. U., Aboh, C. L., Idiku, F. O., &Okoi, K. O. (2021). An assessment of the level of occupational safety awareness for agricultural extension agents in Cross River State. *International Journal of Agriculture and Earth Science, 7*(2).

Etim, O. U., Kennedy, O. O., Ntui, O. E., & Ayi, N. A. (2022). An assessment of the role of extension officers in enhancing agricultural safety awareness in Cross River State, Nigeria. *International Journal of Agriculture and Environmental Science, 8*(4). https://doi.org/10.56201/ijaes.v8.no4.2022.pg1.17

Etim, O. U., Okoi, K. O., Yahaya, M., &Ntui, O. E. (2023). Environmental safety awareness, extension, and agricultural development in Nigeria. *IIARD International Journal of Geography & Environmental Management (IJGEM), 9*(6).

Food and Agriculture Organization. (2018). *The state of food and agriculture 2018.* Rome, Italy: Food and Agriculture Organization of the United Nations.

Ifeanyi-Obi, C. C., Togun, A. O., Lamboll, R., &Arokoyu, S. (2017). Socio-economic determinants of cocoyam farmer's strategies for climate change adaptation in Southeast Nigeria. *Journal of Agricultural Extension, 21*(2). https://doi.org/10.4314/jae.v21i2.8

Idiku, F. O., Eta, H. C., &Elemi, G. F. (2021). Utilization of new media for agricultural information by farmers in South-South Nigeria. *Library Philosophy and Practice (e-journal), 6449.* https://digitalcommons.unl.edu/libphilprac/6449

Lasisi, J. (2019). Post-Harvest Handling of Maize and the Impact on Food Security in Sub-Saharan Africa. *African Journal of Food Science*, 13(1), 10-17. Available at: https://academicjournals.org/journal/AJFS

Lutomia, C. K., Obare, G. A., Kariuki, I. M., &Muricho, G. (2019). Determinants of gender differences in household food security perceptions in the Western and Eastern regions of Kenya. *Cogent Food & Agriculture, 5*(1), 1694755. https://doi.org/10.1080/23311932.2019.1694755

National Population Commission. (2020). *Cross River State population report.* Abuja, Nigeria: National Population Commission.

Nwalieji, H. U., &Ojike, H. U. (2018). Characteristics of small–scale oil palm production enterprises in Anambra State. *Journal of Agricultural Extension, 22*(1), 22-34.

Surry, D. W. (1997). Diffusion theory and instructional technology. *University of Southern Mississippi.* [Online] Available: http://www.gsu.edu/-wwwitr/docs/diffusion/

OPTIMIZING AGRICULTURAL DRONE SPRAYING: THE IMPACT OF DUTY CYCLE AND NOZZLE SIZE ON FLOW RATE CONSISTENCY

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Abstract

The integration of Unmanned Aerial Vehicles (UAVs) in agriculture has transformed precision farming by enhancing crop monitoring and optimizing agrochemical applications. This study examines how duty cycle and nozzle size influence flow rate in UAV-based spraying systems. Conducted at Universiti Putra Malaysia, the study used a 42W diaphragm pump with Pulse Width Modulation (PWM) technology to vary the duty cycle from 10% to 100% across three nozzle sizes: Green (0.15), Red (0.4), and White (0.8). Flow rates were measured, revealing that the Green nozzle's flow rate increased from 0.1633 L/min at 20% duty cycle to 0.5333 L/min at 100%, with low variability. The Red nozzle's flow rate ranged from 0.4333 L/min to 0.9567 L/min, showing a more linear increase. The White nozzle exhibited the highest flow rate, peaking at 1.5267 L/min at 50% duty cycle, but with increased variability at higher duty cycles. ANOVA results indicated that nozzle size significantly affected flow rate, while duty cycle had a lesser impact. The interaction between nozzle size and duty cycle also influenced flow rate. Regression analysis showed that the Green nozzle had a strong linear relationship with duty cycle ($R^2 = 0.9882$), while the White nozzle displayed significant non-linearity (quadratic $R^2 = 0.7768$ vs. linear $R^2 = 0.3515$). These results highlight the importance of selecting appropriate nozzle size and duty cycle to optimize flow rate control and consistency, thus improving the effectiveness and sustainability of UAV-based spraying systems.

Keywords: Unmanned aerial system (UAS), Flowrate, Duty Cycle, Nozzle Size, Precision Agriculture, Spray Efficiency.

1.0 Introduction

The use of Unmanned Aerial Vehicles (UAVs) in agriculture has rapidly evolved, offering innovative solutions for modern farming challenges (Del Cerro et al., 2021; Boursianis et al., 2022; Tahir et al., 2023). As precision agriculture advances, UAVs have become essential tools for monitoring crop health, mapping fields, and notably, applying fertilizers and pesticides (Radoglou-Grammatikis et al., 2020; Velusamy et al., 2021). Their ability to cover large areas quickly, coupled with precise application technologies, has made UAVs an efficient alternative to traditional ground-based machinery (Yang et al., 2018; Tsouros et al., 2019). UAVs equipped with spray systems provide more targeted application of agrochemicals, reducing overuse, minimizing environmental impact, and enhancing resource efficiency (Uche & Audu, 2021; Sahni et al., 2024). This technology is particularly valuable in paddy cultivation, where timely and precise foliar spraying can significantly impact yield and quality. As the demand for

sustainable agricultural practices grows, UAV-based spray systems represent a crucial step towards reducing resource waste, improving crop management, and increasing overall farm productivity (Rahman et al., 2021; Nahiyoon et al., 2024).

Variable rate technologies for agricultural spraying include pressure-based systems, injection systems, and pulse width modulation (PWM) systems. PWM technology, preferred over pressure-based and direct injection systems, offers real-time flow rate changes while maintaining operating pressure (Anglund & Ayers, 2003; Giles & Comino, 1989). It regulates the nozzle flow rate by intermittently activating an electronically controlled solenoid valve positioned before the nozzle, varying the duty cycle to control how long the valve remains open. This technology enables precise control of spray droplet size and flow rate independently for each nozzle, reducing chemical inputs and spray drift. Studies have demonstrated that PWM technology minimizes effects on droplet sizes and velocities, making it a key component in the development of innovative variable rate sprayers aligned with precision agriculture techniques (Giles & Comino, 1990; Giles & Ben-Salem, 1992; Gopala et al., 1999; Giles et al., 2002; Giles, 2020). Some authors have also explored the effects of PWM on droplet size ranges, flow rate, and activation pressure at different duty cycles with various nozzle types (Butts et al., 2018, 2019; Llorens & Hewitt, 2019; Deng et al., 2020; Wei et al., 2020).

Despite these promising results, concerns remain about the accuracy and uniformity of spray coverage in PWM systems due to solenoid activation latency and the alternating on/off action of neighbouring nozzles. Lower duty cycles may lead to decreased spray coverage accuracy, resulting in more under- or over-application (Mangus et al., 2017). Early studies identified distortions in spray distribution patterns with reduced duty cycles, particularly for solid-cone nozzles (Giles & Comino, 1990). Recent research has further investigated the effects of PWM on droplet size distribution, activation pressure, and flow rate (Butts et al., 2018, 2019; Llorens & Hewitt, 2019; Deng et al., 2020; Wei et al., 2020). However, there has been limited exploration into the combined effects of PWM, nozzle size, and nozzle count on flow rate under real-world conditions.

This study investigates the influence of duty cycle and nozzle sizes on system flow rate. By the end of the study, the researcher aims to identify the most effective nozzle for spraying and determine the optimal combinations of duty cycles and nozzle sizes for achieving desired flow rates, and to aid in the development of a variable rate sprayer drone.

2.0 Materials and Method

2.1 Test Condition

The nozzle flowrate test was carried out in the Aerial distribution test facility and the faculty of Engineering postgraduate room of the Universiti Putra Malaysia. It was conducted under controlled conditions. The ambient temperatures and relative humidity were 24±2 °C and 37±4 %, respectively. The instruments and materials used were essential components of an advanced agricultural spraying system designed for precise and efficient chemical application. These instruments include: A raspberry Pi 4 model B, HAT-MDD10 motor driver, power supply adapter, SpotOn sprayer calibrator (Model: SC-1), Teejet 110° flat fan nozzles (XR110015VS,

XR11004VS, and XR11008VS), The SBW borosilicate 6.5 glass cylinder, Pressure gauge, and a 42 W brushless motor pump. These materials and components collectively make up the system used to perform and test in the experiment. They are graphically represented in Figure 1.

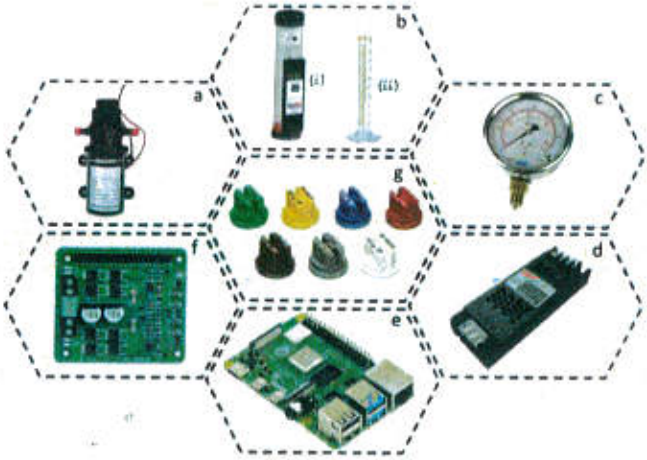

Figure 1. Components and instruments for flow-rate measurement. (a) the pump, (b) the SpotOn flowrate sensor (i) and the graduated cylinder (ii), (c) the pressure gauge, (d) power adapter, (e) the raspberry pi 4, (f) the motor driver hat, and (g) different nozzles

2.2 System Setup

The Pulse Width Modulation (PWM) technology was used to vary the flowrate from 10 to 100 % duty cycle, with 10 % incremental steps. Figure 2 shows the setup for the experiment; where the motor driver connects to the micro-controller (raspberry pi), and linked to the pump. The pump delivers water to the nozzles from the reservoir (tank). The four-nozzle-line used the average of flowrate from the near and far end nozzles. The pump was operated at 35 psi at the beginning of the test involving the four XR110015VP nozzles and was not changed all through the investigations.

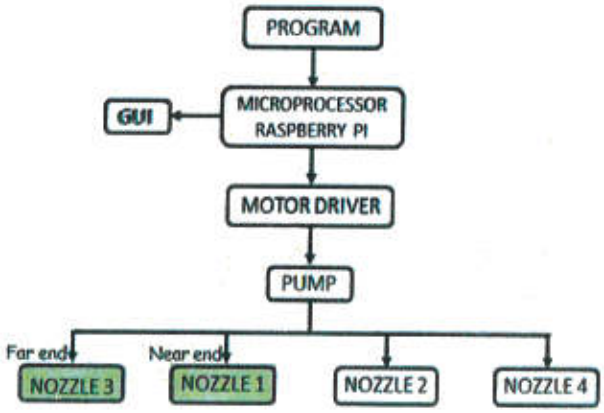

Figure 2. Test setup for the experiment

2.3 Determination of Flowrate

Two approaches were used to cross reference the flowrate for accuracy. In the first, a flowrate sensor was used to directly measure flowrate after allowing the nozzle operate for ten seconds to establish constant flow. In the second, a graduated cylinder was used to collect flow from the nozzle over a period of 60 seconds. Each test was replicated thrice. Figure 3 shows an operational setup of the test spray.

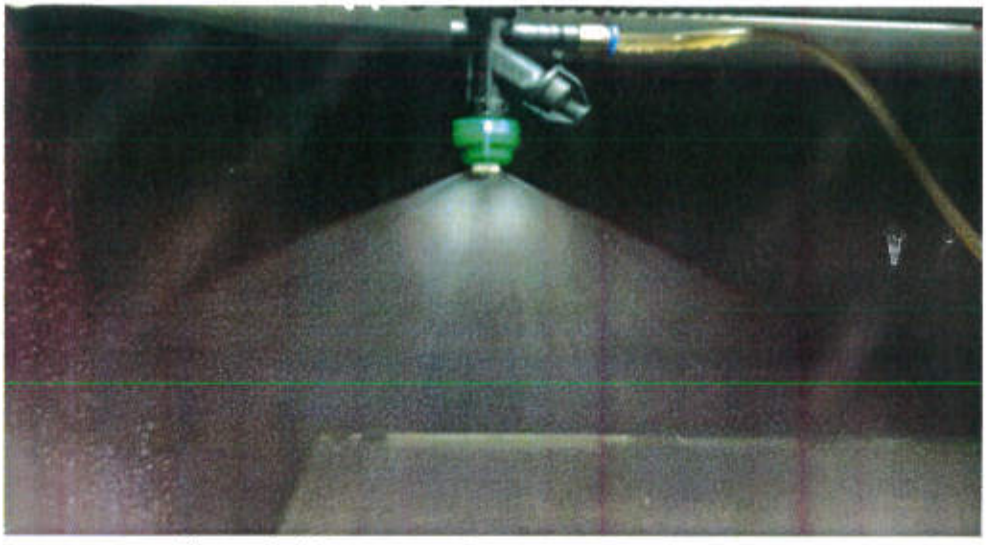

Figure 3. Water spray from the XR110015VS nozzle

2.4 Experimental Design and Statistical Analysis

The experimental design is a 3 x 9 complete randomized design (CRD) with a total of 27 treatments. Each treatment was replicated three times. The factors included three Nozzle sizes (NS: 0.15, 0.4, and 0.8), and nine Duty cycles (DUC: 10 to 100%).

Descriptive statistics was used to summarise the data. The effect of the of each variable and the combine effect of each was tested on flowrate using the analysis of variance (ANOVA). Models and relationships were established and compared using the both linear and quadratic regression. SigmaPlot15.0, and Origin2021 were statistical packages that were employed during the tests.

3.0 Results and Discussion

Table 1 presents the flow rates for the three nozzles across different duty cycles. The Green nozzle's flow rate increased from 0.1633 L/min at 20% duty cycle to 0.5333 L/min at 100%, showing low variation. The Red nozzle exhibited a more linear increase, from 0.4333 L/min to 0.9567 L/min. The White nozzle had the highest flow rate, peaking at 1.5267 L/min at 50% duty cycle, but showed increased variability at higher duty cycles. These results suggest that larger nozzles and higher duty cycles boost flow rates but may reduce consistency at higher levels.

Table 2 presents ANOVA results showing the effects of nozzle size, duty cycle, and their interaction on flow rate. Nozzle size contributes significantly to the variation in flow rate, accounting for a substantial portion of the total variance. Duty cycle also impacts flow rate, though less than nozzle size. The interaction between nozzle size and duty cycle shows a notable effect, indicating they influence flowrate differently when combined. The minimal error term (0.006) suggests that most of the variability is explained by these factors, highlighting a well-fitting model.

Table 3 presents regression models describing the relationship between flowrate and duty cycle for three nozzle sizes (Green 0.15, Red 0.4, White 0.8), using linear and quadratic equations with the corresponding coefficient of determinants. The Green nozzle shows a strong linear relationship with duty cycle ($R^2 = 0.9882$), while the quadratic model slightly improves the fit ($R^2 = 0.9911$). The Red nozzle exhibits weaker linearity ($R^2 = 0.492$), with a quadratic model providing a better fit ($R^2 = 0.5386$). The White nozzle demonstrates significant non-linearity, with a much better quadratic fit ($R^2 = 0.7768$) over the linear model ($R^2 = 0.3515$). The figure 4 further expresses these observations.

Table 1. Means and standard deviations of flowrates of nozzle sizes and duty cycles

DUC (%)	Flowrate (L/min)			N
	Green (0.15)	Red (0.4)	White (0.8)	
20	0.1633 (0.00577)	0.4333 (0.01155)	0.2467 (0.00577)	3
30	0.2533 (0.00289)	0.7533 (0.00577)	0.2467 (0.00577)	3
40	0.2667 (0.00289)	0.8000 (0.01000)	0.7267 (0.00577)	3
50	0.3233 (0.00289)	0.4767 (0.00577)	1.5267 (0.00577)	3
60	0.3700 (0.00000)	0.6033 (0.00577)	1.8000 (0.00000)	3
70	0.4133 (0.00289)	0.6733 (0.00577)	1.6400 (0.01732)	3
80	0.4550 (0.00000)	0.8600 (0.01000)	1.2033 (0.02517)	3
90	0.4983 (0.00289)	0.9033 (0.01155)	1.0833 (0.03215)	3
100	0.5333 (0.00289)	0.9567 (0.00577)	2.2100 02000)	3

The findings of this study align with previous research, such as Smith et al. (2019), Jones et al. (2020), and Johnson and Lee (2020), which also highlight the significant impact of nozzle size and duty cycle on flow rate variability. The strong fit of the quadratic models suggests that non-linear relationships better capture the dynamics of flow rate changes,

particularly for larger nozzles. These insights are crucial for optimizing the application of agricultural inputs, ensuring both efficiency and environmental sustainability. By understanding the specific characteristics of each nozzle and how they interact with duty cycles, farmers can make more informed decisions to enhance the efficiency and effectiveness of their pesticide, herbicide, and fertilizer applications.

Table 2. ANOVA for nozzle sizes and duty cycles tested

Source	df	SS
Nozzle Size	2	6.841
Duty Cycle	8	3.941
Nozzle size * Duty Cycle	16	4.976
Error	54	0.006

Table 3. Regression models describing the relationship between flowrate and duty cycle for varying spray nozzles

Nozzle Size	Model	Equation	R^2
Green (0.15)	Linear	$y = 0.0045x + 0.0964$	0.9882
	Quadratic	$y = -0.0000x2 + 0.0057x + 0.0651$	0.9911
Red (0.4)	Linear	$y = 0.0048x + 0.4351$	0.492
	Quadratic	$y = 0.0001x^2 - 0.0030x + 0.6250$	0.5386
White (0.8)	Linear	$y = 0.0123x + 0.3386$	0.3515
	Quadratic	$y = -0.0006x^2 + 0.0846x - 1.4294$	0.7768

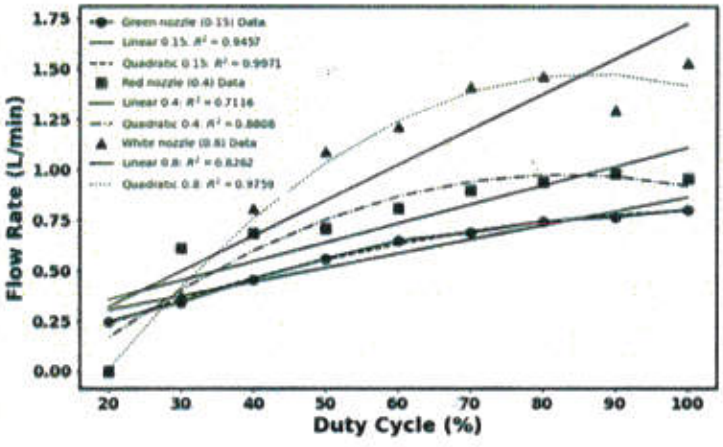

Figure 4. Flowrate vs. Duty cycle for varying nozzle sizes

4.0 Conclusion

This investigation utilized a 42W diaphragm pump, pre-set at 35 psi using a four green nozzle (XR110015VP) configuration. From the study, it is evident that larger nozzles and higher duty cycles generally produce higher flowrates, though at the cost of consistency, particularly for the largest nozzle (White 0.8), which exhibited greater variability at higher duty

cycles. ANOVA results confirm that nozzle size significantly impacts flowrate, while the interaction between nozzle size and duty cycle further influences flowrate behaviour. Regression analysis reveals a strong linear relationship for smaller nozzles, while larger nozzles exhibit more complex, non-linear behaviour. This highlights the importance of selecting the appropriate nozzle size and duty cycle to optimize flowrate control and maintain consistency in application. Proper nozzle selection can enhance the efficiency and effectiveness of agricultural input applications, thereby supporting high-yield and environmentally sustainable farming practices.

References

Anglund, E. A., & Ayers, P. D. (2003). Field evaluation of response times for a variable rate (pressure-based and injection) liquid chemical applicator. *Applied Engineering in Agriculture, 19*(3), 273–282.

Boursianis, A. D., Papadopoulou, M. S., Diamantoulakis, P., Liopa-Tsakalidi, A., Barouchas, P., Salahas, G., ... & Goudos, S. K. (2022). Internet of things (IoT) and agricultural unmanned aerial vehicles (UAVs) in smart farming: A comprehensive review. *Internet of Things, 18*, 100187.

Butts, T. R., Butts, L. E., Luck, J. D., Fritz, B. K., Hoffmann, W. C., & Kruger, G. R. (2019). Droplet size and nozzle tip pressure from a pulse-width modulation sprayer. *Biosystems Engineering, 178*, 52–69.

Butts, T., Hoffmann, W., Luck, J., & Kruger, G. (2018). Droplet velocity from broadcast agricultural nozzles as influenced by pulse-width modulation. *Pesticide Formulation and Delivery Systems: 38th Volume, Innovative Application, Formulation, and Adjuvant Technologies: ASTM International.*

Deng, W., Zhao, C., & Zhou, J. (2020). Comparison and evaluation of spray characteristics of three types of variable-rate spray. *Proceedings of Virtual ICPA –International Conference on Precision Agriculture—2020.* Retrieved January 8, 2021.

Del Cerro, J., Cruz Ulloa, C., Barrientos, A., & de León Rivas, J. (2021). Unmanned aerial vehicles in agriculture: A survey. *Agronomy, 11*(2), 203.

Giles, D. K. (2020). Pulse width modulation for nozzle flow control: Principles, development and status of the technology. *Aspects of Applied Biology, 144*, 59–66.

Giles, D. K., & Ben-Salem, E. (1992). Spray droplet velocity and energy in intermittent flow from hydraulic nozzles. *Journal of Agricultural Engineering Research, 51*, 101–112.

Giles, D. K., & Comino, J. A. (1989). Variable flow control for pressure atomization nozzles. *SAE Transactions, 98*(2), 237–249.

Giles, D. K., & Comino, J. A. (1990). Droplet size and spray pattern characteristics of an electronic flow controller for spray nozzles. *Journal of Agricultural Engineering Research, 47*, 249–267.

Giles, D. K., Andersen, P. G., & Nilars, M. (2002). Flow control and spray cloud dynamics from hydraulic atomizers. *Transactions of the ASAE, 45*(3), 539–546.

Gopala P., S., Tian, L., & Zheng, J. (1999). Evaluation of a flow control system for site-specific herbicide applications. *Transactions of the ASAE, 42*(4), 863–870.

Johnson, L., & Lee, H. (2020). Comprehensive analytical strategies in drug development. *American Journal of Pharmaceutical Education, 84*(6), 758–769. https://doi.org/10.5688/ajpe758769

Jones, A., Smith, B., Liu, C., Huang, D., & Kim, E. (2020). Evaluating the effects of duty cycle on nozzle performance in precision agriculture. *Precision Agriculture, 21*(4), 567–580. https://doi.org/10.1007/s11119-020-09712-3

Llorens, J., & Hewitt, A. (2019). Droplet size effect in a PWM system: first results to improve orchard spray application. *Proceedings of SUPROFRUIT 2019—15th Workshop on Spray Application and Precision Technology in Fruit Growing*, 16–18 July 2019, East Malling—UK, (pp. 55–56). NIAB EMR. Retrieved July 15, 2021, from https://edepot.wur.nl/494871

Mangus, D. L., Sharda, A., Engelhardt, A., Flippo, D., Strasser, R., Luck, J. D., et al. (2017). Analyzing the nozzle spray fan pattern of an agricultural sprayer using pulse width modulation technology to generate an on-ground coverage map. *Transactions of the ASABE, 60*(2), 315–325.

Nahiyoon, S. A., Ren, Z., Wei, P., Li, X., Li, X., Xu, J., ... & Yuan, H. (2024). Recent Development Trends in Plant Protection UAVs: A Journey from Conventional Practices to Cutting-Edge Technologies—A Comprehensive Review. *Drones, 8*(9), 457.

Radoglou-Grammatikis, P., Sarigiannidis, P., Lagkas, T., & Moscholios, I. (2020). A Compilation of UAV Applications for Precision Agriculture. *Comput. Netw., 172*, 107148.

Rahman, M. et al. (2018). Comparative performance of fertilizer spreading machinery for wheat cultivation. *Agronomy, 8*(11), 250.

Rahman, M. F. F., Fan, S., Zhang, Y., & Chen, L. (2021). A comparative study on application of unmanned aerial vehicle systems in agriculture. *Agriculture, 11*(1), 22.

Sahni, R. K., Kumar, S. P., Thorat, D., Rajwade, Y., Jyoti, B., Ranjan, J., & Anand, R. (2024). Drone Spraying System for Efficient Agrochemical Application in Precision Agriculture. In *Applications of Computer Vision and Drone Technology in Agriculture 4.0* (pp. 225–244). Singapore: Springer Nature Singapore.

Smith, J., Sanchez, M., Davies, R., Baldwin, I., & Caulfield, J. (2019). The impact of nozzle size on flow rate variability in agricultural applications. *Journal of Agricultural Engineering, 45*(3), 123–135. https://doi.org/10.1016/j.jagreng.2019.03.004

Tahir, M. N., Lan, Y., Zhang, Y., Wenjiang, H., Wang, Y., & Naqvi, S. M. Z. A. (2023). Application of unmanned aerial vehicles in precision agriculture. In *Precision Agriculture* (pp. 55–70). Academic Press.

Tsouros, D. C., Bibi, S., & Sarigiannidis, P. G. (2019). A review on UAV-based applications for precision agriculture. *Information, 10*(11), 349.

Uche, U. E., & Audu, S. T. (2021). UAV for agrochemical application: a review. *Nigerian Journal of Technology, 40*(5), 795–809.

Velusamy, P., Rajendran, S., Mahendran, R. K., Naseer, S., Shafiq, M., & Choi, J. G. (2022). Unmanned Aerial Vehicles (UAV) in Precision Agriculture: Applications and Challenges. *Energies, 15*, 217. https://doi.org/10.3390/en15010217

Wei, Z., Zhu, H., Zhang, Z., Salcedo, R., & Duan, D. (2020). Droplet size spectrum, activation pressure and flow rate discharged from PWM flat-fan nozzles. *Transactions of the ASABE, 64*(1), 313–325.

Yang, S., Yang, X., & Mo, J. (2018). The application of unmanned aircraft systems to plant protection in China. *Precision Agriculture, 19*, 278–292.

FERTILITY CAPABILITY CLASSIFICATION OF SOILS IN BOKI LOCAL GOVERNMENT AREA, CROSS RIVER STATE – NIGERIA

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ABSTRACT

Soil mapping and categorization put data in a form that is useful to farmers by evaluating soil units for diverse land uses. This study was conducted to determine the fertility capability classification (FCC) of soils in Boki. Low, middle and high elevation ranges were identified with digital elevation model, and four profile pits were spatially distributed in each elevation range. Twelve profile pits were studied. Soil pH was less than 5.5 pH units whereas soil organic carbon exceeded 1.5 % in all elevation ranges. Exchangeable K^+ was less than 1.0 cmol/kg in all the soils and rated low. Fertility capability classifications of the soils of low elevation range were Lkg and Lk (loamy type and loamy substrata type) with condition modifiers indicating gleying (g) and low K reserve (k). The middle elevation range soils had loamy type and loamy substrata type (Lak) with high Al saturation (a) and low K reserve (k) as condition modifiers. Loamy type and clayey substrata type (LCrak and LCak) characterized soils of the high elevation with indications of high Al (a), gravels (r) and low K reserve as condition modifiers. The results indicate comparatively more limitations in the low elevation range being caused by high water table.

Keywords Soil classification, soil fertility, rainforest soils, cocoa supporting soils

INTRODUCTION

The essence of land evaluation is to identify the best kind of land for what purpose, and interpret the land quality parameters in relation to the requirements of land use, thereby assessing the value of each tract of land for diverse kinds of uses. Good land management begins with generating basic information for land evaluation, and assessing the fitness of tracts of land for specific purposes. As necessary and very useful as soil classification and mapping are for general land use planning, what is of utmost importance to the farmer is knowing how fertile a tract of land is, and being equipped with appropriate amendments to optimize productivity of the soil for specific crops. This is clearly addressed by fertility capability classification of soils.

In recent times, a number of attempts have been made to identify the problems associated with agricultural soils in order to suggest ameliorative measures. One major attempt in this direction is the advent of the fertility capability classification (FCC). Fertility capability classification is the first technical soil classification system that categorizes soils according to their fertility constraints in a qualitative manner and emphasizes topsoil parameters as well as subsoil properties directly relevant to plant growth (Buol and Couto, 1980). The system was designed

to group soils having similar limitation for effective fertility management and as a guide for the extrapolation of fertilizer response based on soil parameters (Buol and Couto, 1980).
Fertility capability classification was developed by Buol *et al.* (1975). Fertility capability classification is a technical system that groups the soils according to the kinds of problems they present for management of their physical and chemical properties (Sanchez *et al.* 1982). Fertility capability classification system comprises three levels; the type (texture of surface soil), substrata type (texture of sub-surface soil) and modifiers with respect to their characteristics in the 50 cm depth of soil (Sanchez *et al.* 2003). The FCC interprets the soil properties in such a way that it can be used to identify the soil fertility constraints for their better management (Vasu *et al.* 2016).

Soils in the Boki area have been studied recently by Kekong and Udie (2020), and Kekong and Ndifon (2020) mainly by their routine physical and chemical properties without due consideration of the possible soil units and land evaluation for the identification of fertility constraints for agronomic land use. This gap tends to limit the agricultural potentials of the soils and gives little consideration to the fertility management options of the soils. Consequently, farmers in the study area have limited access to land use options, and soil management measures currently adopted for the land use may not be appropriate. Hence, the soils are exposed to wrong management measures and degradation may set in. The current study seeks to determine the fertility capability classification and identify limiting soil properties for site-specific management measures for crop production.

MATERIALS AND METHODS

Location of study area

The study area, Boki Local Government Area is in the central agricultural zone of Cross River State and bordered by Obudu, Ogoja, Ikom and Etung as well as a contiguous territorial border with the Republic of Cameroon.

The soils of Boki are predominantly fine, medium and coarse textured and are sandy-loam, loamy-sand, sandy-clay-loam, sandy-clay and clay (Kekong and Ndifon, 2020). The topography is undulating with clearly defined landscape position. The geology comprises the Sedimentary Basin and Basement Complex. The Sedimentary formations in the low-lying areas comprise recent alluvium, whereas in the uplands is a dominant shale and limestone with sandstone intercalation. The Basement Complex is a mix between igneous and metamorphic rocks which form the dominant geology in the area and comprises porphyritic granite and biotite hornblende granite, and granite gneiss.

Boki LGA has a humid tropical climate with distinct wet and dry seasons and classified in the Koppen climate system as tropical moist with temperatures that exceed 18 °C (22.56 to 31.95 °C) all year-round, while precipitation exceeds 1500 mm/year (1200 – 3000 mm). Average daily relative humidity of 81.7 % and average daily evaporation rate of 2.24 mm day^{-1} characterize the area and have been reported by Sambo *et al.* (2016).

The vegetation of the study area is tropical rainforest, with the dominance of thick forests with tall and luxuriant trees. The area is commercialized by agricultural produce, timber and wildlife. Boki is a hub for timber and cash crops like cocoa, oil palm, bush mango, timber and arable crops like plantain, banana, yam, cassava, maize and melon.

Field studies

Field reconnaissance visits were carried out to Borum, Okundi, Bukalum, Boje, Biakwan, Bamba and Kataba in Boki LGA to confirm the geology, elevation ranges and their various locations based on information obtained from the topographic map.

Considering the areas occupied by elevation ranges: 42-135 (BJv, BKv, BMv, BKl), 136-576 (BMl, Ba1, Ba2, OK2) and 577-1377 m (OK1, BMm, BJu, Kb) spread across different agrarian communities. Four (4) soil profile pits were sunk in each of these elevations leading to twelve (12) soil profile pits.

Soil samples were collected from identified horizons based on the natural boundaries starting from the bottom to top. The soil samples were air-dried, grinded and sieved using 2 mm mesh-sized sieve.

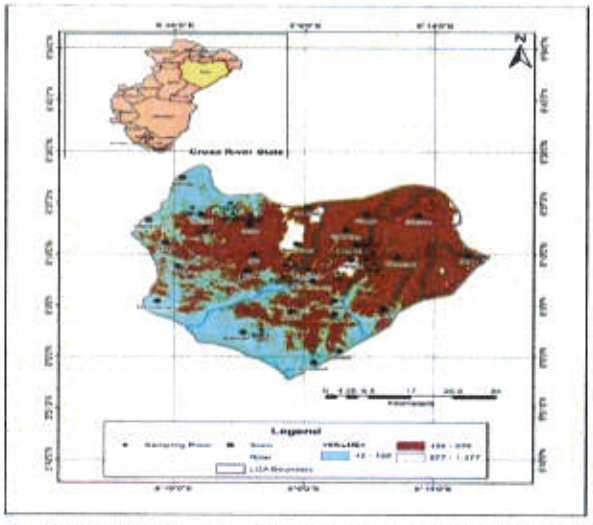

Fig. 1: Elevation ranges of Boki LGA and the distribution of soil profile pits

Laboratory studies

Processed soil samples were subjected to laboratory analysis. Particle size distribution was carried out by the Bouyoucos hydrometer method using Calgon as a dispersing agent. The percentage size separates were then traced on a soil textural triangle for the determination of soil textural classes. Soil pH was determined potentiometrically after standardization with a buffer of pH 7.0 in a soil to water ratio of 1:2:5 using a glass electrode pH meter. Organic carbon content was determined by Walkey-Black wet oxidation method using diphenol amine as indicator and potassium dichromate as the oxidizing agent as outlined by Allison (1965). Available phosphorus was determined with the use of Bray 1 solution as extractant. The extracted phosphorous was measured colorimetrically by the blue colour method of Brady and

Kurzt (1945). Exchangeable Ca^{2+}, Mg^{2+}, K^+ and Na^+ were determined by leaching the soils with 1 *N* neutral NH_4OAc as the extractant solution at pH 7.0, after which it was titrated with KOH so as to determine exchangeable Ca^{2+} and Mg^{2+}. This is the versenate EDTA titration method, whereas K^+ and Na^+ were determined by flame photometry. Cation exchange capacity (CEC) by NH_4OAc at pH 7.0 was obtained by saturating the soil exchange sites with NH_4^+ at pH of 7.0.

All soil analyses were carried out by the procedures outlined in the Soil Survey Staff (2014).

Procedure for Fertility Capability Classification

Results obtained from the laboratory on the analyses of the soils were employed for the fertility capability classification (FCC) of the soils. The conversion data used in evaluating the soils are as outlined by Sanchez *et. al.*, (1982; 2003). The system consists of three categorical levels: 'type' (texture of plough layer or top 20 cm), 'substrata type' (texture of subsoils) and 'modifiers' (soil properties or conditions which act as constraints to crop performance). Class designations from the three categorical levels are combined to form an FCC unit.

The FCC type is determined by the average texture of the plough layer or the upper 20 cm of soil. The substrata type is the average texture of the subsurface soil assessed at the depth of 20 to 50 cm and used wherever the texture of the subsurface differs from the surface soil within the defined limit of 20.00-50.00 cm. Finally, the condition modifiers signify fertility limitations. The modifiers and their meanings are reported in Sanchez *et. al.* (1982, 2003).

Results and discussion

Results of the study are presented in Table 1, while the fertility capability classes of the studied soils are presented in Table 2.

a. Soils of the lower elevation range

The FCC rated the soils in BJv, BKv and BMv as Lkg and Bkl as Lk (loamy type and substrata type) (Table 2). However, the soils' condition modifiers indicate that BJv, BKv and BMv had aquic soil moisture regime depicted by high water table which results in gleying (g), whereas BKl was not influenced by the aquic modifier. BJv, BKv and BMv were poorly drained and found at slope of 0 – 2 % while BKl was at 2-4 % slope. Also, irrespective of drainage condition, the soils recorded low exchangeable K reserve (k) due to the somewhat intense weathering condition and high rainfall in the area. The soils qualified in FCC as Lkg for BJv, BKv and BMv and Lk for BKl. Generally, the FCC unit indicates that nutrient content, particularly exchangeable K is low for the soils of the elevation range and aquic moisture regime dominates the soils in BJv, Bkv, and BMv.

Low potassium in the soils can be corrected by the proper application of potassic fertilizers like muriate (KCl) and potassium nitrate (KNO_3) in their proper dosages. However, other researchers have advocated the use of organic manure rather than chemical fertilizers which could degrade soil fertility with time (Puvan *et al.* 2021). Also, the application of organic matter could improve the soil with time and also make other nutrients to be available to plants (Obalum

et al. 2017; Usharani *et al.* 2019). The aquic moisture regime dominates the soils of low elevation range. The soils can be drained for a wider agricultural value or cultivated to water tolerant crops like paddy rice and sugar cane.

b. Soils of the middle elevation range

The FCC unit rated the soils of Ba_1, Ba_2 and Ok_2 as Lak as the soils belong to loamy type and loamy substrata type whereas BMl was classified as LC_{rak} as the soils belong to loamy type and clayey substrata type. The condition modifiers of BMl have gravels (r), high Al saturation (a) and low K reserve (K) whereas the condition modifiers of Ba1, Ba2 and Ok2 were high Al saturation (a) and low K reserve (k). The application of humified organic matter (Wong and Swift, 2003) and proper liming will ameliorate the challenge of high Al saturation of the soils by improving the pH of the soils.

Potassic fertilizers like muriate (0-0-60) and organic matter applications will improve the availability of low exchangeable potassium in the soils. However, high gravel content can barely be removed from the soil.

Table 1: Characteristics of the studied soils

Horizon depth	clay	silt	sand	Texture	pH H_2O	OC	K^+	Al^{3+}	CEC
	←	%	→			%	←	cmol/kg	→
Bjv									
0-14	12.8	30	57.2	SL	4.8	1.72	0.09	1.2	14
14-50	20.8	28	51.2	SCL	4.9	0.46	0.1	1.28	9
Bkv									
0-15	12.8	20	69.2	SL	4.8	1.55	0.08	0.48	13
15-47	20.8	24	55.2	SCL	4.9	0.58	0.09	0.72	8
Bmv									
0-15	16.8	24	59.2	SL	4.9	1.58	0.09	0.8	12
15-40	14.8	30	55.2	SL	5	0.68	0.1	0.68	13
BK1									
0-30	18.8	54	27.2	SiL	5.5	2.13	0.11	0	20
30-58	26.8	42	31.2	L	5.5	1.89	0.11	0	18
Bml									
0-28	16.8	24	59.2	SL	5	1.6	0.09	0.48	17
28-75	42.8	26	31.2	C	5	0.7	0.1	1.84	19
Ba1									
0-20	12.8	32	55.2	SL	4.9	2.03	0.09	0.32	18
20-57	20.8	32	27.2	L	5.2	0.48	0.1	0	23
Ba2									
0-15	12.8	26	61.2	SL	5.4	1.64	0.11	0	19
15-68	26.8	36	37.2	L	5	0.76	0.09	0.4	16
Ok2									
0-30	14.8	20	65.2	SL	5.2	1.34	0.1	0	17
30-100	38.8	40	21.2	CL	5	0.58	0.09	1.16	13
Ok1									
0-18	22.8	30	47.2	L	5.1	3.11	0.08	0.52	11
18-77	44.8	34	21.2	C	4.7	0.66	0.09	0.8	12
Bmm									
0-15	10.8	22	67.2	SL	4.9	2.59	0.08	0.08	18

15-34	28.8	28	43.2	CL	5.1	0.42	0.1	0	11
Bju									
0-30	16.8	30	53.2	SL	5.3	1.08	0.09	2	9
30-95	28.8	38	33.2	CL	4.9	0.5	0.08	1.92	18
Kb									
0-15	16.8	26	57.2	SL	5.1	1.44	0.11	0	18
15-58	42.8	28	29.2	C	5	0.76	0.1	1.92	14

OC= organic carbon, CEC= Cation exchange capacity, C= Clay, CL= Clay loam, SL= Sandy loam, L= Loam, SiL= Silt loam, SCL= Sandy clay loam

TABLE 2

Soil Fertility Capability Classification for soils of the study areas

Pedon /type	Type	Sub type	Condition modifiers	SFCC unit	Interpretation	Management options
			r a k e n m g			
Bjv	L	L	- - + - - - +	Lkg (0-2%)	Loamy topsoil and subsoil, wet, low K and reserve on 0-2% slope landscape	Application of potassic fertilizers and provision of drainage
Bkv	L	L	- - + - - - +	Lkg (0-2%)	Loamy topsoil and subsoil, wet, low K reserved, on 0.2% slope landscape	Application of potassic appropriate fertilizer and provision of drainage facilities
BMv	L	L	- - + - - - +	Lkg (0-2%)	Loamy topsoil and subsoil wet, low K reserve, on 0-2% slope landscape	Application of the right potassic fertilizer and provision of drainage facilities
Bk$_1$	L	L	- - + - - - -	L_k (2-4%)	Loamy topsoil and subsoil, low K reserve, on 2-4%, slope landscape	Application of appropriate fertilizer especially potassic fertilizers.
			Soils on middle elevation range			
BmL	L	C	+ + + - - - -	LC_{nk} (0-2%)	Loamy topsoil and clayey subsoil, high grave. Content (>10%), high Al saturation and low K reserve on 0-2% slope landscape	Application of K fertilizer, organic matter, (Buffer) and lime application.
Ba1	L	L	- + + - - - -	L_{ak} (2-4%)	Loamy topsoil and subsoil, high Al saturation and low K reserve on 2-4% slope landscape	Right application of potassic fertilizer, organic matter (buffer) and lime application
Ba2	L	L	- + + - - - -	L_{ak} (2-4%)	Loamy topsoil and subsoil, high Al saturation and low K reserve on 2 – 4% scope landscape.	Right application of potassic fertilizer, organic matter (Buffer) and lime application
Ok2	L	L	- + + - - - -	L_{ak} (0-2%)	Loamy topsoil and subsoil high Al saturation and low K	Right application of potassic fertilizer (sodaic)

					reserve on 0- 2% slope landscape	plus organic matter and liming
				Soils on high elevation range		
Ok1	L	C	+ + + - - - -	LC_{rak} (2-4%)	Loamy topsoil and clayey subsoil, high gravel content (>10%), high Al saturation and low K reserved on 2 – 4% slope landscape	Application of K fertilizer, lime application.
BMm	L	L	+ - + - - - -	L_{rk} (2-4%)	Loamy topsoil and subsoil, high gravel content (>10%) low K reserve on 2-5% slope topography	Application of K fertilizer and organic matter
BJu	L	L	- + + - - + -	L_{akm} (2-12%)	Loamy topsoil high Al saturation, reserve and medium organic carbon content on 7-12% slope landscape.	Right application of K fertilizer, organic matter, cover cropping could be adopted.
Kb	L	C	- + + - - - -	LC_{ak} (2-4%)	Loamy topsoil and clayey subsoil, high Al saturation and low K reserve on 2-4% of slope landscape	Right application of fertilizer and organic matter

L = Loamy, C = Clayey, r = high gravel content, a = high aluminum content, k = low exchangeable K, m= low organic matter, g = gleying

c. Soils of the high elevation range

Fertility capability classification rated the soils on high elevation range represented by OK_1, BMm, Bju and Kb as LC_{rak}, Lrk, Lakm and LC_{ak}, respectively. Both OK_1 and Kb belong to loamy type and clayey substrata type classes whereas BMm and Bju belong to loamy type and loamy substrata type. The four soils have different limitations but with low K reserve as a common condition modifier. Low K is a common nutrient challenge in tropical soils due to the high intensity of rainfall, intensive weathering and probably high temperature of the region that could cause K to be lost from the soil or leached due to weathering of K containing minerals (Puvan *et al.* 2021). This could be corrected by the use of the right application of potassic fertilizer as well as organic manure. Another condition modifier that is found in three (OK1, BJu and Kb) out of the four units is high Al-saturation (a). This can be handled by the application of organic matter, liming and cover cropping. The soils of OK_1 and BMw have condition modifier of high gravel content (r). Although it is difficult to remove gravel from the soil and also not economical but with the addition of organic matter the soil can be improved. Among the pedons in this elevation range, only Bju has organic carbon content (m) as a condition modifier as the soil was rated medium in organic carbon content. This is however, not a major limitation as it can be removed by the application of organic matter, cover cropping and the use of crop residues, crop rotation in the proper proportions (Agboola and Akinfesi,

1991). Hence, it is imperative that sustainable agricultural practices be developed to guarantee stable soil organic matter levels.

The FCC rating of soils of the three elevation ranges project them as relatively good arable soils with few limitations. The common limitation was low K reserve (k) which can be handle with the right application of potassic fertilizer. Although the soils of low elevation range have gleying (g) as a condition modifier, the condition modifier can be corrected by providing drainage facilities. However, considering the scale of crop production and the economics of production, the production of crops that are tolerant of high-water table may be encouraged.

Summary

Three elevation ranges were identified in Boki Local Government Area ranging from low to middle and high. The low elevation range soils were poorly-drained, while the middle and high elevations were well-drained.

Sandy clay, silt loam, loam and clay loam textures dominate soils of low elevation range, whereas the middle and high elevations had sandy loam, clay and clay loam textures with clay movements to the subsurface layers. However, sand-sized particles dominated the entire soils.

Soil pH was less than 5.5 pH units irrespective of elevation range with indications of strongly acid and weathered soils. Soil organic carbon exceeded 1.5 % and was generally high in the soils but decreased with increasing soil depth, exchangeable K+ was less than 0.30 cmol/kg in all the soils and rated low alongside the cation exchange capacity.

Fertility capability classifications (FCC) of the soils of low elevation range were Lkg and Lk (loamy type and substrata type) with condition modifiers that indicate gleying (g) and low K reserve (k). In the middle elevation range, FCC rated the soils as Lak (loamy type and loamy substrata type) and LCrak (loamy type and clayey substrata type). Both classes had high Al saturation (a) and low K reserve (k) as condition modifiers. Soils of the high elevation range, were classified as LCrak, Lrk, Lakm and LCak; LC indicates loamy type and clayey substrata type, whereas L belongs to loamy type and loamy substrata type. The four soils had various condition modifiers but with low K reserve as a common condition modifier.

Conclusion

Overall, the characteristics of soils in Boki Local Government Area are adapted for regular crop production with easy-to-manage limiting soil properties. The fertility capability classification rating of the soils project them as relatively good with few limitations. The common limitation being low K reserve (k) and Al saturation which can be handled with the right application of potassic fertilizer and liming, respectively. However, the soils of low elevation range had gleying (g) and could be put to sugarcane or rice production.

REFERENCES

Agboola, A.A. & Akinfesi, F. K. (1991). Soil fertility management for the humid tropics off Africa. Proceedings of the 2nd Africa soil science conference, Cairo, Egypt. *Soil Water Management Sustainable Productive.* Pp. 107-122

Allison, L. E. (1965). Determination of organic carbon. In: Methods of Soil Analysis (Black CA, *et al.*, ed). *Agronomy*, 9:374-390, American Society of Agronomy Inc. Publishers, Madison Wisconsin, USA.

Brady, R. H. & L. T. Kurtz (1945). Determination of soil pH, total nitrogen and available forms of phosphorus soil science, 59:45-49.

Buol, S. W., Sanchez, P. A., Cate, Jr., R. B. & Ganger, M. A. (1975). Soil fertility capacity classification. In: Soil Management in Tropical America Ed. By Bomemisza, E. Alvardo, A. Proceedings of Seminar held at QAT Cali Columbia Feb 1974, 126-141.

Kekong, M. A. & Ndifon, S. O. (2020). Physical and chemical properties of cocoa growing soils of Boki, Cross River State Nigeria, *Nigerian Agricultural Journal*, 51(3), 161-167.

Kekong, M. A. & Udie, U. L. (2020). Soil fertility evaluation of major cocoa producing areas of Cross River State, Nigeria. EJFOOD, *European Journal of Agriculture and Food Sciences,* 2(6):1-6.

Obalum, S. E., Chibuike, G. U., Peth, Si., Onyang, Y. (2017). Soil organic matter as sole indicator of soil degradation Environ. Monit. Assess 189, 176.

Puvan, P., Osumanu, H. A., Latifah, O., Huck, Y. C., Prisca, D. J. (2021). Wood Ash to improve potassium availability in tropical mineral. *Acid Soils.* 11(10), 2081, https://doi.org/10.3390/agronomy 11102081.

Sambo, E. E, Ufoegbune, G. C., Eruola, A. O. & Ojekunle, O. Z. (2016b). Pattern of Climate Change in Cross River Basin of Nigeria: Implication to Agriculture and Food Security Nigerian Meteorological Society (NMETS), "Climate Variability and Change: Impact, Science, Innovation and Policy" at Federal College of Education Osiele, Abeokuta. 21 - 24 November, 2016

Sanchez, P. A., Palm, C. A. & Boul, S. W. (2003). Fertility capability soil classification. A tust to help assess soil quality in the tropics. *Geoderma*, 114, 159-185.

Sanchez, P. A., Walter, C. & Buot, S. A. (1982). The fertility capability soil classification system, interpretation, applicability and modification, Geodema, 27, 283-309.

Soil Survey Staff (SSS) (2014). Kellogg Soil Survey Laboratory Methods Manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (ed.). U.S Department of Agriculture, Natural Resources Conservation Service. P. 1001.

Usharani, K. V., Roopashree, K. M. & Naik, D. (2019). Role of soil physical, chemical and biological properties for soil health improvement and sustainable agricultural *J. Pharmacogn, Phytochem.* 8, 1256- 1267.

Vasu, D., Singh, S. K., Karthikeyan, K. & Duraisami, V. P. (2016). Fertility capability classification (FCC): A case study in rain-fed soils of semi-arid Deccan Plateau-Agropedology, 26(01): 22-28.

Wong, M. T. & Swift, R. S. (2003). Role of organic matter in alleviating soil acidity. Research Gate. Net. 235-242.

LAND SUITABILITY CLASSIFICATION FOR COCOA PRODUCTION IN BOKI, CROSS RIVER STATE – NIGERIA

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ABSTRACT

Soil categorization provides a platform for making decisions and reconciling competing demands for land use. The current study was carried out to determine the land suitability evaluation for cocoa production in Boki Local Government Area. Three elevation ranges (low, medium and high) were identified with the aid of digital elevation model and four profile pits were spatially distributed in each elevation range. Twelve profile pits were therefore used for the study. Potential aggregate suitability indicates that 723.25 ha (0.22%) of the total area of 290451.16 ha was highly suitable, while 278971.40 ha (96.02%) was moderately suitable and 10756. 51 ha (31.70%) was currently not suitable for cocoa production in Boki Local Government Area. The results indicate comparatively more suitable high and medium elevation areas for cocoa production with limitations in the low elevation range being caused by high water table.

Keywords: Cocoa; technical classification, land evaluation, rainforest soils.

INTRODUCTION

Land evaluation identifies the best kind of land for specified use, and interprets the land quality parameters in relation to the requirements of land use, thereby assessing the value of each tract of land for diverse kinds of uses. Land suitability evaluation estimates the potentials of land for alternate kinds of use (Ibanga, 2003). It appraises and groups specific tracts of land in terms of their absolute or relative suitability for a specified kind of use (FAO, 1976). It is a simple avenue to combat the problems caused by land use as many a time, soils are not comparatively used for the purpose that best suits their properties. Land suitability classification therefore reduces the incidence of land degradation, and wrong allocation of land to uses (Ofem *et al.*, 2022) and allows for proper decisions for assessing the potentials and constraints of the soils for different uses and management (Olasoji *et al.*, 2022).

In recent years, cocoa production has suffered a decline due to the depletion of the humid tropical rainforest, decline in soil fertility and poor soil management (Iremiren *et al.* 2012). In the cocoa growing soils of Boki, Kekong and Ndifon (2020) reported that the levels of total N, exchangeable Ca, Mg and base saturation were adequate for the crop production, while available P, exchangeable K, organic matter and effective cation exchange capacity were below critical levels. In the Etung area, Ajiboye *et al.* (2015) reported low fertility, low pH in KCl (3.5-4.9) and CEC (1.67-10.75 cmol/kg) as well as high rainfall (>2500 mm/annum) as limiting factors to cocoa production. The authors further reported a marginally suitable (13.4 - 45.0%) potential index of productivity in the Etung area.

Among the agricultural export crops, cocoa is the first Nigerian foreign exchange earner (Tijani *et al.* 2001) and employs over 5 million Nigerians along the cocoa value chain. About 34 billion naira is derived annually from cocoa beans export, besides revenue from cocoa by-products like

butter, cake, liquor and powder (Akinwale, 2006). Nigeria ranks fourth in world's production of cocoa, and third largest exporter (Verter and Becyarova, 2014), while Cross River State ranks second in cocoa production in Nigeria after Ondo State (Iremiren *et al.*, 2012). In Cross River State, Ikom, Boki and Etung Local Government Areas are the highest producers of the crop (Tuku *et al.*, 2016).

Soils in the Boki area have been studied recently by Kekong and Udie (2020) and Kekong and Ndifon (2020) mainly by their routine physical and chemical properties without due consideration of the soil units and land evaluation for specified land uses. This gap shrinks the agricultural potentials and gives little consideration to the degradative and fertility management options of the soils. Consequently, farmers in the area have little access to land use options and soil management measures. The current study seeks to identify limiting soil properties for cocoa production and determines the land suitability classes in Boki LGA.

MATERIALS AND METHODS

Location of study area

The study was carried out in Boki Local Government Area (LGA) of Cross River state, Nigeria. Boki LGA is located in the central agricultural zone of Cross River State and is bounded in the North by Obudu, in the West by Ogoja, South by Ikom and Etung, and in the East by a contiguous territorial border with the Republic of Cameroon.

Boki LGA is tropical moist with distinct wet and dry seasons. Rainfall is bimodal in distribution with range of 1200 – 3000 mm and average of 2248.8 mm per year, whereas temperature varies from 22.56 to 31.95 °C, with mean annual value of 26.9 °C (Sambo *et al.*, 2016). Daily relative humidity of 81.7 % and evaporation rate of 2.24 mm day^{-1} characterize the area.

The vegetation is tropical rainforest with a dominance of thick forests with tall and luxuriant trees making up more than half of the land area. Boki is a hub for timber and cash crops like cocoa, oil palm, bush mango and arable crops like plantain, banana, yam, cassava, maize and melon. Boki bears a national and international reputation as a commercial area where heavy timber products like Iroko tree and agricultural products such as cocoa, oil palm, banana and plantain are produced in commercial quantities.

The geology of Boki comprises majorly of Sedimentary Basin and Basement Complex. The Sedimentary formations in the low-lying areas comprise recent alluvium, whereas in the uplands is a dominant shale and limestone with sandstone intercalation. The Basement Complex area is an admixture of igneous and metamorphic rocks. The Basement Complex comprises porphyritic granite and biotite hornblende granite, and hornblende granite gneiss. Few areas of Boki supporting cocoa production are underlain by shale-basalt (Amajor, 1989).

Field study

Field reconnaissance visits were carried out to Borum, Okundi, Bukalum, Boje, Biakwan, Bamba and Kataba in Boki LGA to verify the geology, elevation ranges and their various locations based on information obtained from the topographic map. Four soil profile pits were sunk at each of the elevation ranges; 42-135 (BJv, BKv, BMv, BKl), 136-576 (BMl, Ba1, Ba2, OK2) and 577-1377 m (OK1, BMm, BJu, Kb) above sea level representing low, medium and high elevation ranges, respectively. Twelve (12) soil profile pits were therefore sunk across Borum, Okundi, Bukalum, Boje, Biakwan, Bamba and Kataba and used for the study.

Soil profiles were dug at a specification of 2m (length), 1.5m (breath) and 0.40 – 2.0 m deep. Soil depth varied based on the depth to impenetrable layer or water table. General site information of each profile pit was recorded and the profile pits described using soil description sheets according to the guidelines of Schoeneberger *et al.* (2012). Soil samples were collected from identified horizons based on the natural boundaries starting from the lowest.

The soil samples were air-dried, grinded with a wooden pestle to pass through a 2 mm mesh-sized sieve. Fine-sized fractions were used for laboratory analyses, while coarse fractions were weighed and expressed as coarse fraction.

Laboratory analyses

Particle size distribution was carried out by the Bouyoucos hydrometer method using calgon as a dispersing agent. The percentage size separates of sand, silt and clay were then traced on the USDA soil textural triangle for the determination of soil textural classes. After standardization with a buffer of pH 7.0, soil pH was determined potentiometrically in a soil to water ratio of 1:2.5 using a glass electrode pH meter.

Soil organic carbon content was determined by Walkey and Black wet oxidation method using diphenol amine as indicator and potassium dichromate as the oxidizing agent. Exchangeable Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} were determined by leaching the soil sample with 1 *N* neutral NH_4OAc as the extractant solution at pH of 7.0, and titrated with KOH so as to determine exchangeable Ca^{2+} and Mg^{2-}. This is the versenate EDTA titration method, whereas K^{+} and Na^{+} were determined by flame photometry. Cation exchange capacity (CEC) by NH_4OAc at pH 7.0 was obtained by saturating the soil exchange sites with NH_4^{+} at pH of 7.0 through treating the soil with 1 *M* NH_4OAc. Base saturation was estimated by expressing the sum of exchangeable bases (Ca^{2+}, Mg^{2+} K^{+} and Na^{+}) as a percentage of CEC (IITA, 1979), while the sum of basic cations was calculated by summing up the exchangeable basic cations and the apparent cation exchange capacity was obtained by dividing the CEC by percent clay and multiplying by 100.

All soil analyses were carried out by the procedures outlined in the Soil Survey Staff (2014).

Land Suitability Classification Procedures for Cocoa production

The tract of land was assessed for its suitability for cocoa production in accordance with the requirements of Sys *et al.* (1993) as presented in the land requirements and limitations ratings for cocoa in Table 1. Since risks in production are minimized by matching the requirements for land use to land qualities, the profile pits were placed in suitability classes by comparing data obtained in the study area to the land requirement information for cocoa production. Ratings that indicate the adequacy or inadequacy of land qualities for cocoa were used to explain the extent of the limitations, while the most limiting factors determined the overall suitability ratings in accordance with Liebig's law of minimum (Ofem *et al.*, 2016). For the parametric method, the index of productivity (IP) for each pedon was computed using the equation:

$IP = Ax \sqrt{B/100} \times C/100 \ldots \times E/100$

Where:

A = Overall lowest characteristics rating, B, C…E = The lowest characteristics rating for each land quality group. The land quality groups were climate (c), wetness (w), slope or topography (t), physical soil characteristics (s), and soil fertility (f).

Land requirements and limitations ratings for cocoa production have been presented in Table 1. Based on strong correlations experienced within a land quality group, only one member in each of c, w, t, s, and f is used for the rating.

TABLE 1: Land use requirements for suitability classes for cocoa production (limitation-parametric method of evaluation)

Land Characteristics	Class, degree of limitation and rating scale S1 0 100-95	S1 1 95-85	S2 2 85-60	S3 3 60-40	N1 40-25	N2 4 25-0
Suitability to land use: permanently	High		moderate	ma rginal	currently	
Climate (c)						
MAR(mm/yr)	1900-1800 1900-2000	1800-1600 2000-2500	1600-1400 2500-3500	1400-1200 3500-4400	- -	<1200 >4400
MAT (°C)	26-25 26-28	25-23 28-29	23-22 29-30	22-21 -	- -	<21 >30
Topography (t)						
Slope (%)	0-1	1-2	2-4	4-6	-	>6
Wetness (w)						
Flooding	Fo (No flooding limitation)	- (No flooding limitation)	- Slight limitation; no longer than 1-2 mths	F1 Moderate limitation; 2-3mths of flood in every 5-10 yrs	- -	F2+ Severe limitation; Every year, 2-4 mths of flood.
Drainage	Good (GW > 150cm)	Good (GW 100-150 CM)	Moderate	Imperfect	Poor	V. Poor
Physical characteristics (s)						
Texture	C,SiCL,CL,SiL	C, L, SC	C, SCL	C, LfS, SL	-	SiC,LS,LCS,Fs,S
CF (Vol. %)	0-15	15-35	35-55	55-75	-	>75
Soil depth (cm)	>200	200-150	150-100	100-50	-	<50
Soil fertility (f)						
ACEC (cmol/kg)	>24	24-16	<16(-)	<16(+)	-	-
BS (%)	>50	50-35	35-20	<20	-	-
SBC	>6.5	6.5-4.0	4.0-2.8	2.8-1.6	<1.6	-
pH (H_2O)	6.4-6.2, 6.4-6.6	6.2-6.0 6.6-7.0	6.0-5.5 7.0-7.6	5.5-5.0 7.6-8.2	-	>8.2
Org. C (%)	>2.4	2.4-1.5	1.5-0.8	<0.8	-	-

Source: Sys *et al.* 1993

F1 = slight, C-60V to L = Clay vertisol structure to loam, C + 60S to s=very fine clay, C+60s to fs=very fine clay blocky structure to fine sand, C+60s to SCL=very fine clay blocky to structure to clay loam, C+60v to fs=very fine clay vertisol to fine sand, vertisol structure to sandy soil, CM to SC=massive clay to sandy clay.

S1=highly suitable, S2=moderately suitable, S3=marginally suitable, N1=presently not suitable, N2=permanently not suitable.

RESULTS AND DISCUSSION

Land suitability evaluation for cocoa production

Land characteristics of the area were corrected to 160.00 cm depth since the deepest tap root of cocoa is reported as 160 cm (Moser *et al.* 2010), and presented in Table 2. These characteristics in comparison with values in Table 1 gave rise to the suitability classes and scores in Table 3. Furthermore, aggregate suitability scores for each pedon were calculate and presented in Table 4.

Land Requirements for Cocoa

Temperature and rainfall characteristics were evaluated for climate quality. In Boki these characteristics were optimum for the cultivation of coca (Table 3), with suitability scores ranging from S1 (95.00) to S1 (100.00) for mean annual rainfall and mean annual temperature,

respectively. Climate did not constitute a limitation for the cultivation of cocoa in Boki. Southern Nigeria, particular Cross River State has been found to have a comparative advantage in terms of cocoa cultivation over some states in Nigeria probably because of its favourable climate. However, climate is not a sole determinant of land suitability for coca cultivation.

The topography of the study areas was highly suitable for coca production with a score of S_1 (95.00) to S_1 (100.00) (Table 3).

Wetness quality is defined by flooding and drainage. Soils in high and middle elevations ranges were well–drained and free of flooding. Flooding characteristics of the soil had scores of S_2 (83.00) to S_1 (100) and drainage had scores of S_2 (84.00) to S_1 (100.00) with soils in the low elevation range having scores in the lower limit. This shows that the soils in the low elevation were most affected by flooding and drainage characteristics. Such characteristics can cause severe limitations to cocoa cultivation in the low elevation.

Soil physical quality was represented by soil texture, coarse fraction (CF) and soil depth. Soil texture was optimum and did not constitute a major limitation in the middle and high elevation ranges for the cultivation of cocoa with a suitability class score of S1 (95.00 - 100.00). Such optimum soil textures (Table 3) may encourage nutrients and moisture retention for use by cocoa.

However, the soils of low elevation range were not optimal and could cause a major limitation in cocoa production; with a suitability class score of S_3 (58.00) to S1 (100.00). The problem of flooding in the elevation range could be a major challenge as sand-sized sediments get deposited within the area from adjoining streams.

The coarse fraction (CF) of the three elevation (low, middle and high) ranges was at optimum and did not constitute any limitation to growth of cocoa in Boki, resulting in a suitability class of S1 (100.00).

Soil depth was optimum for soils of middle and high elevations with class scores of S1 (100.00). However, the suitability class scores for soil depth in soils of low elevation was too degraded leading to the scores of N_1 (38.00) to S_1 (100.00). The high-water table especially at the BJv, BKV and BMV pedons automatically imported severe limitations in cocoa cultivation as a result of poor drainage.

The entire soils were optimum in terms of apparent cation exchangeable capacity (ACEC) with a suitability class of S_1 (100.00). Similarly, for SBC, majority of the soils were at optimum level although few areas experienced slight limitations and were rated S_2 (85.00) to S_1 (97.00).

Base saturation (BS) was optimum in some soils while others witnessed slight limitations, giving suitability classes ranging from S_2 (74.00) to S_1 (97.00). Soil pH was not optimum in most of the soils, with suitability class scores of S_3 (58.00 – 65.00) basically because the pH in the study areas was less than 6.2 – 6.4 pH unit required for cocoa production. This indicates slight to severe limitations. Soil pH controls nutrient availability and toxicity as well as microbial population. The soils should therefore be

TABLE 2: Land characteristics of the area

Pedons	MAR	MAT	SLOPE	Flooding	Drainage	Texture	CF	Soil depth (cm)	ACEC	BS	SBC	pH(H_2O)	% O.C
BJV	2248.8	26.9	1	F1+	Mo	SL	0	50	76.3	48	5.47	4.9	1.09
BKV	2248.8	26.9	1	F1+	Mo	SL	0	47	70.01	49	5.05	4.9	1.07
BMv	2248.8	26.9	1	F1+	Mo	SL	0	40	79.64	3	4.67	5.0	1.13
BKl	2248.8	26.9	2	F_0	Go	SiL	0	200	84.89	31	4.99	5.3	1/15
BMl	2248.8	26.9	1	F_0	Go	CL	0	200	73.85	25	4.94	5.1	0.81
Bal	2248.8	26.9	2	F_0	Go	L	0	180	97.62	27	4.92	5.1	0.86

Ba2	2248.8	26.9	2	F_0	Go	L	0	200	76.34	32	4.99	5.3	0.78
OK2	2248.8	26.9	1	F_0	Go	L	0	200	66.13	29	4.37	5.1	0.63
OK1	2248.8	26.9	2	F_0	Go	CL	0	200	50.86	27	3.48?	5.0	1.17
BMm	2248.8	26.9	2	F_0	Go	L	0	200	66.00	39	5.34	5.2	0.79
BJu	2248.8	26.9	2	F_0	Go	L	0	158	66.57	24	3.57?	5.1	0.58
Kb	2248.8	26.9	2	F_0	Go	CL	0	200	55.35	29	3.75?	5.1	0.7

Fo = no flooding, F1+ = flooding, CF = Coarse fragment, SL = Sandy loam, SiL = Silty loam, CL = Clay loam, L = Loam, ACEC = Apparent cation exchange capacity, BS = Base saturation, SBC = Sum of basic cations, OC = Organic carbon

Pedons	MAR	MAT	SLOPE	Flooding	Drainage	Texture	CF	Soil depth	ACEC	BS	SBC	pH(H_2O)	O.C
	Climatic		Topographic	Wetness quality		Physical					Fertility		
BJV	S1(95)	S1(100)	S1(100)	S2(83)	S2(84)	S3(58)	S1(100)	N1(38)	S1(100)	S1(94)	S1(94)	S3(58)	S2(84)
BKV	S1(95)	S1(100)	S1(100)	S2(82)	S2(84)	S3(58)	S1(100)	N2(38)	S1(100)	S1(94)	S1(93)	S3(58)	S2(84)
BMv	S1(95)	S1(100)	S1(100)	S2(82)	S2(84)	S3 (58)	S1(100)	N2(38)	S1(100)	S1(93)	S1(91)	S3(60)	S2(85)
BKl	S1(95)	S1(100)	S1(95)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S2(84)	S1(92)	S3(64)	S2(85)
BMl	S1(95)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S2(75)	S1(92)	S3(64)	S2(70)
Bal	S1(95)	S1(100)	S1(95)	S1(100)	S1(100)	S1(95)	S1(100)	S1(100)	S1(100)	S2(78)	S1(91)	S2(60)	S2(72)
Ba2	S1(95)	S1(100)	S1(95)	S1(100)	S1(100)	S1(95)	S1(100)	S1(100)	S1(100)	S2(84)	S1(92)	S3(60)	S2(69)
OK2	S1(95)	S1(100)	S1(100)	S1(100)	S1(100)	S1(95)	S1(100)	S1(100)	S1(100)	S2(76)	S1(97)	S3(64)	S3(54)
OK1	S1(95)	S1(100)	S1(95)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S2(78)	S2(85)	S3(65)	S2(85)
BMm	S1(95)	S1(100)	S1(95)	S1(100)	S1(100)	S1(95)	S1(100)	S1(100)	S1(100)	S1(96)	S1(94)	S3(60)	S2(65)
BJu	S1(95)	S1(100)	S1(95)	S1(100)	S1(100)	S1(95)	S1(100)	S1(100)	S1(100)	S2(74)	S2(85)	S3(60)	S3(55)
Kb	S1(95)	S1(100)	S1(95)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S2(78)	S2(85)	S3(65)	S2(64)

TABLE 3: Suitability classification and scores of the pedons
CF = Coarse fragment, ACEC = Apparent cation exchange capacity, BS = Base saturation, SBC = Sum of basic cations, OC = Organic carbon

Table 4: Aggregate suitability and classification of the pedons for cocoa production

Pedons	BJV	BKv	BMv	BK1	BMl	Bal	Ba2	OK2	OK1	BMM	BJU	Kb
						Current Suitability						
Parametric	N1(25.7)	N1 (25.7)	N1(26.4)	S2(60.8)	S2(62.5)	53(55.5)	S3(55.6)	S2(60.8)	S2(61.8)	S3(56)	S3(56)	S2(61.8)
Non-para	$S3_{wsf}$	$S3_{wsf}$	$S3_{wsf}$	S2f	S2f	S2f	S2f	S2f	S2f	S2f	S2f	S2f
						Potential Suitability						

Parametric	N1 (32.7)	N1(32.54)	N1(32.24)	S2(79.8)	S2(73.14)	S2(72.24)	S2(77.88)	S2(72.2)	S2(74.1)	S1(87.04)	S2(68.54)	S2(74.1)
Non-para	$S2_{ws}$	$S2_{ws}$	$S3_{ws}$	S1	S1	S1	S1	S1	S1	S1	S1	S1

Non-para = non – parametric, S1= Highly suitable, S2 = Moderately suitable, S3= Marginally suitable, N1= Currently not suitable

limed to raise the pH to about 5.5 – 6.5. Organic carbon was adequate for the soils with suitability class scores of S_2 (64.00 to 85.00), however, slight limitations were observed in OK_2 and BJU pedons giving rise to marginal suitability class (S_3).

Major limitations of the soils to suitability for cocoa cultivation

In most of the areas in Boki, climate (temperature and rainfall), slope as well as exchangeable sodium percent, soil texture, CF and ACEC were optimum or nearly so for cocoa production. However, K – reserve in the soils was low and may cause a major challenge to cocoa production as regards the yield. The soils may require K application (Egbe *et al.* 1989).

Sandy loam, clay loam, silt loam and loam were among the soil textures obtained in the area. Sandy clay, clay, silt clay and loam textures have been recommended for optimum cocoa production (Ritang *et al.*, 2007; Anim-kwapong and Frimpong, 2004). Such textural classes encourage soil water and nutrients retention.

In the soils of Boki, exchangeable potassium was a major limitation because of high rainfall in the area. Also, soil depth and wetness properties were optimum in the well-drained middle and high elevation ranges and grossly limiting in the low elevation range; hence the sub – optimal drainage and flooding condition for cocoa production. This condition is unfavourable and may affect cocoa cultivation. When base saturation and soil pH become marginal or sub – optimum, the soil may not be economically favourable for cocoa production and the yield may decline.

Suitability classes

Suitability classification and scores of individual pedons are presented in Table 4. The aggregate rating was done for current and potential suitability using the parametric and non – parametric approaches and summarized in Table 4. In Table 3, all the pedons in middle and high elevation ranges were suitable for cocoa production at varying degrees except that pH (H_2O) and organic carbon showed low suitability.

With the parametric method, the soils of low elevation (BJV, BKV, BMV) were currently not suitable (N1) and moderately suitable (S2) (BKI) for cocoa production. Bal and Ba2 pedons were marginally suitable (S3), and at high elevation range; OK_1 and Kb pedons were moderately suitable (S2), while Bmm and Mju pedons were marginally suitable (S3), currently.

Potentially, the pedons were more suitable with one pedon (Bmm) being highly suitable (S_1), while seven pedons (Bm_1, Ba_1, Ba_2, OK_1, OK2, BJU, Kb) were moderately suitable (S_2) in the well – drained middle and high elevations; whereas, in the low elevations three pedons (Bjv, Bkv, Bmv) were currently not suitable (N_1) while only one (Bk_1) was rated as moderately suitable (S_2).

The distribution of the elevation ranges as well as their current and potential suitability classes by the parametric approach are as presented in Figs. 1 and 2, respectively. In Fig. 1, moderately suitable area occupies a total of 57944.46 ha (S_2; 19.94%) out of the total area of 290541.25 ha (currently) for cocoa cultivation, while 225575.50 ha (S_3; 77.64%) was marginally suitable and 7012.29 ha (N_1; 2.42%) was currently not suitable.

In Fig. 2, potentially, 723.25 ha (S_1; 0.22%) of the total area of 290451.16 ha was highly suitable (S_1) for cocoa production, while 278971.40 ha (S_2: 96.02%) was moderately suitable and 10756. 51 ha (31.70%) was currently not suitable. Again, it was observed that a good percentage of area that were currently rated moderately suitable (S_2) could have been upgraded later to highly suitable (S_1) and those that were not suitable were upgraded to marginally suitable after commonly altered fertility limitations may have been removed.

According to Ogunkunle (1993), the efficiency of each method (parametric and non-parametric) of land evaluation depends on the relevance of the most limiting characteristic for crop

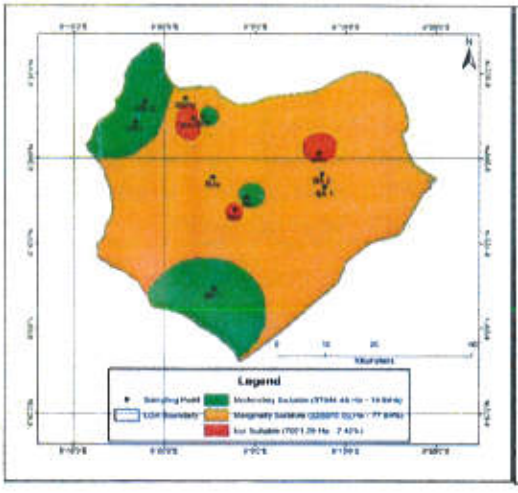

Fig. 1: Distribution of Current land suitability classes

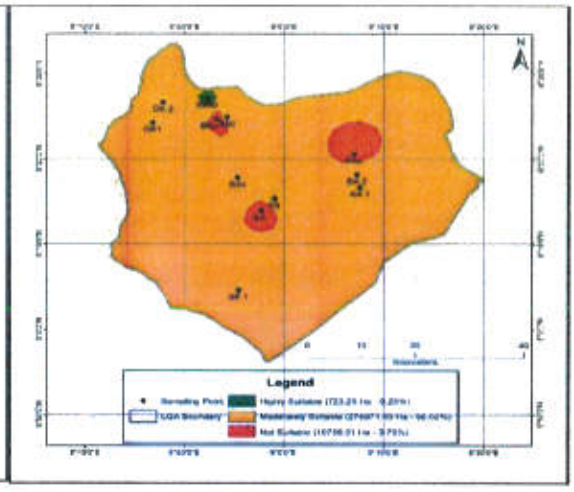

Fig. 2: Distribution of potential land suitability classes

production. Consequently, where climate, soil physical condition or ACEC is identified as the most limiting property, the non-parametric system may be most accurate. In this way, a limiting soil characteristic determines crop performance and reduces the effects of other soil properties (Ofem *et al.*, 2022). For instance, if soil depth or wetness is unsuitable as the case of BKV, BJV and BMV, the land is unsuitable irrespective of the fertility status of soil chemical or other land qualities (Ofem et al, 2022). If easily amended chemical properties are rather limiting, the parametric method may be a better approach (Ogunkule, 1993).

NON-PARAMETRIC METHOD.

By the non-parametric approach, the soils were more suitable for cocoa cultivation, potentially than it was obtained by the parametric method. This is so because after the removal of limitations except in situations where the main limitation was caused by soil physical characteristics such as wetness or depth (BJV, BKV, BMV), the suitability scores are most likely to be upgraded. In these situations, the cost implication of removing soil limitation may be more than the risk in cultivating with such limitations, if the land use type is changed to a more suitable one. For instance, in BJV, organic carbon content was rated S_2 (84:00) and constituted a slight limitation, while soil depth was rated N_1 (38.00). The BJV was therefore classified as S_{3wsf}, currently. Potentially, the organic carbon content of the soil may be improved by the use of organic soil amendments such as animal droppings, plants residues, compost etc. while wetness condition and physical limitations remain unchanged due to the difficulty in removing the limitations. Hence, the potential suitability becomes S3ws. The report of Ololade *et al.* (2010) showed that organic carbon supports the cultivation of cocoa.

For each of BJV (S3wsf), BKV (S3wsf) and BMV (S3wsf), the soils were either limited by wetness (w), depth (s), soil pH or organic carbon (f); currently. Potentially, all the soils were upgraded to S_{2ws} as fertility limitations due to pH may be removed by liming and suitable mineral fertilizers. On the other hand, BK_1, BM_1, Ba_1, Ba_2, OK_2, OK_1, BMm, BJU and Kb were classified as S_2f in the suitability subclass. Currently, it shows that all the soils were limited by one kind of fertility characteristic or the order.

Ranking the pedons for cocoa cultivation by their score using the parametric approach (Tables 3 and 4), the best 9 pedons were well-drained and found in high and middle elevations. This suggested that, wetness quality was the major constraint to cocoa production in the low elevations.

Summary

Land suitability for cocoa production in Boki Local Government Area indicates that moderately suitable area occupies a total of 57944.46 ha (19.94 %) of the total area of 290,541.25 ha, currently, while 225,575.50 ha (77.64%) was marginally suitable and 7,012.29 ha (2.42 %) was currently not suitable. The soils can be upgraded when good land management procedures like liming have been applied.

Potentially, 723.25 ha (0.22%) of the total area of 290451.16 ha was highly suitable (S_1) for cocoa production, while 278971.40 ha (96.02%) was moderately suitable and 10756. 51 ha (31.70%) was currently not suitable. Therefore, a good percentage of soils that were currently rated moderately suitable (S_2) were upgraded to highly suitable (S_1) and those that were not suitable were upgraded to marginally suitable after commonly altered fertility limitations may have been removed.

It is recommended that the land use type of the soils in the low elevation rage (BJV, BJV, BMV) be changed and used for the cultivation of more water tolerant crops. This is because of the expenses that may be incurred during the installation of drainage facilities if it must be used for the cultivation of cocoa. The economic implication of the installation may outweigh the benefit that will accrue from the installation process.

REFERENCES

Ajiboye, G. A., Jaiyeoba, J. O., Olaniyan, J. O. & Olaiya, A. O. (2015). The characteristics and suitability of the soils of some major cocoa growing areas of Nigeria: Etung LGA of Cross River. *Agrosearch*, 15(1):101-116.

Akinwale, O. (2016). Prospects and challenges in local production of Cocoa as raw material in Nigeria. Cocoa mirror, 1: 9 – 11

Amajor, L. C. (1989). The Eze-Aku sand stone ridge of South Eastern Nigeria. A re-interpretation of their depositional origin. *Journal of Mineral Geology*, 23:17-26.

Anim-Kwapong, G. J. & Frimpong, E. B. (2004). Vulnerability and adaptation assessment under the Netherlands Climate Change Studies Assistance Programme Phase 2 (NCCSAP2): vulnerability of agriculture to climate change – impact of climate on cocoa production, *Cocoa Research Institute of Ghana*, P. 12

Egbe, N. E., Ayodele, E. A. & Obatolu, C. R. (1989). "Soils and nutrition of cocoa, coffee, Kola, Cashew and Tea." *Progress in Tree Crops Research*, 2, 28-38.

FAO, (1976). A framework for land evaluation. Soils Bull. No.32, FAO, Rome, P. 79

Ibanga, I. J. (2003). Guidelines for Soil Survey, Classification and Land Use. De-Rio Press Nig. Ltd. 408Pp.

Iremiren, G. O., Oduwole, O., Obatolu, B. O., Aigbekaen, E., Sanusi, R. A., Shittu, T. R., Emeku, L. E., Iberemo, O. S., Aikpokpodion, P., Agbeniyi, S. O., Ndubuku, T. C. B., Adeogun, S. & Olaiya, A. (2012). Cocoa production survey in Nigeria, Report of Cocoa Research Institute of Nigeria (CRIN) ISBN: 97897850 65664 84Pp.

Kekong, M. A. & Ndifon, S. O. (2020). Physical and chemical properties of cocoa growing soils of Boki, Cross River State Nigeria, *Nigerian Agricultural Journal*, 51(3), 161-167.

Kekong, M. A. & Udie, U. L. (2020). Soil fertility evaluation of major cocoa producing areas of Cross River State, Nigeria. EJFOOD, *European Journal of Agriculture and Food Sciences,* 2(6):1-6.

Moser, G., Leuschner, C., Hertel, D., Ho ¨lscher, D., Kohler., M., Leitner, D., Michalzik, B., Prihastanti, E., Tjitrosemito, S. & Schwendenmann, L. (2010). Response of cocoa trees (Theobroma cacao) to a 13-month desiccation period in Sulawesi, Indonesia. Agroforest Syst (2010) 79:171–187 DOI 10.1007/s10457-010-9303-1

Ofem K. I., Kefas P. K. & Garjila Y.A. (2022). Land suitability evaluation for oil palm production in Cross River State, Nigeria. *Agro-Science,* 21 (3), 85-93. DOI: https://dx.doi.org/10.4314/as.v21i3.10

Ofem, K. I., Akpan-Idiok, A. U., Afu, S. M. & Esu, I. E. (2016). *African Journal of Agricultural Science and Technology (AJAST)*, 4(4):683-691.

Ogunkunle A. O. (1993). Soil as land suitability evaluation: in example with soil oil palm in Niger. *Soil Use Manage* (1), 35.40.

Olasoji, H. O., Ogunlade, M. O. & Iloyanomon, C. J. (2022). Soil characterization, classification and land suitability evaluation for cocoa production in Ijaka-Isale, Yewa North, Ogun State, Nigeria. *Quest Journals, Journal of Research in Agriculture and Animal Science.* 9(12):12-21.

Ololade, I. A., Ayayi, I. R., Gbadamosi, A. E., Mohammed, O. Z. & Sunday, A. G. (2010). A study on effects of soils physic-chemical properties on cocoa production in Ondo State. *Modern Applied Science,* 4(5):

Ritang, S. W., Agus, F. & Hidayat, H. (2007). Land suitability evaluation with a case map of Aceh Barat District. Indonesian Soil Research Institute and World Agroforestry Centre, Bogor-Indonesia, 42Pp.

Sambo, E. E, Ufoegbune, G. C., Eruola, A. O. & Ojekunle, O. Z. (2016). Pattern of Climate Change in Cross River Basin of Nigeria: Implication to Agriculture and Food Security Nigerian Meteorological Society (NMETS), "Climate Variability and Change: Impact,

Science, Innovation and Policy" at Federal College of Education Osiele, Abeokuta. 21 - 24 November, 2016

Schoeneberger, P. J., Wysocki, D. A., Benham, E. C., and Soil Survey Staff (2012). *Field Book for Sampling and describing Soils, Version 3.0.* Natural Resources Conservation Service, National Soil Survey Centre, Lincoln, NE

Soil Survey Staff (SSS) (2014). Kellogg Soil Survey Laboratory Methods Manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (ed.). U.S Department of Agriculture, Natural Resources Conservation Service. P. 1001.

Sys, C. E., Van Ranst, E., Debaveye, J. & Beermeart, F. (1993). Land Evaluation: Part 111. Crop Requirements, Agricultural Publication No, International Training Centre for Post Graduate Soil Scientist, University Ghent, Brussels, Belguim. 166P.

Tijani, A. A., Farinde, A. & Agboola, A. A. (2001). Measuring the impact of Extension on Cocoa production in Ondo State, Nigeria. Moor Journal of Agricultural Research, 2: 186 – 190

Tuku, N. E. Galadima, M. & Iyala, D. (2006). Scale efficiency of cocoa production in Cross River State. Federal University Wukari Trends in Science and Technology Journal. Vol1(2):417-422.

Verter, N. & Becyarova, V. (2014). Analysis of some drivers of cocoa export in Nigeria in the Era of Trade Liberalization Agris on-line papers in Economics and Informations, 6(4):208-218.

META-ANALYSIS OF THE ENVIRONMENTAL IMPACTS OF UNCONTROLLED PALM OIL MILL EFFLUENT (POME) DISCHARGE ON SOIL ECOSYSTEM

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ABSTRACT

Palm oil mill effluent (POME) is a significant by-product of the palm oil industry, with devastating environmental consequences when discharged uncontrolled into the environment. Palm oil mill effluent discharge poses significant environmental concerns, particularly in tropical regions. This empirical study using meta-analysis investigates the effects of uncontrolled POME discharge on soil ecosystem properties, including pH, microbial diversity, and plant growth. Our analysis of 25 peer-reviewed studies reveals significant detrimental impacts on soil health, posing a major threat to soil ecosystems, as evidence indicates it leads to soil contamination, imbalance in microbial communities, and nutrient depletion. Drawing on empirical studies, this study underscores the need for effective management practices for POME to reduce environmental harm.

Introduction

The growing palm oil industry, particularly in Southeast Asia, Africa, and Latin America, has major economic benefits but also produces large volumes of palm oil mill effluent (POME), a by-product that threatens environmental health, if discharged without treatment. POME is produced during the oil extraction process, especially during fruit sterilization, clarification, and other stages. It has high levels of chemical oxygen demand (COD), biochemical oxygen demand (BOD), organic compounds, and essential nutrients such as nitrogen and phosphorus (Ahmad *et al.*, 2003). Due to its acidic nature (pH around 4-5) and high content of oils, suspended solids, and phenolic compounds, POME is difficult to decompose naturally and can persist in the environment for extended periods (Okwute & Isu, 2007).

Palm oil is a key agricultural product in countries like Malaysia, Indonesia, Nigeria and Thailand, meeting global needs for food and fuel. However, the wastewater, known as palm oil mill effluent (POME), contains high levels of organic pollutants, nutrients, and toxic materials (Lim *et al.*, 2015). As demand for palm oil has increased, the environmental footprint of its production has also grown, mainly through the disposal of POME. Composed of organic materials, nutrients, and other toxic compounds, POME poses risks to soil ecosystems when improperly managed (Osaki *et al.*, 2018). High levels of chemical oxygen demand (COD), biochemical oxygen demand (BOD), and nutrients make untreated POME discharge a major environmental hazard (Wu *et al.*, 2009). Uncontrolled discharge of POME, common in regions

with limited regulatory oversight and treatment facilities, may result in soil contamination, nutrient imbalance, and reduced soil productivity (Ahmad *et al.*, 2019).

LITERATURE REVIEW

Characteristics and Composition of Palm Oil Mill Effluent

POME is a complex by-product created during the sterilization, clarification, and hydrocyclone phases in palm oil processing. It contains substantial organic matter, nitrogen, phosphorus, potassium, and other trace elements (Ahmad *et al.*, 2003). POME also has significant suspended solids, oils, lignin, cellulose, and other fibers that contribute to its high COD and BOD levels (Tabassum *et al.*, 2015). POME is acidic (pH around 4–5) and rich in phenolic compounds, tannins, and lipids, all of which are resistant to decomposition and can remain in the soil. POME contains anaerobic and facultative microorganisms, including some that can produce harmful by-products (Wu *et al.*, 2010).

Effects of POME on Soil Ecosystems

i. Soil physical Properties

Studies have consistently shown that POME leads to a significant decrease in soil pH (Chiew & Yeoh, 2012; Wahid *et al.*, 2017; Wu *et al.*, 2017; Idris *et al.*, 2020), reduces soil porosity (Ibrahim *et al.*, 2018), and increases electrical conductivity (EC) (Hassan *et al.*, 2020). This decrease in pH can be attributed to the high acidity of POME, which can alter the soil's chemical properties and affect microbial activity. The acidic nature of POME can alter soil pH balance, leading to nutrient leaching and heavy metal accumulation, which ultimately reduces soil's water retention and makes it unfit for agriculture (Wu *et al.*, 2009).

ii. Soil Fertility Decline and Nutrient Imbalance and plant growth

The uncontrolled discharge of palm oil mill effluent (POME) has become a significant environmental concern, particularly in tropical regions where palm oil production is prevalent. The existing literature suggests that uncontrolled POME discharge can have detrimental effects on soil ecosystem properties. Though POME is rich in nitrogen, phosphorus, and potassium (NPK), excessive discharge can lead to nutrient imbalances. Ongoing POME exposure has been linked to nitrogen leaching, which diminishes soil nitrogen levels and affects the availability of essential nutrients like calcium and magnesium (Singh *et al.*, 2010). High nitrogen levels can also encourage the growth of invasive plants, which can out-compete native species and disturb the local ecosystem (Fadhil *et al.*, 2011). Furthermore, nutrient overload can lead to eutrophication in nearby water sources if the soil cannot retain the nutrients, worsening environmental impacts (Lim *et al.*, 2015). Literature suggests that POME can inhibit plant growth due to the toxicity of its constituents (Ahmad *et al.*, 2013; Jusop *et al.*, 2017; Ramli *et al.*, 2020). The decrease in soil pH and microbial diversity can also contribute to reduced plant growth.

iii. Impact on Soil Microbial Communities

Research has indicated that POME discharge can reduce microbial diversity in soil (Husin *et al.*, 2014; Singh *et al.*, 2016; Othman *et al.*, 2020). This reduction in microbial diversity can

have cascading effects on ecosystem functioning and plant growth. Soil microbial populations are vital for nutrient cycling, organic matter breakdown, and maintaining soil health. The introduction of high levels of organic carbon and nutrients from POME promotes anaerobic bacterial growth, upsetting the natural microbial balance (Fadhil *et al.*, 2011). Studies suggest that prolonged exposure to POME favors anaerobic microbes, increasing methane and hydrogen sulfide production. These gases are toxic to aerobic organisms and suppress nitrogen-fixing bacteria, reducing soil fertility (Ahmad *et al.*, 2003). Additionally, high concentrations of phenolic compounds in POME inhibit soil enzymes like dehydrogenase, which is essential for breaking down organic matter (Tabassum *et al.*, 2015).

iv. Soil Contamination and Degradation

Discharging untreated POME can lead to soil contamination, as organic matter, nutrients, and other harmful substances accumulate. High COD and BOD deplete oxygen in the soil, creating anaerobic conditions that damage plant growth and disrupt beneficial soil microbes (Singh *et al.*, 2010). Research shows that continued discharge of untreated POME can acidify soil, reducing its fertility and crop productivity (Lim & Lim, 2013).

v. Accumulation of Toxic Compounds

Uncontrolled POME discharge can lead to bioaccumulation of toxic substances, including phenolic compounds, tannins, and other organic toxins, which can remain in soil long-term, threatening soil health and biodiversity (Wu *et al.*, 2010). In high amounts, these compounds are toxic to plants, preventing seed germination, root growth, and other essential functions (Ahmad *et al.*, 2003).

Strategies for POME Treatment

Due to the environmental risks associated with uncontrolled POME discharge, various strategies have been developed for its treatment and safe disposal:

1. Biological Treatment: Processes like anaerobic and aerobic digestion are widely used to reduce organic matter in POME, significantly lowering COD and BOD levels (Tabassum *et al.*, 2015) and making the effluent less harmful when applied to the soil (Okwute & Isu, 2007)

2. Controlled Land Application: When applied in regulated amounts, POME can serve as an organic fertilizer, providing nutrients without degrading the soil (Fadhil *et al.*, 2011). Studies suggest that, when applied at controlled dosages, POME can enhance soil fertility as an organic fertilizer, provided it is used within acceptable limits (Akpan *et al.*, 2019)

3. Phytoremediation: Certain plants are effective in absorbing and neutralizing specific compounds in POME, potentially reducing soil contamination (Lim & Lim, 2013) and restoring soil health over time. This approach is particularly suitable for regions with high POME production, where it can complement other treatment methods (Usoro et al., 2020).

4. Advanced Treatment Methods: Techniques like chemical coagulation, membrane filtration, and advanced oxidation are promising for reducing the toxic load of POME before discharge

(Wu *et al.*, 2009). However, these methods require significant initial investment and technical expertise (Okwute & Isu, 2007).

Research Question

This study seeks to find answers to the following research question: What is the impact of uncontrolled palm oil mill effluent (POME) discharge on soil ecosystem (taking into consideration properties such as: pH, microbial diversity, plant growth)?

Methodology

Meta-analysis was used for this study. Meta-analysis is a quantitative analytical method. It involves systematically collecting, evaluating, and synthesizing data from multiple studies to draw more general conclusions. This is achieved through statistical methods that combine the results of individual studies, accounting for variations in study design, sample size, and other factors. The goal is to provide a more comprehensive understanding of a research question or hypothesis, increasing the reliability and generalizability of findings (Lipsey and Wilson, 2001; Borenstein *et al* 2009; Cooper, 2010),

A systematic review (Higgins and Green, 2011) of 150 studies was conducted using Meta-analysis and after screening 25 studies published between 2010-2022 met the inclusion criteria. Previous studies were selected based on relevance to POME's impact on soil ecosystems. To ensure a comprehensive search, the following criteria were considered: Databases, Keywords, inclusion and exclusion criteria, data extraction and data coding, study selection and data extraction.

Databases Search and Keyword Select Studies

A systematic search was performed across major scientific databases including Scopus, Web of Science, PubMed, Google Scholar, and ScienceDirect. The search used specific keywords and Boolean operators to capture studies linking POME and its effects on soil ecosystems. This initial search yielded 150 studies, which were then screened based on the defined inclusion criteria. Ultimately, 25 studies were identified as meeting all criteria, representing a refined dataset of highly relevant research for further analysis.

Inclusion and exclusion criteria

The Inclusion Criteria for selecting relevant studies were strictly defined to ensure data quality and relevance to the research focus. Only peer-reviewed articles published between 2010 and 2023 in English were considered. The studies had to be conducted specifically on tropical soils, as these conditions are crucial to accurately assess the impact of palm oil mill effluent (POME) discharge on tropical ecosystems. Pail oil mill effluent discharge was set as the independent variable, while soil ecosystem properties such as pH, microbial diversity, and plant growth were the dependent variables of interest. Furthermore, only studies providing quantitative data on these soil ecosystem properties were selected to facilitate consistent and reliable data analysis. None peer-reviewed articles, unpublished theses/dissertations, studies not focused on POME's environmental impact and articles not in English language were excluded from the study.

Data extraction and data coding

Extract and Code Data involved systematic extraction and coding to ensure that all relevant details were documented and categorized for subsequent analysis. The extracted data included study characteristics (e.g., author, publication year, and geographic location), details on POME discharge (e.g., volume and duration of application), and measures of soil ecosystem properties (pH, microbial diversity, and plant growth outcomes). Coding criteria were also established, classifying each study by its design (experimental or observational), POME treatment (controlled or uncontrolled), and soil type (such as clay, loam, or sand). This structured coding process enabled a uniform dataset, allowing for comprehensive and comparable insights across the studies.

limitations of the study

The limitations of this study include: limited geographical scope, variability in study methodologies and lack of long-term studies.

Statistical Analysis

Statistical analysis was performed using the Comprehensive Meta-Analysis (CMA) software, Random-Effects Model (REM)

Results and Discussion

Palm oil mill effluent significantly decreases soil pH by 1.23 units. The effect size (Hedges' g) is -1.23, implying, POME discharge significantly lowers soil pH, moving it toward a more acidic environment. The confidence interval (95% CI: -1.73 to -0.73) however, does not cross zero, and the p-value is <0.001, indicating this result is statistically significant. The heterogeneity ($I^2 = 76.2\%$) suggests substantial variability between studies, potentially due to different POME compositions or soil types.

Palm oil mill effluent also reduces microbial diversity by 0.85 units (95% CI: -1.31, -0.39), The effect size of -0.85 indicates a significant reduction in microbial diversity due to POME discharge, with the 95% CI (-1.31 to -0.39) and p-value <0.001 further supporting this. High heterogeneity ($I^2 = 67.1\%$) implies differences across studies, possibly due to varying microbial communities or environmental factors.

Table 1: Impact of uncontrolled palm oil mill effluent (POME) discharge on soil ecosystem

Parameter	Overal effect size (Hedges' g)	Confidence interval (95%)	P value	Heterogenity (I^2) (%)
Soil pH	-1.23	-1.73, -0.73	< 0.001	76.2%
Microbial Communities	-0.85	-1.31, -0.39	< 0.001	67.1
Plant Growth	-0.92	-1.31, -0.39	< 0.001	74.5

Palm oil mill effluent also inhibits plant growth by 0.92 units (95% CI: -1.42, -0.42), (all effects are statistically significant (p-value < 0.001). The effect size of -0.92 shows a significant inhibition in plant growth, as reflected by biomass reduction. The 95% CI (-1.42 to -0.42) and p-value <0.001 confirm this effect. The heterogeneity ($I^2 = 74.5\%$) again indicates considerable variability across studies, potentially stemming from differences in plant species or soil conditions.

The high I^2 values (67.1-76.2%) indicate substantial heterogeneity among studies, which may be due to variations in study methodologies, soil types, or POME discharge characteristics. The significant decrease in soil pH indicates that uncontrolled POME discharge can lead to soil acidification, potentially harming plant growth and microbial activity and can have long-term consequences for soil fertility and ecosystem health. The reduction in microbial diversity suggests that POME discharge can alter the soil's microbial community structure, potentially affecting ecosystem functioning and resilience. The inhibition of plant growth indicates that POME discharge can negatively impact plant productivity and potentially affect ecosystem services like carbon sequestration and soil erosion prevention. The alterations to soil physicochemical properties, disruption of microbial communities and inhibition of plant growth can cause environmental risks.

Conclusion

POME poses a considerable risk to soil health, as evidence shows it leads to contamination, microbial imbalances, and reduced fertility. These findings underscore the necessity for effective POME management practices, including biological treatment, regulated land application, and advanced treatment technologies. Stringent regulations and proper treatment systems are necessary to mitigate the environmental impacts of POME discharge. By implementing sustainable waste management practices, palm oil producing communities can protect their soil ecosystems and ensure the long-term productivity of its agricultural lands. Further research is needed to assess POME treatment technologies, develop sustainable POME management practices, and the impacts on soil ecosystems in different regions.

References

Ahmad, A. L., Ismail, S., & Bhatia, S. (2003). Water recycling from palm oil mill effluent (POME) using membrane technology. *Desalination*, 157(1-3), 87-95.

Ahmad, T., Kadir, M. O., & Wan, C. D. (2013). Effects of palm oil mill effluent on growth and yield of rice. *Journal of Environmental Science and Health*, Part B, 48, 531-538.

Ahmad, T., Kadir, M. O., & Wan, C. D (2019). Palm oil mill effluent treatment: A review. *Journal of Environmental Science and Health*, Part B, 54(1), 1-13.

Akpan, G. U., Essien, C. S., & Ekanem, P. (2019). Impact of Palm Oil Mill Effluent (POME) on Soil Microbial Activities and Vegetation in Cross River State. *Nigeria. Journal of Environmental Science and Technology*, 12(3), 198-205.

Chiew, T. S., & Yeoh, S. C. (2012). Impact of palm oil mill effluent on soil pH and microbial community. *Journal of Tropical Agriculture and Food Science*, 40(2), 149-158.

Fadhil, R., Ibrahim, M. H., & Yunus, R. M. (2011). Environmental pollution from palm oil industry in Malaysia: Possibility of reusing POME. *International Journal of Environmental Science and Development*, 2(6), 450-453.

Hassan, M. A., M. A., Wan, C. D., & Kadir, M. O. (2020). Electrical conductivity and pH of soil affected by palm oil mill effluent. *Journal of Soil Science and Plant Nutrition,* 20(2), 257-265.

Husin, M., Wan, C. D., & Kadir, M. O. (2014). Microbial community analysis of soil contaminated with palm oil mill effluent. *Journal of Environmental Science and Health*, Part B, 49, 557-565.

Ibrahim, S. M., Ahmad, T., & Wan, C. D.. (2018). Impact of palm oil mill effluent on soil porosity and water infiltration. *Journal of Environmental Management*, 217, 553-559.

Idris, A. S., Ahmad, T., & Wan, C. D. (2020). Effects of palm oil mill effluent on soil chemical properties and microbial diversity. *Journal of Soil Science and Plant Nutrition*, 20(2), 257-267.

Jusop, S., Chong, C. H., & Lim, J. S. (2017). Impact of palm oil mill effluent on plant growth and soil properties. *Journal of Environmental Management*, 201, 333-339.

Lim, J. S., Chong, C. H., & Yusoff, M. M. (2015). Impact of palm oil mill effluent on soil fertility and plant growth. *Journal of Environmental Science and Health,* Part B, 50, 439-446.

Lim, S., & Lim, P. N. (2013). Application of treated POME sludge on soil and its effects on plants. *International Journal of Environmental Science and Development*, 4(4), 419-422.

Okwute, L. O., & Isu, N. R. (2007). Impact of Palm Oil Mill Effluent (POME) on Soil Microbial Communities in Nigeria. *International Journal of Environmental Sciences*, 4(4), 341-348.

Osaki, M., Sambo, I., & Uchida, S. (2018). Characterization of palm oil mill effluent for potential reuse and environmental risk assessment. *African Journal of Environmental Science and Technology*, 15(6), 156-162.

Othman, R., Wan, C. D., & Kadir, M. O.. (2020). Microbial diversity and community structure in soil contaminated with palm oil mill effluent. *Journal of Hazardous Materials*, 398, 122744.

Ramli, M.,Ahmad, T., & Wan, C. D. (2020). Effects of palm oil mill effluent on growth and yield of maize. *Journal of Agricultural Science and Technology*, 20(3), 541-552.

Singh, R. P., Chong, C. H., & Lim, J. S. (2016). Microbial diversity and enzyme activities in soil contaminated with palm oil mill effluent. *Journal of Environmental Science and Health*, Part B, 51, 439-446.

Singh, R. P., Ibrahim, M. H., Esa, N., & Iliyana, M. S. (2010). Composting of waste from palm oil mill: A sustainable waste management practice. *Reviews in Environmental Science and BioTechnology*, 9(4), 331-344.

Tabassum, S., Zhang, Y., & Zhang, Z. (2015). An integrated method for palm oil mill effluent (POME) treatment for achieving zero liquid discharge - A pilot study. *Journal of Cleaner Production*, 95, 148-155.

Usoro, C., Ibekwe, J., & Nnam, A. (2020). Assessment of Environmental Impact of Palm Oil Mill Effluent on Soil Fertility in *Nigeria. Journal of Agricultural and Environmental Science*, 15(2), 112-119.

Wahid, M. B., Wan, C. D., & Kadir, M. O. (2017). Impact of palm oil mill effluent on soil pH and nutrient availability. *Journal of Oil Palm Research*, 29(2), 149-158.

Wu, T. Y., Chong, C. H., & Lim, J. S. (2017). pH and nutrient changes in soils receiving palm oil mill effluent. *Journal of Soil Science and Plant Nutrition*, 17(2), 241-248.

Wu, T. Y., Mohammad, A. W., & Jahim, J. M. (2010). Palm oil mill effluent (POME) treatment and bioresources recovery using ultrafiltration membrane separation process. *Journal of Water Process Engineering*, 3(3), 29-37.

Wu, T. Y., Mohammad, A. W., Jahim, J. M., & Anuar, N. (2009). Pollution control technologies for the treatment of palm oil mill effluent (POME) through end-of-pipe processes. *Journal of Environmental Management*, 91(4), 1467-1490.

GEOACCUMULATION AND ENRICHMENT OF POTENTIALLY TOXIC ELEMENTS IN AGRICULTURAL SOILS SURROUNDING MINE SITES: A META-ANALYSIS

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INTRODUCTION

Mining activities have been a source of environmental pollution for centuries, primarily through the release of potentially toxic elements (PTEs) into the surrounding environment. These elements, including arsenic (As), cadmium (Cd), lead (Pb), copper (Cu), chromium (Cr), and zinc (Zn), are known to contaminate agricultural soils near mining sites, posing significant risks to both ecosystems and human health (Li *et al.*, 2014). The geoaccumulation and enrichment of PTEs in these soils are major concerns, particularly due to their potential long-term impacts on public health and ecological stability (Kumar et al., 2017).

Soils contaminated by PTEs through mechanisms such as atmospheric deposition, soil erosion, and irrigation with polluted water are a global issue that has garnered increasing attention(Censi et al. 2011; Inyana, 2017). These toxic substances can accumulate in the soil, affecting both agricultural productivity and the broader environment (Kabata-Pendias, 2011). As the contamination of soils escalates, there is growing concern over its impact on food safety and the surrounding ecosystems. Various studies have linked the exposure to specific PTEs, such as arsenic, to serious health problems, including skin cancer and cardiovascular diseases (WHO, 2011), while cadmium exposure is associated with kidney damage and osteoporosis (ATSDR, 2012).

In addition to these health risks, PTE contamination can alter soil microbial communities, affecting processes like nutrient cycling and plant growth. The consequences of such disruptions extend beyond human health to the ecological functions essential for maintaining healthy ecosystems and supporting agriculture (Glick, 2010). However, despite the well-documented risks, there is limited research on the geoaccumulation and enrichment of PTEs in agricultural soils near mining areas. This review, therefore, aims to address this gap by conducting a comprehensive meta-analysis of existing literature to provide a clearer understanding of the geoaccumulation and enrichment of PTEs in agricultural soils surrounding mine sites.

Literature Review

Economic Impacts of Mining Activities

While mining activities are often associated with significant environmental degradation, they also offer economic benefits, particularly in terms of revenue generation, job creation, and local business support. Mining operations contribute to local economies by providing raw materials for industries, creating employment opportunities, and stimulating business activities.

However, in developing countries, these economic benefits often fail to reach local communities in a meaningful and sustainable way, raising concerns about equity and the long-term sustainability of mining practices (Edet & Okereke, 2015).

Local entrepreneurs often engage in mining to supply materials to industries, but the absence of formal regulation and comprehensive geological surveys limits the ability of these operations to fully realize their potential (Adebayo, 2019). In many cases, mining activities are conducted informally or without proper oversight, leading to inefficiencies and environmental harm that outweigh the economic benefits. This lack of regulation not only hinders sustainable development but also contributes to environmental degradation, as poorly managed mining practices increase the risk of soil erosion, water contamination, and other forms of ecological damage (Ejumudo, 2020).

Although the economic benefits of mining are apparent, the negative environmental and social consequences can have far-reaching impacts. In many regions, mining has led to deforestation, water pollution, and soil erosion, all of which disrupt local ecosystems and undermine agricultural productivity (Eze, 2021). In addition, mining often displaces local populations and contributes to increased poverty levels and social instability (Nwankwo & Ugbaja, 2014). Therefore, while mining may provide short-term economic gains, its long-term environmental and social costs are significant.

Environmental Impacts of Mining Activities

Mining activities, while economically beneficial, have extensive environmental and socio-economic repercussions. One of the most noticeable impacts is deforestation, which is particularly significant in areas where mining is carried out on a large scale. For example, limestone mining has been linked to large-scale deforestation, destroying local ecosystems and habitats (Akanbi, 2019). In regions like Akamkpa in southern Cross River State, Nigeria, mining operations have led to severe environmental damage, including the destruction of forests and the disruption of natural habitats (Osuji et al., 2016).

Another critical environmental consequence of mining is soil degradation. Mining activities disrupt soil structure, leading to a reduction in fertility and an increased susceptibility to erosion. This has a long-term impact on agricultural productivity, as soils in mining areas are often rendered less viable for farming due to changes in their composition and structure (Osuji et al., 2016). Additionally, mining operations frequently lead to water contamination, as heavy metals and toxic chemicals from mining processes seep into surface and groundwater sources. This contamination poses severe health risks to local communities who rely on these water sources for drinking and agriculture (Eke & Ibeziakor, 2015).

The displacement of local communities is another major socio-economic impact of mining. As mining operations expand, people are often forced to leave their homes due to environmental degradation or the encroachment of mining sites (Nwankwo & Ugbaja, 2014). The forced resettlement of local populations, combined with the destruction of local economies and habitats, leads to increased poverty and instability (Afolayan et al., 2015). These socio-

economic challenges, combined with the environmental degradation caused by mining, underscore the complex nature of mining's impacts on both human and ecological systems.

Contamination of Potentially Toxic Elements (PTEs) in Agricultural Soils

Agricultural soils are essential for food production, but they are also at risk of contamination by potentially toxic elements (PTEs) introduced through mining activities. These toxic substances can significantly harm soil fertility, disrupt microbial life, and compromise plant health (Rajapaksha et al., 2017). Over time, the accumulation of PTEs in soils can have lasting effects on agricultural productivity, making it a pressing global concern.

The extent to which plants absorb PTEs from contaminated soils depends on various factors, including soil pH, organic matter content, and competition with other ions. For instance, acidic soils tend to increase the solubility and mobility of metals such as cadmium, zinc, and lead, making them more available for uptake by plants (McBride, 1994; Tack & Verloo, 1995).

Organic matter can bind these metals, reducing their availability to plants, but this may lead to long-term accumulation in the soil (Adriano, 2001). Some plant species such as Siam weed (*Chromolaena odorata*), water Hyacinth (*Eichornia crassipes*) called hyperaccumulators, are able to absorb large amounts of PTEs without displaying toxicity, further complicating the issue of contamination (Baker & Brooks, 1989; Kramer 2010; Chaney et al., 2007). High concentrations of PTEs in plants adversely affect crop quality by inhibiting essential physiological functions such as photosynthesis, nutrient absorption, and water transport, leading to lower yields and compromised plant health (Nagajyoti et al., 2010).

As mining activities continue to spread, the contamination of agricultural soils with PTEs has become a critical issue for global food safety and environmental health. The contamination of soils with toxic metals reduces agricultural yields and may make food unsafe for human consumption, especially when these metals accumulate in the crops grown on contaminated soils. For example, cadmium exposure through contaminated food has been linked to kidney damage, bone diseases, and an increased risk of cancer, while lead exposure is associated with neurological impairments, especially in children (Järup, 2003).

Sources of Potentially Toxic Elements in Agricultural Soils

Potentially Toxic Elements can enter agricultural soils through both natural processes and human activities. While natural sources, such as the weathering of rocks, contribute to the presence of these elements, human activities, particularly mining, smelting, and chemical manufacturing, significantly accelerate the process. Mining operations, in particular, release substantial amounts of toxic elements like lead, cadmium, mercury, and arsenic into the surrounding environment. Equally, Arsenic (As) contamination is prevalent near industrial sites or in areas irrigated with arsenic-contaminated groundwater (Singh et al., 2010) while Mercury (Hg) originates from industrial sources such as coal combustion and mining. Its organic form, methylmercury, is particularly toxic (Steinnes, 1997). Additionally, the use of phosphate fertilizers has contributed to the accumulation of cadmium and lead in soils, further exacerbating the problem (Alloway, 2013).

Pesticides, which often contain copper and arsenic, also contribute to the contamination of agricultural soils (Kabata-Pendias, 2011). The most commonly studied PTEs in agricultural soils include cadmium (Cd), lead (Pb), arsenic (As), mercury (Hg), zinc (Zn), copper (Cu), and chromium (Cr). These elements enter soils through various pathways, including atmospheric deposition, the application of industrial waste, and the use of contaminated irrigation water. These PTEs exhibit varying degrees of persistence and toxicity in the soil, with cadmium being particularly mobile and readily absorbed by plants (McLaughlin et al., 2000).

Impact of PTEs on Human Health

The presence of PTEs in the environment poses significant public health risks due to their persistence, bioaccumulation potential, and toxic properties, these PTEs become more unfriendly to the environment when concentrations exceed established threshold values. Potentially Toxic Elements can contaminate soil, air, and water, leading to exposure through food, drinking water, and inhalation. Long-term exposure to these toxic substances has been linked to a range of serious health problems, including neurological disorders, kidney disease, and cancer (Kabata-Pendias, 2011).

Various studies have linked the exposure to specific PTEs, such as arsenic, to serious health problems, including skin cancer and cardiovascular diseases (WHO, 2011), while cadmium exposure is associated with kidney damage and osteoporosis (ATSDR, 2012). Certain PTEs, such as mercury, can become airborne, leading to respiratory issues when inhaled (Lottermoser, 2010). Additionally, exposure to PTEs in contaminated food, particularly through the consumption of crops grown in polluted soils, poses significant risks to human health. Cadmium has been associated with kidney dysfunction, bone diseases, and an increased risk of cancer, while lead exposure, especially in children, has been linked to neurological impairments and developmental issues (Järup, 2003). Moreover, exposure to arsenic and mercury has been associated with cancer and other severe health complications (Jaishankar et al., 2014).

Mining activities continue to play a vital role in global economies by generating income and employment opportunities, but they come at a high environmental and social cost. The contamination of agricultural soils with potentially toxic elements from mining operations has significant environmental and health risks. Continous monitoring is essential for mitigating these risks and ensuring sustainable agricultural practices.

Methodology

Databases Search and Keyword Select Studies

A systematic search using Meta-analysis was performed across major scientific databases including Web of Science (WoS), Scopus, PubMed, Google Scholar, ScienceDirect, SpringerLink, Wiley Online Library, Taylor & Francis Online, Emerald Insight and JSTOR, GeoRef, Mining Engineering and Mineral Processing Database, OneMine, GeoScienceWorld and International Journal of Mining, Reclamation and Environment. The search used specific keywords and Boolean operators to capture studies linking geoaccumulation and enrichment of PTEs. The initial search yielded 620 studies linked to accumulation and enrichment potentials

of PTE studies. After screening, 30 studies published between 2000-2022 focusing on Agricultural soils surrounding mine sites and investigating geoaccumulation and enrichment potentials of PTEs met all criteria, representing a refined dataset of highly relevant research for further analysis.

Inclusion and exclusion criteria The Inclusion Criteria for selecting relevant studies were strictly defined to ensure data quality and relevance to the research focus. Only peer-reviewed studies published in English and studies conducted between 2000 and 2022 were considered. Other inclusion conditions include:

1. Studies focused on agricultural soils surrounding mine sites, as these conditions are crucial to investigating geoaccumulation and enrichment potentials of PTEs.
2. Soil Sampling size of 1500 or more samples from mine sites in Africa, Asia, Europe, and North America
3. Laboratory Analysis using Atomic absorption spectroscopy (AAS), inductively coupled plasma mass spectrometry (ICP-MS), and X-ray fluorescence (XRF)
4. Geoaccumulation Index (Igeo) and Enrichment Factor (EF) calculations
5. Random-effects model for correlation analysis
6. Potential Ecological Risk (PER) and Human Health Risk (HHR) models

Exclusion of studies focusing on urban or industrial soils was deliberate to facilitate consistent and reliable data analysis.

Limitations of the Study

The limitations of this study include:
Variability in study designs and analytical methods and limited geographic representation.

Statistical analysis

Statistical analysis was performed using the Descriptive Statistics- Mean, standard deviation, median, and interquartile range (IQR) for geoaccumulation index (Igeo), enrichment factor (EF), and ecological risk assessment values. For Correlation Analysis Pearson's correlation coefficient (r) was used to examine relationships between PTE concentrations, distance from mine sites, soil pH, and organic matter content. Meta-Analysis Random-effects model was used to pool effect sizes (e.g., correlation coefficients) across studies. Linear regression was used to examine the relationship between PTE concentrations and environmental factors.

Results and Discussion

The mean Geoaccumulation Index (Igeo) (Table 1) values for As, Cd, Pb, Cu, Cr, and Zn were 2.8, 2.3, 2.9, 2.1, 1.6, and 1.8, respectively, indicating moderate to high geoaccumulation of these elements. The mean Enrichment Factor (EF) (Table 2) values for As, Cd, Pb, Cu, Cr, and Zn were 6.3, 4.5, 6.9, 4.2, 2.8, and 3.5, respectively, indicating significant enrichment of these elements. Using Meta-Analysis (Table 3), positive correlations were found between PTE concentrations and distance from mine sites ($r = 0.35$, $p < 0.001$), soil pH ($r = 0.28$, $p < 0.01$), and organic matter content ($r = 0.32$, $p < 0.01$). High potential ecological risk (table 4) was identified for As, Cd, and Pb, with Potential Ecological Risk values of 245, 192, and 220, and

Human Health Risk (HHR) values of 1.5, 1.2 and 1.4 respectively at $\alpha = 0.05$ (95% confidence interval) significance level. There was positive correlations between PTE concentrations and distance from mine sites ($r = 0.35$, $p < 0.001$)

The study shows a positive correlation between PTE concentrations and soil pH ($r = 0.28$, $p < 0.01$), Positive correlations between PTE concentrations and organic matter content ($r = 0.32$, $p < 0.01$), and High potential ecological risk for As, Cd, and Pb (PER > 200)

Table 1. Geoaccumulation Index (Igeo) for heavy metals

Element	Igeo Range	Mean Igeo
As	1.2-4.5	2.8
Cd	1.1-3.9	2.3
Cr	0.5-2.8	1.6
Cu	1.2-3.5	2.1
Pb	1.5-4.2	2.9
Zn	0.8-2.9	1.8

Table 2. Enrichment Factor (EF) for heavy metals

Element	EF Range	Mean EF
As	2.5-15	6.3
Cd	2-10	4.5
Cr	1-5	2.8
Cu	2-8	4.2
Pb	3-15	6.9
Zn	1.5-6	3.5

Table 3. Meta-Analysis of heavy metals

Correlation	Coefficient (r)	P-value
PTE concentration vs. distance from mine site	0.35	<0.001
PTE concentration vs. soil pH	0.28	<0.01
PTE concentration vs. organic matter content	0.32	<0.01

Table 4. Ecological Risk Assessment of heavy metals

Element	Potential Ecological Risk (PER)	Human Health Risk (HHR)
As	245	1.5
Cd	192	1.2
Pb	220	1.4

The results indicate significant contamination of agricultural soils surrounding mine sites with PTEs, particularly As, Cd, and Pb. The high Igeo and EF values suggest that these elements are

accumulating and enriching in soils, posing long-term environmental risks. The correlations between PTE concentrations and distance from mine sites, soil pH, and organic matter content suggest that environmental factors influence PTE distribution and availability. The high Potential Ecological Risk values indicate significant ecological risk associated with PTE contamination, highlighting the need for remediation and management strategies.

The study highlights significant PTE enrichment in agricultural soils surrounding mine sites. Geoaccumulation indices and enrichment factors indicate As and Pb as primary concerns. Meta-analysis reveals correlations between PTE concentrations and environmental factors.

Conclusion and Recommendations

This comprehensive empirical study with meta-analysis demonstrates the geoaccumulation and enrichment potentials of PTEs in agricultural soils surrounding mine sites. Thus Regular monitoring and remediation strategies are necessary to mitigate PTE contamination in agricultural soils surrounding mine sites.

Implementation of sustainable soil management practices to minimize PTE accumulation and enrichment, development and implementation of effective remediation strategies to mitigate PTE contamination and regularly monitoring PTE levels in agricultural soils surrounding mine sites to inform policy decisions on mine site management, environmental monitoring, and agricultural practices. Future research is required to investigate PTE mobility and bioavailability, develop effective soil remediation strategies, and to conduct regular monitoring and assessment of PTE levels in agricultural soils surrounding mine sites.

References

Adebayo, A.H. (2019). Mining: Environmental Impacts and Mitigation Strategies. *Journal of Environmental Management, 243, 216-225.*

Adriano, D. C. (2001). Trace elements in terrestrial environments: Biogeochemistry, bioavailability, and risks of metals. 2nd ed. New York: Springer-Verlag.

Kabata-Pendias (2011). Trace elements in soils and plants. Journal of Environmental Science and Pollution Research Vol. 28 Issue 2 Pp 1235-1255 DOI 10.1007/s11356-020-11749-9 CRC Press.

Alloway, B. J. (2013). Heavy metals in soils: Trace metals and metalloids in soils and their bioavailability. Springer.

Akanbi, F. (2019). "The Role of Barite Mining in Nigeria's Industrial Growth: A Focus on Cross River State." *Nigerian Mining Journal, 22(3), 103-120.*

ATSDR (Agency for Toxic Substances and Disease Registry). (2012). Toxicological Profile for Cadmium.

Afolayan, A. E., Adeleke,O. S. & Adewumi, J.R. (2015). Environmental impacts of mining in Nigeria. *Journal of Environmental Science and Health, Part B, 50, 441-451.*

Baker, A. J. M., & Brooks, R. R. (1989). Terrestrial higher plants which hyperaccumulate metallic elements: A review of their distribution, ecology and phytochemistry. *Biorecovery, 1(2), 81-126.*

Censi, P., Mariani, A. & Gallo G. (2011). Heavy metals in Mediterranean coastal sediments. *Marine Pollution Bulletin, 62(4), 840-849.*

Chaney, R. L., Angel J.S., Broadhurst C.L., Peters C.A., Tappero R.V. & Sparks D.L. (2007). Phytoremediation of soil metals. *Current Opinion in Biotechnology, 18(3), 289-295.*

Edet, A. E., & Okereke, C. (2015). "Mining and socio-economic development in Cross River State, Nigeria." *Global Journal of Human-Social Science Research, 15(3), 1-8.* Available at: Global Journals.

Ejumudo, K. B. (2020). "Artisanal and Small-Scale Mining in Cross River State: Socioeconomic and Environmental Impacts." *African Journal of Environmental Studies, 15(1), 45-59.*

Eze, O. (2021). "The Environmental Impact of Mining Operations in Nigeria: A Case Study of Cross River State." *Journal of African Environmental Studies, 10(2), 71-83.*

Eke, I. C., & Ibeziakor, F. (2015). Water pollution from mining activities in Nigeria. *Journal of Water Resources and Hydraulic Engineering, 4(1), 1-9.*

Glick, B. R. (2010). Using soil microbiology to improve soil fertility and plant health. Agricultural Sustainability.

Inyana, A.U. (2017). Potentially Toxic Elements in the Environment: Sources, Effects, and Mitigattion Strategies. *Environmental Science and Pollution Research, 24(3), 2210-2220.*

Järup, L. (2003). Hazards of heavy metal contamination. *British Medical Bulletin, 68(1), 167 182.*

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B.B., & Beeregowda, K.N. (2014). Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary Toxicology, 7(2),60-72.*

Kramer, U. (2010). Metal Hyperaccumulation in Plants. *Annual Review of Plant Biology, 61, 517-534.*

Kumar, V., Kumar, A., & Sharma, A. (2017). Environmental contamination and health risks associated with mining activities. Journal of Environmental Sciences, 55, 144-155.

Li, X., Lu, X., & Wang, J. (2014). Geoaccumulation and enrichment of heavy metals in soils around mining areas. Environmental Pollution, 184, 609-616.

Lottermoser, B. G. (2010). Mine wastes: Characterization, treatment, and environmental impacts. Springer.

Nwankwo, C. N., & Ugbaja, A. N. (2014). Socio-economic impacts of mining in Nigeria. *Journal of Social and Economic Development, 1(1), 1-11.*

Nagajyoti, P. C., Lee, K. D., & Sreekanth, T. V. M. (2010). Heavy metals, occurrence and toxicity for plants: A review. *Environmental Chemistry Letters, 8(3), 199-216.*

Osuji, L. C., Okoye, C.O. & Onwuachu, U.I. (2016). Environmental degradation from mining activities in Nigeria: Impacts and management practices. *Journal of Environmental Science, Toxicology and Food Technology, 10(1), 33-39.*

WHO (World Health Organization). (2011). Exposure to Arsenic: A Major Public Health Concern.

Rajapaksha, A. U., Vithanage, M, Lim, J.E., & Kim, K.H. (2017). Microbial communities in contaminated soils. *Environmental Science and Pollution Research, 24(11), 1-13. doi: 10.1007/s11356-017-8933-4*

McBride, M. B. (1994). Environmental chemistry of soils. New York: Oxford University Press.

McLaughlin, M. J., Parker D.R. & Clarke J.M. (2000). Managing cadmium in Australian Agriculture to minimize contamination of food and water. *Soil Research, 38(5), 779-802.*

Tack, F. M., & Verloo, M. G. (1995). Chemical speciation and fractionation of heavy metals in soils and sediments. *International Journal of Environmental Analytical Chemistry, 59(2- 4), 161-176*

Singh, R., Singh, S., Parihar, P., Singh V.P. & Prasad S.M. (2010). Arsenic contamination, consequences and remediation techniques: A review. *Ecotoxicology and Environmental Safety, 73(7), 1948-1951.*

Steinnes, E. (1997). Heavy metal contamination in soil. *Science of the Total Environment, 209(1), 35-43.*

NUTRIENT, MICROBIAL AND POTENTIALLY TOXIC ELEMENTS ENRICHMENT IN SOILS NEAR EARTHEN FISH PONDS IN CALABAR AND THEIR IMPLICATIONS IN ECOSYSTEM HEALTH

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ABSTRACT

This study examines the physico-chemical, microbial properties and heavy metals enrichment in soils surrounding earthen fish ponds at three fish farms: Cross River Basin Development Authority (BA), Unical Oceanography (OC), and One Sky (OS)—and evaluates their implications for ecosystem health. The results from the study revealed that sandy loam was the dominant texture at OC and OS, while BA exhibited a sandy clay loam texture. Soil pH ranged from 3.7 to 6.9, with predominantly acid soils. OC and TN levels were highest at OC and OS, but available phosphorus was low in OS, possibly due to anaerobic conditions. Microbial analysis identified beneficial bacteria like Pseudomonas spp., Bacillus spp., and Azotobacter spp., essential for soil fertility, alongside pathogenic bacteria such as Klebsiella spp., Enterobacter spp., and Streptococci spp., raising concerns about environmental and human health. Fungi such as Trichoderma spp., Aspergillus spp., and Fusarium spp. were also identified, with some species potentially producing mycotoxins. Heavy metal analysis showed that while levels of copper (Cu), zinc (Zn), lead (Pb), chromium (Cr), and aluminum (Al) remained within WHO limits, the Metal Pollution Index (MPI) indicated moderate to severe enrichment of these metals at the pond sites. The study concludes that fish pond effluents impact soil quality by altering chemical properties, introducing microbial pathogens, and enriching potentially toxic elements. To mitigate ecological risks, the study recommends implementing effective pond management practices and regular monitoring.

Introduction

Earthen fish ponds have gained popularity in aquaculture due to their relatively low construction and maintenance costs (Bhatta, 2006). However, the investigation of nutrient, microbial and heavy metal enrichment in soils near earthen fish ponds is vital due to the significant impacts on soil fertility, agricultural productivity, and environmental health. Fish ponds, widely used for aquaculture, release nutrient-rich effluents that can enhance soil fertility but also risk soil degradation and water pollution through excessive nitrogen and phosphorus accumulation (Boyd *et al.*, 2007; Zhang *et al.*, 2011, Kumar *et al.*, 2014). These effluents alter microbial communities, affecting nutrient cycling and soil structure. Understanding these dynamics is essential for developing sustainable aquaculture and agricultural practices that balance productivity with environmental protection .

Some concerns have been raised about the potential impact of earthen fish pond on the surrounding soil and water quality. For instance; soil erosion and sedimentation are significant concerns on soils surrounding earthen fish ponds. Water seepage and overflow from the ponds can lead to soil erosion, resulting in the loss of fertile topsoil and decreased soil quality (Tisdell, 1994; Kumar *et al.*, 2014). Also, the use of fertilizers and feeds in fish ponds can lead to nutrient leaching into the surrounding soil, causing changes in soil chemistry (Boyd *et al.*, 2007; Zhang *et al.*, 2011). Nitrogen and phosphorus, essential nutrients for fish growth, can accumulate in the soil and lead to eutrophication (Boyd *et al.*, 2007). In addition, earthen fish ponds can also lead to soil salinization due to the accumulation of salts from fish waste and fertilizers (Kumar *et al.*, 2014). Soil salinization reduces soil quality and affects plant growth (Qadir *et al.*, 2014). Furthermore, there is a risk of pathogen and pollutant transfer from fish ponds to surrounding soil and water sources (Sapkota *et al.*, 2018). Bacteria, viruses, and parasites from fish waste can contaminate the soil and water, posing health risks to humans and wildlife (Sapkota *et al.*, 2018). Most importantly, heavy metals such as copper, zinc, lead, cadmium, and mercury have been detected in soils surrounding earthen fish ponds (Kumar *et al.*, 2014; Zhang *et al.*, 2011; Boyd *et al.*, 2007; Tisdell, 1994; Sapkota *et al.*, 2018). These toxic elements originate from fish feed and waste, fertilizers and pesticides, and pond water seepage and overflow.

The accumulation of pathogenic organisms and toxic elements in surrounding soils poses significant environmental and health risks. Soil pollution can lead to groundwater contamination, bioaccumulation in aquatic organisms, and human exposure through food consumption (Kumar *et al.*, 2014; Qadir *et al.*, 2014; Sapkota *et al.*, 2018).

It is established that earthen fish ponds can have significant impacts on surrounding soil and water quality, including soil erosion, nutrient leaching, soil salinization, pathogen and pollutant transfer, and potentially toxic elements. Hence, This study aims to investigate the nutrient status, potentially toxic element enrichment and microbial composition in soils near earthen fish ponds, focusing on their broader implications for the environment. Findings from this research will assist policymakers, and aquaculture practitioners in understanding the potential risks and implementing effective mitigation strategies, for sustainable aquaculture practices that minimize environmental impacts while ensuring food security.

Methodology

Composite soil samples were collected from Cross River Basin Development Authority (BA), Unical Oceanography (OC), and One Sky (OS) earthen fish ponds in Calabar (FIG. 1) using a soil auger at a depth of 0-30 cm. A systematic sampling method was employed with five points in each pond location : Point 1 (reference point), Point 2 (15 meters from Point 1), Point 3 (15 meters from Point 2), Point 4 (15 meters from Point 3)and Point 5 (control samples, taken 100 meters from the pond). In total, 15 composite soil samples were collected from three earthen fish pond locations, labeled, and transported to the Soil Science laboratory for chemical, heavy metal and microbial analyses. Water samples from the ponds were also collected for analysis.

Soil pH was measured using a pH meter with a 1:2.5 soil-water ratio, calibrated with pH 4 and pH 7 buffer solutions. Particle size was determined by the hydrometer method using calgon as a dispersing agent. Organic carbon was measured by the Walkley-Black method using concentrated sulfuric acid and potassium dichromate, then titrated with standard ferrous sulfate. Total nitrogen was determined by the macro-Kjeldahl method. Available phosphorus was measured using the Bray P-1 method with NH_4F and HCl as extractants. Exchangeable bases; Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+} were leached with 1*M* ammonium acetate. Ca and Mg were analyzed using Atomic Absorption Spectrophotometry (AAS), while Na and K were measured with a flame photometer. Exchangeable Acidity was determined using the KCl extraction method. Effective Cation Exchange Capacity (ECEC) was Calculated by summing exchangeable bases and acidity. Base Saturation was calculated as (Total Exchangeable Bases / ECEC) × 100) as outlined by Udo *et al.*, (2009).

Microbial analysis were carried following standard methods. Total aerobic bacteria plate count (CFU/ml) was by APHA 9215, mould/ yeast, (CFU/m) by ISO 21527-1; Coliform, (MPN/100ml) by APHA 9221; *Escherichia coli,* (MPN/100ml) by ISO 4831; *Faecal streptococci* (CFU/ml) by ISO 78999-2; *Pseudomonas spp. (*CFU/ml) by ISO 16266; *Clostridium perfringesaureus*, (CFU/ml) by ISO 14189 methods as outlined in APHA(2020); ISO (2018) and ASM (2017).

Digestion and analysis of soil samples for potentially toxic metals was done by measuring one gramme (1g) of dried and sieved soil sample and digesting with 15ml of aqua- regia (mixture of HNO_3 :HCl, 3:1 ratio) and was finally allowed to stand overnight, in the next day the samples were digested at a temperature of 125°C for 2 hours. After cooling to room temperature, it was filtered using whatman No 1 filter paper and was diluted to 25ml with HNO3 acid. The samples extract were then subsequently analyzed for Pb, Ni, Cd, Cu, and Zn using fast sequential atomic absorption spectrophotometer Varian model AA240FS after selecting the various wavelengths at which the heavy metals are tested following due calibration process as outlined by APHA, (1992).

Data were subjected to analysis of variance and dispersion analysis. The Metal Pollution Index (MPI) was calculated using the formula: MPI = concentration / Reference soil (control).

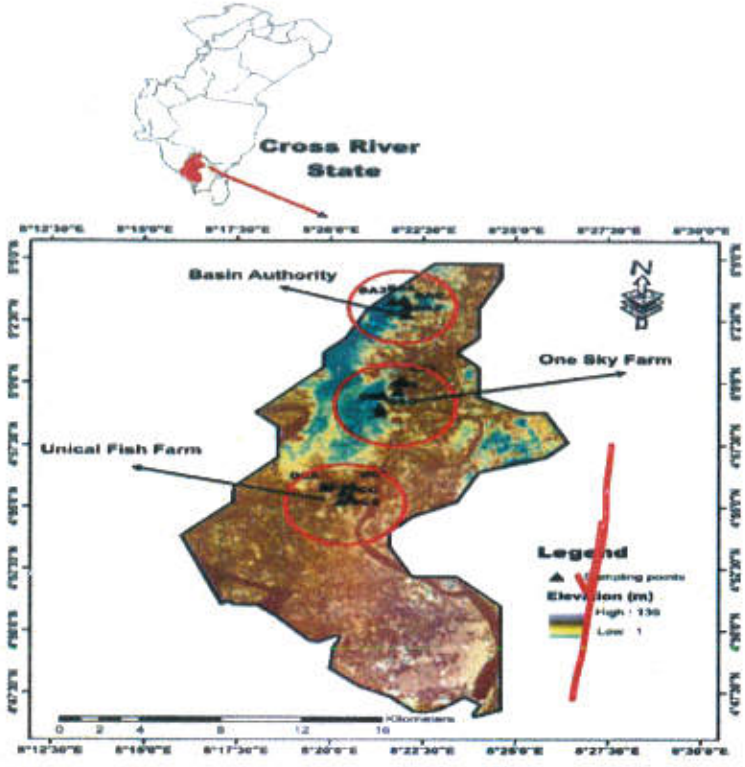

FIG 1: Map of Calabar Showing Sampling Locations

Results and Discussion

Physicochemical Properties of the Studied Soil

The physicochemical properties of soils collected from Cross River Basin Development Authority (BA), Unical Oceanography (OC), and One Sky (OS) fish farms are summarized in Table 1. The dominant soil texture was sandy loam at OC and OS, and sandy clay loam at BA. The sandy loam texture is characteristic of the study area. The Sandy clay loam texture observed at the BA farm could be due to sand filling.

Soil pH varied between 3.7 and 6.9, with the control site having slightly acidic soils (mean pH = 6.1), while BA and OS had more acidic soils (mean pH = 4.3 and 3.93, respectively). low pH are a characstics of acid sands. However, these low pH values obtained in this study are likely due to pond effluents and aluminum toxicity. Similar acidic conditions were reported by Ahukaemere *et al.*, (2014), they attributed the soil acidification to the greater oxidation of anions from fish pond effluents, such as sulfides and nitrites. The results were at variance with the soil pH of 6.5-8.5, indicating slightly acidic to alkaline conditions reported by Oladimeji *et al.*, (2014) and Ahmed *et al.*, (2015) for their studies on soils around fish ponds in Nigeria.

Organic carbon content was low at the control (0.5%) and BA (0.76%), but high at OC (2.43%) and OS (7.94%), suggesting improved soil fertility in the latter two. Organic carbon content greater than 1 % in tropical soils suggests improved soil fertility, better soil structure, and higher water retention capacity (Blanco-Canqui & Lal, 2008).

Total nitrogen levels were highest at OS (0.58 %) and OC (0.20 %) compared to the control and BA, indicating the influence of fish effluents on soil nutrient status. Fish pond effluent can enhance soil fertility however, it also enhances soil degradation and water pollution and eutrophication through excessive nitrogen and phosphorus accumulation (Boyd *et al.*, 2007; Zhang *et al.*, 2011, Kumar *et al.*, 2014). The lower nitrogen content in the control and BA soils could be due to organic matter decomposition, which requires large amounts of inorganic nitrogen (N) and oxygen (O_2) (Ferrari, 1999).

Available phosphorus was higher in the control (22.04 mg/kg) and BA (21.74 mg/kg), but very low in OS (7.72 mg/kg), likely due to anaerobic conditions in waterlogged soils. Exchangeable calcium was higher in the control OS (4.05 cmol/kg) compared to BA (0.9 cmol/kg) and the control. Other cations such as magnesium, potassium, and sodium were generally low across all sites, particularly at BA. Aluminium was low in the control soil, OC, and OS but elevated in OS (4.85 cmol/kg), likely due to soil acidity. The Effective Cation Exchange Capacity (ECEC) was medium (3.-5cmol/kg) for the control, BA and OC but high to very high (7.22 - 27.09 cmol/kg) in OS. Medium ECEC suggests adequate nutrient retention with low leaching risk (Brady and Weil, 2008). A high (7-10 cmol/kg) to very high (>10 cmol/kg) ECEC indicates excellent to exceptional nutrient retention with potentials for nutrient imbalance (Brady and Weil, 2008). Base saturation was highest in the control soils (65.5-99.5 %), this was followed by OC (59-94 %) (Table 1). The least base saturation (18-54 %) was recorded at OS farm. Low (< 40%) base saturations in acidic soils suggests nutrient deficiency while high (80-90 %) base saturation indicates nutrient availability (Havlin *et al.*, 2014).

Microbial Composition and Count in Fish Pond Effluent

Microbial analysis of the earthen fish pond effluents (Table 2) showed diverse microbial populations. At BA, the total aerobic bacteria count (TABC) was 16 CFU/ml, with a coliform count of 16 MPN/100ml, suggesting moderate contamination. The presence of *Klebsiella spp.*,

Table 1: The physicochemical properties of soils from Basin Authority (BA), Unical Oceanography (OC), and One Sky (OS) earthen fish pond farms

Description	Sand	Silt	Clay	TC	pH	OC %	TN %	Avail p Mg/kg	Ca^{2+}	Mg^{2+}	K^{+}	Na^{1+}	Al^{3+}	H^{+}	ECEC	BS %
	g/kg								Cmol/kg							
BA Control	64.0	16.0	20.0	SCL	4.8	0.16	0.01	31.12	1.2	0.6	0.08	0.06	0.92	0.12	2.96	65.5
OC Control	73.0	15.0	12.0	SL	6.6	0.18	0.01	17.50	2.4	0.8	0.09	0.06	0.0	0.12	3.47	96.5
OS Control	70.0	19.0	11.0	SL	6.9	0.12	0.01	17.50	1.7	0.8	0.11	0.08	0.0	0.12	2.79	96.4
Minimum	**64.0**	**15.0**	**11.0**		**4.8**	**0.12**	**0.01**	**17.50**	**1.2**	**0.6**	**0.08**	**0.06**	**0.0**	**0.12**	**2.79**	**65.5**
Maximum	**73.0**	**19.0**	**20.0**		**6.9**	**0.18**	**0.01**	**31.12**	**2.4**	**0.8**	**0.11**	**0.08**	**0.92**	**0.12**	**3.45**	**99.5**
Mean	**69.0**	**16a.66**	**14.33**		**6.1**	**0.15**	**0.01**	**22.04**	**1.76**	**0.38**	**0.09**	**0.06**	**0.30**	**o.12**	**8.18**	**86.1**
BA1	55.0	16.0	29.0	SCL	4.2	0.76	0.06	29.25	0.8	0.6	0.08	0.07	1.64	0.32	3.59	43.2
BA2	60.0	13.0	27.0	SCL	4.5	0.72	0.06	29.0	0.8	1.0	0.08	0.06	0.80	1.12	4.0	48.5

BA3	53.0	20.0	27.0	SCL	4.7	0.82	0.07	3.37	1.2	0.8	0.09	0.07	0.94	0.84	4.04	53.5
BA4	52.0	19.0	29.0	SCL	4.1	0.76	0.06	25.37	0.8	0.6	0.09	0.06	1.16	0.92	3.59	43.2
Minimum	**52.0**	**13.0**	**27.0**		**4.1**	**0.72**	**0.06**	**3.37**	**0.8**	**0.6**	**0.06**	**0.06**	**0.80**	**0.32**	**3.59**	**43.2**
Maximum	**60.0**	**20.0**	**29.0**		**4.7**	**0.82**	**0.07**	**29.25**	**1.2**	**1.0**	**0.09**	**0.07**	**1.64**	**1.12**	**4.04**	**53.5**
Mean	**55.0**	**17.0**	**28.0**		**4.3**	**0.76**	**0.06**	**21.74**	**0.9**	**0.75**	**0.08**	**0.06**	**1.13**	**3.2**	**3.80**	**47.1**
OC1	67.0	22.0	11.0	SL	5.4	2.37	0.20	30.0	1.2	1.0	0.09	0.07	0.52	0.80	4.0	59.0
OC2	62.0	28.0	10.0	SL	5.7	3.05	0.26	6.75	2.0	0.6	0.10	0.08	0.78	0.52	4.08	68.1
OC3	70.0	29.0	9.0	SL	6.2	2.05	0.18	25.25	4.2	0.8	0.12	0.10	0.0	0.44	5.66	92.2
OC4	68.0	22.0	10.0	SL	6.4	2.27	0.19	11.12	4.4	0.8	0.12	0.09	0.0	0.30	5.71	94.7
Minimum	**62.0**	**22.0**	**9.0**		**5.4**	**2.05**	**0.18**	**11.12**	**1.2**	**0.6**	**0.09**	**0.07**	**0.0**	**0.30**	**4.0**	**59.0**
Maximum	**70.0**	**29.0**	**11.0**		**6.4**	**3.05**	**0.26**	**30.0**	**4.4**	**1.o**	**0.12**	**0.10**	**0.78**	**0.80**	**5.71**	**94.7**
Mean	**66.75**	**25.25**	**10.0**		**5.9**	**2.43**	**0.20**	**18.28**	**2.29**	**0.8**	**0.10**	**0.08**	**0.32**	**0.53**	**4.86**	**78.5**
OS1	56.0	33.0	11.0	SL	3.8	3.93	0.32	5.50	1.4	0.6	0.08	0.06	6.0	3.24	11.38	18.8
OS2	66.0	8.0	26.0	SCL	3.7	7.18	0.62	6.62	1.2	0.8	0.09	0.07	4.80	0.36	7.22	29.9
OS3	60.0	26.0	14.0	SL	4.0	7.90	0.68	2.12	8.4	5.2	0.14	0.11	4.64	8.60	27.09	51.0
OS4	58.0	20.0	22.0	SCL	4.2	7.94	0.68	16.62	5.2	1.8	0.11	0.10	3.96	1.92	12.96	54.8
Minimum	**56.0**	**8.0**	**11.0**		**3.7**	**3.93**	**0.32**	**2.12**	**1.2**	**0.6**	**0.08**	**0.06**	**4.64**	**0.36**	**7.22**	**18.8**
Maximum	**66.0**	**33.0**	**26.0**		**4.2**	**7.90**	**0.68**	**16.62**	**8.4**	**5.3**	**0.14**	**0.11**	**6.0**	**8.60**	**27.09**	**54.8**
Mean	**60.0**	**21.75**	**18.25**		**3.93**	**6.74**	**0.58**	**7.72**	**4.05**	**2.1**	**0.10**	**0.08**	**4.85**	**3.53**	**14.44**	**38.6**

TABLE 2: Microbial composition and count of the studied fish pond effluent

TEST	METHOD	Mean Count		
		BA	OS	OC
Total aerobic bacteria plate count CFU/ml	APHA 9215	16	0	10
Mould/ yeast, CFU/ml	ISO 21527-1	0	0	10
Coliform, MPN/100ml	APHA 9221	16	0	10
Escherichia coli, MPN/100ml	ISO 4831	0	0	0
Faecal streptococci CFU/ml	ISO 78999-2	0	04	06
Pseudomonas spp. CFU/ml	ISO 16266	0	0	0
Clostridium perfringesaureus, CFU/ml	ISO 14189	0	0	0

TABLE 3: Microbial Composition and Count in **fish pond effluent contaminated soil**

Location	Probable soil Bacterial Isolates	Mean Count
Control	*Pseudomonas spp, Bacillus spp, Azotobacter spp, Azospirillum spp*	*2.1x10⁶ Cfu/g*
BA	*Klebsiella spp, Enterobacter spp, Azotobacter spp, Azospirillum spp,*	*2.4 x10⁶ Cfu/g*

	Bacillus spp, Pseudomonas spp	
OS	*Azotobacter spp, Azospirillum spp, Bacillus spp, Streptococci Spp, Pseudomonas spp,*	2.2 $x10^6$ *Cfu/g*
OC	*Klebsiella spp, Enterobacter spp, Streptococci Spp, Azotobacter spp, Azospirillum spp, Bacillus spp, Streptococci Spp, Pseudomonas spp.*	2.4 $x10^6$ *Cfu/g*

Location	Probable soil fungi Isolates	Mean Count
Control	*Trichoderma spp, Aspergillus spp, Penicillium spp, Fusarium spp*	1.4 x 10^3 Cfu/g
BA	*Aspergillus spp, Penicillium spp, Fusarium spp, Trichoderma spp,*	1.5 x 10^3 Cfu/g
OS	*Aspergillus spp, Penicillium spp, Fusarium spp*	1.5 x 10^3 Cfu/g
OC	*Mold / yeast spp, Trichoderma spp, Aspergillus spp, Penicillium spp, Fusarium spp*	1.7 $x10^3$ *Cfu/g*

Enterobacter spp., and Streptococci spp. in the ponds, particularly at OC and BA, suggests fecal contamination, possibly linked to the use of animal waste in farming practices. Mold and yeast growths were also detected in OC, further suggesting a degraded water quality with potential risks to aquatic life and human health.

Microbial Composition and Count in soils surrounding earthen Fish Ponds

The microbial analysis indicates that the control soil is dominated by beneficial bacteria like *Pseudomonas spp, Bacillus spp, Azotobacter spp, and Azospirillum spp*, which are involved in nitrogen fixation, decomposition, and plant growth promotion. Cross River Basin Development Authority (BA) and OS sites show a similar bacterial profile, with the addition of *Klebsiella spp, Enterobacter spp,* and *Streptococci spp*, which could be opportunistic pathogens. Oceanography Farm had a more diverse and higher bacterial population, including *Streptococci spp*. For the Fungal Analysis, the control site was dominated by fungi like *Trichoderma spp, Aspergillus spp, Penicillium spp,* and *Fusarium spp*, which are involved in decomposition and nutrient cycling. The BA and OS sites show a similar fungal profile, with a slight increase in counts. The OC site had a more diverse fungal population, including Mold/yeast. Generally, the fish pond sites had higher microbial count than the control site. The increased in microbial population observed at the pond sites could be attributed to the impact of the fish pond effluent. Similar bacterial community structure, dominated by *Proteobacteria, Firmicutes, and Actinobacteria* were reported for soils surrounding fish ponds by (Kumar *et al.*, 2018 and Zhang *et al.*, 2018. These organism are influenced by soil pH, OM, and nutrient levels (Tamtam *et al.*, 2015).

Heavy Metal Distribution in soils surrounding earthen fish ponds

Analysis of heavy metals (Fig. 1) in the soils surrounding the fish ponds in Calabar revealed that copper (Cu), Zinc (Zn), Lead (Pb), Chromium (Cr), and Aluminum (Al) levels were within WHO limits, though the Metal Pollution Index (MPI) (Table 4) indicates moderate to severe

enrichment of these metals at the pond sites. The concentrations of Zinc (Zn) were notably higher at all pond sites compared to the control, suggesting contamination from the fish pond effluents. Increased Cu and Zn levels may indicate fish feed or fertilizer inputs (Alloway, 2013).

Chromium (Cr) and lead (Pb) levels, although higher than in the control soil, remained within acceptable limits for soil. The presence of aluminum (Al) was low across all sites except at OS, where it was elevated. This elevation could be due to management practices at the farm. Similar studies reported copper (Cu) levels of 20-50 ppm, indicating moderate to high levels (Oladimeji et al., 2013; Ahmed *et al.*, 2015); Zinc (Zn): 50-100 ppm, suggesting moderate to high levels (Hossain *et al.*, 2017; Kumar *et al.*, 2018); while Lead (Pb), Cadmium (Cd), and Mercury (Hg) were at generally low levels (<10 ppm) (Tamtam *et al.*, 2015; Zhang *et al.*, 2018).

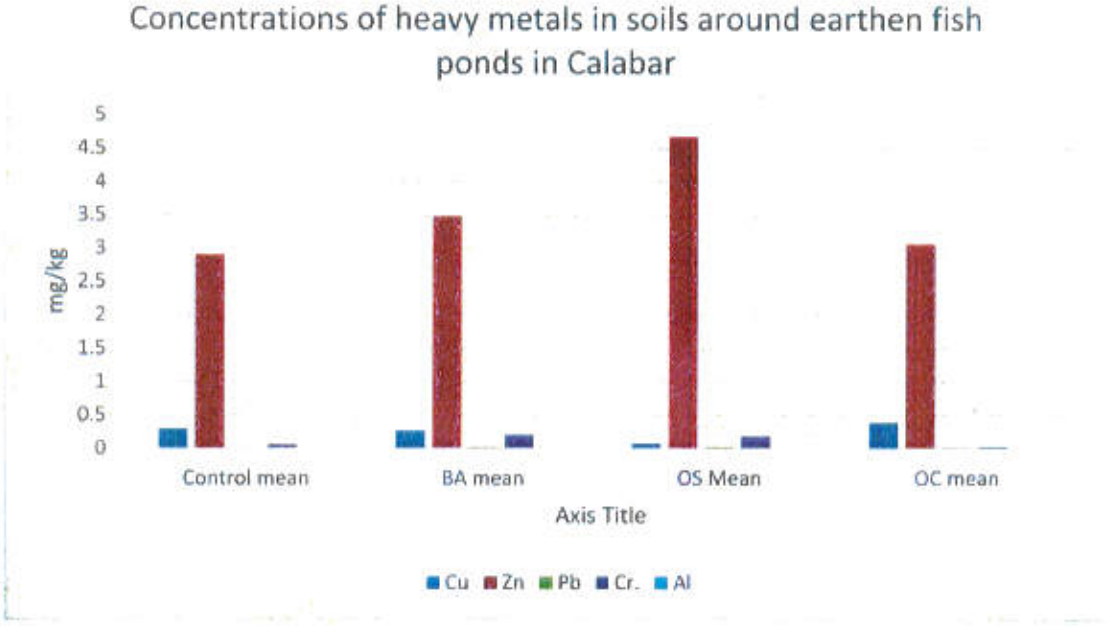

Fig 1: Mean heavy metal concentration on soils surrounding earthen ponds

Environmental and Health Implications of Soil Microbial Composition and Potentially Toxic Elements (PTEs)

Although earthen fish ponds effluent contributes to nutrient enrichment in surrounding soils, they could also pose significant. The enhanced levels of organic carbon and nitrogen observed in soils at the pond sites suggest potential benefits for soil fertility. While beneficial bacteria can enhance soil fertility, the presence of opportunistic pathogens like *Klebsiella spp., Enterobacter spp.,* and *Streptococci spp.* in pond soils raises environmental and health concerns especially if they enter the food chain or water supply. Fungi such as *Fusarium spp.* can produce mycotoxins, which are harmful to human health if inhaled or ingested. *Aspergillus spp.* and *Penicillium spp.* can also cause respiratory issues and allergic reactions. Copper (Cu), Zinc (Zn), Lead (Pb), Chromium (Cr) and Aluminum (Al) were still within the acceptable limits in the studied soils. Low Pb, Cu, and Cr levels suggest minimal pollution risk (Kabata-Pendias,

2011). However, The MPI (Table 4) values suggests moderate to very severe enrichment of these heavy metals in the earthen pond sites above the control. Sustainable management practices are essential to mitigate these risks, ensuring that the benefits of fish farming do not compromise the long-term health of the soil and ecosystem.

Table 4: Mean Contamination/Pollution Index (MPI) of heavy metals in soils surrounding earthen ponds in Calabar

Sampling unit/locations	Heavy metals	Depth (cm)	Concentration (mg/kg)	Control	MPI	Class interval Lacatusu (2000)	Significance
Basin Authority (BA)	Cu	0-30	0.279	0.03	9.3	8.1-16.0	Very sever pollution
	Zn	0-30	3.48	2.90	1.2	1.1-2.0	Slight pollution
	Pb	0-30	0.026	0.012	2.16	2.1-4.0	Moderate pollution
	Cr	0-30	0.19	0.06	3.16	2.14.0	Moderate pollution
	Al	0-30	0.0015	0.001	1.5	1.1-2.0	Slight pollution
One sky farm (OS)	Cu	0-30	0.075	0.03	2.5	2.1-4.0	Moderate pollution
	Pb	0-30	4.67	2.90	1.61	1.1-2.0	Slight pollution
	Cr	0-30	0.03	0.012	2.5	2.1-4.0	Moderate pollution
	Zn	0-30	0.19	0.06	3.16	2.1-4.0	Moderate pollution
	Al	0-30	0.003	0.001	3	2.1-4.0	Moderate pollution
Ocenography fish farm (OC)	Cu	0-30	0.391	0.03	13.03	8.1-16.0	Very sever pollution
	Zn	0-30	3.062	2.90	1.05	1.1-2.0	Slight pollution
	Pb	0-30	0.02	0.012	1.66	1.1-2.0	Slight pollution
	Cr	0-30	0.03	0.06	5	4.1-80	Severe pollution
	Al	0-30	0.0015	0.001	1.5	1.1-2.0	Slight pollution

Conclusion

This study highlights the dual impact of earthen fish ponds on surrounding soils—nutrient enrichment and microbial contamination. While the enriched organic carbon and nitrogen levels suggest improved fertility, the presence of harmful pathogens and elevated heavy metal concentrations raise serious concerns about environmental and human health. it is recommended that fish farm operators adopt sustainable management practices, such as regular monitoring of effluent discharge, implementation of proper waste treatment systems, and the

use of organic matter for soil improvement. Additionally, earthen pond fish farmers should consider periodic soil testing to manage nutrient buildup and prevent contamination. Policy-makers should establish stricter regulations for fish pond effluent disposal to safeguard both soil health and public safety Calabar metropolis.

Reference

Ahmed, M., Islam, M.R., & Alam, M. S... (2015). Soil chemical and microbial properties around fish ponds. *Journal of Environmental Science and Health*, Part B, 50, 537-545.

Ahukaemere, C. C., Opara, F. N., & Nwankwegu, C. J. (2014). Microbial and chemical analysis of soil around fish pond in Delta State. *Journal of Environmental Science and Health*, Part B, 49 (5), 349-358

Alloway, B. J. (2013). Heavy metals in soils. *Springer,* (5), 439-453

American Public Health Association (APHA), (1992). Standard Methods for the Examination of Water and Waste Water. 18th Edition. Washington, DC, American Public Health Association.

American Public Health Association (APHA). (2020). Standard Methods for the Examination of Water and Wastewater (23rd ed.). Washington, DC: APHA.

Bhatta, R. (2006). Water quality management in aquaculture. *Journal of Environmental Science and Health*, Part B, 41(5), 439-453.

Boyd, C. E., Tucker, C. S., & McNevin, A. A. (2007). Pond aquaculture water quality management. *Springer,* 50, 537-545

Brady, N. C., & Weil, R. R. (2008). The nature and properties of soils. 14th ed. Pearson Prentice Hall.

Havlin, J. L., Beaton, J. D., Tisdale, S. L., & Nelson, W. L. (2014). Soil fertility and fertilizers: An introduction to nutrient management (8th ed.). Pearson Prentice Hall.

Hossain, M. Islam, M.T., & Alam, M. S. (2017). Soil chemical and microbial properties around fish ponds in Bangladesh. *Journal of Soil Science and Plant Nutrition*, 17(2), 257-269.

International Organization for Standardization (ISO). (2018). Water Quality - Detection and Enumeration of Bacteriophages - Part 1: Enumeration by Plaque Assay (ISO 10705-1:2018). Geneva, Switzerland: ISO.

Kabata-Pendias, A. (2011). Trace elements in soils and plants. 4th ed. CRC Press.

Kumar, P., Kumar, V., & Sharma, S. (2018). Soil microbial community structure and function around fish ponds. *Journal of Environmental Science and Health,* Part B, 53, 321-330.

Kumar, P., Kumar, V., & Sharma, S. (2014). Impact of fish farming on soil and water quality. *Journal of Environmental Science, Toxicology and Food Technology*, 8(5), 1-8.

Oladimeji, Y. et al. (2013). Soil chemical properties around fish ponds in Nigeria. *Journal of Agricultural Science and Technology*. 13 (3), 432-443.

Qadir, M., Quillérou, E., & Nangia, V. (2014). Soil salinization and groundwater contamination: Challenges and opportunities. *Journal of Soil Science and Plant Nutrition*, 14(2), 231-244.

Sapkota, A., Sapkota, B., & Koirala, A. (2018). Environmental impacts of aquaculture. *Journal of Environmental Science and Health*, Part B, 53(1), 1-13.

Tamtam, F., Ametepeh, J. T. & Adjei-Boateng, D. (2015). Soil chemical and microbial properties around fish ponds in Ghana. *Journal of Environmental Science and Health*, Part B, 50, 546-555.

Tisdell, C. (1994). Environmental impact of aquaculture. *Journal of Environmental Management*, 41(2), 181-194.

Udo, E. J. (2009). Laboratory manual for physicochemical analysis of soil and water. University of Calabar Press.

Zhang, J., Liu, X., & Li, Z. (2011). Effects of fish farming on soil nutrient content and microbial community structure. *Journal of Soil Science and Plant Nutrition*, 11(2), 137-146.

Zhang, Y., Li, M. & Chen, L. (2018). Soil chemical and microbial properties around fish ponds in China. *Journal of Soil Science and Plant Nutrition*, 18(1), 142-153.

IMPACT OF VARYING DIETARY INCLUSION LEVELS OF BLOOD MEAL ON THE OVERALL PERFORMANCE OF FINISHING PIGS

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ABSTRACT

An experiment was carried out to determine the performance of finisher pigs fed blood meal (BM) at varying dietary levels. 24 cross-bred (Large white x Landrace) finisher pigs were randomly distributed into four dietary treatments (D1, D2, D3 and D4) in which BM was incorporated at graded levels of 0%, 2.30%, 4.60% and 6.90% respectively. Each dietary treatment had 6pigs replicated thrice in a Completely Randomized Design. Pigs fed 4.60% BM consumed significantly (P<0.05) higher feed compared to those fed on other BM diets. The feed intake of Pigs on 0 and 2.30% BM diets were similar (P>0.05). Daily weight gain was significantly (P<0.05) highest for pigs fed 4.60% BM diet compared to those on other diets. The feed conversion ratio of pigs on 4.60% BM diet was significantly (P<0.05) better compared to that of pig groups fed on other diets. The feed cost (₦) per kg gain for pigs fed 2.30% BM diet was significantly (P<0.05) higher and similar (P>0.05) to that of pigs on control (0%).The superiority in performance of pigs fed 4.60% BM diet over others appears to be the optimal level of inclusion of BM in the diets of finishing pigs in this study.

Keywords: Blood meal; body weight; feed intake;feed conversion; finisherpig;

Introduction

As feed prices continue to skyrocket, feed efficiency as a parameter for growth performance becomes increasingly important for achieving sustainable pig production (Abiodun *et al.*, 2017). The profitability of a pig enterprise has been linked to the efficient use of feed for lean tissue growth and the rate of growth (Njoku *et al.*, 2015). Insufficient feed intake both in quality and quantity will negatively affect efficiency of feed utilization and general performance of the animal at the finishing phase (Zhong-Xing, *et al.*, 2023).

Though pigs consume most of the feed in their life time during the growing-finishing phase, feed efficiency decreases as the pig's weight increases because of the increasing maintenance requirement (Richard and George, 1977). According to Fomunyam (2003), a possible way of increasing the supply of products at a cheaper price is by reducing the cost of production through the use of cheaper and locally available sources of animal proteins such as BM.BM has been used to supplement diets containing cereals grains, plant by-products as well as providing satisfactory replacement for other protein sources in various diets for livestock production

(McDonald *et al.*, 1998). This study is aimed at evaluating the effect of varying dietary inclusion levels of BM on feed consumption, weight gain and feed efficiency of finishing pigs.

Materials and Methods

Experimental Site

The feeding trial was conducted at the Piggery Unit of the Teaching and Research Farm, College of Agriculture and Animal Science, Mando, Kaduna. The farm lies within latitude 110° and 10' N and longitude 70° and 38°E, located in the Northern Guinea savannah zone of Nigeria. The area has an elevation of 632m above sea level and average rainfall of 1200mm with 95% falling between April and October. The ambient temperature varies between 26 -350C, with relative humidity between 31 and 37% (Abaje *et al.*, 2015).

Sources and processing of Blood

Forty (40) litres of blood was collected directly from slaughtered bovine animals at Zango Abattoir, Tudun Wada, Kaduna, into a clean plastic receptacle and immediately boiled for 30 minutes in a clean metal drum. It was sun-dried for 48 hours and then stored in clean airtight plastic containers for incorporation inside the experimental diets.

Experimental Design, Diets and Management of Experimental Animals

Twenty-four pass bred (Large White x Hampshire) sixteen-weeks-old finishing pigs sourced based on weight equalization from the College Farm, were used for a 56-day feeding trial. The ingredient composition of the finisher diets is as shown in Table 1.

Table 1: Ingredient Composition (%) of Finisher Pig Diets Containing Graded Levels of BM (18-26 weeks)

	Levels of blood meal (%)			
Ingredient	D1(0)	D2(2.30)	D3(4.60)	D4(6.90)
Maize	72.00	75.00	77.00	79.00
Maize offal	3.00	3.00	3.00	3.00
Rice offal	3.00	3.00	3.00	3.00
Brewers' dried grains	3.00	3.00	3.00	3.00
Blood meal	0.00	2.03	4.06	6.09
Groundnut cake	13.50	9.00	4.95	1.00
Fish meal (65%)	1.00	1.00	1.00	1.00
Bone meal	0.75	0.75	0.75	0.75
Limestone	0.44	0.44	0.44	0.44
Palm oil	2.00	1.50	1.50	1.50
Lysine	0.10	0.00	0.00	0.00
Methionine	0.10	0.10	0.10	0.10
[1]Vitamin-mineral premix	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50

Total	100.00	100.00	100.00	100.00
Calculated Analysis				
Crude protein (%)	13.52	13.56	13.78	13.81
ME.(Kcal/kg)	3218	3166	3189	3192
Ether Extract (%)	4.50	4.23	3.85	3.57
Crude fibre (%)	4.89	4.49	3.39	3.29
Calcium (%)	5.40	5.50	5.50	6.60
Phosphorus (%)	6.30	8.50	7.10	9.90
Lysine (%)	0.73	0.69	0.71	0.73
Methionine+ Cysteine (%)	4.20	4.90	5.60	5.90
Feed cost (₦/kg)	119.30	116.60	113.40	113.10

Premix[1] vitamin premix (Animal Care Optimix[R]) supplied per kg of feed: Vit A 5,000 I.U;D3 3500 I.U; Vit.K 2.5mg; B1 2mg, B2 6mg; B6 4g;Niacin 40mgm; B12 0.02mg; Pantothenicacid 10mg; Folic acid 1mg; Biotin 88mg; Choline chloride 0.5gm; Anti-oxidant 0.125mg;Manganese 0.096gm; Iron 0.24gm; Copper 6x103mg; Iodine 1.4x103mg; Selenium 0.240mg;Cobalt 0.240m

The pigs were randomly allotted to four dietary treatment groups where BM was incorporated at graded levels of 0, 2.30, 4.60, and 6.90%. Each treatment had six pigs replicated thrice (2 pigs per replicate) in a Completely Randomized Design. The finisher diets were formulated to have 13% CP and all diets were iso-nitrogenous and iso-caloric. The pigs were fed the finisher diets for 8 weeks. All pigs were fed at 6% of their body weight and water was given *ad libitum*.

The pigs were housed in twelve standard pens; each having well ventilated, open-sided with slated concrete floor measuring 165 x 180cm. The pens were equipped with concrete watering troughs measuring 65 x 30 x 25cm and concrete feeding troughs measuring 48 x 30 x 20cm. The pigs were quarantined for one week prior to the commencement of the experiment.

The pigs were fed twice daily (8:00am and 4:00pm) throughout the experimental period and all the refusals were removed, dried, weighed and recorded each day to determine feed intake. Pigs were weighed at the beginning of the trial and subsequently at weekly intervals. At the end of the finishing phase of the experiment, average daily feed intake, average daily weight gain, feed conversion, feed cost ₦ per kg gain and mortality were computed

Data Evaluation

The data obtained were statistically analyzed using the General Linear Model Procedure of Statistical Analysis software package. Significant differences between treatments means were separated by Duncan's Multiple Range Test (Duncan, 1995) (SAS, 2002). Taking $P<0.05$ as level of significance.

Results and Discussion

The impact of varying dietary levels ofBM on the overall performance of finisher pigs is provided in Table 2.

Table 2: Effect of feeding varying dietary levels of BM on the overall performance of finisher Pigs(18-26weeks)

	Levels of blood meal (%)				
Parameters	D1 (0%)	D2 (2.30%)	D3 (4.60%)	D4 (6.90%)	**SEM**
Initial weight (kg/pig)	26.83	26.83	26.50	26.50	1.59
Final weight (kg/pig)	45.66^{b}	45.66^{b}	51.00^{a}	43.33^{b}	2.02
Weight gain (kg/pig)	18.83^{b}	18.83^{b}	24.66^{a}	17.83^{c}	0.99
Daily weight gain(kg/pig)	0.33^{b}	0.33^{b}	0.44^{a}	0.31^{b}	0.02
Daily feed intake (kg/pig)	1.40^{b}	1.41^{b}	1.55^{a}	1.30^{c}	0.03
Feed conversion ratio	4.18^{b}	4.39^{c}	3.65^{a}	4.09^{b}	0.18
Feed cost (₦/Kg) gain	502.41^{a}	511.87^{a}	413.91^{c}	462.17^{b}	13.99

$^{a, b, c, d}$Means within rows with different superscripts differ significantly ($P<0.05$)
SEM = Standard Error of Mean, ₦ = Naira

,Pigs fed 4.60% BM diet consumed significantly ($P<0.05$) higher feed compared to those fed on other diets. The feed intake of Pigs on control and 2.30% BM diets did not differ significantly ($P>0.05$) but were significantly ($P<0.05$) higher compared to those fed on 6.90% BM diet. It is therefore, possible that the 4.60% of BM diet was more palatable than the 2.03 and 6.90% BM levels of substitution in the diets. This observation was supported by the findings of Coffey *et al.* (2001) who reported that palatability is a first-rate obstacle to the usage of blood meal beyond 4.0%. The result of feed intake in this study is similar to the findings of Paul *et al.* (2007) who reported a range of 1.45 – 1.67kg daily feed intake when finisher pigs were fed BM diets. The final weight gain for pigs fed D3 (4.60%) BM diet was significantly ($P<0.05$) higher than those fed the control, 2.03 and 6.90% diets which were similar ($P>0.05$). However, the performance of pigs fed 4.60% BM diet aligns with the findings of Fombad and Bryant (2004) who recommended 3.0 to 4.0% of BM in the total feed of finisher pigs for better performance.

Daily weight gain was significantly ($P<0.05$) highest for pigs fed 4.60% BM diet compared to those on other diets. This aligned with the findings of Paul *et al.* (2007) who reported daily weight gains of 135 – 431g/day for finisher pigs fed BM within 45 and 60kg body weight.The feed conversion ratio of pigs on 4.60% BM diet was significantly ($P<0.05$) better compared to that of pig groups fed on other diets. This means that pigs fed the 4.60% BM diet utilized their feed better than those fed on control and other BM diets. This is contrary to the findings of Fagbemi (2021) who observed better feed conversion with pigsfed on enzyme supplemented BM at 6% compared to those fed at 0 and 3% diets.The feed cost (₦) per kg gain during the finisher phase for pigs fed 2.30% BM diets was significantly ($P<0.05$) higher and similar ($P>0.05$) to those on the control (0%) diet. The lowest ($P<0.05$) feed cost (₦) per kg gain was

recorded for pigs fed 4.60% BM diet. This supports previous observations that inclusion of alternative feed ingredients such as BM in formulating livestock diets significantly reduces cost of feed (Aka et al., 2009). The superiority in performance of pigs fed 4.60% BM diet over the control (0%), 2.30 and 6.90% appears to be the optimal level of inclusion of BM in the diets of finishing pigs.

Conclusion

Findings from the study showed thatfinishing pigs fed on diet supplemented with BM at 4.60% levelhad significantly ($P<0.05$) higher feed intake, daily weight gains and as better FCRwith significant reduction in production cost compared to other pigs on BM supplemented diets
The superiority in performance of pigs fed 4.60% BM diet over the control (0%), 2.30 and 6.90% appears to suggest that inclusion of BM at 4.60% is the optimal level of inclusion in the diet for finisher pigs.

Recommendation

For optimal growth performance, the inclusion of blood meal at 4.60% level in the diets of finishing pigs is recommended.

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References

Abaje, I. B., Sawa, B. A., Iguisi, E. O. and Ibrahim, A. A. (2015). Assessment of rural communities' adaptive capacity to climate change in Kaduna State, Nigeria. *Journal of Environment and Earth Science*, 5(20): 14 – 23.

Abeodun, E.A., Omotoso, O.O., Olusegun, K.S. (2017). Economic Analysis and Determination of Pig Production in Ogun State, Nigeria. *AgricuturaTropica et Subtropica*. 50 (2):6170

Coffey, R.D. and Cromwell, G.L. (2001): Use of spray–dried plasma in diets for weanling pigs. Pig News and Information, 22: 39 – 48.

Duncan, D.B (1955). Multiple range and Multiple F. Test. Biometrics, 11:1

Fagbemi, A.E. (2021). The effect of enzyme supplemented blood meal on the growth performance and haematological indices of growing piglets. A Thesissubmitted to CAAS/Ahmadu Bello University, Kaduna. p20.

Fombad, R. B. ; Bryant, M. J. (2004). Effects of cottonseed cake-based diets supplemented with BM alone or with lysine, on the growth of pigs. *Tropical Journal of Animal Health and Production,* 36 (4): 385-395

Fomunyam, I. (2003). Animal Nutrition. Pearson Education, Singapore, Pte,Ltd.

Njoku, C.P.,Adeyemi, O.A., Sogunle,O.M. and Aina,A.B.J. (2015). Growth performance, Carcass yield and organ weight of growing pigs fed different levels of feed. *Slovak Journal of Animal Science.* 48 (1): 16-22.

McDonald, P., Edward, R.A., Greenhalg, J.F.D and Morgan, C.a. (1998). Animal Nutrition. (5th Ed). London Longman GRP. Ltd.

Paul, S.S., Mandal, A.B., Chatterjee, P. N., Bhar, R. and Pathak, N.N. (2007). Determination of Nutrient requirements for growth and maintenance of growing pigs under tropical condition. *Journal of Animal Production.* 1:269-282

Richard, C.W. and George, W.L. (1977). Dried blood meal as protein source in diets for Growing-Finishing Swine. Journal of Animal Science. 14 (15):778-783. https://doi.org/10.2527/jas1977.44.5778x

SAS (2002). SAS/STAT[R] Users Guide (released 9.0). SAS Institute Inc., SAS Circle. Cary, North Carolina, U.S.A.

Zhong-Xing, R., Mike, D.T., Jason, C.W., Joel, M.D., Robert, D.G. and Jordan, T.G. (2023). Effect of various feed additives on finishing pig growth performance and carcass characteristics: A review.*Animals.* 13 (2): 200. doi: 10.3390/ani13020200.- DOI-PMC-PubMed

EVALUATION OF THE PRESENCE OF PESTICIDE RESIDUES IN FEED MATERIALS OF COMMERCIAL LAYERS IN ENUGU STATE, NIGERIA

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ABSTRACT

This study was undertaken to evaluate the presence of pesticide residues in some key feedstuffs used in producing layers feed in Enugu state, Nigeria. Maize, soyabeans, PKC, commercial layer feed A, commercial layer feed B and commercial layer feed C samples collected from various feed material outlets in four (4) agricultural zones of Enugu state were analysed for presence of pesticide residues of monocrotophos, cypermethrin and chlorpyrifos respectively. Spectrophotometric analysis was used in determining of the levels of these pesticides. Result showed that residual concentration of monocrotophos, cypermethrin and chlorpyrifos were significant (P<0.05). PKC, layer feed B, and layer feed C had the least monocrotophos concentration of 0.00mg/kg while maize, soyabeans and layer feed A each had 0.01µg/kg monocrotophos in them. PKC had the least chlorpyrifos (0.24mg/kg) content while layer feed A had 0.98mg/kg content. The study also revealed that PKC also had highest (0.49mg/kg) amount of chlorpyrifos while layer feed C (0.23mg/kg) had the least content. The study also showed that interaction effect of agricultural zones and feed material had no significant (p>0.05) effect on monocrotophos residues but had significant (P<0.05) effect on cypermethrin and chlorpyrifos residues found in feed materials sampled from different zones of Enugu state. The 0.14µg/kg chlorpyrifos residue in PKC found within Enugu agricultural zone was the least while 2.37mg/kg detected in layer feed B from Awgu was the highest. Meanwhile the 0.11µg/kg chlorpyrifos concentration in maize from Awgu was the least whereas the 0.7mg/kg in PKC from Awgu had the highest detection. The mere fact that traces of pesticide residues were present in most of the sampled feed materials, calls for increased vigilance on the part of all stakeholders in the livestock industry to guard against the risks associated with pesticide contamination of poultry products.

Keywords: Pesticide, Poultry, Toxic, Insect pests, Population.

INTRODUCTION

Poultry remains a major means of providing safe and affordable animal protein to many parts of the world. Poultry feeding requires the use of several grains and leguminous crops in compounding rations for the birds. The use of chemical pesticides has however led to human and livestock exposure to pesticide poisoning among others (Dugje *et al.*, 2008). This risk is highlighted by Yudelman *et al.*, (1998) who reported that there is a high probability that pesticide use and pesticide – induced side effects will grow more rapidly in developing countries as a whole than in the developed ones. In other to increase poultry products supply and reduce the loss of essential feed materials caused by pests, pesticides have been very helpful. This situation is even more critical in view of the weak monitoring structures and the dearth of up to date information on the pesticide residual content of feed materials sourced from

within and outside a country like Nigeria. These locally available feed resources if amply produced have the potential to support a thriving livestock industry. The agronomic practices used in producing these crops involve the use of pesticides either at farm level or during storage. There is the possibility of the residual effect of these pesticides to be found in the animals that consume these agricultural products. Some processing methods rarely affect or diminish the presence of these pesticides in crops. In addition, the toxic nature of pesticides does not differentiate non targeted species, and are essentially not always subject to safe and cautious usage by many users.

The FAO (2002) defines pesticide as any substance or mixture intended for preventing, destroying or controlling any pest, including vectors of human or animals causing harm during or otherwise interfering with production, processing, storage, transport or marketing of foods, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for control of insects, arachnids or other pest in or on their bodies. The term includes substances intended for use as plant growth regulators, defoliants, desiccants or agents for thinning fruits or preventing premature fall of fruit. It can also refer to substances applied to crops before or after harvest to protect agricultural commodity from deterioration during storage and or transportation. Pesticide residues in or on plants may be unavoidable even when pesticides are used in accordance with Good Agricultural Practice. Further while remarkable progress has been made in the development of effective pesticides, the fact remains that a very small fraction of all applied pesticides is directly involved in the pesticidal mechanism. The extensive use of pesticides for agricultural and non-agricultural purposes has resulted in the presence of their residues in various environmental matrices, especially food stuff (Uygun *et al.*, 2005; Tadeo *et al.*, 2008) and there is a risk of these residues finding their way into the poultry feed chain with humans being the eventual victims.

OBJECTIVES

To evaluate the presence of three (3) pesticide residues in selected feed materials namely; Maize, PKC, Soyabeans, three (3) popular brands of commercial layer feed (A,B,C).

- Determine the presence of pesticides (chlorpyrifos, monocrotophos and cypermethrin) contamination in feed materials (Maize, PKC, Soyabeans and samples of commercial layer feed brands A, B and C respectively) within Enugu State, South East Nigeria.
- Compare the residual content of the pesticides in the feed materials and zones.
- Identify suitable measures that can be used to enhance the safety of layer feed materials in relation to pesticide contamination.

MATERIALS AND METHODS

Location of Study

This study was carried out in four (4) Agricultural Zones in Enugu State with a growing concentration of commercial egg production farms; feed material (feeds and feedstuffs) outlets. The state has an estimated population of about 3.2 million and landmass of about 12,727 sq. km and boundaries with Abia and Imo States in the South, Benue and Kogi States in the North and Ebonyi State in the East and Anambra State in the West (Sanni, 2005). The State is

comprised of six (6) agricultural zones namely; Enugu Ezike, Nsukka, Udi, Agbani, Awgu and Enugu but this work focused on four (4) of its agricultural zones. The study spanned a period of 10 weeks. It covered the period used for collection of samples, laboratory and statistical analysis.

Collection of Samples 2kg each from pooled samples of maize, soyabean, PKC, commercial layer feeds A, B and C respectively were randomly collected from at least two (2) outlets in each of the four (4) selected agricultural zones in Enugu state and the feed material samples collected were rid of any unwanted physical impurities such as stones, bagging materials, among others. Where appropriate, they were reduced into powdery form using mortar and pestle, homogenized, properly labeled and stored in secured air tight containers to protect them from moisture and contamination prior to the laboratory analysis.

Laboratory Analysis: A Spectrum lab 22PC spectrophotometer, electronic scale, pHep pH Tester, clinical centrifuge with swing out rotors and a speed of 3000rpm were used in the course of this analysis.

Monocrotophos analysis:

All reagents used were of Anal R grade or of the best available quality and purchased from agrochemical dealers in Nsukka Township. Double distilled demineralized water was used throughout. Working standard solutions were prepared by suitable dilution of the standard solution, as and when required. 1% m/v sodium nitrite solution was prepared in 10% v/v hydrochloric acid. 1.0 mol l-1 sodium hydroxide aqueous solution was used. 0.2% m/v solution of 2, 4 Dinitrophenylhydrazine (Sigma-Aldrich) prepared by dissolving appropriate weight 250 ml 1M HCl solution.

Sample analysis: 5ml of water was added to the 1g duplicates of each macerated homogenized sample shaken and allowed to stand for 1hour before being centrifuged for 10 minutes. 1ml of NaoH was added to 1ml of supernatant. The solution was kept in cold water at (5-10˚C) for 30 minutes. 1ml of diazotized 2, 4, dinitrophenylhydrazine was then added. The solution was kept for 15minutes for full colour development and then made up to 5ml with water. The absorbance was taken at 490nm against a reagent blank.

Procedure for calibration curve: 1ml of NaoH was added to 4.0 to 16.0 mg of monocrotophos. The solution was kept in cold water at (5-10˚C) for 30 minutes. 1ml of diazotized 2, 4, dinitrophenylhydrazine was then added. The solution was kept for 15minutes for full colour development and then made up to 5ml with water. The absorbance was taken at 490nm against a reagent blank (Prasanna and Surendra, 2012).

Cypermethrin Analysis: All reagents used were of AnalaR grade or of the best available quality. Double distilled demineralized water was used throughout. Cypermethrin (Krishi Rasayan Exports PVT Limited, India): Working standard solutions were prepared by appropriate dilution of the stock standard solution with water. A 3% hydrochloric acid aqueous solution was used. A 20% sodium hydroxide aqueous solution was used (Vitthal *et al.*, 1992). A 0.1% potassium iodide aqueous solution was used. Leuco crystal violet [LCV] was prepared

adding to a 1 liter volumetric flask 200ml of water, 3ml of 85% phosphoric acid and 250 mg of leuco crystal,(4,4',4"-methylidynetris (*N,N'*,-dimethylaniline) (CH[C6H4N (CH3)2]3). It was shaken gently until the dye dissolved. The content of the flask was then diluted to 1 liter with water (Agrawal, *et al.*, 1999).

Sample analysis: 5ml of ethanol was added to the 1g duplicates of each macerated homogenized sample shaken and allowed to stand for 1hour before being centrifuged for 10 minutes. *2ml of supernatant* was taken in a 25 ml graduated cylinder and to it 1.0 ml of 20% sodium hydroxide was added. The solution was kept for 10 min at room temperature for complete hydrolysis. Then, 1.0 ml of 0.1% potassium iodide was added in acidic medium to liberate iodine and then 1 ml leuco crystal violet was added, shaken thoroughly and kept for 15 min for full colour development. The crystal violet dye was produced. The solution was then diluted to the mark with water and absorbance was measured at 595 nm against a reagent blank (Janghel *et al.*, 2007).

Procedure for preparation of calibration of curve: An aliquot of test solution containing 1.0 to 3.0 mg of cypermethrin was taken in a 25 ml graduated cylinder and to it 1.0 ml of 20% sodium hydroxide was added. The solution was kept for 10 min at room temperature for complete hydrolysis. Then, 1 ml of 0.1% potassium iodide was added in acidic medium to liberate iodine and then 1 ml leuco crystal violet was added and shaken thoroughly and kept for 15 min for full colour development. The crystal violet dye was produced. The solution was then diluted to the mark with water and absorbance was measured at 595 nm against a reagent blank.

Chlorpyrifos Analysis: All chemicals and reagents used are AnalR grade. The organic solvent ethyl acetate used was HPLC grade and purchased from E Merck. Technical grade pesticide standards were used for standardizations and diazotized anthranilic acid.

Sample analysis: 5ml of ethyl acetate was added to the 1g duplicates of each macerated homogenized sample shaken and allowed to stand for 1hour before being centrifuged for 10 minutes. 2ml of decimolar sodium hydroxide was added to 2ml of supernatant. To this colorless solution, 1ml of diazotized anthranilic acid was added to give orange-red color. The solution was kept aside for 5 minutes before taking absorbance and absorbance was measured at 450 nm against reagent blank.

Preparation of calibration curve: 2ml of decimolar sodium hydroxide was added to 4.8-1614.4mg of chlorpyrifos. To this colorless solution, 1ml of diazotized anthranilic acid was added to give orange-red color. The solution was kept aside for 5 minutes before taking absorbance and absorbance was measured at 450 nm against reagent blank.
Venugopal *et al.*, (2012) method with slight modifications was followed in the above procedures.

Data Collection

Data on the amount of selected pesticides residues were determined from laboratory analysis of the collected feeds and feedstuff samples. Results were subjected to descriptive statistical analysis viz; percentages and frequency. Data collected from laboratory analysis of the feed

materials (feeds, feedstuffs) samples of commercial layers were statistically analysis with ANOVA using a Completely Randomized Design (CRD) model given below and ranking using Duncan Multiple Range Test (DMRT) of significant means was done with help of SPSS version 16.

$Xijk = \mu + Fi + Zj + (ZF)\ ij + \mu\ ijk$

Where:
$Xijk$ = the Kth observation of the ith feed material obtained from the jth agricultural zone (μ g/kg)
μ = *overall* mean/ population mean
Fi = effect of *ith* Feed material on pesticide residue
Zj = effect of *j*th agricultural zone on pesticide residue content
(ZF) ij = interaction effect of feed material and agricultural zone on pesticide residue content
$\mu\ ijk$ = random experimental error

RESULTS AND DISCUSSION

Table 1: Comparison of Pesticide Residues Content in Feed Materials

Parameters	FEED MATERIAL						
	Maize	**PKC**	**Soyabean**	**A**	**B**	**C**	**SEM**
Monocrotophos(µg /kg)	0.01^{a}	0.00^{a}	0.01^{ab}	0.01^{b}	0.00^{a}	0.00^{ab}	0.01
Cypermethrin (µg /kg)	0.92^{c}	0.24^{a}	0.45^{c}	0.98^{b}	0.37^{b}	0.43^{b}	0.03
Chlorpyrifos (µg/kg)	0.30^{c}	0.49^{e}	0.44^{ab}	0.25^{d}	0.26^{b}	0.23^{a}	0.01

Key: ^{abcde} Row means within the same row with different superscripts are significantly different ($P<0.05$)
PKC= Palm Kernel Cake, A= Layer feed A, B= Layer feed B, C= Layer feed C, SEM means Standard Error of Mean.

The result indicate that pesticide residue content in feed materials were significantly different ($P<0.05$). The monocrotophos residue content in PKC, Soyabeans, layer feeds B and C were statistically the same but different from maize and Layer feed A which were the same. However, layer feed A and maize had the highest residual content of monocrotophos (0.01 µg/kg), while the least value of 0.00µg/kg was detected in PKC and layer feeds B and C respectively. The amounts of cypermethrin residues were highest in Maize (0.92µg/kg) and layer feed A (0.98 µg/kg), while PKC recorded the least value of 0.24 µg/kg. However, the levels of cypermethrin residues found in commercial feeds in this study were below the average 0.14mg/kg reported by the FDA (2008) in an animal feeds survey of imported animal feeds. Maize, PKC, Soyabeans and finished feed C were all significantly different ($P<0.05$) from each another. PKC had the highest (0.487µg/kg) residual content of Chlorpyrifos while layer feed C recorded the least value of 0.23µg/kg. The chlorpyrifos concentration found in the maize samples is lower than the 48.7 µg/kg reported by Ogah and Coker (2012) in maize samples from Lagos markets. Likewise the amount of chlorpyrifos residues detected in soyabeans in this study is lower in comparison to the 0.02µg/kg average value of chlorpyrifos residue reported by USDA (2005) in soyabeans while the highest amount of chlorpyrifos found in the sampled layer feeds

0.26µg/kg, is lower than the range (0.018-0.143) in µg/kg of chlorpyrifos residues detected in animal feed samples reported by the U. S. Food and Drug Administration Agency (EURL-CF, 2010b).

Generally, the pesticides residual concentrations (Monocrotophos, Cypermethrin and Chlorpyrifos) recorded in this study are lower than the codex alimentarius standard for each of the respective pesticides analyzed in the sampled feed materials. The level of monocrotophos residue detected in Maize (0.01µg/kg) was lower when compared to 0.05µg/kg MRLs Codex standard. This could be due to the fact that pesticides containing monocrotophos are almost disappearing from the pesticide shopping list of most farmers as a result of the ban placed on its use and distribution by many countries which have greatly limited its availability and use. Similarly, the average amount of 0.01µg/kg of monocrotophos residues recorded in the soyabeans samples was well below the 0.05µg/kg codex MRL for monocrotophos in soyabeans (FAO/WHO, 2003). PKC, layer feeds B and C respectively recorded the least amount of monocrotophos residues (0.00µg/kg). This could be due to the very limited or none usage of monocrotophos containing pesticides at the production and or storage of these feed materials. In this study, the EU MRL for palm nuts (kernels) at lower limit of determination (0.02µg/kg) (EU Pesticide Database, (2015) was used as the reference standard because as at the time of this work there was no codex MRL for monocrotophos in PKC and the result of this study shows that the amount of monocrotophos detected in PKC is below the EU MRL standard. Since the PKC used in Enugu is largely produced in Enugu State, the very low monocrotophos concentration recorded could be largely be due to fact that the palm tree (source) requires little or no maintenance as soon as it established on the farmland. The quantities of monocrotophos residues detected in all the finished commercial feeds showed that they were all very low and none exceeded the codex monocrotophos MRL range (0.002-0.2µg/kg) for any specified agricultural product (FAO/WHO, 2003).

The amount of cypermethrin residue detected in Maize (0.92µg/kg) is lower when compared to 0.3µg/kg Codex MRL standard (FAO/WHO, 2013). This however is not up to the average 0.02µg/l found in maize samples (Bushra, *et al.*, 2013) in Pakistan. When compared to the average 0.034mg/l reported in mixed feeds from Pakistan the amount of cypermethrin residue detected in layer feed A (0.98µg/kg) is lower. In addition, it is also lesser than the codex MRL range (0.01-30µg/kg) for any specified agricultural product (FAO/WHO, 2013). PKC (0.238µg/kg) had the least amount of residue content which is much lower when compared to the 0.05µg/kg EU MRL (EFSA, 2011) for cypermethrin residue in Palm nuts (kernels) since no codex MRL for cypermethrin in PKC currently exist to compare it with. The same trend was observed for soyabeans (0.45µg/kg) as the amount of residues detected in it is below the 0.05 µg/kg codex MRL (FAO/WHO, 2013) for cypermethrin in this commodity. The observed low levels of cypermethrin residues in the feed materials could be due to observance of good agricultural practice in the use of the pesticide in the production of these agricultural commodities. When animals are fed, the potential for dilution of feed residues is considerable as not all producers of the primary crop are likely to have used the same pesticide simultaneously, and the pesticides used are not always used at their highest permitted use rates or at the nearest time to harvest at all times. However, animals could be exposed for extended

periods to certain commodities such as fodder, grain and feeds treated post-harvest which contain residues at the highest level (FAO, 2004), hence the need for continuous vigilance.

The average residual chlorpyrifos content of maize detected in this study was 0.30µg/kg and this is significantly lower than the mean chlorpyrifos concentration (0.0013µg/l) reported by Bushra, *et al.* (2013) in maize samples in Pakistan and the 0.05mg/kg codex MRL standard for Maize (FAO/WHO, 2013). The 0.44µg/kg of chlorpyrifos residues discovered in soyabeans is also lower than the 0.10µg/kg codex MRL (FAO/WHO, 2013). The 0.49µg/kg of chlorpyrifos residues in PKC sample analysed in this study is lower than the 0.05µg/kg (EFSA, 2012) EU MRL for palm nuts (palm oil kernel). The FAO/WHO (2013) MRL range of 0.01-20µg/kg, specified for different agricultural commodities was not exceeded by the chlorpyrifos concentrations detected in any of the sampled commercial layer feeds (feed A, feed B, feed C). However, the amount of chlorpyrifos residues detected in the sampled finished feeds are lower than the range (0.018-0.143) in µg/kg of chlorpyrifos residues detected in animal feed samples reported by the U. S. Food and Drug Administration Agency (EURL-CF, 2010b) and also lower than the average 0.0016µg/l reported by Bushra *et al.* (2013) in mixed feed in Pakistan. The use of good agricultural practices and relatively high literacy level in the study area might be responsible for low residue content of the feed materials.

Table 2: Pesticide Residual Content in the Different Agricultural Zones

Parameters (µg/kg)	AGRIC ZONES					
	Awgu	**Enugu**	**Enugu Ezike**	**Nsukka**	**SEM**	**LOS**
Monocrotophos	0.01	0.00	0.00	0.01	0.00	NS
Cypermethrin	0.84^{c}	0.39^{a}	0.62^{b}	0.42^{a}	0.03	*
Chlorpyrifos	0.35^{b}	0.37^{c}	0.25^{a}	0.33^{b}	0.01	*

Key: $^{a\,bc}$ Row means within the same row with different superscripts are significantly different (P<0.05) *= P<0.05 NS= Not significant, LOS= Level of Significance

Table 2 shows the monocrotophos residues content in all the feed material under study were not significant (P>0.05) in the entire Agricultural zones considered. However, cypermethrin and chlorpyrifos residual concentrations are significantly different (P<0.05) in all the agricultural zones. Cypermethrin residue levels in feed materials found in Enugu and Nsukka zones are statistically similar but different from those found in Awgu (0.84µg/kg) and Enugu Ezike (0.62 µg/kg) respectively. The highest concentration (0.84µg/kg) of Cypermethrin was detected in Awgu zone while the least amount (0.42µg/kg) was found in Nsukka zone. The result also shows that Chlorpyrifos residues in feed materials found in Awgu and Nsukka zones are statistically the same but different from those found in Enugu and Enugu Ezike zones. The highest Chlorpyrifos residual value of 0.37µg/kg was found in Enugu zone, while Enugu Ezike recorded the least value of 0.25µg/kg. In a similar study of pesticide residue content of food grains from Markets in Nasarawa state, Etonihu *et al.* (2011) reported higher chlorpyrifos residual values of 1.44 x 10-3µg/kg and 1.47 x 10-3µg/kg in bean samples from markets in Akwanga and Keffi markets respectively. In this study, the residue levels detected across Enugu

State are generally low when compared to the codex recommended safety standard for various feed materials and may not pose health risk to poultry layers and consumers of their products.

Table 3: Comparism of the monocrotophos concentrations of feed materials in the various sampled agricultural zones.

AGRIC ZONES	FEED MATERIAL						
	Maize	PKC	Soya Bean	A	B	C	SEM
Awgu	0.01	0.01	0.03	0.01	0.00	0.00	**0.00**
Enugu	0.01	0.00	0.01	0.01	0.00	0.00	**0.00**
Enugu Ezike	0.01	0.00	0.01	0.01	0.00	0.00	**0.00**
Nsukka	0.01	0.00	0.01	0.01	0.00	0.00	**0.00**

Key: PKC= Palm Kernel Cake, A= Layer feed A, B= Layer feed B, C= Layer feed C, SEM means Standard Error of Mean

The result shows that the interaction of agricultural zones and feed materials does not have any significant effect (P>0.05) on monocrotophos residue content. This is reflected in the very sparse amount of the residues detected in this study. There is strong possibility that monocrotophos as a pesticide is not commonly used either at the production or storage levels of the sampled feed materials. The monocrotophos residue values recorded for the various feed material across the entire zone ranges from 0.00µg/kg to 0.01mg/kg which is very low when compared with the codex MRL range of 0.002-0.2µg/kg for any specified agricultural product (FAO/WHO, 2000). Based on the aforementioned reason, it can be inferred that the monocrotophos concentrations are safe and may not pose any significant risk to the laying birds and their products. Nevertheless, it is suggested that care be exercised in using this pesticide because this chemical has the tendency to bioaccumulate in the living tissue of the animals. The withholding period is 42 days for harvest or 7 days for grazing or cutting for stock food.

The residual content of monocrotophos in the sampled layer feeds which ranged from 0.00µg/kg to 0.01µg/kg is lower than 0.005µg/kg reported by Soomro *et al.* (2008) for monocrotophos residues detected in feeds. The very low amounts of monocrotophos residues observed in this study might not be far from the fact that its use and distribution is currently prohibited in Nigeria (Shaibu, 2008) and it is increasingly difficult but not impossible access pesticides that contain it.

Table 4: Interaction of Agric Zones and in Feed materials on cypermethrin Residues Content

AGRIC ZONES	FEED MATERIAL						
	Maize	PKC	Soya Bean	A	B	C	SEM
Awgu	1.29^{b}	0.18^{e}	0.48^{c}	2.37^{a}	0.28^{de}	0.43^{cd}	0.07*
Enugu	0.38^{a}	0.14^{b}	0.38^{a}	0.49^{a}	0.47^{a}	0.48^{a}	0.07*
Enugu Ezike	1.37^{a}	0.37^{c}	0.56^{b}	0.47^{bc}	0.45^{bc}	0.51^{bc}	0.07*
Nsukka	0.65^{a}	0.26^{c}	0.42^{bc}	0.59^{ab}	0.28^{c}	0.31^{c}	0.07*

Key: $^{a\,bcde}$ Row means within the same row with different superscripts are significantly different *= P<0.05
PKC= Palm Kernel Cake, A= Layer feed A, B= Layer feed B, C= Layer feed C, SEM means Standard Error of Mean.

The result shows that the amount (µg/kg) of cypermethrin residues in feed materials are significantly (P< 0.05) different across the sampled agricultural zones in Enugu State. In Awgu, the amount of cypermethrin residue in layer feed A (2.37µg/kg) is statistically different from the residue concentration of all other sampled feed materials. Residual cypermethrin content of Maize (1.30µg/kg) was also significantly different in comparison to the other sampled feed materials. Meanwhile the Soyabeans (0.48µg/kg) and finished feed C (0.43µg/kg) were statistically similar but different from the amounts detected in Maize (1.30µg/kg), PKC (0.18µg/kg), layer feeds A (2.37µg/kg) and B (0.28µg/kg) respectively. The amount of residues detected in finished feed B (028µg/kg) and C (0.43µg/kg) and soyabeans (0.48µg/kg) were statistically similar, in the same way PKC (0.18µg/kg) and feed B (0.28µg/kg) showed statistical similarities. Enugu zone was shown to have similar statistical characteristic in the residual contents found in Maize (0.38µg/kg), Soyabean (0.38µg/kg) and all the sampled layer feeds (A, B, C) with PKC (0.14µg/kg) being the only exception. In Enugu Ezike, while the residual content of maize (1.37µg/kg) differs from the other sampled feed materials, PKC (0.37µg/kg), layer feeds A (0.47µg/kg), B (0.45µg/kg) and C (0.51µg/kg) respectively were statistically similar. In Nsukka, residual cypermethrin content of maize and feed A (0.59µg/kg) were significantly (p<0.05) similar. The result of the comparison of interaction effect of agricultural zone and feed material on cypermethrin residue concentration indicated that in Nsukka zone, PKC (0.26µg/kg), Soyabean (0.42µg/kg) and feeds B (0.28µg/kg) and C (0.31µg/kg) respectively were statistically similar.

The residual cypermethrin values for none of feed materials in all the agricultural zones exceeded their codex MRL where applicable. The highest value for Maize (1.37µg/kg) found in Enugu Ezike is lower than the 0.3µg/kg codex MRL (FAO/WHO, 2013) while the 0.56µg/kg detected in soyabeans from Enugu Ezike is lower than the 0.05µg/kg codex MRL standard for pulses (FAO/WHO, 2013). In the same manner the 0.37µg/kg residual content of PKC is below the EU MRL for palm nuts (palm oil kernel) 0.05µg/kg (EFSA, 2011) at the lower limit of determination given that there is currently no codex MRL for this feed material. The amount of cypermethrin residues found in the finished feeds ranged from 2.37µg/kg to 0.28µg/kg. The low concentration of cypermethrin in the feed materials could be as a result of the observance of good agricultural practices in relation to the use of pesticides by stakeholders involved at different stages of the feed industry.

Table 4: Interaction of Agric Zones and Chlorpyrifos residual Content of Feed Material

AGRIC ZONES	FEED MATERIAL						
	Maize	PKC	Soya Bean	A	B	C	SEM
Awgu	0.11^{d}	0.70^{a}	0.57^{b}	0.29^{c}	0.15^{d}	0.26^{c}	0.02
Enugu Ezike	0.21^{c}	0.33^{b}	0.44^{a}	0.16^{d}	0.17^{cd}	0.21^{c}	0.02
Nsukka	0.57^{a}	0.38^{bc}	0.41^{b}	0.19^{d}	0.36^{c}	0.10^{e}	0.02
Enugu	0.31^{c}	0.54^{a}	0.35^{bc}	0.34^{bc}	0.38^{b}	0.33^{bc}	0.02

Key: ^{abcde} Row means within the same row with different superscripts are significantly different *= P<0.05
PKC= Palm Kernel Cake, A= Layer feed A, B= Layer feed B, C= Layer feed C, SEM means Standard Error of Mean.

Table 5 shows that there was significant ($P<0.05$) difference in the amount of chlorpyrifos residues discovered in feed materials found in all the agricultural zones in Enugu State. In Awgu, the amount of residues found in PKC (0.70µg/kg) is higher and different from the residual content of all other feed materials. However, the amount detected in finished feed C (0.26µg/kg) is statistically similar to 0.29µg/kg in layer feed A, but different from 0.57mg/kg residues found in soyabeans, 0.15µg/kg for layer feed B and 0.11µg/kg in maize. The quantity of residue recorded in PKC could be as a result of post-harvest application during storage, because the use of pesticides in the production of PKC is very uncommon. Comparing the chlorpyrifos residue values of the feed materials analyzed, with their codex MRL values, 0.11µg/kg and 0.57µg/kg detected in maize and soyabeans respectively are lower than their respective 0.05µg/kg and 0.1µg/kg codex MRL standards (FAO/WHO, 2013). The EU MRL for palm nuts (kernel), 0.05µg/kg (EFSA, 2012) at the lower limit of determination was used to evaluate the residual chlorpyrifos content in PKC as there is presently no codex chlorpyrifos MRL for this feed material.

In Enugu agricultural zone, the amount of chlorpyrifos residues in PKC (0.54µg/kg) is higher and significantly different from the values found in other feed materials. The least quantity of chlorpyrifos residue (0.11µg/kg) detected in Maize was statistically similar to the amount detected in layer feed B. Meanwhile, the amount of chlorpyrifos residue detected in soyabeans (0.35µg/kg), layer feeds A (0.34µg/kg), B (0.38µg/kg) and C (0.33µg/kg) are statistically similar. This point to the fact that in addition to having common feed material sources, the pesticide (chlorpyrifos) usage practices in this zone might be similar. The amount of residues found in PKC could also be due to post harvest application since the Palm crop from which PKC is produced with very minimal or no pesticide use. Comparatively, the 0.31µg/kg found in Maize is lower than the 0.3µg/kg codex MRL, while the 0.35µg/kg recorded in soyabeans below the 0.10µg/kg codex MRL (FAO/WHO, 2013) while the 0.54µg/kg detected in PKC is lower than the 0.05µg/kg EU MRL (EFSA, 2012) of palm nuts (palm oil kernel) at the lower limit of determination. However, the chlorpyrifos residue concentration in maize (0.310µg/kg) is lower than the 0.013µg/kg of chlorpyrifos residues in maize reported by Bushra *et al.* (2014). Also, the 0.35 mg/kg of soyabeans in this study is lesser than the 50.10 mg/kg chlorpyrifos residue reported by Ogah *et al.* (2011) in beans samples from Lagos markets but higher than the 0.0014 mg/kg and 0.0015 mg/kg chlorpyrifos residual content detected in bean samples from Akwanga and Keffi markets respectively (Etonihu *et al;* 2011).

The result shows that for Enugu Ezike, the amount of chlorpyrifos residues recorded in soyabeans (0.44µg/kg) is higher and statistically different from the values detected in other feed materials. The residue concentrations detected in layer feed A (0.16µg/kg) is the lowest and it is significantly similar to the 0.17µg/kg of layer feed B. However, their values statistically differed from those recorded in soyabeans (0.44µg/kg) and PKC (0.33µg/kg). This might be attributable to variations in the pesticide usage practices of the sources of these feed materials. When compared to the codex MRL (FAO/WHO, 2013) for chlorpyrifos, the feed materials from Enugu Ezike were below their respective limits (0.05µg/kg for maize; 0.10mg/kg for soyabeans). While the amount of residues found in PKC (0.33µg/kg) is lower than the

0.05µg/kg EU MRL (EFSA, 2012) of palm nuts (palm oil kernel) at the lower limit of determination. The result as shown in table 5 also indicates that the range of 0.16µg/kg to 0.21µg/kg of chlorpyrifos residues detected in the sampled finished feeds in this zone are lower than the 0.018-0.143µg/kg reported by Susan *et al.,* (2011), in a US FDA (Federal Department of Agriculture) survey of chlorpyrifos residues in feed imports into the US conducted in 2007. Even though, the use of this pesticide has been prohibited in the US (Muller and Franz, 2000) and in 2010 in South Africa (Gerhard, 2010). However, this same chemical pesticide is presently widely used and distributed in Enugu State.

The result in table 5 for Nsukka agricultural zone shows that the amount of chlorpyrifos residues recorded were significantly affected by interaction effect of agricultural zone and feed material. Maize with 0.57µg/kg had the highest residual content and was statistically different from other feed materials. This was followed by soyabeans (0.41µg/kg) which is significantly similar to residual content of PKC (0.38µg/kg). This result might be as a result of similar pattern of chlorpyrifos pesticide use. However, layer feed C, in addition to having the least chlorpyrifos residue content (0.10µg/kg) is statistically different from the other feed materials. However, just like was the situation in the other zones earlier mentioned no feed material in Nsukka was in violation of their respective codex MRL. The chlorpyrifos residue amount detected in layer feed C could be due to the fact that the cumulative chlorpyrifos pesticide usage along its production and storage stages is very insignificant.

The average quantity of chlorpyrifos residues in the layer feeds ranged from 0.10µg/kg to 0.36µg/kg and they are lower than the 0.018 and 0.143µg/kg reported by Susan *et al.,* (2011), Even though, the use of this pesticide has been prohibited in the US (Muller and Franz, 2000), (Gerhard, 2010). This same chemical pesticide is widely used in Enugu State.

Recommendations

Based on the findings of this study the following are my recommendations;

- The relevant government bodies responsible for pesticides should work hard to improve on the monitoring of the residual content of feed materials along the poultry feed chain.
- Feed industry, livestock producers and government agencies in the Nigeria should liaise with one another regularly to ensure that global best practices are maintained by all stakeholders in the feed industry.
- Nigeria should specify the pesticides authorized for use in the feeds and feedstuffs and see to it that stakeholders in the feeds and feedstuff industry key into this to ensure safer nutrition for livestock and man.
- The labellings on pesticide packages should also be written in the language understandable to the average pesticide user.
- Government policies on pesticides in addition to being publicized should further encourage 'Integrated Pest Management' (IPM) approach such as the use of cheap bio-pesticides to reduce risk of high pesticide residual content in feed materials.
- The codex commission should endeavor to establish pesticide residue standards for non-conventional but widely used feed materials such as PKC.

REFERENCES

Agrawal, O., Sunita, G. and Gupta, V. K. (1999): A New Sensitive Spectrophotometric Determination of Cypermethrin Insecticide In Environmental And Biological Samples. *J. Chin. Chem. Soc.*, **46**: 641.

Dugje, I. Y., Ekeleme, F., Kamara, A. Y., Omoigui, L. O., Tegbaru, A., Teli, I. A. and Onyibe, J. E. (2008): Guide to Safe And Effective Use of Pesticides For Crop Production In Borno State, Nigeria. International Institute of Tropical Agriculture (IITA) Ibadan, 23 pp.

Bushra, I., Samina, S. and Shafiqur, R. (2013): Assessment of the Dietary Transfer of Pesticides To Dairy Milk And Its Effect On Human Health. *African Journal of Biotechnology*, **13**(3): 476-485.

European Pesticide Database (2015): Maximum Residue Levels - European Commission. Retrieved from www.ec.europa.eu/food/plant/pesticides/max_residue_levels/index_en.htm on 25/2/2105.

Etonihu, A. C., Aminu, B. A., Ambo, A. I. and Etonihu K. I. (2011): Iodine Content and Pesticide Residues of Some Nigerian Food Grains". *Continental J. Agricultural Science*, **5** (1): 26 – 32.

EURL-CF (2010b): Pesticide Residues in Animal Feeding Stuff. EU Reference Laboratories For residues of Pesticides. Retrieved from http://www.crl-pesticides.eu/docs/public/tmplt_article.asp?CntID=757&LabID=400&Lang=EN on 20th February, 2015.

European Food Safety Authority (EFSA), (2011): Modification of the Existing MRLs for Cypermethrin in Various Crops. *EFSA Journal*. **9**(6):2280.

European Food Safety Authority (EFSA), (2012): Modification of the Existing MRLs for Cypermethrin in Various Crops. *EFSA Journal*. **10**(1):2510.

FAO/WHO (2013). Food Standards. Codex alimentarius Pesticide Residues in Food and Feed. Rome, Italy.

FAO/WHO (2003). Food Standards Programme Codex Alimentarius Commission. Twenty sixth Session. Rome, Italy. Report of the Thirty-Fifth Session of the Codex Committee on Pesticide Residues Rotterdam, Netherlands.

FAO (2002): The Legacy of Obsolete Pesticide Stocks in Africa. Retrieved from http//www.mindfully.org/pesticide 2002/African-obsolete-pesticides on 21/10/2014.

FAO (2004): Pesticide Residues in Food, Report, FAO Plant Production and Protection Paper No. 178 FAO, Rome p. 26.

Janghel, E. K., Rai, J. K., Rai, M. K. and Gupta, V. K. (2007): A New Sensitive Spectrophotometric Determination of Cypermethrin Insecticide in Environmental And

Biological Samples. *J. Braz. Chem. Soc.* **18**(3):590.

Ogah, C. O. and Coker, H. B. (2012): Quantification of Organophosphate and Carbamate Pesticide Residues in Maize. *Journal of Applied Pharmaceutical Science.* **2** (9): 093-097.

R & D Analytical Method (1973). *Determination of Monocrotophos (C-1414) Residues in Soyabeans.* No. 124, Ciba-Geigy Australia Ltd.

Susan, S.H., Karen, H., Hanne, B.C. and Mette, E.P. (2011). Cereals and Feeding stuff-production, consumption and pesticides. (Version 5) Appendix 5.EURL for Cereal and feeding stuff, National Food Institue, DTU Technical University of Denmark.

Soomro, A. M., Seehar, G. M. Bhanger, M. I. and Channa, N. A., (2008). Pesticides in the Blood Samples of Spray-workers at Agriculture Environment: The Toxicological Evaluation *Pak. J. anal. Environ. Chem. 9(1):32-37.*

Shaibu, I. (2008). NAFDAC bans 30 agrochemical products. Vanguard, May 14, 2008. www.allafrica.com retrieved on 20th October, 2014.

Sanni, L. O. (2005). Food safety, weights, measures and consumption patterns: The case of Gari in Enugu and Benin Markets. University of Agriculture, Abeokuta, Nigeria International Institute of Tropical Agriculture, Onne, Nigeria.

Tadeo, J. L, Sánchez-Brunete, C. and González L. (2008): Analysis of Pesticides in Food and Environmental Samples, Crc Press Taylor and Francis Group. pp. 32-228.

PREDICTION OF BODY WEIGHT FROM LINEAR BODY MEASUREMENTS OF GOATS IN EBONYI STATE, SOUTHEAST NIGERIA.

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Abstract
This study explores the prediction of body weight in goats using linear body measurements in Ebonyi State, South East Nigeria. Records were taken on a total of 372 goats (151 males and 221 females) kept by traditional farmers, covering six out of the thirteen Local Government Areas (LGA), two from each of the three senatorial districts of the State. In each LGA, 15 farmers were selected at random and measurements taken of a random sample of 2-5 goats depending on the flock size. There was high, positive and highly significant ($P<0.01$) correlation between body weight and among linear body measurements. Highly significant ($p<0.01$) coefficient of determination was recorded for three regression models used. The relationship between body weight and linear body measurements was best described by the quadratic equation. The R value for the male was higher than that of the female goats. A stepwise multiple linear regression showed that heart girth, height at withers and body could be used to predict body weight, with heart girth being the single linear body measurement that can predict body weight with high degree of reliability. Hip width is not reliable for prediction of body weight from linear body measurements.

Keywords: Prediction, Body weight, linear, body measurement, goat

Introduction

Goats play a crucial role in the livelihoods of smallholder farmers worldwide, particularly in developing regions. Goats not only enhance the economic resilience of rural communities but also contribute to improved nutrition and food diversity (Lohani and Bhandari, 2020). Goats are instrumental to environmental conservation and resource management. Their manure is a valuable source of nutrients, aiding in soil improvement and reducing the need for chemical fertilizers. Goats are highly valued for their adaptability and low maintenance requirements; thus, they are ideal choice for small holder and marginal farmers.

Accurate prediction of body weight in goats is crucial for effective breeding, nutrition, and health management. Knowing the body mass of goats is vital for determining appropriate medication dosages, adjusting feed supply, monitoring growth, and selecting replacement animals (Mahieu *et al*, 2011). Traditional methods of weighing can be cumbersome, especially in rural settings. Therefore, using linear body measurements offers a practical alternative. This study aimed to identify the most reliable body measurements for predicting the body weight of

goats, in Ebonyi State. The study focused on identifying key body measurements that correlate with body weight and developing regression models for accurate weight prediction. The findings are intended to aid local farmers in effective livestock management.

Materials and Method

Study Area

The study was carried out in Ebonyi State Nigeria. Ebonyi State is located in the Southeastern region of Nigeria. It is bounded to the North by Benue State, to the West by Enugu State, to the East by Cross River State and to the South by Abia State. With a land area of about 5,935 sq. km, the State lies approximately within longitude 7°30' and 8°30'E and latitude 5°40' and 6°45'N. The average annual rainfall is about 2500 mm, annual temperature range of about 20-38°c, with average of 28°c and a relative humidity of 82.1-85.9%. The State is situated within the rainforest zone (https://en.wikipedia.org/wiki/Ebonyi_State#Climate. Retrieved: 08/11/2024). The population of the State stands at 4.339 million (https://www.ebonyistate.gov.ng/profile.html. Retrieved: 08/11/2024).

Data Collection

Data was collected from 372 goats, comprising 151 males and 221 females, kept by traditional farmers in Ebonyi State. Linear body measurements, including heart girth, height at withers, and body length, were recorded for each animal. Regression equations were developed to predict body weight based on these measurements, considering the sex and age of the goats.

Data Analysis

The categorical traits were analyzed using simple percentages in the Statistical Package for the Social Sciences (SPSS) version 11 .0 (2005). The linear body measurements mentioned above and body weights were correlated with each other. In addition, each of the linear body measurements was regressed against the body weight of the animal using linear, quadratic and allornetric models as given below.

Linear $Y=a+bX$
Quadratic $Y = a + b_1 X_1 + c_2X_2$
Allometric $Y = aXt'$
Where Y = Body weight of goats (dependent variable)
a = intercept (the value of' Y when X is zero)
b = 1 order regression coefficient
c = 2' order regression coefficient
X = independent variables (body length, heart girth, height at withers and hip width)

A stepwise multiple regression of all the linear body measurements against the body weight were also done. This will give room for the effect of each body parameter on body weight to be measured however little it may be and those body measurements that have no significant effect on body weight are excluded in the model.

The model is stated below.

$Y = a \pm b_1X_1 \pm b_2X_2\text{-t-}b_3X_3 \pm b_4X_4$

Where Y = dependent variable (body weight)

a = intercept

b_1 — b_4 = regression coefficient associated with X_1 — X_4

X_1 — X_4 = independent variables (body length, heart girth, height at withers, hip width respectively).

Results and Discussion

Mean of Body Weight and Linear Body Measurements of Goats in Ebonyi State

Table 1 shows mean values of body weight (BW), body length (BL), heart girth (HG), height at withers (HAW) and hip width (HW). The BW, BL, HG, HAW and HW means for male and female goats sampled were 16.60 kg and 16.00 kg, 69.90 cm and 68.70 cm, 59.00 cm and 57.00 cm, 45.60 cm and 44.80 cm, and 62.00 cm and 63.00 cm, respectively. The BW, BL, 1-1G. HAW and HW mean values for adult goats sampled were 16. 10kg, 70.00 cm, 58.00 cm, 45.00 cm and 62.00 cm. James *et al.* (2007) reported an average live weight of the goats sampled as 15.2 kg, heart girth as 58.4 cm and an average withers height as 42.3 cm. The higher values recorded in the present study as compared to the findings of James *et al.*(2007) could be because of greater number of older animals, examined in the present study

Correlation of Body Measurements with Body Weight

Correlation of Body Measurements with Body Weight is presented in Table 2. Body weight was found to be significantly ($P<0.01$) and positively correlated with several linear body measurements. This agrees with Nwaodu *et al.* (2024) who reported high correlation between body weight and body measurements

Regression Models for Weight Prediction

The regression equation for predicting body weight from body length, heart girth, height at withers and hip width for male and female goats are presented in Table 2. Significant ($P<0.01$) coefficient of determination (R2) values (0.590-0.0.9 10) were recorded for all the three models investigated, with the quadratic model giving the best estimates, followed by linear and allometric models. All the equations gave best estimates with hearth girth (0.807- 0.910) while the lowest estimates were recorded for height at withers (0.584-0.611). The allometric model gave better estimates for height at withers compared to quadratic and linear models.

Generally, the estimates for male goats were better than that of the female goats in all the models. This finding is in agreement with the findings of James et al. (2007), who reported that heart girth accounted for most of the variations in body weight of goats and that heart girth and withers height gave better estimates for adult goats than for kids. They also reported that chest girth and withers height estimated the live weight of does better than bucks which is in contrast with the finding of this study. Yakubu et al. (2007) also reported that heart girth accounted for most of the variations in body weight of goats. The result of this study also agreed with the findings of Smial and Da (2006) who concluded that the quadratic model gave a better fit to the body parameters investigated by its higher R2 and lower MSE (residual mean square).

Stepwise Multiple Linear Regression Model for Weight Prediction

A stepwise multiple linear regression analysis as shown in Table 3 revealed that heart girth, height at withers, and body length could be used to predict body weight effectively. The regression models developed in this study showed high coefficients of determination, indicating a strong predictive capability.

Heart girth emerged as the most reliable predictor of body weight, showing a high degree of correlation. The findings align with previous research indicating the strong predictive power of heart girth for estimating body weight (Mohammed et al., 2013; Yakubu, 2010). The high R^2 values suggest that linear measurements can reliably predict body weight, offering a practical tool for farmers in Ebonyi State.

Conclusion

This study confirmed that heart girth, height at withers, and body length are reliable and significant predictors of body weight in goats. The regression models developed provide a practical tool for farmers in Ebonyi State, to estimate goat body weight accurately. The ability to predict body weight accurately using simple linear measurements can greatly benefit local farmers in Ebonyi State. It allows for better management of feeding, breeding, and health care practices without the need for expensive weighing equipment.

Recommendation

Linear body measurements have high, positive and highly significant correlation with body weight and thus, could be used to determine body weight of WAD goats where measuring scale is not readily available.

The combination of HG, BL and HAW in a predictor model gave the best estimate of body weight. This should be used for prediction of body instead of using a single factor as this will capture combined effects of the linear measurements.

Result Tables

Table 1: Mean of Body Weight and Linear Body Measurements of Goats in Ebonyi State.

		BW(cm)	BL(cm)	HG(cm)	HAW(cm)	HW(cm)
Group	No	Mean				
Male	151	16.60 +0.30	69.90±0.55	59.00±0.46	45.60±0.26	62.00+0.52
Female	221	16.00 ± 0.2	68.70+0.45	57.00±0.40	44.80±0.25	63.00±0.46

(BW=Body Weight, BL=Body Length, HG=Heart Girth, HAW=Height at Withers, HW=Hip Width)

Table 2: Correlation between traits of goats in Ebonyi State

Trait	Category	Bl	HG	HAW	HW
BW	Male	0.884**	0.954**	0.764**	0.875**
	Female	0.871**	0.933**	0.768**	0.885**
BL	Male		0.897**	0.693*	0.873**
	Female		0.867**	0.771**	0.918**
HG	Male			0.747**	0.906**
	Female			0.724**	0.898**
HAW	Male				0.744**
	Female				0.747**

BW=Body Weight, BL=Body Length. HG=Heart Girth, HAW=Height at Withers. HW=Hip Width, **=P<0.01

Table 3: Regression of body weight on body measurements of male and female goat

	Regression Equation	S.E	R^2
Male			
	$BW = -21.055 + 0.5308BL$	1.56	0.782***
	$BW = -51.379 + 1.4163BL - 0.0064BL^2$	1.87	0.791***
	$BW = 0.0002BL^{2.68}$	0.17	0.696***
	$BW = 20.474 + 0.6275HG$	1.22	0.910***
	$BW = -18.510 + 0.5566HG + 0.0006HG^2$	1.23	0.910***
	$BW = 0.0004HG^{2.60}$	0.13	0.839***
	BW = -26.313 + 0.	2.62	0.584***
	$BW = -69.729+2.9758HAW-0.0236HAW^2$	1.08	0.594***
	$BW= 0.00007HAW^{324}$	0.19	0.618***
	BW= -17.410+0.5418HW	1.50	0.766***
	BW = -22.420+0.7 1 191-IW-0.0014HW²	0.32	0.767***
	$BW=0.00008HW^{241}$	0.17	0.719***
Female			
	$BW = -22.376 + 0.5442BL$	1.39	0.758***
	$BW = -63.481 + 1.7708BL-0.009 I BL^2$	1.99	0.779***
	$BW = 0.00006BL^{294}$	0.19	0.712***
	BW = -22. 105+0.6534HG	1.51	0.871***
	$BW = -19.482 + 0.5567HG-0.0009HG^2$	1.51	0.871***
	$BW= 0.0002HG^{281}$	0.15	0.807***
	BW=-24.166+0.8857HAW	2.15	0.590**
	$BW = -71.003 + 3.07I7HAW-0.0253HAW^2$	0.64	0.611**
	$BW = 0.000091HAW^{317}$	0.22	0.598**

BW=-18.752 + 0.5412HW	1.17	0.784^{***}
BW = -36.764 + 1.145 IHW-0.0050HW^2	0.25	0.789^{***}
BW= 0.0003HW^{260}	0.18	0.741^{***}

BW=Weight, BL=Body Length. HG=Heart Girth, HAW=Height at Withers, HW=Hip Width, ***= P<0.001, **= P<0.01

Table 4: Stepwise Multiple linear regression of body weight on body length, heart girth, height at withers and hip width

Category	Regression equation[a]	R^2	S.E.
Sex			
Male	BW -20.27 + 0.627HG	0.909	1.222
	BW = -23.57 + 0.570MG + 0.I44HAW	0.916	1.186
	BW = -24.39 + 0.494HG + 0.I35HAW + 0.O81BL	0.919	1.156
Female	BW = -22.11 + 0.653HG	0.871	1.512
	BW = -26.30 + 0.560HG + 0.223HAW	0.889	1.410
	BW = -26.58 + 0.480HG + 0.166HAW + 0.103BL	0.895	1.373

(BW=Body weight, HG= Heart girth, HAW=Height at withers, BL= Body length)

Reference

Babale, D.M., Hussein AU and Gworgwor. Z (2018). Relationship between liveweights, linear body measurements and cost prices of small ruminants sold in and around mubi environs, adamawa state, Nigeria. *J Dairy Vet Anim Res. 2018;7(6):273-277*

James, I.J., Osinowo, O.A. and Amoo, T.O (2007). Estimation of live weight from Chest Girth and Withers Height Measurements in West African Dwarf Goats. *Nigerian Journal of Animal Produciion.34 (2): 181-1 87.*

Lohani, M and Bhandari, D (2020) The importance of goats in the world. *Professional Agricultural Workers Journal, Vol. 6, No. 2, Art. 4*

Mahieu M, Navès M and Arquet R (2011). Predicting the body mass of goats from body measurements. *Livestock Research for Rural Development. Volume 23, Article #192.*

Matsebula, M., Bhebhe, E., Mupangwa, J F and Dlamini, B J (2013). Prediction of live weight from linear body measurements of indigenous goats of Swaziland. *Livestock Research for Rural*

Development 25 (8), Art. 140.

Nwaodu , O. B., Chikwendu, M. E., & Deakpe , T. E. (2024). Phenotypic Characterizstion of Indigenous Goat in Afikpo South Local Government Area Ebonyi State. *Nigerian Journal of Animal Production, 54–56.*

Smail, K. and Da. B. (2006). Comparisim of the linear and quadratic models for describing the growth of live weight and body measurements in Anatolian Merino male lambs in fattening period. *J. Anim. Vet. Adv 5(1): 81-84.*

Yakubu, A., Ogah, D.M., Ladokun, A.O. and Adua, M.M. (2007). Comparism of linear and non-linear models in the estimation of body weight from body measurements in West African Dwarf goats in North Central Nigeria. *Proceeding of the 32nd Annual Conf. Nig. Society for Animal Prod.-Calabar March 18-21. Pp 130-133.*

Yakubu, A. (2010). Path coefficient and path analysis of body weight and biometric traits in Yankasa lambs. *Nigerian Journal of Animal Science, 12(2), 23-28.*

GROWTH PERFORMANCE OF BROILER CHICKENS RAISED UNDER DIFFERENT LIGHTING REGIMES AND THEIR CARCASS CHARACTERISTICS

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Abstract

An eight-week feeding trial was conducted to determine the effect of different lighting regimes on the growth performance and carcass characteristics of broiler chickens. A total of one hundred- and twenty-day old chicks were used. The chicks were separated into different light treatment groups such as; 24L (control group), 18L: 6D, 15L: 9D, 12L: 12D designated as T_1, T_2, T_3 and T_4 respectively, in a completely randomized design experiment. The feeding trial lasted for eight weeks and during this period growth performance was monitored while at the end of the feeding trial carcass characteristics and economic analysis were evaluated. Result showed that there was no significant ($P>0.05$) difference in all growth and carcass characteristics of broiler chickens raised under different lighting regimes. The economics of raising broiler chicken under different regimes showed that 12L: 12D was more profitable (₦520.04) compared to other lighting regimes. The study concludes that different lighting regimes did not have any adverse effect on the growth performance and carcass characteristics of broiler chickens with the additional benefit of increasing the profit margin.

Introduction

Poultry meat is an important source of protein eaten by most people irrespective of their religious backgrounds. Broilers are birds kept specifically for meat. Broiler chickens have been reared under 23 hours light(L): 1hour dark(D) lighting regime to maximize growth rate, allow maximum feeding time and conscious feed consumption (Lien *et al.*, 2007). According to Petersen (2004), broilers should not be in continuous light and need to have at least 8 hours of dark during day, although in future this period can be reduced to 3 hours. Broiler chickens have usually been kept on a continuous or nearly continuous lighting (23 L: 1 D, CL) schedule so as to maximize feed intake and growth rate (Campo and Davila, 2002).Several undesirable traits, however, including increased fat deposition, higher incidence of metabolic diseases, skeletal deformities, and circulatory problems can become quite prevalent for birds reared under a continuous lighting schedule (Kristensen *et al.*, 2006; Olanrewaju *et al.*, 2006). The study therefore assesses the effect of lighting regimes on the growth performance and Carcass characteristics of broiler chickens

MATERIALS AND METHODS

The study was carried out at the Poultry Unit of the Teaching and Research Farm, University of Calabar, Calabar, Cross River State, Nigeria. One hundred and twenty (120) day-old chicks of the Chikun strain purchased from a reputable hatchery in Kaduna were used in the study. The chicks were divided into four groups of thirty (30) each, the chicks were allocated to different light treatments (T_1,T_2,$T_3$and T_4) in a completely randomised design (CRD) with three (3) replicates per treatment of 10 chicks each. Water was provided *ad libitum* until they were

eight (8) weeks old. The chicks were brooded together and separated at 3weeks old before the light treatment commenced.

The chicks were housed in a deep litter floor with adequate spacing, ventilation, protection against predators and other environmental factors were ensured. Vaccines were administered and other daily routine management practices such as daily inspection of birds for symptoms of diseases, cleaning of feeding troughs, washing of drinkers and provision of clean water were carried out. The lighting regimes for the different treatments were as follows:
T_1 = 24 hours light: 0-hour darkness (positive control), T_2 = 18 hours light: 6hours darkness, T_3 = 15 hours light: 9 hours darkness and T_4 = 12 hours light: 12 hours darkness (negative control)

Experimental diets

Birds were fed commercial broiler starter diet for four (4) weeks, followed by the finisher diet for another four (4) weeks. The commercial diet (Top Feed) for starter phase had 22%CP and 2900Kcal/KgME and the finisher diet had 18%CP and 3000Kcal/KgME.
A total of 36 birds (9 per treatment) were randomly selected, starved over night and weighed individually before slaughter. The dressed weight was determined and prime cuts and organ measurements were carried out and expressed as percentages of the live weight.

I. Dressing percentage $= \frac{\text{dressed weight}}{\text{Live weight}} \times \frac{100}{1}$

II. Prime cuts: The carcass was dissected into different parts such as: Thighs, Back cut, Drumstick and Breast.
Other parts included: Head, Wings, Intestine, Shank and Internal organs

III. Relative organ weight (%) $= \frac{\text{Organ weight (g)}}{\text{Live weight}} \times \frac{100}{1}$

All data obtained from this study was subjected to one way analysis of variance (ANOVA) for CRD and the significant means were separated using the Least Significance Difference (LSD) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Results of the growth performance characteristics of broiler chickens raised under different lighting regimes of 24hours light (positive control), 18hourslight, 15hours light and 12hours light (negative control) are presented in Tables 1 and 2, for the starter and finisher phases respectively. The starter phase shows that the different lighting regimes had no significant ($P>0.05$) effect on the growth performance parameters of the broiler chickens. The total weight gain was in the range (512.50-552.50g/bird). Total feed intake range was 555.29-616.74g/bird. The average daily feed intake and FCR ranged between (19.83-22.03g/bird) and 1.09-1.15, respectively.

The finisher phase (Table 2) shows that the final body weight, total weight gain, daily weight gain, average feed intake and FCR were not significantly($P>0.05$) influenced by exposure to the different lighting regimes. The total weight gain was in the range (1962.50-2367.50g/bird). The final weight gain was in the range (2535.00-2920.00g/bird). Total feed intake range was 6351.64-6844.33g/bird. The average daily and weekly feed intake was (226.84-244.44g/bird)

and 1587.91-1711.0825g/bird. The average daily and weekly weight gain were in the range (70.09-84.55g/bird) and (490.63-591.88g/bird) respectively. FCR was in the range (2.68-3.32). The result for the economics of producing broiler chickens under different lighting regimes showed the Cost/kg of experimental diet (₦/kg) was in the range (₦142- ₦142).Total feed cost of feed intake was in the range ₦32.66- ₦34.08. Cost/kg flesh was in the range ₦479.96- ₦656.04. Profit (₦) was in the range ₦343.96- ₦520.04.Cost of feed intake was higher in T_1(24hours light) and T_2(18hours lighting) (₦34.08)and lower in T_3(15hours light) and T_4(12 hours light). Revenue per kilogram was ₦1000 and cost per kilogram flesh was higher in T_1(24hours light) ₦656.04 and lower in T_4(12hours light)₦479.96.Therefore higher profit was obtained in T_4(12hours light)(₦520.04) and lower profit in T_1(24hours light)₦343.96.

The result of the carcass characteristics relative weight of broiler chickens exposed to different lighting regimes is shown in Table 3.There was no significant difference (P>0.05) in carcass characteristics including internal organs and primal cuts of broiler chickens exposed to different lighting regimes. The live weight and dressed weight ranged between (2362.50-2525.00g/bird) and 1797.50 -1937.50g/bird. The dressing percentage was in the range 82.01-74.13%.

TABLE 1: Growth performance of broiler chickens exposed to different lighting regimes (Starter Phase)

Parameter	T_1 24hours light	T_2 18hours light	T_3 15hours light	T_4 12hours light	SEM
Initial weight (g/bird)	40.00	40.00	40.00	40.00	0.00
Final weight (g/bird)	572.50	576.50	592.50	552.50	8.23 NS
Total weight gain (g/bird)	532.50	536.50	552.50	512.50	8.23 NS
Total feed intake (g/bird)	579.38	616.74	555.29	567.29	13.30 NS
Average daily weight gain (g/bird)	19.02	19.16	19.73	18.30	0.30 NS
Average daily feed intake(g/bird)	20.69	22.03	19.83	20.26	0.48 NS
FCR	1.09	1.15	1.01	1.11	0.03 NS
Mortality (%)	0.00	6.67	0.00	0.00	5.56

SEM: Standard error of mean
NS: Not significant (P>0.05)
FCR: Feed conversion ratio

TABLE 2: Growth performance and economics of producing broiler chickens exposed to different lighting regimes (Finisher Phase)

Parameter	T_1 24hours light	T_2 18hours light	T_3 15hours light	T_4 12hours light	SEM	
Initial weight (g/bird)	572.50	576.50	592.50	552.50	8.23	
Final weight (g/bird)	2535.00	2755.00	2780.00	2920.00	79.60	NS
Total weight gain (g/bird)	1962.50	2178.50	2187.00	2367.50	82.85	NS
Total feed intake(g/bird)	974.68	978.84	916.92	907.40	18.77	NS
Average weekly feed intake (g/bird)	243.67	244.71	229.23	226.85	4.69	NS
Average daily feed intake(g/bird)	34.81	34.96	32.75	32.41	0.67	NS
Average weekly weight gain (g/bird)	490.63	544.63	546.75	591.88	20.71	NS
Average daily weight gain(g/bird)	70.09	77.80	78.11	84.55	2.96	NS
FCR	0.50	0.45	0.42	0.38	0.03	NS
Mortality (%)	0.00	0.00	0.00	0.00	0.00	NS
Cost/kg feed (₦)	142.00	142.00	142.00	142.00	0.00	NS
Cost of feed intake (₦)	34.08	34.08	32.66	32.66	0.41	NS
Cost of 1kg flesh (₦)	656.04	568.00	523.98	479.96	37.59	NS
Revenue per kg (₦)	1000.00	1000.00	1000.00	1000.00	0.00	
Profit (₦)	343.96	432.00	476.02	520.04	37.59	NS

NS: Not significant (P>0.05)
SEM: Standard error of mean

TABLE 3: Carcass characteristics of broiler chickens exposed to different light regimes

NS: Not significant (P>0.05)

Parameter (%LW)	T_1 24hours light	T_2 18hours light	T_3 15hours light	T_4 12hours light	SEM	
Live weight(g/bird)	2512.50	2537.50	2362.50	2525.00	81.89	NS
Dressed weight(g/bird)	1862.50	1937.50	1797.50	1900.00	29.85	NS
Dressing percentage(%)	74.13	82.01	76.08	75.25	1.76	NS
Heart	0.48	0.47	0.49	0.41	0.02	NS
Liver	1.54	1.59	1.51	1.40	0.04	NS
Full Gizzard	2.40	2.44	2.48	2.36	0.03	NS
Empty Gizzard	1.64	1.71	1.73	1.69	0.02	NS
Kidney	0.17	0.28	0.33	0.11	0.05	NS
Spleen	0.07	0.11	0.05	0.06	0.02	NS
Pancreas	0.33	0.47	0.37	0.35	0.03	NS
Proventriculus	0.44	0.40	0.48	0.41	0.02	NS
Crop	0.14	0.43	0.17	0.22	0.07	NS
Lungs	0.58	0.46	0.50	0.47	0.03	NS
Gall bladder	0.10	0.08	0.08	0.47	0.10	NS
Head	2.22	2.32	2.18	2.18	0.05	NS
Breast	23.82	25.92	26.11	24.57	0.55	NS
Thighs	11.29	11.07	10.69	10.55	0.17	NS
Neck	4.67	5.18	4.77	5.23	0.14	NS
Drumsticks	10.37	10.62	10.42	10.77	0.09	NS
Shanks	3.61	3.35	3.57	3.30	0.07	NS
Back cut	15.79	12.97	13.62	12.49	0.73	NS
Trachea	0.08	0.07	0.10	0.08	0.01	NS
Wings	7.74	7.93	8.27	7.49	0.17	NS
Visceral fat	1.77	1.60	0.99	1.53	0.17	NS
Total GIT weight	11.63	10.83	10.89	10.57	0.23	NS
Total GIT length(cm)	272.50	274.00	254.25	266.25	4.49	NS

SEM: Standard error of mean
%LW: Relative weight expressed in percent live weight.

Growth performance characteristics and economics of producing broiler chickens exposed to different lighting regimes

In broiler production, lighting program is one of the major factors with others(relative humidity, wind velocity, ambient temperature and stocking density) that affect the birds metabolism which in turn is responsible for maximizing growth performance and maintaining normal physiological processes and functions (Olanrewaju *et al.*,2010).In this study, at the starter phase shown in Table 3, average daily weight gain range (18.3-19.73g) was similar and in agreement with Kristensen *et al.* (2006) who observed that lower Light intensity had no significant effect on overall broiler live performance as indicated in body weight, feed intake, and feed conversion ratio. This is also similar to the findings of Lien *et al.* (2008), who observed increased body weight and feed intake with dim light (1 lux) in comparison to 150 lux. There was no significant difference in average daily feed intake in the four light treatments, but birds on 18hours lighting regime had higher average daily feed intake (20.69g) while the lowest was recorded for birds under 15hours lighting regime (19.83g).Feed conversion ratio was best under 15hours lighting regime (1.01).This implies that birds raised under T_3 (15hours light:9hours darkness) consumed the least feed to yield 1kg of their body weight. This is in agreement with the findings of Kristensen *et al.* (2006), who observed improved feed conversion as light intensities were decreased from 10 to 0.1 lux.

At the finisher phase, there was no significant ($P>0.05$) difference in the final weight of birds in the four light regimes, but birds under 12hours lighting regime had the highest final weight (2920.00g),while birds raised under 24 hours lighting had the lowest final weight(2535.00g).This result agrees with Ohtani and Leeson (2000), who reported that the body weight of broiler chickens reared under intermittent light was lower during the early stage and manifest catch-up growth during the subsequent period and the difference in final body weights between groups were not statistically significant.

There was no significant ($P>0.05$) difference in total body weight gain, average weekly weight gain and average daily weight gain. These were highest with birds raised under 12hours lighting, while those raised under 24hours light were the lowest. The range (490.63-591.88g) obtained in this study for average weekly weight gain is not in agreement with the range(261.60-272.70g) reported by Amakiri and Monsi,1992. There was no significant ($P>0.05$) difference in total feed intake, average weekly feed intake and average daily feed intake. Birds raised under 18 hours lighting and 24hours lighting consumed more feed, while those raised under 12hours lighting consumed the least amount of feed (6351.64,1587.91 and 226.84g/bird) respectively for total, weekly and daily feed intake. The birds exposed to 12 hours light treatment program consumed slightly less feed as compared with those exposed to 18hours light and continuous light (24hours light).The higher feed consumed by the birds raised under 18hours and 24hours lighting regime suggested that the birds feed more under light. This study agrees with Classen (2004), who observed that lighting schedule demonstrated clearly that longer period of darkness prevents regular access to feed and consequently reduce feed intake. The results of this study in connection with feed consumption is similar with the results reported by Ohtani and Leeson(2000), indicating lower feed intake under different lighting groups than the continuous light groups in 3-6 weeks old chicken. In the findings of Downs *et al.*(2006), it is generally accepted that changes in photoperiod result in changes in feed consumption and

body weight and lower intensities may improve feed conversion because of a reduction in activity.

Feed conversion ratio was not significantly (P>0.05) influenced by exposure to different lighting regimes, this implies that the broiler chickens response to FCR by exposure to either light treatments were the same. Feed conversion ratio was best in birds raised under 12hours lighting regime (2.68). This implies that birds raised under 12hours lighting regime consumed the least feed to yield 1kg of their body weight while birds in other treatments consumed more feed to yield 1kg of their body weight. The results from this study are in line with the findings of Renden *et al.* (1996) who observed that intermittent restricted lighting programs, incorporating short periods of light and darkness have shown increased body weight. Kristensen *et al.*(2006), Lien *et al.*(2007) and Blatchford *et al.* (2009),observed that improvement of performance under low light intensity is expected due to decrease in the physical activity (walking, fighting and flightiness) of birds. The results from this study agrees with the findings of Onbasilar *et al.*(2007), that feed conversion ratio of chickens reared under intermittent light was better than those under continuous light because of the short meal feeding period, followed by a larger period for digesting the meal. As chickens under intermittent light will be essentially quiet during a dark period, it is assumed that the reduction of activity during darkness may result in lower heat production and higher feed efficiency. Olanrewaju *et al.* (2006), also observed that restricted lighting programs enhanced broiler production through improvements in body weight, feed conversion ratio and better health. The result from this study agrees with the findings of Onbasilar *et al. (*2007), that lighting program did not influence final body weight, body weight gain, feed consumption, feed to gain ratio.

Carcass characteristics of broiler chickens exposed to different lighting regimes (relative weights)

The live weight was not significantly (P>0.05) affected by the different lighting regimes. From the result presented in Table 5, the range (2512.50-2522.00g/bird) for the live weight showed that T_4(24hours light) had the highest live weight (2537.50g) while T_3(15hours light) had the lowest live weight (2362.50g). Onbasilar *et al.* (2007) who examined the effect of different light regime on the performance and carcass traits of broiler chickens observed no significant(P>0.05) difference for the different lighting regime on broiler birds. In this study no significant difference was observed in the dressed weight and dressing percentage. These findings agree with the findings of Onbasilar *et al.* (2007), that the dressing percentage was not significantly (P>0.05) affected by the different lighting regimes. T_2 (18hours light) had the highest dressed weight (1937.50g), while T_3 (15hours light) had the lowest dressed weight (1797.50g). Birds in T_3 (15hours light) had the highest dressing percentage (75.93%) while those in T_1 (24hours light) had the lowest dressing percentage (74.03%). The dressing percentage range in this study was similar to the findings of Ke *et al.(*2011) who reported that dressing percentage did not differ significantly (P>0.05) among the different light treatments(69.05-75.37%). Internal organs and carcass such as heart, liver, full gizzard, empty gizzard, kidney, spleen, pancreas, proventriculus, crop, lungs, gallbladder, head, breast, thigh, neck, drumstick, shanks, back cut, trachea, wings, visceral fat, total GIT weight and total GIT length did not differ significantly (P>0.05).This agrees with the findings of Onbasilar *et al.*

(2007), that none of the carcass traits varied significantly due to the different lighting groups in their previous study, this is because light has no effect on carcass characteristics

Conclusion

There was no significant (P>0.05) difference in the light treatments and therefore no effect of light on overall broiler chicken production parameters. Since longer periods of lighting are viewed by the general public and animal welfare organisations as an improvement in broiler welfare, the findings of this research suggest that it is possible to raise broiler chickens with no artificial lighting since there was no difference in the growth performance and carcass characteristics of the broiler chickens with increased profit as a result of lowered or no additional cost of light provision for the birds by the farmers.

REFERENCES

Amakiri, A. O and Monsi A.(1992).Effects of nocturnal variations in lighting regimes on broiler performance in a humid tropical environment.Delta Agric. 1:37-42.

Blatchford, R. A., Klasing, K. C., Shivaprasad, H. L, Wakenell, P. S., Archerand,G. S and Mench, J. A. (2009). The effect of light intensity on the behavior, eye and leg health, and immune function of broiler chickens.*Poultry Science*. 88:20–28.

Campo, J. L. and Davila ,S. G. (2002).Effect of photoperiod on heterophil to lymphocyte ratio and tonic immobility duration of chickens.*Poultry Science,* 81: 1637-1639.

Classen, H. L. Annett, C. B. Schwean-Lardener, K. V. Gonda, R., Derow,.D. (2004). The effect of lighting programmes with twelve hours of darkness per day provided in one, six or twelve hour intervals on the productivity and health of broiler chickens. *BritishPoultry Science,* 45:531-532.

Downs, K. M., Lien, R. J., Hess, J. B., Bilgili, S. F. and Dozier ,W. A. III (2006). The effects of photoperiod length, light intensity, and feed energy on growth responses and meat yield of broilers. *Journal of Applied Poultry Research.* 15:406–416.

Kristensen H.H., Perry G.C., Prescott N.B., Ladewig J., Ersboll A.K. and Wathes C.M. (2006). Leg health and performance of broiler chickens reared in different light environments. *British Poultry Science*, 47(3): 257-263.

Lien R. J., Hess J.B., Mckee S. R., Bigili S. F.(2008). Effect of light intensity on live performance and processing characteristics of broilers.*PoultryScience*,87:857.

Lien, R.J., Hess, J.B., McKee, S.R., Bilgili, S.F. and Townsend, J.C. (2007).Effect of light intensity and photoperiod on live performance, heterophil-to-lymphocyte ratio, and processing yields of broilers intensity and photoperiod on live performance, heterophil-to-lymphocyte ratio, and processing yields of broilers.*Poultry Science*, 86: 1287–1293.

Ohtani, S. and Leeson, S. (2000).The effect of intermittent lighting on metabolizable energy intake and heat production of male broilers.*Poultry Science,*79:167–171.

Olanrewaju, H. A., Thaxton,J. P. Dozier,W. A. Urswell,W. B. Roush, J. P. and Branton, S. L.. (2006). A review of lighting programs for broiler production. *International Journal of PoultrySci*ence5(4):301-308.

Olanrewaju, H. A., Purswell,J. L., Collier, S. D. and Branton, S. L. (2010).Effect of ambient temperature and light intensity on physiological reactions of heavy broiler chickens. *Poultry Science,*volume 89,pages 2668-2677.

Onbasilar, E. E., Eroll, H., Cantekin, Z. and Kaya, U. (2007). Influence of intermittent lighting on broiler performance, incidence of tibial dyschondroplasia, tonic immobility, some blood parameters and antibody production. *Asian-Australian Journal of Animal Science*, 20(4):550-555.

Peterson J.S. (2004): Management and housing systems for broilers – Effects on welfare and production. XXII World's Poultry Congress, Istanbul-Turkey, 8-13 June 2004, Book of abstracts, 325.

Renden, J. A., Moran, E. T. and Kincaid, S. A. (1996).Effect of lighting regimes on lighting programs for broilers that reduce leg problems without loss of performance or yield.*Poultry Science.*75:1345-1350.

Steel, R.G.D and Torrie, J.H. (1980).Principles and Procedures of Statistics. A Biometric Approach.2nd edition, McGraw Hill Book co. Inc. New York, USA. 481pp.

Ke, Y., Liu, W.J., Wang, Z.X and Chen, Y.X. (2011).Effects of monochromatic light on quality properties and antioxidation of meat in broilers. *Poultry Science,* 90(11): 26.

EFFECT OF GRADED LEVELS OF FORTIFIED SANDBOX (*HURA CREPITANS*) SEED MEAL ON THE PERFORMANCE OF GROWING PULLET CHICKS IN CALABAR, NIGERIA

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Abstract
The response of pullet chicks to graded levels of fortified sandbox seed meal (FSBM) in place of soya bean meal was investigated. One hundred and twenty (120) four weeks old growing pullets of Rhode Island Red strain, weighing between 259.00 and 260.45 g/chick were weighed and randomly divided into five groups of 24 chicks each using a Completely Randomized Design (CRD). Each group was further replicated thrice, with each replicate having 8 chicks, and placed on a deep litter floor pen. Water and feed were provided ad libitum for 35 days of the experimental duration. Soya bean meal in the diets was replaced with fortified sandbox seed meal (0.5g lysine per 100g sandbox seed meal) at 0, 25, 50, 75 and 100 % levels to represent treatments T1, T2, T3, T4 and T5, respectively. Results showed that final live weight and average weight gain were not significantly ($p>0.05$) affected by dietary treatments. However, feed intake, feed conversion ratio, total feed cost and feed cost/weight gain (kg) significantly ($p<0.05$) decreased as the level of FSBM increased in the diets. In conclusion FSBM could totally replace soya bean meal without adverse effect on live weight and weight gain and with drastic reduction in feed cost and feed cost/weight gain (kg).

Keywords: Fortified sandbox meal, soya bean meal, lysine, pullet chicks

INTRODUCTION

Feed shortage is the major constraint affecting livestock and poultry industry in developing countries including Nigeria with resultant effect of low level of animal production (Archibong *et al.*, 2023). This is partly due to the cost of feed and feed ingredients. Feed cost constitutes over 80 % of poultry farm recurrent expenditure (Nsa *et al.*, 2019). The food deficit problem is indeed more precarious with conventional protein sources when compared with the availability of energy sources (Ani *et al.*, 2010).

Thus, it is imperative to source for alternative plant protein sources, which must be cheap, readily available and less competitive by man and industry (Oluremi *et al.*, 2010). The alternative cheap and available plant protein feedstuff to be considered in this study is sandbox (*Hura crepitans*) seed meal. The sandbox tree, also known as the Dynamite tree, produces small green flowers that are followed by large, woody fruit capsules that are up to 30 cm long (Vogel, 2013). These fruit capsules contain many seeds, when dry, burst, releasing several flattened circular seeds of about 18-20 mm in diameter (Keay, 2010). The seed is of high dry matter content of 91-95 %, a good indicator of high storage capacity (Keay, 2013). The ether extract is quite high, ranges from 38.95-51.24 %. The seed is moderate in crude protein, rich in methionine, leucine, arginine but limited in lysine and phenylamine (Esonu, 2006; Oyeleke *et al.*, 2013). Sandbox seed is rich in minerals, especially sodium (Na), potassium (K), calcium

(Ca), some trace amount of manganese (Mg), Iron (Fe) and Zinc (Zn). Notwithstanding, the seed is known to have some anti-nutritional factors like saponin, phytate and hemagglutinin (Esonu *et al.*, 2014). However, many processing methods including toasting have been found to reduce/eliminate the toxins, making it safe for feeding of livestock and poultry birds (Archibong *et al.*, 2023). In Nigeria, sandbox tree is found virtually everywhere in the country including Cross River State. The State Government planted the tree to control erosion and to improve the aesthetic value of the clean and green environment of Calabar. The objective of this study was to determine the response of growing pullet chicks to graded levels of fortified sandbox seed meal as replacement for soya bean meal.

Materials and methods

The study was carried out at the Poultry Unit of the Teaching and Research Farm, University of Calabar, Nigeria. Calabar has an average temperature of 27°C, average annual rainfall of 1850 mm and relative humidity between 70% and 80 % (NiMet, 2023).

Mature sandbox seeds were harvested from sandbox trees within the University of Calabar premises. The pods were broken with hammer and the seeds toasted. Toasting involved adding about 5kg of sandbox seeds into an open cast-iron pan already set over fire. The seeds were steadily stirred to prevent them from sticking to the pan and from burning. Stirring was carried out for 30 minutes, before being allowed to cool down. The seeds were then milled with a hammer mill through a 2 mm sieve and defatted with n-hexane. Five diets were formulated in which soya bean meal was replaced at 0, 25, 50, 75 and 100% levels with fortified sandbox seed meal (i.e. 25g lysine + 100 kg sandbox seed meal) to represent treatment diets T1, T2, T3, T4 and T5, respectively (Table 1).

One hundred and twenty (120), 4-weeks old pullet chicks of Rhode Island Red (RIR) strain with a weight range (259.00 - 260.45 g) were randomly allotted into five treatment groups of 24 birds each. Each treatment was replicated 3 times with 8 birds per replicate, kept in 2 m × 3 m deep litter pens of fresh wood shavings. The birds were properly vaccinated against new castle disease in the first, third and six weeks and against gumboro disease in the second and fourth weeks, while fowl pox vaccine was given at the fifth week. At the beginning and every other week of the experiment which lasted for 5 weeks (35 days), birds in each replicate were weighed and used to determine the body weight gain. Feed intake was determined daily by subtracting the remnant amounts from the quantities served. Feed conversion ratio (FCR) was calculated as ratio of feed intake to that of body weight gain. Protein efficiency ratio and feed cost per kg weight gain were also determined. The prevalent cost of feedstuffs and quantity consumed was used in calculating feed cost and feed cost per kilogram weight gain.

The proximate composition of the diets was determined according to AOAC (2010) methods and the gross energy of each diet was also determined using the adiabatic bomb calorimeter.

Data obtained were subjected to one - way analysis of variance (ANOVA) (Steel and Torrie, 1980). Significant differences were separated using Duncan's New Multiple Range Test (Duncan, 1955).

Table 1: Gross composition of experimental diets

Ingredient	Levels of fortified sandbox seed meal				
	T_1 (0%)	T_2 (25%)	T_3 (50%)	T_4 (75%)	T_5 (100%)
Maize	49.50	49.50	49.50	49.50	49.50
Wheat offal	9.00	9.00	9.00	9.00	9.00
Palm kernel cake	8.70	8.70	8.70	8.70	8.70
Soya bean meal	28.00	21.00	14.00	7.00	0.00
FSBM	0.00	7.00	14.00	21.00	28.00
Fish meal	1.00	1.00	1.00	1.00	1.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Oyster meal	1.00	1.00	1.00	1.00	1.00
Salt	0.20	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Vit/min premix	0.20	0.20	0.20	0.20	0.20
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated composition:					
% CP	19.50	19.15	18.82	18.58	18.31
ME (Kcal/kg)	2580.22	2600.18	2650.92	2715.00	2788.05
% CF	5.01	5.31	5.92	6.78	7.91
% EE	3.40	3.82	4.75	5.98	6.35
Determined composition:					
% CP	19.81	19.32	19.01	18.69	18.22
% CF	5.23	5.61	6.32	7.18	7.99
% EE	3.22	4.14	4.69	5.82	6.30

Results and Discussion

Result on the response of pullet chicks to graded levels of fortified sandbox seed meal as replacement for soya bean meal are presented in Table 2. Results show that average daily feed intake (ADFI) significantly ($p<0.05$) decreased as the level of FSBM increases in the diets. This could be attributed to the high oil content of the diet as a result of FSBM which is of high oil content (Keay, 2010). Birds are known to eat to satisfy their energy requirements, the birds apparently might have reduced their intake of the diet immediately their energy requirement was met in treatment diets 1 and 2. The high fibre content of the feed (Table 1), might have equally contributed to the low intake. According to Ani *et al.* (2010), high dietary fibre has a laxative effect and can cause reduction in feed intake. A high range of gastric evacuation is usually compensated by decreased feed intake (McDonald *et al.*, 2002). The feed conversion ratio also followed the same trend as the feed intake as it significantly ($p<0.05$) depressed as the inclusion level of FSBM increased in the diets. The poor feed conversion ratio recorded for birds fed FSBM tends to indicate that the nutrients were less available, efficiently digested and utilized by the birds that were fed high levels of FSBM. The final live weight and weight gain, however, did not show significant ($p>0.05$) differences. Also, an indication that sandbox seed meal is poorly utilized by birds, as compared to soya bean meal. The observed poor utilization of feed with high FSBM could also be attributed to the high oil and fibre content of the diets. Ajiala *et al.* (2003) had reported decreases in feed utilization of highly fibrous diets. According to the authors, there was a resultant metabolic dysfunction with the attendant weight reduction.

The feed cost/kg, total feed cost and feed cost/weight gain significantly ($p < 0.05$) decreased as the level of FSBM increased in the diets. The reduced feed cost as observed in the experiment is not a surprise bearing in mind the current high cost of soya bean meal of ₦82, 000/50 kg,

while sandbox seed is simply harvested and processed without attracting any serious cost. The reduction in feed cost per kg weight gain is in consonant with the findings of Broz and Frigg (1990) and Tuleun *et al.* (2001) who observed that increasing dietary fibre level resulted in significant reduction in feed cost per kg weight gain. This could also be due to the fact FSBM did not significantly affect the weight gain, but significantly ($p< 0.05$) reduced the cost of feed. It could therefore be deducted that feed cost per kg weight gain will also reduce.

Table 2: Response of pullet chicks to varying levels of fortified sandbox seed meal as replacement for soya bean meal

Ingredients	Fortified sandbox seed meal levels				
	T_1 (0%)	T_2 (25%)	T_3 (50%)	T_4 (75%)	T_5 (100%)
Initial body weight (g)	260.45	260.11	259.99	259.00	260.13
Final body weight (g)	712.00	709.33	700.80	694.41	687.1c
Average daily feed intake (g)	51.02	50.92	47.46	45.00c	44.93c
Average daily weight gain (g)	12.90	12.83	12.58	12.50	12.20
Feed conversion ratio	4.02a	3.97a	3.77b	3.60c	3.69c
Protein efficiency ratio	0.68c	0.67c	0.75b	0.81a	0.83a
Cost of feed per kg (₦)	615.00a	590.42b	525.66c	500.18c	487.15e
Total cost of feed (g)	1,115.43	1052.45	872.62	787.78	766.3c
Cost of feed per kg weight gain	246.96a	234.37b	198.32c	180.27d	179.90d

Conclusion

It is evident from the study that fortified sandbox seed meal could totally replace (100%) soya bean meal in diets meant for pullet chicks without compromising growth performance characteristics (live weight and weight gain), it is also more profitable and economical in diet formulations.

Recommendation

The study recommends the total replacement of soybean meal by lysine fortified sandbox seed meal in the diets of pullet chicks for optimum performance and economic gain.

References

Ajiala, K., J. O. Agbede & Aletor, V. A. (2003). Influence of Roxazyme G supplementation on the utilization of wheat offal or rice bran by broiler chickens. *Proceedings of the 8th Annual Conference of Animal Science Association of Nigeria* (ASAN), Sept. 16-18th, University of Tech. Minna, Nigeria pp 32 - 34.

Ani, A. O., Alutu, N. O. & Osita, C. O. (2010). Effect of enzyme supplementation on performance of pullet chicks fed different levels of dietary fibre. *Proceedings of the 35th Conference of Nigeria Society for Animal Production*, 14th -17th March, University of Ibadan, Nigeria Pg. 453-457.

AOAC (2010). Association of Official Analytical Chemists. Official methods of analysis 15th Edi. Washington DC.

Archibong, E. E., Nsa, E. E., Ozung, P. O. & Izuki, E. D. (2023). Response of broiler chickens to sandbox seed meal-based diets supplemented with or without enzyme. *Global Journal of Agricultural Sciences* 22(1), 163-174.

Broz, J. & Frigg, R. J. (1990). *Trichoderma viride* enzyme complex on nutrient value of barley and oats for broilers. *Archive*, 54, 34 - 37.

Duncan, D. B. (1955). New Multiple Range Test. *Biometrics,* 11,1 - 42.

Esonu, B. O. (2006). Animal Nutrition and Feeding. A functional approach, 2nd edition, Rukzede and Ruksons Associate Memory Press, Owerri, Nigeria, P. 49.

NiMet (2023). Nigerian Meteorological Agency. Seasonal rainfall prediction. Margaret Ekpo International Airport, Calabar, Nigeria

Nsa, E. E. & Essien, A. I. (2019). Growth performance of broiler chickens fed maize offal and crayfish waste - based diets. *Nigerian Journal of Animal Production* 46(3),263-269.

Keay, R. W. (2010). Trees of Nigeria. *Nordic Journal of Botany*, 11,322.

McDonald, P., Edward, R. A. and Morgan, C. A. (2002). *Animal Nutrition*. 6th Ed. Pearson Education, (Singapore) Press Ltd. Delhi, 693 pp.

Oluremi, O. I. A., Ebe, A. I., Ngi, J. & Aku, E. O. (2010). Effect of naturally fermented sweet orange (*Citrus sinensis*) peel meal on its maize replacement value in broiler diets on performance and carcass indices. *Proceedings of the 35th Conference of Nigerian Society for Animal Production*, 14th – 17th March, University of Ibadan, Nigeria, Pp. 449 - 451.

Oyeleke, C., Ishida, K., Tsutsui, T., Naito, A., Kurita, K. & Otidera, M. (2013). Effect of *Hura crepitans* and its active ingredient, daphine factor F3 in dihydrotestosterone-induced neurotrophin-4 activation and hair retardation. *Journal of Biology and Pharmaceutical Research*, 15, 87 – 94.

Steel, R. G. D. & Torrie, J. H. (1980). *Principles of Procedures of Statistics*. McGraw Hill Books Co. Ltd., New York.

Tuleun, C. D., Njoka, P. C. & Yaakugh, I. D. I. (2001). The performance of growing pullets fed Roxazyme in rice offal-based diets. *Proceedings of the 26th Annual Conference of the Nigerian Society for Animal Production* (NSAP), Zaria, Nigeria, Pp. 219 - 221.

Vogels, S. (2013). The flight of the seeds of *Hura crepitans*. *Journal of Biology*, 1, 6 - 24.

PERFORMANCE RESPONSES OF GROWING RABBITS TO INCREASING SUBSTITUTION LEVELS OF PLANTAIN PEEL MEAL FOR MAIZE

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ABSTRACT

This study investigated the effect of unripe plantain peel meal based diets on performance characteristics of growing rabbits. A total of sixty rabbits of mixed breeds and sexes with initial average live weight of 519.30±0.46g/rabbit were randomly allotted to five experimental diets in a completely randomized design (CRD) experiment. Each treatment was replicated three times with four rabbits per replicate. The rabbits were fed diets with 0, 15, 30, 45 and 60 % unripe plantain peel meal as replacement for maize, representing dietary treatments T1, T2, T3, T4 and T5, respectively. Proximate composition of plantain peel meal and maize was determined. Performance characteristics were determined during the feeding trial and data statistically analyzed using one - way ANOVA. Result of this study revealed that feed intake was not significantly ($p>0.05$) affected by dietary treatments. However, rabbits fed diet 2 (15%) plantain peel meal replacement had the most favorable final live weight (1210g/rabbit), daily weight gain (9.89g/rabbit/day) and feed conversion ratio (5.78), this was followed by rabbits fed the control diet and others. The nutrient retention showed no significant ($p>0.05$) difference between dietary treatments. Among the nutrient parameters of the meat, only the lipid content showed significant ($p<0.05$) difference. The feed cost and the total cost of feed consumed declined as the dietary plantain peel meals increased in the diets. The study concluded that unripe plantain peel meal can replace up to 60% maize without any deleterious effect on performance characteristics of rabbits and with a better profit margin.

Keywords: Cost, growth, nutrient, plantain peel, rabbits

Introduction

In Nigeria and other developing countries, there is acute shortage of conventional protein and energy sources for use in formulating balance diets for farm animals (Nsa *et al.*, 2018; Ukorebi *et al.*, 2019). This is partly due to the high demand of these conventional feedstuffs by man and industries. This existing competition has resulted in escalated prices of these feedstuffs. However, several low cost agro by-products have been identified. These include cassava peel meal (Esonu and Udedibie, 1993), pea nut shell (Aduku *et al.*, 1998), yam peels (Inaku *et al.*, 2011), soya bean hulls (Shaahu, *et al.*, 2011), palm kernel cake (Omole, 2011), maize sieviate

(Nsa and Essien, 2019), cocoa pod husk meal (Ozung *et al.*, 2019), unripe plantain peel meal (Robert *et al.*, 2020), and kolanut husk meal (Ozung *et* al., 2019; Eburu and Ozung, 2020).

Plantain peels are waste materials obtained from plantain processing and account for about 30 to 40% of the total weight of the fruit (Nwogu and Ogboruka, 2003). These waste materials, if not properly disposed can pollute the environment. Recent studies (Robert *et al.*, 2020) have shown that unripe plantain peel meal can be included in the diets of livestock as it is relatively high in energy and if well managed can partially replace maize in monogastric diets. In furtherance to this, the use of micro livestock and short-cycled animals is to be encouraged in the face of the high demand for animal proteins due to rapid growth in the population, coupled with the already poor feed supply due to increasing cost of conventional feedstuffs. Rabbit keeping has gained prominence in the Nigerian Society. This is mainly due to the relatively cheap maintenance cost especially in feeding which could be mainly forages and kitchen wastes (Akinnusi and Alade, 2011). Rabbits are very prolific, producing at least 4 - 5 litters per doe per annum under the traditional management system (Akinnusi and Alade, 2011, Ozung 2016). This is made possible as its gestation period is very short, about 30-31 days. Furthermore, the cost of housing, equipment and feeding is relatively low. This study was therefore designed to determine the effect of plantain peel meal as a partial replacement for maize in the performance characteristics of growing rabbits.

Materials and methods

Location of study

This feeding trial was carried out at the Rabbitry Unit of the Teaching and Research Farm, University of Calabar, Calabar. The study site (Calabar) is located within latitudes 40°58′N and 15° 39′ N of the equator and longitudes 80° 17′E and 100° 43′E of the Greenwich meridian with relative humidity of 55- 99% at an elevation of 99 meters above sea level (Akpan *et al.*, 2006); the average temperature ranges between 25° and 30° C, while average rainfall is between 1,260 and 3,500 mm per annum (NiMet, 2024).

Procurement and processing of plantain peel meal, experimental design, diets and management of rabbits

The peels from unripe plantain were collected from roadside food vendors within Calabar municipality. They were washed with clean water and further cut into tiny pieces and air- dried to constant weight, thereafter milled in a meadow's model 35 hammer mill and sieved through a mesh of 5mm to obtain unripe plantain peel meal. Samples of the plantain peel meal were analyzed for proximate composition, according to AOAC (2022) methods. Five experimental diets were formulated such that the plantain peel meal replaced maize at 0, 15, 30, 45 and 60 % levels to represent treatments T1, T2, T3, T4 and T5, respectively. The composition of experimental diets is presented in Table 1.

A total of sixty growing rabbits (30 bucks & 30 does of mixed breeds) aged between 7 and 8 weeks of age with average initial body weight of 519.30±0.46g/rabbit were randomly allocated to the five experimental diets using a Completely Randomized Design (CRD) after weight and sex equalization. Each treatment had 12 rabbits, replicated thrice with 4 rabbits (2 bucks & 2

does). They were housed in wooden hutches with dimension of 50 × 50 × 70 cm. The rabbits were weighed at the beginning of the experiment and at weekly interval, while water was provided *ad libitum*. Feed intake was recorded daily by subtracting the quantity of feed left from the quantity offered the previous day. Daily weight gain was calculated as the difference between final weight and initial weight and divided by the number of days, while feed conversion ratio was calculated as the ratio of feed intake to. weight gain

Table 1: Composition of experimental diets

Ingredient	Levels of unripe plantain peel replacement for maize				
	T1(0%)	T2 (15%)	T3 (30%)	T4(45%)	T5 (60%)
Yellow maize	52.00	44.20	36.40	28.60	20.80
Plantain peel meal (unripe)	0.00	7.80	15.60	23.40	31.20
Soya bean meal	27.00	27.00	27.00	27.00	27.00
Wheat offal	15.00	15.00	15.00	15.00	15.00
Fish meal	2.00	2.00	2.00	2.00	2.00
DCP	2.50	2.50	2.50	2.50	2.50
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.20	0.20	0.20	0.20	0.20
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Premix*	0.10	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated composition (%):					
Crude protein	15.63	15.67	15.71	15.75	15.79
Energy (Kcal/Kg ME) **	2550.22	2541.03	2532.00	2523.40	2514.80

*Composition of premix: Vit. A 1500 I.U. Vit. D 3000I.U, Vit. E:3.0g, Vit. K 2.0g, Vit, B2, 0.3g, Vit. B6, 8.0mg, Vit B12, 8.0g, Nicotinic Acid, 3.0g, Ca-Pantothenate; 5.0 mg, Fe, 10.00g, AI, 0.2g, Cu, 3.5mg, Zn,0.15mg, I, 0.02g, Co, 0.01g

**ME (Kcal/Kg) =37 x %CP + 81.1 x %EE + 35.5 x %NFE (Pauzenga, 1985)

Determination of proximate composition of meat from rabbits fed unripe plantain peel meal

At the end of the feeding trial, two rabbits (1buck & 1 doe) per replicate were selected and sacrificed by exsanguination for determination of proximate composition. From the sacrificed rabbits, the rack and loins regions were analyzed for nutrient composition using AOAC (2022) methods.

Nutrient retention

Two other rabbits per replicate were randomly selected at the end of the feeding trial and housed in a previously disinfected two- tier wire floor metabolic cages and a dropping tray inserted for

easy collection of faecal droppings. After the initial five days of acclimatization where the rabbits were fed *ad libitum* with a known quantity of the respective experimental diets in the morning hours after which the leftovers were weighed and pooled. Daily voluntary feed intake was measured and recorded. Their faeces were collected and weighed fresh, oven dried using GallenKamp® oven at 80°C for 48 hours to obtain constant weight, and milled to pass through a standard 0.02mm sieve for proximate determination (AOAC, 2022). The nutrient retention was calculated using appropriate formulae.

Cost analyses

Cost Analyses using appropriate formulae were used to determine the economics of production based on the prevailing prices of feedstuffs during the study period.

$$\text{Feed cost/kg} = \frac{\text{sum of prices of ingredients}}{\text{Kilogram of feed at the time of experiment}}$$

$$\text{Total feed cost} = \frac{\text{Total feed intake} \times \text{Feed cost/kg}}{100}$$

Total cost of feed consumed / Kg (₦) = cost of feed/Kg(₦) × Total feed consumed (K g/rabbit)

$$\text{Cost of feed/Kg live weight gain (₦)} = \frac{\text{Total cost of feed consumed/kg(₦)}}{\text{Total weight gain (g/rabbit)}}$$

Statistical analysis

All Data obtained in this study were subjected to analysis of variance (Steel and Torrie, 1980) and significant means were separated using the Duncan's New Multiple Range Test. The analysis was carried using SPPSS version 14.

Results and Discussion

The proximate composition (Table 2) showed that crude protein (11.69%) and crude fibre contents (16.03%) of unripe plantain peel meal were higher than that of maize which had crude protein and crude fibre of 8.96 and 2.09% respectively. The crude proteins and fibre contents of both maize and unripe plantain peel meal fell within the ranges reported by Aduku (1993). Table 3 shows the result of the growth performance of growing rabbits fed unripe plantain peel meal as replacement for maize. There were no significant ($p>0.05$) differences between dietary treatments in growth performance indicators. This implied that there was no inhibition in the feed intake. The diet containing 15% (T2) replacement level of plantain peel, significantly ($p<0.05$) improved final body weight (1210.00g), daily weight gain (9.89g) and feed conversion ratio (5.78), compared to other dietary treatments. Diet T3, 30% replacement level of maize with plantain peel meal had values of final live weight (1200.22g), daily weight gain (9.72g)

and feed conversion ratio (5.88) that were numerically ($p>0.05$) similar to rabbits in the of control diet. The diets containing 60% plantain peel meal had significantly ($p<0.05$) different final live weight (1190.10g), daily weight gain (9.58g) and feed conversion ratio (5.95) compared to all the dietary treatments. The above range (9.58-9.89g) for daily weight gain was however, lower than 12.91 - 17.96 g and 18.20 - 19.20g reported by Abejeshi *et al.* (2017); Aduku *et al.* (1998), respectively for rabbits fed tropical evergreen browses. The earlier observed lower range could be attributed to differences in breed, feed used and other environmental factors in the separate studies. The retention of nutrients by rabbits is presented in Table 4. The dry matter (DM), crude protein (CP) and crude fibre (CF) contents of the experimental diets did not show any significant ($p>0.05$) difference between dietary treatments. This observation is a clear indication that unripe plantain peel meal is not poorly utilized by growing rabbits. This result is in agreement with the findings of Nsa *et al.* (2019), who reported non-significant differences on nutrient retention (DM, CP and CF) for growing rabbits fed various agro-industrial by - products.

In terms of the meat quality, the proximate composition (Table 5), apart from the meat lipid (ether extract), other nutrients in the meat indicated no significant ($p>0.05$) difference between dietary treatments. The crude protein content (28.67 – 31.805) was high and it has confirmed that rabbit meat is rich in easily digestible protein. A moderate range (5.30 – 6.75%) obtained for lipid (ether extract) confirms the fact that rabbit meat is low in fat and cholesterol (Ozung, 2016). This could be as a result of the appreciable amount of unripe plantain peel, which tended to decrease the ether extract content of the meat (Robert *et al.*, 2020). The result of the economics of production is represented in Table 6. The total cost per feed consumed (₦), stood at 633.67, 602.41, 567.77, 535.69 and 504.00 for diets containing 0, 15, 30, 45 and 60% (plantain peel diets as replacement for maize) respectively. The cost tended to significantly ($p<0.05$) decreased with dietary increase of unripe plantain peel meal. This was expected because of the high cost of conventional feedstuff (maize) compared to the low or zero cost of unconventional feed stuff (unripe plantain peel) which is even regarded as a waste and imposes a disposal problem.

Table 2: Proximate composition of unripe plantain peel meal and maize

Unripe	plantain peel meal	Maize
Dry matter (%)	92.09	87.98
Crude protein (CP) (%)	11.69	8.96
Crude fibre (CF) (%)	16.03	2.09
Ether extract (%)	4.01	3.24
Nitrogen Free Extract (%)	68.27	85.71
ME (Kcal/Kg)	2790.41	3438.02

Each mean value was obtained from triplicate determinations

Table 3: Performance characteristics of rabbits fed unripe plantain peel meal based- diets

Parameters	T1 (0%)	T2 (15%)	T3 (30%)	T4 (45%)	T5 (60%)	SEM
Initial Weight (g)	520.50	518.00	520.00	518.50	519.50	7.80

Final Live Weight (g)	1200.50[b]	1210.00[a]	1200.22[b]	1195.80[c]	1190.10[d]	3.99
Total Weight gain (g)	680.00[b]	692.00[a]	680.22[b]	677.30[c]	670.60[d]	1.90
Daily weight gain (g)	9.71[b]	9.89[a]	9.72[b]	9.68[c]	9.58[d]	0.22
Total feed intake (g)	3987.50	3999.00	3998.40	3993.50	3997.00	8.43
Daily feed intake (g)	56.96	57.13	57.12	57.05	56.96	4.90
FCR	5.87[b]	5.78[c]	5.88[b]	5.89[b]	5.95[a]	0.13
Mortality	0.00	0.00	0.00	0.00	0.00	0.00

[a,b,c,d] Means on the same row with different superscripts are significantly different ($p<0.05$)

Table 4: Nutrient retention of growing rabbits fed plantain peel-based diets

Parameter (%)	T1(0%)	T2 (15%)	T3 (30%)	T4 (45%)	T5 (60%)	SEM
Dry matter	65.87	67.00	67.10	66.90	65.80	7.60
Crude protein	56.00	60.70	58.75	57.45	54.43	2.80
Crude fibre	45.90	47.00	46.18	46.00	45.60	7.09
Ether extracts	60.00	61.68	59.05	57.97	56.85	9.05
Ash	76.00	77.80	74.70	72.76	77.65	5.81
NFE	58.01	59.60	57.32	55.90	58.68	2.00

Each mean value was obtained from triplicate determinations

Table 5: Proximate composition of meat from growing rabbits fed plantain peel-based diets

Parameters (%)	T1(0%)	T2 (15%)	T3 (30%)	T4 (45%)	T5 (60%)	SEM
Dry matter	60.23	61.90	61.90	60.20	61.08	2.00
Crude protein	28.67	29.57	30.20	31.00	31.80	1.88
Crude fibre	8.09	8.80	8.30	8.30	8.10	1.99
Ether extract	5.30[b]	6.69[b]	6.73[b]	6.75[b]	6.55[a]	1.87
Ash	14.76	15.21	15.27	15.32	15.34	0.98
NFE	43.18	39.73	39.50	38.63	38.21	2.88

[a,b,c,d,e] Means on the same row with different superscripts are significantly different ($p<0.05$)

Each mean value was obtained from triplicate determinations

Table 6: Economic implication of feeding plantain peel meal to growing rabbits

Parameter	T1(0%)	T2 (15%)	T3 (30%)	T4 (45%)	T5 (60%)	SEM
Cost of feed/Kg	158.90[a]	150.64[b]	142.00[c]	134.14[d]	126.41[e]	1.49
Total cost of feed consumed(₦/Kg)	633.61[a]	602.41[b]	567.77[c]	535.69[d]	504.00[e]	3.57
Selling price(₦/Rabbit)	2500.00	2500.00	2500.00	2500.00	2500.00	0.00
Cost of rearing (₦/Rabbit)	1733.61	1702.41	1767.77	1775.69	1704.00	11.08

Profit (₦)	766.36	797.59	732.23	724.31	796.00	8.32
% Gross profitability	44.21	46.85	41.42	40.79	46.71	3.60

[a,b,c,d,e] Means on the same row with different superscripts are significantly different ($p<0.05$)

Conclusion

Following the results obtained in this study, it is therefore concluded that up to 60 % unripe plantain peel meal can be used to replace maize in diets meant for growing rabbits without any deleterious effects on biological characteristics and economics of production.

Recommendation

Based on the outcome of this study, the replacement of the expensive maize with unconventional unripe plantain peel meal in rabbit diets at 60% level is recommended for rabbit farmers.

References

Abejeshi, I. M., Okwori, A.I., Shaahu, D. T. & Enaku, O. O. (2017). Effect of feeding some tropical browse plant leaves on performance, digestibility and economic analysis of growing rabbits. *Nigerian Journal of Animal Science*, 20 (1), 200 - 211.

Aduku, A. O., Dim, N. L. & Aganga, A. A. (1998). Note on a comparative evaluation of palm kernel meal, peanut meal and sunflower meal in diets for weanling rabbits. *Journal of Applied Rabbits Research*, 11(4), 264 - 266.

Akinnusi, F. A. O. & Alade, A. A. (2011). Performance and carcass characteristics of weaner rabbits raised under two different housing systems. *Proceedings of the 36th Conference of the Nigerian Society for Animal Production,* 13 – 16 March, 2011, University of Abuja, Nigeria. Pp. 299 – 301.

Akpan, E. R., Offem, J, O. & Nya, A. E. (2006). Baseline ecological studies of the great Qua River, Nigeria 'Physico-chemical studies' *Ecoserve*, retrieved 21st July, 2024, 1: 23pm.

AOAC (2020). Association of Official Analytical Chemists. Official Methods of Analysis, 15st edition, Washington D.C.

Eburu, P. O. & Ozung, P. O. (2020). Replacing dietary maize with kolanut husk meal could influence growth performance and apparent nutrient digestibility of rabbits. *Journal of Food, Agriculture and Environment*, 18 (1), 46 – 50.

Esonu, B. O. & Udedibie, A. B. I. (1993). The effect of replacing maize with cassava peel meal on performance of weaned rabbits. *Nigerian Journal of Animal Production,* 20, 81 - 85.

Inaku, E. N., Bawa, G. S. Olugbemi, T. S. & Babatunde, G. M. (2011). Nutritive value of yam peel meal in broiler diets. *Proceedings of Annual Conference of Nigerian Society for Animal Production* (NSAP). 13th-16th march, Abuja, Nigeria.

NiMet (2024). Nigerian Meteorological Agency, Daily Weather Report and Forecast, Margaret Ekpo Int'l Airport, Calabar, Nigeria.

Nsa, E. E., Ukoha, O. A. & Onunkwo, D. N. (2019). Growth response, nutrient digestibility and cost benefit of feeding growing rabbits with selected agro-industrial by-products-based diets. *Nigeria Journal of Animal Production*, 46 (1), 85-93.

Nsa, E. E. & Essien, A. I. (2019). Growth performance of broiler chickens fed maize offal and crayfish waste - based diets. *Nigerian Journal of Animal Production* 46(3),263-269.

Omole, A. J. (2011). Nutritional evaluation of cassava peel meal - palm kernel cake mixture in snail's diets. *Proceedings of the 36th Annual Conference of Nigerian Society for Animal Production* (NSAP), 13th-16th March, Abuja, Nigeria, Pp. 303- 307.

Ozung, P. O. (2016). Performance and physiological responses of rabbits to processed cocoa (*Theobroma cacao* L.) pod husk meal based – Diets (Ph. D Thesis, Department of Animal Science, University of Calabar, Calabar, 269Pp.

Ozung, P. O., Oko, O. O. O. K., Ubua, J.A., Anya, M. I., Eburu, P.O. & Osaba, A. S. (2019). Organ histopathology and total protein concentrations in epididymal/testicular fluids of rabbit bucks fed kolanut husk meal as replacement for maize. *Nigerian Journal of Animal Production*, Pp. 62-66.

Pauzenga, U. 1985. *Feeding parent Stock. Zootecnia International*, Pp. 22-24.

Robert, A.N., Ayuk, A. A., Ozung, P. O. & Harry, B. J. (2020). Growth performance, nutrient digestibility and cost of production of weaned rabbits fed processed unripe plantain peel meal based-diets. *Pakistan Journal of Nutrition*, 19 (6), 303 - 308. DOI: 10.3923/pjn.2020.303.308;

Shaahu, D. T., Ikurior, S. A. & Falano, O. I. (2011). Effect of replacing dietary full fat soybean with raw decorticated and cooked lablab seed meal on the performance of weaner rabbits. *Proceedings of the 36th Annual Conference of the Nigerian Society for Animal Production* (NSAP), 13th-16th March, Abuja, Nigeria, Pp. 315 - 317.

Steel, R.G.D. & Torrie, J.H. (1980). Principles and Procedures of Statistics. A Biometric Approach. 2nd edition, McGraw Hill Book Co. Inc. New York, USA. 481pp.

Ukorebi, B. A., Gboshe, P. N. & Meremikwu, V. N. (2019). Performance characteristics of rabbits fed some wild evergreen forages. *Nigerian Journal of Animal Production*, 46(2), 176-185

HAEMATOLOGICAL AND SERUM BIOCHEMICAL INDICES OF FINISHER BROILER CHICKENS FED CASSAVA (*Manihot esculenta*) PEEL MEAL AS A REPLACEMENT FOR WHEAT OFFAL

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ABSTRACT

The study was conducted to determine the effect of cassava (Manihot esculenta) peel meal-based diet on haematological and serum biochemical indices of finisher broiler chickens. One hundred and fifty (150) Arbor acres broiler chickens aged four (4) weeks were used for the study. They were divided into five (5) treatment groups identified as T_1, T_2, T_3, T_4 and T_5. Each treatment group consisted of thirty (30) birds, replicated three (3) times with ten (10) birds per replicate in a Completely Randomized Design (CRD) with cassava peel meal as treatment. The levels of cassava peel meal were 0%, 25%, 50%, 75% and 100% replacing wheat offal in the diet respectively. Treatment one (T_1) had no cassava peel meal and served as the control. Feed and water were given ad libitum to the birds. The results showed that the monocytes, heterophils, platelets and red blood cell counts (RBC) were significantly ($P<0.05$) different between dietary treatments. The basophils, lymphocytes, mean corpuscular volume (MCV), eosinophils, mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH), packed cell volume (PCV), white blood cell (WBC) count, haemaglobin concentration recorded no significant ($P>0.05$) effect among the group. However, treatment 5 with 100% level of cassava peel meal had packed cell volume of 30.00% while the least was treatment 1 with 27.96%. The results further indicated that there were significant ($P<0.05$) differences among the treatment groups in all the serum biochemical parameters measured: urea, cholesterol, glucose and calcium except aspartate transaminase which was similar ($P>0.05$) among the treatment groups. It could be concluded that feeding cassava peel meal up to 100% in the diet of broiler chickens had no toxic effect on the haematological and serum metabolites since it is within the normal ranges as represented in tables 4 and 5. Therefore, it could serve as an alternative feed in commercial poultry production.

INTRODUCTION

Broiler chicken production is one of the fastest and lucrative means of providing animal protein through the increasing population in the world due to rapid weight gain and short generation interval (Fatokun, 2013). Broiler chickens are important source of protein, rich in essential amino acids that are necessary and required for human body growth, maintenance and repairs. The demand for animal protein is on the increase as the population of the world increases every day. Another factor that favors the demand of broiler meat is it low level of cholesterol after processing. The problem of protein deficiency in underdeveloped and developing countries

have continued to worsen due to the perpetual increase in human population. However, in spite of the potentials of broiler chicken production in ameliorating animal protein malnourishment in a developing country like Nigeria. It is still confronted with the challenge of increasing cost of production attributed to the cost of feeding the birds to acceptable market weight. The high cost of conventional feed ingredients has sent a lot of poultry farmers out of poultry business as cost of feeding alone account for about 65 to 75% of the total production cost in Nigeria. This sustenance and the expected increase in broiler production is subject to readily available sources of dietary feed ingredients necessary for formulating diets. It is therefore necessary to introduce an alternative, cheap and available feed material to substitute the existing broiler feed (Fatokun, 2013).

Cassava peel meal (CPM) has gained attention as a potential alternative to conventional feed ingredients like wheat offal due to its availability and cost-effectiveness. Cassava peel meals typically contain around 5.18% crude protein (CP), which is significantly lower than that of wheat offal having 16.25% crude protein (CP) therefore making wheat offal a richer source of protein, crude fiber (CF) content in cassava peel meal is about 15.18% which is slightly lower than that of wheat offal which has about 18.86% crude fiber, providing more fiber than cassava peel meal. The ether extract (EE) value in cassava peel meal is approximately 1.99%, indicating a higher fat content compared to wheat offal which has ether extract (EE) value of about 1.18%, lower than that of cassava peel meal (Nsa *et al.*, 2013).

The merit of cassava peel meal compared to wheat offal is that; cassava peel is a by-product of cassava processing, making it a cheaper alternative to wheat offal, which is often more expensive due to its high demand in human food production. Cassava is also widely grown in tropical regions, ensuring a steady supply of cassava peels throughout the year, utilizing cassava peels for animal feed helps in waste management and reduces environmental pollution associated with cassava processing (Nsa *et al.*, 2013).

Cassava peel meal has limitations which includes its low protein content, digestibility and anti-nutritional factors. As such, the low protein content in cassava peel meal necessitates supplementation with other protein-rich ingredients to meet the nutritional requirements of animals, the high fiber content in cassava peel meal can affect its digestibility and the overall feed conversion ratio in poultry birds. Cassava peels also contain cyanogenic glycosides, which can be toxic if not properly processed, therefore ensuring adequate detoxification is crucial and necessary before using cassava peel meal in poultry diets (International Institute of Tropical Agriculture, 2024).

By comparison, studies has shown that replacing wheat offal with cassava peel meal in poultry diets can be economically beneficial without significantly compromising growth performance. Cassava peel meal presents a viable alternative to wheat offal in animal feed, particularly in regions where cassava is abundantly available. While it offers cost and environmental benefits, its lower protein content and potential anti-nutritional factors must be addressed through proper processing and supplementation (Oghenejoboh *et al.*, 2021).

Cassava peel meal (CPM) has been used in broiler diets. According to Oladunjoye *et al.*, (2010), cassava peel is moderate in energy and fiber, but low in crude protein less than 5% compared to maize's 9-10%. It is important to note that cassava peels also contain cyanogenic glycosides, which can be very toxic if not properly processed. The outbreak of the Corona virus (Covid-19) had globally affected the socioeconomic livelihood of farmers, especially in developing countries. In Nigeria the poultry sector was not left out as it had also suffered significant setback

to avail the maximum animal protein requirement per day to the populace. This had led to the closure of some poultry farms due to cost and lack of feed resources which about 70% are imported and had led to unbalanced feed rations to poultry animals and subsequent malnutrition to the populace (Ogunsipe *et al.,* 2017).

In recent times, before the covid-19 virus, climate change had been a major challenging factor affecting poultry production in Africa. In Nigeria, heat stress and disease outbreaks have also affected poultry farming and the livelihood of rural poultry farmers. Also, the competitiveness of man and livestock for conventional feed ingredients had spiked high cost of this feed resources (Avigen,2015; Ogunsipe *et al.,* 2017). All these factors have negative effects on this commercial enterprise which provides animal protein, cash income and subsequently create employment for populace (Ogunsipe *et al.,* 2017b, SDGs, 2018). If there must be improvement and sustainability of the poultry sector, alternative feed resources which must be cheap and available must be sourced and an example of such feed resource is the cassava peel. Some decades ago, researchers sought alternative, less expensive resources and easily accessible for broiler production (Melesse *et al.,* 2017). The use of cassava peels and agro-wastes has recently been appreciably utilized in the feeding of poultry birds. Therefore, nutritionists are suggesting cheaper, non-conventional, locally available feed resource like cassava peel meal (CPM) for improved performance and profitability (Melesse *et al.,* 2017). The major limiting factor in using cassava peel as animal feed is its high content of cyanogenic glycosides, which can release hydrogen cyanide (HCN) when consumed. This compound is toxic, particularly to monogastric animals like poultry and pigs (Avigen, 2015) and if well processed can eliminate the toxic/anti-nutrients from the cassava peel.

Although, cassava peel meal (CPM) has been explored as a cost-effective feed ingredient for broiler chickens. However, its use is limited by the presence of anti-nutritional factors, primarily cyanogenic glucosides such as *linamarin* and *lotaustralin*, which release hydrocyanic acid (HCN) upon hydrolysis (Ogbuewu, 2023). These anti-nutritional factors can impact the blood parameters of broiler chickens, which are critical indicators of their health and nutritional status.

In terms of haematological indices, the presence of hydrocyanic acid (HCN) can lead to reduced oxygen-carrying capacity of the blood due to its inhibitory effect on cytochrome oxidase, an enzyme crucial for cellular respiration (Akpet & Ibekwe, 2018). This can result in lower red blood cell counts and haemoglobin levels in broilers fed high levels of cassava peel meal. Increased levels of white blood cells have been observed in broilers fed fermented cassava peel meal, indicating a possible immune response to the anti-nutritional factors present (Ogbuewu, 2023).

Broilers fed cassava peel meal diets often show increased serum protein levels, which may be a compensatory response to the anti-nutritional stress (Akpet & Ibekwe, 2018). Higher levels of serum cholesterol and creatinine have also been reported, suggesting altered lipid metabolism and kidney function due to the detoxification process of hydrocyanic acid (Ogbuewu, 2023).

To address the adverse effects of anti-nutritional factors in cassava peel meal, several processing methods have been employed such as; fermentation which can significantly reduce the cyanogenic glucoside content, thereby lowering the hydrocyanic acid levels in the feed. Fermented cassava peel meal has been shown to improve feed intake and feed conversion ratio in broilers (Akpet & Ibekwe, 2018). Sun-drying is another effective method to reduce hydrocyanic acid content. However, it may not be as effective as fermentation in improving the overall nutritional quality of cassava peel meal (Akpet & Ibekwe, 2018).

It should also be worthy of note that; while cassava peel meal offers a cost-effective alternative to conventional feed ingredient such as wheat offal, its use is constrained by the presence of anti-nutritional factors that can adversely affect the blood parameters of broiler chickens. Processing methods such as fermentation and sun-drying can help mitigate these effects, making cassava peel meal a more viable feed option (Oghenejoboh *et al.*, 2021). This study is intended to evaluate the haematological and serum biochemical indices of the cassava peel meal at various levels of replacement in diets of broiler chicken.

MATERIAL AND METHODS

Location of the study

The study was carried out at the poultry unit of the Teaching and Research Farm, University of Calabar, Calabar, Cross River State, Nigeria. Calabar is geographically located within the tropical rain forest zone of Nigeria, with a land mass of 233.2 square mile (604km2) and lies between latitude 4°50N to 415°39N and longitude 8°17E to 10°43E of the equator. The relative humidity is 55-85 % with an elevation above sea level of 28 meters. The annual temperature and rainfall ranges between 25°C and 30°C and 1260 to 3500 mm respectively (NMA, 2022).

Collection and processing of test material

Fresh cassava (*Manihot esculenta*) peels were sourced from garri/fufu processing industries within Calabar metropolis. The peels were rinsed with clean flowing tap water to remove sand and dirt. The peels were milled using cassava processing mill and put inside sack bags, tied and pressed to remove excess moisture for two days, then sieved through a mesh of 5mm to produce the meal. The meal was then fried for ten (10) minutes and spread on a clean floor to cool.

Experimental diets for broiler birds

Five (5) experimental diets were formulated for both starter and finisher phases (Table 1). The starter diet had 22.80 - 23.05 crude protein and metabolizable energy of 2,949.18 - 2,980.50. At the finisher phase, the crude protein supplied in the feed was 19.83 - 20.00 and 3,080.33 - 3,100.18 for metabolizable energy. There were five (5) treatment groups representing T_1, T_2, T_3, T_4 and T_5 respectively. T_1 serves as the control diet (0 %) while diets T_2, T_3, T_4 and T_5 contained cassava peel meal, replacing wheat offal at (25, 50, 75 and 100 %) respectively.

Experimental birds and management

A total of one hundred and fifty (150) 28-day-old arbor acres strain of broiler chicks were purchased from a renowned hatchery in Ibadan. They were randomly allotted to five (5) dietary treatments in a Completely Randomized Design (CRD). Each treatment had thirty (30) birds with three (3) replicates of ten (10) birds each. The birds were managed for twenty-eight (28) days (4 weeks) in a deep litter system. Feed and water were given ad-libitum while other routine management procedures were adopted properly to ensure maximum health and productivity.

Blood collection and analysis

At the end of the feeding trial, blood samples (5ml) each were collected from the vein of the wing web of three (3) birds per replicate by vein puncture of the wings. The samples were put into a well labelled Ethylene Diamine Tetra-acetic Acid (EDTA) anticoagulant bottles for haematological studies, while the blood samples were put in another set of bottles without EDTA for serum biochemical assay.

Statistical analysis

All data collected from blood assay were subjected to One Way Analysis of Variance (ANOVA) for Completely Randomized Design (CRD) using Genstat Release 8.1 (2021) statistical package. Significance were separated using the Least Significance Difference (LSD) method of the same statistical software as described by AOAC (2015).

Table 1: Gross composition of experimental broiler chicken starter diets

	Dietary replacement levels of wheat offal with cassava peel meal				
Ingredients	**T_1 (0%)**	**T_2 (25%)**	**T_3 (50%)**	**T_4 (75%)**	**T_5 (100%)**
Maize	55.00	55.00	55.00	55.00	55.00
Wheat offal	8.00	6.00	4.00	2.00	0.00
Cassava peel meal	0.00	2.00	4.00	6.00	8.00
Soya bean meal	30.00	30.00	30.00	30.00	30.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Calcium diphosphate	3.00	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin/mineral premixes	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
%CP	23.05	22.98	22.90	22.86	22.80
ME/Kcal/kg	2980.50	2976.41	2971.22	2960.90	2949.18
Ca	1.20	1.20	1.20	1.20	1.20
P	0.77	0.76	0.76	0.75	0.75

*vitamin/mineral premix containing the following per kg. vitamin A, 10,000000IU; Vitamin B3, 2,000000IU, Vitamin E, 20,000IU; Vitamin 500mg, K, 2250mg, Thiamine 1,750mg; Riboflavin B2 5,000mg. Pyridoxine B6, 2750mg; Antioxidant 125g; Niacin 27,500mg; Vitamin B12, 15mg; Panthotenic acids, 7,500mg; Biotin, 50mg; Chlorine chloride 400g; Manganese, 80g, Zinc, 50g, Iron, 20g; Copper, 5g; Iodine 1.2g; Selenium, 200mg; Cobalt, 200mg

Table 2: Gross composition of experimental broiler chicken finisher diets

	Dietary replacement levels of wheat offal with cassava peel meal				
Ingredients	**T_1 (0%)**	**T_2 (25%)**	**T_3 (50%)**	**T_4 (75%)**	**T_5 (100%)**
Maize	60.00	60.00	60.00	60.00	60.00
Wheat offal	10.00	7.50	5.00	2.50	0.00
Cassava peel meal	0.00	2.50	5.00	7.50	10.00
Soya bean meal	24.00	24.00	24.00	24.00	24.00
Fish meal	2.00	2.00	2.00	2.00	2.00
Calcium diphosphate	3.00	3.00	3.00	3.00	3.00
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25

Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin/mineral premixes	0.25	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
%CP	20.00	19.91	19.94	19.9	19.83
ME/Kcal/kg	3100.18	3098.50	3095.00	3091.82	3080.33
Ca	1.16	1.16	1.16	1.16	1.16
P	0.75	0.75	0.74	0.74	0.74

*vitamin/mineral premix containing the following per kg. vitamin A, 8.000000 IU, Vitamin D3, 1,6000000IU, Vitamin E, 5,000IU; Vitamin K, 2000mg; Thiamin, 1,500mg; Riboflavin B2 4,000mg; Pyridoxine B6, 1,500mg; Antioxidant, 125g; Niacin, 1,500mg; vitamin B12 10mg; Panthotenic acids, 5,000mg; Folic acid, 500mg; Biotin, 20mg; Chlorine chloride 200g; manganese, 80g; Zinc, 50g; Iron, 20g; Co pper, 5g; Iodine 1.2g, Selenium 200mg; Cobalt, 200mg.

RESULTS AND DISCUSSION

Haematological characteristics of finisher broiler chickens fed cassava peel meal as a replacement for wheat offal

The haematological characteristics of finisher broiler chickens fed cassava peel meal as a replacement for wheat offal are presented in Table 4. The monocytes, heterophils, platelets and red blood cell counts (RBCs) were significantly ($P<0.05$) different among the treatment groups. The basophils, lymphocytes, mean corpuscular volume (MCV), eosinophils, mean corpuscular haemoglobin (MCH), packed cell volume (PCV), the white blood cell (WBC) counts, haemoglobin concentration recorded no significant effect ($P>0.05$). However, T_5 with 100% replacement level of cassava peel meal for PCV (30.00%) was better and the least was T_1 (27.96%) with 0% cassava peel meal replacement.

The platelets count(93.63×10^9/L) in T_5 was significantly higher ($P<0.05$) than (49.98×109/L) in T_1. The red blood cell (RBC) counts recorded high significant effect ($P<0.05$) in T_5 (3.96×10^{12}/L) and T_1 with 0% replacement level of cassava peel meal (3.09×10^{12}/L), the lowest. The mean corpuscular haemoglobin (MCH) recorded the highest value in T_3 (52.68pg) and T_4 (24.66pg) recorded the lowest value. The packed cell volume (PCV), white blood cell (WBC), mean corpuscular volume (MCV), heterophils and lymphocytes recorded increase across treatments. However, PCV recorded no significant effect ($P>0.05$) in T_1 (control), even though it was the lowest. The WBC recorded no significant effect ($P>0.05$) even in T_5 which recorded the highest (8.54×10^9/L).

The MCHC recorded better value in T_2 (35.31g/dl), T_4 and T_5 (34.00g/dl) each respectively had the lowest values. The MCV recorded no significant effect ($P>0.05$) T_3 and T_5 had (74.33fl) each but T_4 recorded the highest (76.00fl). The lymphocytes recorded no significant effect even though T_4 and T_5 had the least (82.00%) and T_3, T_2 and T_1 had the highest (86.68%), (86.65%), (86.60%) at 50%, 25% and 0% levels of replacement respectively.

The eosinophils recorded no significant effect ($P>0.05$) between treatments, T_5 had the highest value of 0.66% with 100% replacement level, while T_1, T_2 and T_3 recorded no values. The monocytes recorded significant ($P<0.05$) effect, T_2, T_4 and T_5 had the highest values of 3.31% each while T_3 had the lowest value of 2.33%. Basophils recorded no significant ($P>0.05$) effect, T_5 with 100% cassava peel meal replacement had 0.33% while basophils were completely absent in T_1, T_2, T_3 and T_4, respectively.

The similarities in haematological indices across the treatments indicate the wellbeing of the birds throughout the period of experiment as normal haematological parameters of an animal are a direct indication of absence of disease. The values obtained were within normal range for

healthy birds, according to Mitruka *et al.*, (1977). This is an indication that these animals were not stressed due to replacement levels of cassava peel meal. Packed cell volume (PCV) was not affected due to replacement with cassava peel meal as the results were similar with those observed by Olugbemi *et al.*, (2010).

Table 3: Haematological characteristics of finisher broiler chickens feed cassava peel meal as a replacement for wheat offal

	Dietary levels of replacement of wheal offal with cassava peel meal						
Parameters	**T_1 (0%)**	**T_2 (25%)**	**T_3 (50%)**	**T_4 (75%)**	**T_5 (100%)**	**SEM**	**Normal Ranges**
PCV (%)	27.96	28.64	29.96	29.96	30.00	0.70	30-50%
WBC ($x10^9$/L)	7.32	7.44	7.71	8.22	8.54	0.56	5.2-12.5 ($x10^9$/L)
Plat ($x10^9$/L)	49.98^b	53.38^b	59.66^a	83.34^a	93.63^a	8.87	200-650 ($x10^9$/L)
RBC ($x10^{12}$/L)	3.48^b	3.66^b	3.09^a	3.83^b	3.96^a	0.11	5.2-12.5 ($x10^9$/L)
HB (g/dl)	9.87	9.91	9.66	9.34	9.72	0.36	10-17.4 (g/dl)
MCH (pg)	26.98	27.69	52.68	24.66	25.68	0.77	17.1-23.9 (pg)
MCHC (g/dl)	35.20	35.31	34.31	34.00	34.00	0.52	28.2-40 (g/dl)
MCV (fl)	74.41	74.63	74.33	76.00	74.33	1.61	57.5-75 (fl)
HET (%)	10.00^b	10.02^b	74.34^{ab}	11.61^a	13.66^a	1.05	NA (%)
LYM (%)	86.60	86.65	86.68	82.00	82.00	1.02	43-80%
EOS (%)	0.00	0.00	0.00	0.33	0.66	0.27	NA (%)
MON (%)	3.26^a	3.31^a	2.33^b	3.31^a	3.31^a	0.40	NA (%)
BAS (%)	0.00	0.00	0.00	0.00	0.33	0.20	NA (%)

a, ab, b = means along the same row with different superscript are significantly ($p<0.05$) different

SEM - Standard error of mean
PVC - Packed cell volume
WBC - White blood cell
Plat - Platelets
RBC - Red Blood cell
HB - Haemoglobin
MCH - Mean Corpuscular Haemoglobin
HET - Heterophils
LYM - Lymphocytes
EOS - Eosinophils
Mon - Monocytes
BAS - Basophils

Serum biochemical indices of finisher broiler chickens fed cassava peel meal as a replacement for wheat offal

The results of serum biochemical parameters of finisher broiler chickens fed cassava peel meal as a replacement for wheat offal are shown in Table 5. There were significant differences ($P<0.05$) among the treatment groups in urea, cholesterol, glucose, calcium and alkaline phosphate values. However, there were no significant differences ($P>0.05$) among the treatment groups in Aspartate transaminase values.

Serum urea content was significantly ($P<0.05$) higher in birds fed control diet (T_1) than those fed 100% cassava peel meal. However, there was no significant difference ($P>0.05$) between birds fed control diet and those fed 25% and 50% cassava peel meal. The highest serum urea was observed in T_2 (13.50mg/dl) while the lowest serum urea value of 5.00mg/dl was observed in T_5. The serum urea values obtained in this study were within the normal range of 4.80-19.80mg/dl as reported by Kaneko *et al.,* (1997). However, the urea values in this study were lower than the range of 30.46 ± 2.51 to 54.08 ± 11mg/dl reported by Iheukwumere *et al.,* (2006) in chickens. This disparity in urea values may be attributed to the differences in breed and nutritional status of the birds, as it has been observed that serum urea content depends on both the quantity and quality of protein in the diet (Iheukwumere and Herbert, 2002). Higher blood urea levels have been associated with poor protein quality or excess tissue protein catabolism associated with protein deficiency (Eggum, 1970).

Serum cholesterol was significantly higher ($P<0.05$) in birds fed 25% cassava peel meal in T_2 than those fed 0%, 50%, 75% and 100% cassava peel meal. The lowest cholesterol value of 63.50mg/dl was observed in birds fed 100% cassava peel meal. The cholesterol values obtained in this experiment were within the normal range of 52 to 143mg/dl reported by Banerjee (2007) for birds except birds fed cassava peel meal in T_2 whose cholesterol value (164.00mg/dl) was higher than normal range. Cholesterol levels in the serum has been associated with the quantity and quality of fat supplied in the diet (Eggum, 1970).

Serum glucose content was significantly ($P<0.05$) higher in birds fed 25% cassava peel meal than those fed 0%, 50%, 75% and 100% cassava peel meal. Serum glucose levels decreased as the level of cassava peel meal increased. The lowest value for serum glucose was observed in birds fed 100% cassava peel meal in T_5 (84.50mmol/L). The serum glucose values obtained in this study were lower than the value of 167.8mg/dl reported by Kaneko *et al.,* (1997). Glucose is one of the metabolites measured as an indicator of the energy status of the birds. Serum calcium content was significantly ($P<0.05$) higher in birds fed 100% cassava peel meal than those fed 0%, 25%, 50% and 75% cassava peel meal. However, serum calcium contents were similar ($P>0.05$) among birds fed 0%, 25%, 50%, 75% and 100% cassava peel meal. The lowest value in serum calcium was observed in broiler chickens fed control diet T_1 (7.36mmol/L). The serum calcium content increased as the level of cassava peel meal fed also increased. The calcium values obtained in this study were slightly higher than the normal values of 7.10mmol/L reported by Kaneko *et al.,* (1997) for chickens. This disparity in calcium values may be connected to the nutritional status of the birds.

Serum alkaline phosphatase content was significantly ($P<0.05$) higher in birds fed 50% cassava peel meal in T_3. However, serum alkaline content were similar among birds fed control diet in T_1, those in T_2, T_3, T_4 and T_5 respectively. The lowest serum alkaline phosphatase value was observed in birds fed 75% cassava peel meal in T_4 (132.50iμ/L). Serum alkaline phosphatase values obtained in this research were lower than the normal values of 482.5iμ/L reported by Kaneko *et al.,* (1997) for chicken. This disparity may be due to differences in breed, physiological and nutritional status of the birds. Alkaline phosphatase assays is useful in the diagnosis of obstructive liver disease (Murray *et al.*, 2003).

Serum aspartate transaminase content were similar ($P>0.05$) among the treatment groups fed cassava peel meal. The birds recorded 89.00iμ/L across the treatments. This 89.00iμ/L was lower than the range of 178.40iμ/L reported by Kaneko *et al.,* (1997) for chickens.

Alanin transaminase was not detected among the treatment groups. This was in agreement with the report of Egu (2017). An increase in alkaline phosphatase, alanine transaminase and

aspartate transaminase values would signify necrosis or myocardial infarction which are all indicators of drug toxicity or harmful chemicals in the body (Nelson and Cox, 2005).

Table 4: Serum Biochemical parameters of finisher broiler chickens fed cassava peel meal as a replacement for wheat offal

	Dietary levels of replacement of wheat offal with cassava peel meal					
Parameters	**T1 (0%)**	**T2 (25%)**	**T3 (50%)**	**T4 (75%)**	**T5 (100%)**	**SEM**
Urea (mg/dl)	13.42[a]	13.50[a]	10.50[a]	11.50[a]	5.00[b]	1.82
Cholesterol (mg/dl)	162.98[a]	164.00[a]	122.50[ab]	116.50[ab]	63.50[b]	20.62
Glucose (mmol/L)	142.39[a]	142.50[a]	101.00[b]	93.00[b]	84.50[b]	12.87
Calcium (mmol/L)	7.36[b]	7.40[b]	7.70[ab]	7.75[a]	7.85[a]	0.10
Alkaline phosphatase (iμ/L)	160.02[a]	161.00[a]	162.0[0a]	132.50[b]	157.00[a]	9.19
Alkaline transaminase (μi/L)	0.00	0.00	0.00	0.00	0.00	0.00
Aspartate transaminase (iμ/L)	88.89	89.00	89.00	89.00	89.00	0.00

a, ab, b = means in the same row with different superscript are significantly (P<0.05) different
SEM = Standard error of mean.

CONCLUSION AND RECOMMENDATIONS

There were similarities in haematological indices across the treatment groups which indicate wellness of the birds throughout the period of the experiment. The haematological parameters were within the normal range which is a direct indication of absence of disease. It therefore means that the birds were not stressed as a result of being fed cassava peel meal. However, there were changes in serum biochemical indices of the birds. Glucose and cholesterol levels in serum decreased as the level of cassava peel meal increased (Table 4), and this is good for maintenance of body homeostasis. Therefore, it can be concluded that feeding 100% cassava peel meal as diet to broiler chickens had no toxic effect on the haematological and serum metabolites.

Based on the results obtained from this study, feeding broiler chickens with cassava peel meal as a replacement for wheat offal is viable, and could be recommended as feed in commercial broiler production.

REFERENCES

Akpet, S. O., & Ibekwe, H. A. (2018). Growth response, carcass characteristics and some blood parameters of broiler chickens fed sun-dried and fermented cassava peel meal based diets. *International Journal of Applied Research*, 4(9), 139-143.

AOAC (2015). Association of Official Analytical Chemist. Official Methods of Analysis, 19th edn. Washington D. C.

Avigen (2015). Feed ingredients: Consideration of alternatives when facing increased price volatility. Vol. 14th May 2015.

Eggum, B. O (1970). Blood urea measurement as a technique for assessing protein quality. British Journal of Nutrition, 29, 985-988.

Egu, U. N. (2017). Haematological and serum biochemical parameters of mature Harco cocks treated with human menopausal gonadotrophin (Diclair®) for spermatogenesis. *International Journal of Environment, Agriculture and Biotechnology*, 1-29(1), 429-436.

Fatokun, F. (2013). Problem of food deficiency in Nigeria. *Journal sustainable Agricultural Environment*, (8), 1-13.

Iheukwumere, F. C. & Herbert, U. (2006). Physiological responses of broiler chickens to quantitative water restrictions. Haematology and Serum Biochemistry, *International Journal of poultry science*, 2(2), 117-119.

International Institute of Tropical Agriculture (IITA). (2024). Solution: Cassava Peels for Animal Feed Production. Retrieved from https://propas.iita.org/en/solutions/cassava-peels-for-animal-feed-production/57/details/

Kaneko, J. J., Harvey, J. W. & Bruss, H. I, (1997). Clinical Biochemistry of Domestic Animals 5th Edition. Academic Press. San Diego, California Pp. 885-905.

Melesse, A. Temesgen, A., Sandip, B. & Kefyalew, B. (2017). The effect of the partial substitution of roasted soybean seed with graded levels of sweet potato (Ipomoea batatas) leaf meal on growth performances and carcass components of broiler chickens. *Asian-Australas JAnimSci* 00:1-7

Melesse, M., Steingass, H., Schollenberger, M., Rodehutscord, M. (2018). Component composition, in vitro gas and methane production profiles of fruit byproducts and leaves of root crops. *Journal of Agricultural Science*, 156, 949-958.

Mitruka, B. M., Rawnsley, H. M. & Vandehra, B. V. (1977). Clinical biochemical and haematological reference value in normal experimental animal. Masson Publishing. U.S.A. Inc. 272.

Murrray, R. K., Granner, D. R., Mayes, P. A. & Rodwell, V. W. (2003). Herpers Illustrated Biochemistry. 25th Edn. Mc Graw Hill Companies, Inc. U.S.A. p. 693.

Nelson, D. L., & Cox, M. M. (2005). Lehninger Principles of Biochemistry 4th Edn. W. H. Freeman and Company New York. P. 119

NMA - Nigerian Meteorological Agency. Seasonal rainfall and prediction data, Margaret Ekpo International Airport, 2022.

Nsa, E. E., Ozung, P. O., Etuk, E. A., & Archibong, E. E. (2023). Economics and effect of replacing wheat offal with cassava peel meal on growth performance, nutrient digestibility of growing pigs. *African Journal of Food, Agriculture, Nutrition and Development*, 23(8), 24423-24442. https://doi.org/10.18697/ajfand.123.23540

Ogbuewu, I. P., & Mbajiorgu, C. A. (2023). Utilisation of cassava as energy and protein feed resource in broiler chicken and laying hen diets. *Tropical Animal Health and Production*. https://link.springer.com/article/10.1007/s11250-023-03579-3

Oghenejoboh, K. M., Fathima, A. S., & Parmar, A. (2021). Cassava waste as an animal feed treatment: past and future. *Environmental Science and Pollution Research*, 28, 11157-11167. https://doi.org/10.1007/s11157-024-09701-7

Ogunsipe, M. H., Balogun, K. B., Oladepo, A. D., Ayoola, M. A. & Arikewuyo, M. T. (2017a). Nutritive value of cocoa bean shell meal and its effect on growth and haematology of weaning rabbits. *Nigerian J Agric Food Environ* 13(1):23-28.

Ogunsipe, M. H., Ibidapo, I., Oloruntola, O. D. and Agbede, J. O. (2017b). Growth performance of pigs on dietary cocoa bean shell meal. *Livestock Res Rural Dev* 29(1).

Olugbemi, T. S., Mutayoba, S. K. & Lekili, F. P. (2010). Effects of cassava-based diets fed to broiler chickens. *International Journal of Poultry Sciences*. 9:363-367

SDGs (2018). The 2030 Agenda for Sustainable Development provides a global blueprint for dignity, peace and prosperity for people and the planet, now and in the future.

DIETARY EFFECT OF SANDBOX SEED MEAL ON BLOOD CHEMISTRY AND ORGAN HISTOPATHOLOGY OF RABBITS IN CALABAR, NIGERIA

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ABSTRACT

This study evaluated the effect of sandbox seed meal (SBSM) based – diets on the blood chemistry and organ histopathology of rabbits. Sixty mixed breed weaned rabbits between the ages of 6 and 7 weeks old with initial mean body weight of 580.79±0.34g/rabbit were used. The rabbits were weight individually and randomly distributed into 5 groups after equalizing for body weight and sex using a completely randomized design, with 12 rabbits per treatment. Five isocaloric (2,624.58 Kcal/KgME) and isonitrogenous (16% CP) diets were formulated such that SBSM replaced soybean meal at 0, 25, 50, 75, 100 % for T_1, T_2, T_3, T_4, and T_5, respectively. The feeding trial lasted 12 weeks and at the end, blood samples were obtained for blood assay. Thereafter, three rabbits per treatment were sacrificed and samples of liver and kidney were carefully harvested for histopathological evaluation. Results showed that haematological parameters recorded significant ($p<0.05$) differences between treatments in platelets (53.33 – 118.00 $\times 10^9$/L), red blood cell counts (3.66 – 4.16 $\times 10^{12}$/L), neutrophils (10.00 – 20.33%) and monocytes (2.33 – 3.33%). The serum biochemical indices recorded significant ($p<0.0.5$) effect in glucose (2.28 – 3.27 g/dl), total protein (5.55 – 7.25 mmol/L), chloride (91.33 -103.33 mmol/L), high density lipoprotein (0.66 – 1.30 g/dl), cholesterol (21.33 – 23.50 mmol/L), aspartate amino transferase (14.66 – 23.00 mmol/L) and alanine amino phosphatase (12 – 18 mmol/L). Histological sections of the liver and kidney revealed no adverse effect of dietary treatments. The study concluded that sandbox seed meal could replace soybean meal up to 100% level in diets without deleterious effects on blood chemistry and internal organs of rabbits.

Key words: Blood, feedstuff, histology, organs, rabbits, sandbox

Introduction

Feed and feeding account for over 75 - 80% of the total cost of production of livestock (Agbede and Aletor, 2013). Feed insufficiency is due to stiff competition for feedstuffs between humans and livestock (Iyayi and Davies, 2015). This competition has led to the high cost of production of livestock. The Animal industry is geared towards converting cheap and available feedstuffs into more balanced animal protein. A search for alternative feedstuffs that are readily available, cheap and nutritive has become imperative to sustain the livestock industry, particularly the fast growing and prolific monogastric species (Vasudeva and Sharma, 2012). According to FAO (2010), animal feed is the pivot for the food industry globally. Therefore, for effective profit maximization, rabbit production in Nigeria and other developing countries is geared towards exploring input resources which can reduce the cost of feeding (Obeidat *et al*., 2009) and can also moderately improve growth rate, boost haematopoietic processes, organ development and reproductive performance. Nutritive, available and affordable animal feedstuffs make livestock production more viable throughout the world (Ravindran *et al*., 2016). Omole and Onwudike

(2014), reported that most of the unconventional feedstuffs are plagued with dietary toxins which may pose danger to the general health of livestock and eventually affect productive and reproductive performance of animals. Oloyede and Olatinwo (2014), stated that shortage and high cost of some conventional plant protein sources such as cowpea, soybean and groundnut cake due to their ever-increasing demand as staple foodstuffs for man, raw materials for industries and as feed ingredients for farm animals have called for alternative plant materials which are rich in protein and of less industrial uses and human preference. Raising rabbits on forages and tree crops foliage with an energy supplement has been reported to be more appropriate in developing countries where commercial feeds are either not available or cost-prohibitive (Linga and Lukefahr, 2000). One of such plants is the sandbox tree with nutritious leaves and seeds. Sandbox tree (*Hura crepitans*) is an angiosperm belonging to the family *Euphorbiaceae* (Olatidoye *et al.*, 2010). It can grow to heights of 35 - 60 metres depending on the soil conditions. Sandbox seeds contain appreciable quantities of useful nutrients and secondary metabolites such as alkaloids, steroids, phenolics, flavonoids, cardiac-active glycosides and tannins (Oyeleke *et al.*, 2012). According to Oloyede and Olatinwo (2014), the leaves and stem bark of the crude methanol extract of *Hura crepitans* have been exploited in many medicinal applications as emetic, purgative, antimicrobial, anti-inflammatory agents (Oderinde *et al.*, 2009). Hura seeds contain amino acids at levels that compare favourable with soybean meal. According to Iyeghe-Erakpotobor *et al.* (2002), rabbits fed 15 % inclusion Hura seeds meal in their diets had high content of total protein, albumin, globulin, glucose, urea, calcium, phosphorus and creatinine.

According to Ajayi and Raji (2011), blood indices are critical indicators of the physiological status of farm animals, thus reflecting the relationship between their nutrition and health. They are important for clinical evaluation of different animal diseases and feed quality. Gatti *et al.* (2014) stated that most biochemical parameters of rabbits can be measured from serum or plasma. According to Napirah *et al.* (2013), blood parameters change in relation to the physiological status of an animal. These changes could be as a result of several factors such feeding level, feed quality, age, sex, breed, temperature and physiological status of animals (Harcourt-Brown and Barker, 2011). There is paucity of scientific information on the effect of sandbox seed meal on the blood chemistry and organ histology of rabbits, hence its utilization in this study to fill this research gap. This study was designed to determine the dietary effect of toasted sandbox seed meal on the haematological characteristics, serum biochemical indices and histopathology of internal organs in rabbits.

Materials and methods

Location of study

This study was carried out at the Rabbitry Unit of the Teaching and Research Farm, University of Calabar, Calabar, Nigeria. Calabar is located at 4°E 57' latitude of the Equator and 8°E 19' longitude of the Greenwich meridian with an average elevation/altitude of 99 m above sea level. The average annual rainfall ranges between 3000 and 3500 mm and the average daily temperature is between 25° (77°F) and 30°C (86°F). (NiMet, 2023).

Experimental housing

The rabbits were housed in concrete double tier cages, with a wire mesh floor measuring 65×65×65 cm^3, raised 25 cm from ground level. The cages and entire rabbitry unit were thoroughly washed with disinfectant (Izal) to curb parasites and were allowed to dry for seven days before animals were brought in. Concrete watering and feeding troughs were placed in each hutch.

Experimental feed materials and diets

The test ingredient was the sandbox (*Hura crepitans*) seed meal. Mature sandbox seeds were harvested from sandbox trees within the University of Calabar premises. The pods were broken with a hammer to remove the seeds, which were subsequently sun dried to constant weight for 7 days to prevent sprouting out. The seeds were further toasted and oil extracted through mechanical means. Thereafter, the oil extracted seeds were milled with a hammer mill to obtain sandbox seed meal (SBSM) and stored for feed formulation. Five isocaloric (2,624.58 Kcal/Kg ME) and isonitrogenous (16% CP) experimental diets were formulated and SBSM replaced soybean meal at 0, 25, 50, 75, 100 % levels for treatments T1, T2, T3, T4, and T5, respectively. The rabbits were fed a control diet and a uniform quantity of *Tridax procumbens* during the first two weeks of adjustment/acclimatization period. Thereafter, the actual feeding trial with the respective dietary treatments lasted 12 weeks.

Experimental animals, design and management

A total of sixty (60) mixed breed weaned rabbits (30 bucks and 30 does) were used for this study between the ages of 6 and 8 weeks old with initial mean body weight of 580.79±0.34g/rabbit. The rabbits were obtained from a standard rabbitry in Calabar. On arrival, the rabbits were given antistress vitalyte via drinking water. The rabbits were thereafter weight individually and randomly distributed into 5 dietary groups after equalizing their body weight and sex using a Completely Randomized Design (CRD), with a stocking rate of 12 rabbits per treatment. The treatments were replicated 6 times with 2 rabbit per replicate. The rabbits were conditioned by screening against ecto- and endo - parasites using Ivomec sub - cutaneous injection at 0.2 ml/rabbit. Clean drinking water was provided *ad libitum*.

Blood collection

Blood samples were obtained at the end of the feeding trial for haematological and serum biochemical assays. Two blood samples (5ml) per rabbits were collected from 4 rabbits (2 bucks: 2 does) per treatment, from the prominent ear vein by means of hypodermic needles and syringes into test tubes. One set of the test tubes contained an anticoagulant (Ethylene Diamine tetra acetic acid, EDTA) for haematological analysis which the other set of test tubes were without EDTA was for serum biochemical assay.

Determination of haematological characteristics

All haematological parameters were determined by standard laboratory methods as described by Bitto and Gemade (2001).

Determination of serum biochemical indices

Total serum protein determination was by the Biuret method as described by Kohn and Allen (1995). Albumin was determined using Bromocresol Green (BCG) method as described by Peter *et al.* (1982). The globulin concentration was obtained by subtracting albumin values from the total protein. Alanine and aspartate aminotransferase (ALP and AST) activities were assayed using Randox commercial enzyme kit as described by Schmidt (1963). Glucose and cholesterol were determined using spectrophotometric method as described by Braham and Trinder (1972) and Allaine (1974) respectively.

Histopathological evaluation

Samples of the liver and kidney were carefully harvested *intoto* and preserved in 10 % buffered formalin solution for histopathological evaluation using standard laboratory procedures described by Drury and Wallington (1976).

Statistical analysis

All data obtained were subjected to one – way analysis of variance (ANOVA) using GenStat Release 10.3 statistical package. Significance means were separated using the least significance difference (LSD) method of the same statistical software as described by Steel and Torrie (1980).

RESULTS

Haematological characteristics of rabbits fed sandbox seed meal based - diets

Result of the haematological characteristics of rabbits fed sandbox seed meal based - diets is presented in Table 1. The platelets, red blood cell counts (RBC), neutrophils and monocytes were significantly ($p<0.05$) different between dietary treatments. The platelet counts (118.00 %) in treatment 5 was significantly higher ($p<0.05$) than 83.33 % in treatment 3. The red blood cell (RBC) counts recorded high significant effect ($p<0.05$) in treatment 5 (4.16 $x10^9$/L) and treatment 1 with 0% replacement level of sandbox seed meal (3 .66$x10^9$/L) the lowest. The MCH recorded the highest value in treatment 1 (27.00pg) and treatment 3 recorded the lowest value. The PCV, WBC, MCHC, MCV, Neutrophils and Lymphocytes recorded increasing trends across dietary treatments. Hence PCV recorded no significant effect ($p>0.05$) and treatment 1 (the control), was the lowest. The WBC recorded no significant effect ($p>0.05$) and treatment 5 recorded the highest (12.10$x10^9$/L). The MCHC recorded better value in treatment 1(35.33 percent) and treatments 3 and 4 (34.00 g/dl) had the lowest values. The MCV recorded no significant effect ($p>0.05$) and treatment 2 and 4 (74.33 &74.33fl) recorded the least values but treatment 3 recorded the highest (76.00 fl). The lymphocytes recorded no significant effect and treatment 5 was the least and treatments 1 and 2 with 0 and 25% replacement levels of sandbox seed meal based - diet had the highest (86.66 %). The eosinophils recorded no significant effect ($p>0.05$) between treatments and treatment 4 with 75% sandbox seed meal based - diets (0.66%) had the highest value, while treatments 1 and 2 with 0 and 25% level of sandbox seed meal recorded no value (0.00). The monocytes recorded significant ($p<0.05$) effect and treatment 1, 3, 4 and 5 recorded the highest with the same value (3.33%) and treatment 2 had the lowest (2.33%). The Basophils recorded no significant ($p>0.05$) effect and treatments 4 and 5 with 75 and 100% replacement level of SBM with sandbox seed meal recorded (0.33%) while basophils were conspicuously absent in treatments 1, 2 and 3, respectively.

Table 1: Haematological characteristics of rabbits fed sandbox seed meal based diets

Parameter	T1 0%	T2 25%	T3 50%	T4 75%	T5 100%	SEM	Normal Ranges*
Packed cell vol. (%)	28.66	29.00	29.00	30.00	31.66	0.71	30-50
WBC ($x10^9$/L)	7.40	7.73	8.20	8.56	12.10	0.58	5.2-12.5
Platelets ($x10^9$/L)	53.33^b	59.67^b	83.33^a	93.67^a	118.00^a	8.89	200-650
RBC ($x10^{12}$/L)	3.66^b	3.90^a	3.83^b	3.96^a	4.16^a	0.12	5.2-12.5
Haemoglobin (g/dl)	9.70	9.66	9.36	9.73	10.76	0.39	10-17.4
MCH (pg)	27.00	25.66	24.66	25.66	25.66	0.78	17.1-23.9
MCHC (g/dl)	35.33	34.33	34.00	34.00	34.33	0.51	28.2-40
MCV (fl)	74.66	74.33	76.00	74.33	75.33	1.63	57.5-75
Neutrophils (%)	10.00^b	10.33^b	11.66^{ab}	13.66^a	20.33^a	1.07	NA
Lymphocytes (%)	86.66	86.66	84.00	80.00	75.66	1.06	43-80
Eosinophils (%)	0.00	0.00	0.33	0.66	1.33	0.25	NA
Monocytes (%)	3.33^a	2.33^b	3.33^a	3.33^a	3.33^a	0.42	NA
Basophils (%)	0.00	0.00	0.00	0.33	0.33	0.21	NA

a, b, ab means along the same row with different superscripts are significantly ($p<0.05$) different

*Normal reference ranges: http://www.medirabbit.com/EN/Haematology/blood_chemistry.htm/13/05/2024.11:00am
Key: WBC: White blood cell; RBC: Red blood cell counts; MCH: Mean corpuscular haemoglobin; MCHC: Mean corpuscular haemoglobin concentration; MCV: Mean corpuscular volume

Serum biochemical indices of rabbits fed sandbox seed meal based diets

The serum biochemical indices of rabbits fed sandbox seed meal based diets are presented in Table 2. Results obtained recorded significant ($p<0.05$) differences for most parameters except triglycerides (TRIG), albumin (ALB) and bicarbonate (HCO_3). The gamma-glutamyl transferase recorded the highest value in treatment 5 (100% SBSM) (36.00g/dl) and the lowest value (0.75g/dl) was in treatment 4 with 75% replacement level SBSM. The glucose level recorded the highest significant effect ($p<0.05$) in all parameters. Treatment 2 (2.28mmol/l) with 25% replacement of SBSM recorded the lowest value. The Total protein (TP) recorded the highest value in treatment 1 (7.25mmol/l) and treatment 5 was the lowest (5.55mmol/l). The chloride (Cl) recorded the highest (103.33 mmol/l) in treatment 1 and treatment 4 with 75% replacement of SBSM recorded the lowest (91.33mmol/l) for chloride. The high-density lipoprotein recorded the highest in treatment 1 (1.30g/dl) with 0% SBSM and treatment 5 recorded the lowest value (0.66mmol/l) with 100% replacement of SBSM. Cholesterol recorded the highest value (23.50mmol/l) in treatment 2 with 25% replacement of SBSM and treatment 5 had the lowest (21.33mmol/l). Aspartate amino transferase (AST) recorded the highest value (23.00mmol/) in treatments 4 and 5 with 75% and 100% replacement of SBSM and treatments 1 and 2 recorded the lowest (14.66mmol/l). Alanine amino phosphatase recorded the highest value (18.00mmol/l) in treatment 4 and treatment 2 recorded the lowest value (13.00mmol/l). Triglycerides (TRIG) recorded the highest value (1.70g/dl) in treatment 5 and treatment 1 recorded the lowest value (1.16g/dl). Albumin (ALB) recorded the highest value (4.24g/dl) in treatment 1 and treatment 4 recorded the lowest value (3.50g/dl) with replacement of 75% SBSM. Bicarbonate (HCO_3) recorded the highest value (24.00) in treatment 2 and treatment 3 recorded the lowest value (21.50).

Table 2: Serum biochemical indices of rabbits fed sandbox seed meal based-diets

Parameter	T1 0%	T2 25%	T3 50%	T4 75%	T5 100%	SEM	Normal Ranges*
Glucose (g/dl)	3.03^{b}	2.28^{a}	3.22^{b}	3.05^{b}	3.27^{b}	0.10	4.2-8.9 mmol/l
GGT (g/dl)	29.00^{b}	28.00^{b}	34.00^{a}	34.00^{a}	36.00^{a}	0.96	NA
TP (mmol/l)	7.25^{a}	6.04^{ab}	6.06^{ab}	5.92^{b}	5.55^{b}	0.10	5-7.5g/dl
TRIG (g/dl)	1.16	1.42	1.65	1.59	1.70	0.05	1.4-1.8 mmol/l
Albumin (g/dl)	4.24	3.65	3.65	3.50	4.00	4.76	2.7-5.0g/dl
CL (mmol/l)	103.33^{a}	97.67^{b}	100.00^{ab}	91.33^{b}	95.00^{b}	1.52	NA
HDL (g/dl)	1.30^{a}	1.20^{a}	0.90^{b}	0.75^{c}	0.66^{c}	0.04	NA
CHOL (mmol/l)	22.50^{b}	23.50^{a}	21.50^{b}	21.83^{b}	21.33^{b}	0.80	0.10-2.0mmol/l
HCO_3 (g/dl)	22.50	24.00	21.50	21.83	23.33	0.83	NA
AST (mmol/l)	14.66^{b}	14.66	19.00^{ab}	23.00^{a}	23.00^{a}	1.28	10-98(UI)
ALP (mmol/l)	13.00^{b}	12.00^{b}	16.50^{ab}	18.00	17.33^{a}	0.71	NA

a, b, ab means along the same row with different superscripts are significantly ($p<0.05$) different
* Reference interval: http://www.medirabbit.com/EN/Haematology/blood_chemistry.htm/13/06/2024
Key: GGT: Gamma-glutamyl transferase; TP: Total protein; TRIG: Triglycerides, CL: Chloride, high density lipoprotein, CHOL: Cholesterol, HCO: Bicarbonate, AST: Aspartate amino transferase, ALP: Alanine amino phosphatase

Histopathology of the kidney and liver

The photomicrographs of the histopathological evaluation of the kidney and liver of rabbits fed sandbox seed meal are presented in Plates 1a-2e respectively.

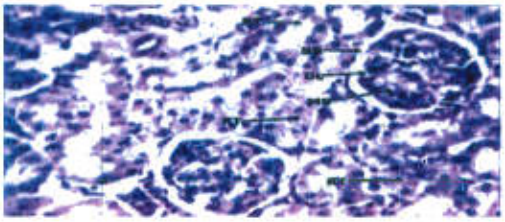

Plate 1a: Kidney section in 0% SBSM (x 100) (T1) (T2)

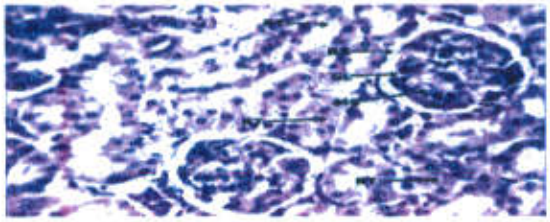

Plate 1b: Kidney section in 25% SBSM (x 100)

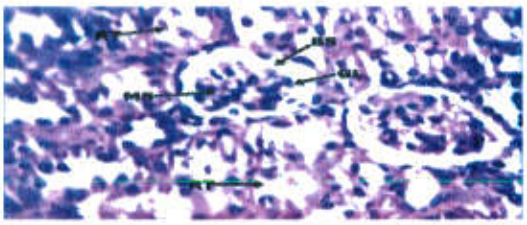

Plate 1c: Kidney section in 50 % SBSM (x 100) T3 (T4)

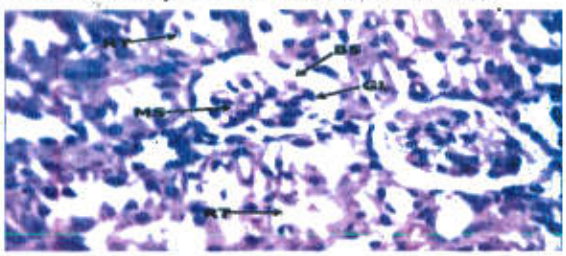

Plate 1d Kidney section in 75% SBSM (x 100)

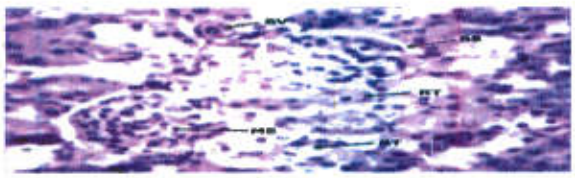

Plate 1e: Kidney section in 100% SBSM (x 100) (T5)

Key: BS = Bowman's space; RT = Renal tubule; GL = Glomeruli and MS = Mesangium.
*There was no visible tubular or glomeruli destruction of the kidney (T1 – T5) in all photomicrographs

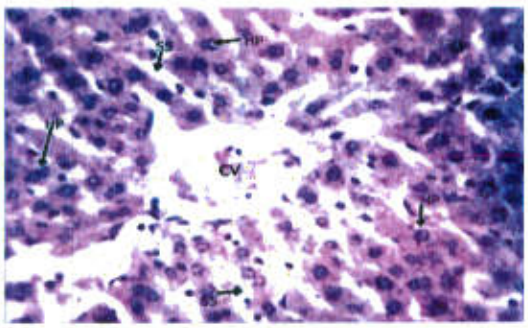

Plate 2a: Liver section in 0% SBSM (x 100) (T1)

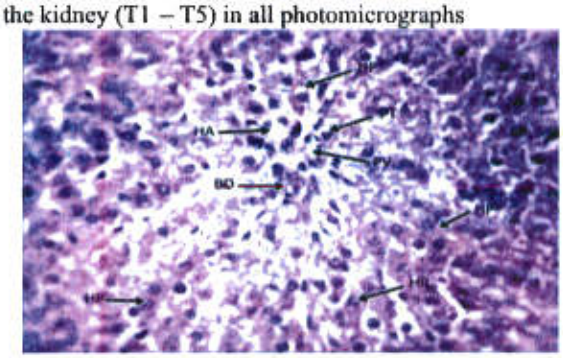

Plate 2b: Liver section in 25% SBSM (x 100) (T2)

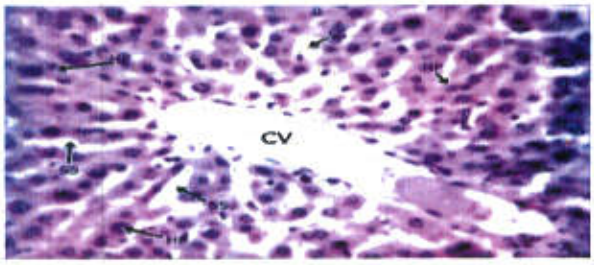

Plate 2c: Liver section in 50% SBSM (x 100) (T3)

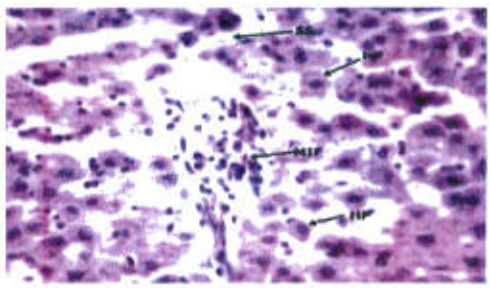

Plate 2d: Liver section in 75% SBSM (x 100) (T4)

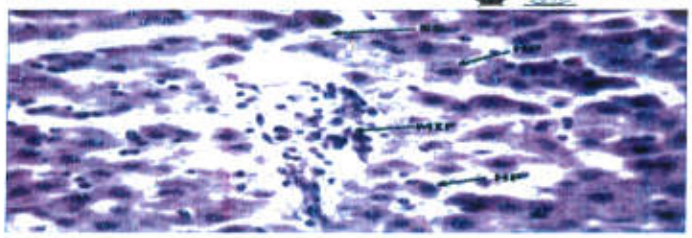

Plate 2e: Liver section in 100% SBSM (x 100) (T4)

Key: SS = Sinusoid space.; HP = Hepatocytes; CV = Central vein; MIF = Mild mononuclear cellular inflammation; PT = Portal vein. *The overall cellular architecture (T1 - T5) did not show hepatotoxicity nor severe cellular inflammations of the liver sections.

DISCUSSION

Haematological characteristics of rabbits fed sandbox seed meal (SBSM) based diets

The haematological characteristics of rabbits fed sandbox seed meal based diets (Table 1) recorded significant ($p<0.05$) effect except for packed cell volume, white blood cell, haemoglobin, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, mean corpuscular volume, lymphocytes, Eosinophils and basophils. The result of all haematological parameter fell within the normal clinical ranges for rabbits as reported by Leinesweber *et al.* (2018) and Medirabbit (2020). This implies that the SBSM and its associated anti nutrients may not have any adverse effect on the haematological characteristic of rabbits. The white blood cell counts were not significantly ($p>0.05$) affected. This means that SBSM did not negatively affect the immune status of rabbits. The range (7.40-12.10 x 10^9/L) was slightly higher than the range (5.90-6.78 x 10^9/L) reported by Jerebi and Nandam (2015) who fed *Sida acuta* and *Synedrella nodi* flora to rabbits. Ubua *et al.* (2019), who fed neem leaf meal to rabbits reported WBC a range of (4.00-11.30 x 10^9/L). Differences could be attributed to different leaf meals used in separate studies. The PCV recorded an increased pattern as the replacement levels of SBSM increased. The range (28.66-31.66%) was fairly lower than the range (31-38%) reported by Ewuola *et al.* (2012) who fed Moringa leaf meal to rabbits. Melilo (2007) reported that PCV of less than 30% indicates anaemia, especially if the red blood cell and haemoglobin levels are low as well. Animals in this study did not display any form of infection. The results of the RBC recorded fluctuated pattern as dietary replacement levels of SBSM increased. The RBC range (3.66-4.16 x 10^{12}/L) was lower than (3.94-4.50x 10^{12}/L) reported by Ewuola *et al.* (2012) who fed Moringa to rabbits. Haemoglobin range (9.36-10.76g/dl) obtained in this study was almost the same range (9.33-10.45g/dl) reported by Jerebi and Naandam, (2015) who fed *Sida acuta* and *Syndrella nodi* flora leaves to rabbits. The lymphocytes recorded a higher value of (75.66-86.66%) when compared to the range (1.89-3.35%) reported by Herbert (2015) who fed diets containing garcinia kola seed meal to rabbits. MCV recorded a fluctuating value as dietary replacement of SBSM increased. The range (74.33-76.00fl) obtained was far higher than (29-28fl) reported by Okpanachi *et al.* (2010), who fed different leaf meals to rabbits. MCV recorded no significant ($p>0.05$) effect meaning that the sandbox seed meal diets did not affect the red blood cell. MCH and MCHC were not equally affected by the seed meal. The MCH range (24.66-27.00pg) was higher than (23.69-23.12pg/cell) reported by Henry *et al.* (2017) and the MCHC range (34.00-35.33pg) was slightly higher than the range (30.23-33.05g/dl) reported by Ahemen *et al.* (2013). Neutrophils, basophils and eosinophils evacuate foreign bodies and prevent infections (Ochei and Kolhatkar, 2007). However, their ranges were within recommended values for rabbits. Monocytes with the value (2.33-3.33%) were higher (0.05-0.15%) when compared to Herbert (2015). The platelets recorded an increased pattern as the dietary inclusion level increased. The range (53.33-118.00 x10^9/L) was higher at the end of the feeding trial.

Serum biochemical indices of rabbits fed sandbox seed meal based diets

The serum biochemical indices of rabbits fed sandbox seed meal based diets (Table 2) revealed significant effect ($p<0.05$) for most parameters except Triglycerides (TRIG), Albumin (ALB) and Bicarbonate (HCO_3). All parameters obtained were within the recommended ranges which indicated that sandbox seed meal did not have any adverse effect on the rabbit serum biochemical parameters. The glucose recorded an increased fluctuating trend across the dietary treatment. The range (2.28-3.27mmol/l) was the same (2.28-3.27mmol/l) reported by Jiwuba *et al.* (2016) who fed moringa leaf meal to rabbits. The Gamma-glutamyl transferase (GGT) was significantly ($p<0.05$) affected, indicating that sandbox seed meal affected this parameter. The Total protein range (5.55-7.25g/dl) recorded an increased pattern as dietary replacement levels increased and was within the range (7.03-8.15g/dl) reported by Aljohani and Abduljawad (2019) who fed moringa leaf meal to rabbits. Triglycerides recorded an increased pattern as the dietary replacement levels increased. The albumin range (3.50-4.24g/dl) was within the range (3.41-3.91g/dl) reported by Adeyemi (2014). The Chloride recorded an increase in a fluctuating trend across dietary treatments. The high-density Lipoprotein (HDL) recorded a decrease significant ($p<0.05$) effect between dietary treatments. The cholesterol recorded decreased significant effect ($p<0.05$) as dietary replacement of SBSM increased across dietary treatment. The range (21.33-23.50 mmol/l) was higher than range (1.17-2.60mmol/l) reported by Audu *et al* (2018) who fed diets containing *Ficus sycomorus* and *Parkia biglobosa* leaf meals to rabbits. Bicarbonates recorded fluctuating increased pattern across treatments. Aspartate amino transferase (AST) recorded a significant effect ($p<0.05$) value obtained increased. The range (14.66-23.00UI) was within range (11.33-28.67UI) reported by Ozung (2016) who fed diets containing cocoa pod husk meal to rabbits. Alanine amino phosphatase (ALP) recorded an increase in a fluctuating trend across the dietary treatments with the range (13.00-18.00(mmol/l), variations could be as a result of differences in dietary leaf meal used.

Organ histopathology of rabbits fed sandbox seed meal based diets

The outcome of histopathological evaluation of some organs (kidney and liver) of rabbits fed sandbox seed meal based-diets and the associated photomicrographs (plates 1a-2e) revealed absence of histopathological damages to these organs by the dietary treatments compared with the control and other dietary treatment groups. The histopathological examination outcome of the kidney revealed no visible tubular glomeruli destruction in all treatment groups. This observation is not in line with the report of EFSA (2008), that animals like rodents and laying hens exposed to anti- nutrients like theobromine from any source will suffer from kidney toxicity, depressed weight gain and lowered egg-production (layers). This study has confirmed that SBSM has no residual theobromine like in cocoa by – products. The photomicrographs of the liver revealed the normal appearance of liver sections for all treatments. This study has further confirmed that the overall cellular architecture (T1-T5) did not show hepatoxicity or severe cellular inflammations. It did not agree with the finding of EFSA (2008) that rabbits, dogs, dairy cows and horses exposed to theobromine suffer liver and thyroid damages, while pigs showed lethargy. The differences could be attributed to the effect of theobromine in previous studies, which was absent in this present study with rabbits fed sandbox seed meal based – diets.

Conclusion

With the findings in this study, it is concluded that sandbox seed meal can replaced soybean meal in rabbit diets as it improved blood (haematopoietic) characteristics and histology of internal organs of rabbits.

Recommendation

The study recommends that sandbox seed meal can replace soybean meal up to 100 % in rabbit diets without deleterious effect on physiological processes such as blood formation and organ histology.

References

Adeyemi, F. A. (2014). Effects of replacement of wheat bran with cassava root sieviate supplemented or unsupplemented with enzyme on the haematology and serum biochemistry of pullet chicks. *Tropical Journal of Animal Science*, 7, 147-153.

Agbede, J. O. & Aletor, V. A. (2013). Evaluation of fishmeal with leaf protein concentrate from glyricidia in diets for broiler chicks: effect on performance, muscle growth, haematology and serum metabolites. *International Journal of Poultry Science*, 2(4), 242-250.

Ahemen, T., Abu, A. H. & Gbor, V. (2013). Haematological and biochemical parameters of rabbits fed varying levels of water spinach (*Ipomoea aquatica*) leaf meal. *Pelagia Advances in Applied Science Research*, 4 (2), 370 – 373.

Ajayi, A. F. & Raji, Y. (2011). Haematological and serum biochemical indices of prepubertal male rabbits fed graded level of blood and wild sunflower forage meal mixture. *African Journal of Biotechnology*, 11(35), 8730 - 8734.

Aljohani, N. E. & Abduljawad, S. H. (2019). Efficiency of *Moringa oleifera* leaf supplementation for enhanced growth performance, haematology and serum biochemistry of rabbits. *Food and Nutrition Science Journal*, 9 (11), 2157 – 2209.

Allain, C.C., Poon, L. S. & Chan, C. S. G. (1974). Enzymatic determination of total serum cholesterol. *Mietes Clinical Chemistry*, 20 (4), 56 – 65.

Audu, R., Tijani, A., Ibrahim, A. A., Amin, A. B., Gumel, I. A. & Suleiman, A. T. (2018). Evaluation of haematology and serum biochemistry of weaner rabbits fed diets containing *Ficus sycomorus* and *Parkia biglobosa* leaf meals. *Nigerian Journal of Animal Production*, 45 (5), 30 – 38.

Braham, D. & Trinder, P. (1972). Methods of determination of blood glucose levels by spectrophotometer. *Analyst*, 97, 142.

Bitto, I. I. & Gemade, M. (2001). Preliminary investigations on the effect of pawpaw peel meal on growth, visceral organ and endocrine gland weights, testicular morphometry and the haematology of male rabbits. *Global Journal of Pure and Applied Sciences*, 7(4), 62 – 65.

Drury, K. A. S. & Wallington, A. (1976). *Histopathological Techniques*. 4th Edition, Oxford University Press, Pp. 48 – 58.

EFFA (2008). European Food Safety Authority. Scientific Opinion of the Panel on Contaminants in the Food Chain on a request from the European Commission on theobromine as undesirable substance in animal feed. *The EFSA Journal* 725, 1- 66.

Ewuola, E. O., Sokunbi, A. O., Alaba, O., Omotoso, J. O. & Omoniyi, A. B. (2012). Haematology and serum biochemistry of weaned rabbits fed dietary prebiotics and probiotics. *Proceedings of the 35th Annual Conference of the Nigeria Society for Animal Production,* 147 – 149.

FAO (2010). Food and Agriculture Organization. *The state of food and Agricultural world review, livestock production a world perspective.* Antalya turkey. Pp. 83.

Gatti, J. L., Castella, S., Dacheux, F., Ecroyd, H., Métayer, S., Thimon, V. & J. L Dacheux, J. L. (2014). Post-testicular sperm environment and fertility. *Journal of Animal Reproduction Science*, 82-83, 321-339.

Harcourt-Brown, F. M. & Baker, S. J. (2011). Parathyroid hormone, hematological and biochemical parameters in relation to dental disease and husbandry in pet rabbits. *Journal of Small Animal Practices,* 42,130 – 136.

Henry, A. J., Ozung, P.O. & Udoh, P. I. (2017). Haematological profile and serum biochemical indices of weaned rabbits fed pawpaw leaves (*Carica papaya*) as supplement to corn-soybean basal diets. *Global Journal of Pure and Applied Sciences,* 23, 21 – 25.

Herbert, U, (2015). Haematological and serum biochemical characteristics of rabbit bucks fed diets containing *Garcinia kola* seed meal. *Journal of Natural Science Research,* 5(3), 24- 31.

Iyeghe-Erakpotobor, G. T., Abdulmalik, M. E., Uguru, J. O. & Abeke, F.O. (2002). Determination of optimum concentrate and *Hura crepitans* for small holder feeding of rabbits. *Tropical Journal of Animal Science*, 5, 181 – 187.

Iyayi, E. A. & Davies, B. I. (2015). Effect of enzyme supplementation on palm kernel meal and brewers dried grain on the performance of broiler. *International Journal of Poultry Science*, 4(2),76-80.

Jerebi, D. A. & Naandam, J. (2015). Haematological characteristics of local rabbits fed *Sida acuta* and *Synedrella nodiflora*. *Ghana Journal of Science, Technology and Development*, 2(1), 23 – 43.

Jiwuba P. C., Ikwunze, K., Dauda, E. & Ugwu, D. O. (2016). Haematological and serum biochemical indices of growing rabbits fed diets containing varying levels of *Moringa Oleifera* meal. *British Biotechnology Journal*, 15(2), 1- 7.

Kohn, R. A. & Allen, M. S. (1995). Enrichment of proteolytic activity relative to nitrogen in preparation from the rumen for *in vitro* studies. *Animal Feed Science and Technology*, 52 (1), 1 – 14.

Leinesweber, C., Muller, E. & Rachel, E. M. (2018). Blood reference values for rabbits (*Oryctolagus cuniculus*) from routine diagnostic samples. *Journal of Haematology*, 46(6), 393 – 398.

Linga, S. S. & Lukefahr, S. D. (2000). Feeding of alfalfa hay with molasses blocks or crumbles to growing rabbit fryers. *Journal of Livestock Resources and Rural Development*, 12: 1-10.

Medirabbit (2020). Complete blood count and reference values in rabbits. http://www.medirabbit.com/EN/Hematology/blood_chemistry.htm,

Melilo, A. (2007). Rabbit Clinical Pathology. *Journal of Exotic Pet Medine*, 16(3), 135 – 145.

Napirah, A., Supadmo, M. & Zuprizal, C. (2013). Effect of turmeric powder supplement in feed on haematological parameters of broiler quail's blood *(Coturnix coturnix* japonica*)*. *Bulletin Peternikan*, 37(2),114-119.

NiMet (2022). Nigerian Meteorological Agency. Extreme Weather Report. National Weather Forecasting and Climate Research Centre, Bill Clinton Drive, Nnamdi Azikiwe International Airport, Abuja, Nigeria.

Obeidat, B. S., Abdullah, A. Y., Mahmoud, K. Z., Awawdeh, M. S., Al-beitawi, N. Z. & Al-Lataifeh, F.A. (2009). Effects of feeding sesame meal on growth performance, nutrient digestibility and carcass characteristics of Awassi lambs. *Journal of Small Ruminant Research*, 82, 13-17.

Ochei, J. & Kolhatkar, A. (2007). *Medical Laboratory Science Theory and Practice*. 6th Edition, McGraw- Hill Publishing Company Limited, New York, U. S.A. 1338Pp.

Oderinde, R. A., Ajayi, I. & Adewuyi, A. (2009). Preliminary toxicological evaluation and effect of the seed oil of *Hura crepitans* and Blighia unijugata bark on the lipid profile of rats. *EJEAFChe*, 8(3), 209 – 221.

Okpanachi, U., Aribido, S. O. & Daikwo, I. S. (2010). Growth and haematological response of growing rabbits to diets containing graded levels of sundried bovine rumen content. *African Journal of Food, Agriculture, Nutrition and Development*, 10, 11 -22.

Olatidoye, O. P., Adeleke, A. E., Adegbite, S. A. & Sobowale, S. S. (2010). Chemical composition and nutritional evaluation of sandbox (*Hura crepitans*) seed flour for domestic consumption and industrial utilization in Nigeria. *Journal of Medicine and Applied Bioscience*, 5(2), 125 – 129.

Oloyede, G. K. & Olatinwo, M. B. (2014). Phytochemical investigation, toxicity and antimicrobial screening of essential oil and extracts from leaves and stem bark of Hura *crepitans* (Euphorbiaceae). *Academia Arena*, 6(5), 7 - 15.

Omole, T. A. & Onwudike, O. O. (2014). Effects of palm oil on the use of cassava peel meal by rabbits. *Journal of Tropical Animal Production*, 8: 27-32.

Oyeleke, C., Ishida, K., Tsutsui, T., Naito, A., Kurita, K., Hanihara, H., Serizawa, T., Fujiwara, M. & Ohdera, M. (2012). Effects of *Hura crepitans* and its active ingredient, daphne factor F3 on dihydrotestosterone – induced neurotrophin-4 activation and hair retardation. *Journal of Biology and Pharmaceutical Research*, 35(1), 42 – 47.

Ozung, P. O. (2016). Performance and physiological responses of rabbits to processed cocoa (*Theobroma cacao* L.) pod husk meal (CPHM) based – diets. Ph.D. Thesis, Department of Animal Science, University of Calabar, Calabar, 265Pp.

Peter, T., Biamonte, G. T. & Doumas, B.T. (1982). Protein (Total protein) in serum, urine and cerebrospinal fluids; Albumin in serum. In: *Selected methods of Clinical Chemistry,* 9, Paulkner, W. R. & Meites, S. (Eds.), *America Association for Clinical Chemistry*, Washington, DC.

Ravindran, V., Rajadevan, P., Goonewardene, L. A. & Rajaguru, A. S. B. (2016). Effects of feeding cassava leaf meal on the growth of rabbits. *Journal of Agricultural Wastes,* 17, 217-224.

Steel, R.G.D. & Torrie, J.H. (1980). Principles and Procedures of Statistics. A Biometric Approach. 2nd edition, McGraw Hill Book Co. Inc. New York, USA. 481pp.

Ubua, J. A., Al-Isah, W., Inuwa, I., Abdullahi, B. I. & Ozung, P. O. (2019). Utilization of neem leaf meal: effect on growth response, haematology and serum biochemistry of rabbit does. *Global Journal of Agricultural Sciences*, 18, 31 – 37.

Vasudeva, N. & Sharma, S. K. (2012). Post-coital antifertility activity of Hibiscus rosasinensis Linn roots. *Oxford Journal of Biology*, 5(1), 91 - 94.

EFFECTS OF DIETARY INCLUSION OF MISTLETOE LEAF MEAL ON PERFORMANCE AND NUTRITIONAL QUALITIES OF RABBIT MEAT

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ABSTRACT

The study evaluated the effects of dietary inclusion of mistletoe leaf meal on the performance and meat qualities of rabbit. The mistletoe was included at 0, 5, 10 and 15% levels. Twenty-four (24) New Zealand White x Chinchilla weaners rabbit were randomly assigned to the treatments with six (6) rabbits each in a Completely Randomized Design (CRD). After week seven, four rabbits were randomly picked per treatment and slaughtered for chemical analysis. Data collected were subjected to one-way ANOVA. Results showed that Ash, crude fibre, Nitrogen Free Extract, moisture, crude protein and ether extract in meat did not differ significantly ($p>0.05$) while moisture and crude protein contents were significant ($p<0.05$). Ether Extract was significantly ($p<0.05$) higher in control. The final weight, average weekly weight gain and average weekly feed intake were significantly ($p<0.05$) influenced by dietary treatments while feed efficiency and dressing percentage was not different ($p>0.05$). Internal organs were not affected by the dietary treatments ($p>0.05$). It can be concluded that up to 15% mistletoe leaf meal in the diets did not have adverse effect on the performance and meat qualities of the rabbit. Mistletoe leaf meal could be included (15%) in rabbit diet during scarcity of forage.

Key words: Mistletoe leaf meal, performance and nutritional qualities, rabbit meat.

Introduction

In Nigeria, livestock production has gained popularity from macro to micro livestock production as potential sources of animal proteins and provision of by-products. Rabbits' production has shown to be cheap, based on the cost of production, prolificacy and their ability to transform proteinous forages not competed for by human into animal protein and they can be produce on sole forage or mixed feeding regimen (Fasuyi, 2005; Cardinali *et al.*, 2015; Dalle Zotte *et al.*, 2016; Ozung *et al.*, 2017).

Research works have proved a rise in the exploitation of plant materials (forages), vegetables, shrubs and tree leaves which are abound and available all the year round serving medicinal purposes, food for humans and feed stuffs for livestock (Bamikole *et al.*, 1999; Omoikhoje *et al.*, 2006; Ibekwe *et al.*, 2007). In Nigeria, among several vegetables plants, tree plants, species abound which are utilized as medicinal herbs, supplement in livestock's feeding for rabbits, poultry, snail, swine and grasscutter production, considering nutrients requirement of these farm animals (FAO, 1982; Aduku *et al.*, 1991; Taiwo *et al.*, 2004 and Akpan *et al.*, 2006).

Mistletoe is commonly called parasitic plant, shrub that grows on many tree plants (Broad leaves trees) called true mistletoe of broad-leaved trees). They are found growing and absorbing the organic food from the host through its sucking roots (Haustoria) (Becker, 1986; Berver, 1987; Gordon *et al* 2001; Umarudeen and Magaji, 2020). The word "mistletoe" was derived from the Celtic word "all-heal". The use of some as animal feed ingredients may be limited by the presence in high quantity of secondary metabolites such as oxalates, phytic acid and saponin which may act as antifeedant and could have some effects on physiological performance in animal (Ijeh *et al.*, 1996; Olawoyin, 2007; Umarudeen and Magaji, 2020). However, livestock production in Nigeria is influence by wet and dry seasons especially in feeding of farm animals. The wet season is characterized by lush pastures for forages for animal while during dry season the conventional green forages withered and may not be available due to their short cycles. During dry season some plants materials such as tree plants, forbs, shrubs usually provide supplementary feed for livestock feeding as hay, silage or in mixed feeding regime (Iso and Kennedy, 2021). Also, some are processed and use in feed formulation for livestock production.

Materials and methods: The experiment was carried out at the rabbit unit of the Teaching and Research Farm University of Calabar, Calabar, Nigeria. The leaves of mistletoe were harvested from the host trees (pears), spread and air dried for two weeks in Calabar. The proximate composition of the mistletoe leaf meal was determined using standard methods (A.O.A.C. 2000) (Table 1). The leaf meal was included to the basal diets containing 18% crude protein and 2800Kcal/kg metabolizable energy at 5, 10 and 15% levels.

Table 1: Proximate composition of mistletoe leaf meal (MLM) in the sub-humid zone

Nutrients	**Percentage (%)**
Moisture	16.85
Dry matter (%)	83.15
Crude protein (%Dm)	18.28
Crude fibre (%)	4.02
Ash. (DM)	6.03
Ether Extract (E.E)	10.20
Nitrogen free Extract (NFE)	64.88
Minerals composition (%DM)	
Calcium	0.84
Magnesium	1.90
Potassium	1.53
Copper	1.34
Sodium	0.65
Iron	1.64
Zinc	1.33
Lead	0.95
Cobalt	1.02
Phosphorus	1.21

Twenty-four (24) weaned male and female rabbits of the New Zealand White and Chinchilla crossed were assigned to experimental diets in a complete randomized design with six rabbits per treatment. Feed and water were offered *ad libitum* throughout the seven weeks.

Records of the initial, final weight, average weekly feed intake were recorded while feed efficiency was calculated as the amount of feed intake divided by weight gain. At the end of

the feeding trial, four rabbits were randomly picked from each treatment and slaughtered for carcass and chemical evaluation.

Carcass parameters measured includes: dressing percentage, dressed weight and internal organs (heart, liver, lung, kidney, spleen). Muscles of the thigh from four (4) rabbits in each treatment were obtained for analysis chemical analysis. The muscles were reduced to smaller pieces of about 16.85g with a knife, then oven dried for 24 hours at 70-80^{0}C and stored in air-tight containers at 25^{0}c for proximate analysis. Proximate composition was determined using standard method (A.O.A.C, 1990).

The mineral composition in meat samples was determined using an atomic absorption spectrophotometer (AAS) and the potassium and sodium (K and Na) was determined using flame photometer. Phosphorus was determined using vanadomolybdate (yellow) method and spectrophotometer (model – spectroUr_VIS RS spectrophotometer vu – 2500). Data collected was subjected to one way Analysis of variance (ANOVA) while significant means were separated using least significant difference (Steel and Torrie 1980).

Results and Discussion

The effects of dietary inclusion of mistletoe leaf meal on performance of rabbit are represented in table 3 and cross composition of diets is represented in Table 2.

Table 2: Composition of experimental Rabbit diets

Feedstuff	0 % (control)	5 % MLM	10 % MLM	15 % MLM
Maize	49.99	49.99	49.99	39.99
Soybean meal	31.01	31.01	31.01	31.01
Rice bran	5.00	-	-	-
Mistletoe leaf meal	-	5	10.00	15.00
Wheat offal	10.00	10.00	10.00	10.00
Bone meal	3.00	3.00	3.00	3.00
Salt	0.50	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient				
% crude protein	18.00	18.24	18.28	18.39
Metabolizable energy (Kcal/kg)	2800.00	2800.37	2820.45	2.829.93
Analysed value:				
% Crude protein	18.21	18.16	18.22	18.26
% Crude fibre	8.61	8.72	8.77	9.01
% Ether Extract	2.86	2.89	2.84	2.90

MLM: Mistletoe leaf meal

Table 3: Effect of mistletoe leaf meal (MLM) inclusion levels on Rabbits performance

Parameters	Treatment			
	0 % (control)	5 % MLM	10 % MLM	15 % MLM
Initial weight (g)	656	695	693	689
Final weight (g)	$1629^{c}\pm2.97$	$1788\pm^{b}4.10$	$1997\pm^{b}5.21$	$2231^{a}\pm6.12$
Average weekly body Weight gain	$54.30^{c}\pm2.97$	$59.60^{c}\pm3.12$	$66.57^{b}\pm5.15$	$74.38^{a}\pm5.24$
Average weekly feed Intake g/rabbit	$163.00^{b}\pm3.15$	$162.86^{b}\pm3.09$	$164.86^{b}\pm3.16$	$173.29^{a}\pm4.19$
Dressing percentage	57.00	58.06	58.12	58.29
Feed efficiency	1.10	1.40	1.20	1.30

a,b,c: Mean with different superscripts on the same row differ significantly ($P<0.05$).

The final body weight, average weekly body weight gain and average weekly feed intake were significantly ($p<0.05$) in treatment 4 (15%) followed by treatments 3 (10%), 2 (5%) and the control respectively. However, rabbit on treatment 4 (1.5%) showed significant ($p<0.05$) in performance as well as those in varied levels of inclusion. This may probably be due to the lower crude fibre of the mistletoe contribution, compared to high crude fibre of the following rabbits' favourable forages use in feeding rabbit in rabbit production; *Centrosema pubescens* (35.27%), *Ipomea batatas* (19.3%), *Lcucaema leucocephala* (27.19%) and *Tridax procumbens* (27.67%) (Aduku, 1993). However, Lukefahr (1992) reported that high crude fibre in forage could hinder effective intake of feed, although it helps in rabbit faecal impaction and contraction.

Allessandro (2008) reported that rabbit can utilize feed stuffs that are rich in fibre and lignin. There was no significant ($p>0.05$) difference in the feed efficiency, dressing percentage between treatments and the control. Rabbit on 15% mistletoe diet inclusion had the highest final body weight and weekly weight gain which were significantly ($p<0.05$) higher than values recorded in other treatments. This shows that there was a progressive improvement in intake, utilization and growth performance in the rabbits as the inclusion levels of mistletoe leaf meal increased. The range in final body weight observed in this study (Table 3) was higher than the range of 1400 – 1500g and 1150 – 1625g reported by Omoikhoje *et al.* (2006) and Abubakar *et al.* (2011) on rabbits fed forages inclusion levels. There were no significant influence of treatment groups on relative organs weights reported as percentage slaughter weight of rabbits (Table 4).

Table 4: Effect of MLM on relative organs weights (as % slaughter weight of rabbits)

Parameters	Treatment				SEM
	0 % (control)	5 % MLM	10 % MLM	15 % MLM	
Head	10.65	10.21	10.24	10.23	0.37
Liver	1.95	2.19	2.82	2.38	0.17
Kidney	0.63	0.52	0.69	0.55	0.03
Lung	0.50	0.57	0.58	0.45	0.01
Heart	0.44	0.31	0.35	0.30	0.02
Body length (cm)	30.5	35.2	36.7	35.8	4.21

The proximate composition (%) of rabbit meat among the four treatments is represented in Table 5. The moisture content of rabbit meat did not significantly differ ($p>0.05$) among treatments; but the highest value was obtained in treatment 4 (15%) rabbits fed with the highest inclusion level. Treatment 2 and 3 had moisture composition comparable to the control. The crude protein percentage values of the treatments were significantly higher than the control (Table 3). Values obtained in this study are lower than values (85.00 - 93.5g) reported by Agiang *et al.* (2009) for rabbit fed forages – concentrate. This may have been due to the utilization of the nutrients composition and digestibility of the diets, which in turn influenced the deposition of the proteins in the meat.

Significant differences ($p<0.05$) were noted among treatments for percentage ether extract (Table 5) in control with the highest values, while treatments with mistletoe leaf meal were not significantly difference ($p>0.05$). These values were higher than values reported by Agiang *et al.* (2009).

Table 5: Effect of mistletoe leaf meal on proximate composition of Rabbit meat (%)

Parameters	Treatments				SEM
	0 % (control)	5 % MLM	10 % MLM	15 % MLM	
Moisture content	70.90^{b}	70.80^{b}	68.90^{c}	72.10^{a}	0.66
Crude protein	77.00^{b}	83.12^{a}	83.75^{a}	84.00^{a}	1.67
Ether Extract	18.25^{a}	11.25^{b}	11.75^{b}	12.50^{b}	1.62
Ash	4.00	3.04	3.40	4.10	0.25
Crude fibre	0.50	0.28	0.30	0.45	0.05
Nitrogen free Extract	1.25	2.32	2.39	2.53	0.29

a,b,c: Mean with different superscripts on the same row differ significantly ($P<0.05$)

Ash, crude fibre (CF) and nitrogen Free Extract (NFE) did not significantly differ among treatments. This suggests that the rabbits were comfortable with the diet for their physiological development and performance. The calcium content of the rabbit meat showed no significant ($p>0.05$) difference among the treatments. But the lowest content was in control (Table 6).

Table 6: Effect of mistletoe leaf meal on macro-element composition (%) of rabbit meat

Parameters	Treatments				SEM
	0 % (control)	5 % MLM	10 % MLM	15 % MLM	
Calcium	0.16	0.24	0.24	0.24	0.02
Phosphorus	0.30^{b}	0.34^{b}	0.29^{c}	0.60^{a}	0.07
Sodium	0.03^{b}	0.05^{b}	0.05^{b}	0.07^{a}	0.01
Magnesium	0.38^{b}	0.34^{c}	0.34^{c}	0.48^{a}	0.03
Potassium	1.07^{c}	1.14^{b}	0.94^{c}	1.19^{a}	0.05

a,b,c: Mean with different superscripts on the same row differ significantly ($P<0.05$)

This shows that the nutrients in the diets were properly utilized and deposited for bone formulation and body development. There was no significant difference ($p>0.05$) in magnesium, potassium, phosphorus and sodium among treatments. But the contents of magnesium, potassium, and phosphorus in meat from rabbits fed 15 % MLM was high as confirmed in this study of macro-elements composition (%) of rabbit meat.

Conclusion: Generally, no adverse effect was noticed in the meat composition of Rabbits fed mistletoe leaf meal inclusion. Although the sensory properties of rabbits fed mistletoe leaf meal

were not determined, some of the rabbits left were processed oven dried and served. The report received was that the following sensory properties, tenderness, residue juiciness, colour, flavour and Aroma were met and the meat was acceptable. This shows that mistletoe leaf meal could improve on the acceptability of the rabbit meat, because the diet contributed the highest crude protein in the rabbit meat as well as the lowest crude fibre and Ash respectively. It can be concluded that the range of 15-25% mistletoe leaf meal in diet inclusion could improve the performance and meat composition of the rabbit in the sub-humid zone during forage scarcity during dry season.

REFERENCES

Abubakar, M., Yusuf, A. U., Doma, U. D., Ibrahim, U. and Muhammed, A. S. (2011). Growth performance carcass and organ characteristic of growing rabbit fed Graded levels of *Moringa oleifera* leaf meal in diets. *Proceedings of Animal science Association of Nigeria*, pp 362-278.

Adudu, A. O. and Olukos, J. O. (1991). *Rabbit management in the tropics*. G. U. publication P.O. Box 228, Abuja.

Aduku, A. O. (1993). Tropical feed stuff Analysis Table. Department of Animal science, Faculty of Agriculture, Ahmadu Bello University, Samaru – Zaria Nigeria.

Agiang, E. A., Eneji, C. A., Iso, E. I. and Isika, M. A. (2009). Effects of mixed-feeding on physiological development and nutritional qualities of rabbit meat. *Journal of Agriculture, Biotechnology and Ecology*, 2 (1): 69-77.

Akpan, I. A., Olawoyin, O. O. and Ekpenyong, I. (2006). Growth Response of weaned Rabbits to three different leaf diet supplemented with Growers mash. *Tropical Journal of Animal Science*, 7 (1): 23-29.

Alessandro, F. (2008). Rabbit production development, new strategies to avoid the conflict between use of natural resources for food and feed. MEKARN workshop 2008. Organic rabbit production from forages pp. 1 - 6.

AOAC (1990). Association of Analytical chemistry official method of Analysis Washington DC, U.S.A.

AOAC (2000). Official methods of Analysis 16th edition. Association of Official Analytical Chemist, Washington. D.C.

Bamikole, M. A. and Ezenwa, I. (1999). Performance of rabbits on guinea grass and veranostylohays in the dry season and effect of concentrate supplementation. *Animal feed science Technology*, 80: 67 - 74.

Becker, H. (1986). Botany of European on mistletoe oncology, 43: 2-7.

Bever, B. E. P. (1987). Medicinal plants in tropical West Africa. Cambridge University press Cambridge.

Cardinali, R., Cullere, M., Dal Bosco, A., Mugnai, C., Ruggeri, S., Mattioli, S., Castellini, C., Trabalza Marinucci, M. and Dalle Zotte, A. (2015). Oregano, rosemary and vitamin E dietary supplementation in growing rabbits: Effect on growth performance, carcass traits, bone development and meat chemical composition. *Journal of Livestock Science*, 175: 83 - 89. https://doi .org/10.1016/j.livsci.2015.02.010.

Dalle Zotte, A., Celia, C. and Szendro, Zs. (2016). Herbs and spices inclusion as feedstuff or additive in growing rabbit diets and as additive in rabbit meat: a review. *Journal of Livestock Science*, 189: 82 - 90. https://doi.org/10.1016/j.livsci.2016.04.024.

FAO (1982). Food and Agricultural Organizations. Nutrient requirement of farm livestock (3). Pp. 244, F.A.O. publications division Rome Italy.

Fasuyi, A. O. (2005). Nutritional potentials of some tropical vegetables leaf meals: chemical characterization and functional properties. *African Journal Biotechnology*, 5 (1): 49 - 53.

Gordon, U., Storey, R. and Randy, M. (2001). Principles of Botany MC. Graw Hill, Inc. New York.

Ibekwe, H. A., Eteng, M. U. and Antigha, E. (2001). Proximate and phytochemical composition of *Garcinia kola* and *Veronica amygdalina*. *Proceedings of the 32nd Annual conference of the Nigeria Society for Animal production* (E.A. Agiang, L.N. Agwunobi and O. O. Olawoyin (Eds). March 18-21, Calabar. pp. 255-258.

Ijeh, I. I., Nwaugo, V. O. and Obiadua, O. (1996). Comparative study on the nutritive, phytochemical and antimicrobial properties of two varieties of *Vernomia amygaline* plant products. *Research communication*, 1:71-35.

Iso, I. E. and Kennedy, O. O. O. (2021). Growth performance, carcass and meat quality of rabbits fed mistletoe leaf meal diet. *Journal of Livestock Science*, (ISSN online 2277 - 6214) 12: 220 – 228.

Lukefar, S. D. (1992). The rabbit project manual a heifer project international, Little Rock U.S.A.

Olawoyin, O. O. and Iso. I. E. (2007). Performance indices of rabbits fed *Vernonia amygdalina* leaf meal. Supplement. *Tropical journal of animal science*, 10 (1-2): 377 - 382.

Omoikhoje, S. O., Bamgbose, A. M., Aruna, M. B. and Animashaun, R. A. (2996). Response of weaner rabbits to concentrate supplement with varying levels of syndrellamodiflora-forage. *Pakistan journal of Nutrition*, 5 (6): 577 - 579.

Ozung, P. O., Kennedy, Oko. O. O., Agiang, E. A., Eburu, P. O., Evans, E. I. and Ewa, C. E. (2017). Growth performance and apparent nutrient digestibility coefficients of weaned rabbits fed diets containing different forms of cocoa pod husk meal. *Agriculture and Food Science Research*, 4 (1): 8-19.

Steel, R. G. D. and Torrie, J. H. (1980). Principles and procedures of statistics A Biometrical approach. 2nd edition. MC. Graw-Hill Book company.

Taiwo, A. A., Olupona, J. A., Fapohundo, B. and Adebowale, E. A. (2004). Comparative study of the effect of *Tridox procumbens* and *Tithonia diversifolia* supplanted with concentrate on the performance of weaned rabbits. *Proceedings of 9th Annual conference of Animal Science Association of Nigeria (ASAN)* 74-78.

Umarudeen, A. M. and Magaji, M. G. (2020). Anxiolytic Mechanisms and Corticosterone-Attenuating effect of hydro-alcoholic leaf extract of Tapinanthus globiferus mistletoe growing on Azadirachta indica tree. *Journal of Complementary and Alternative Medicine Reseasrch*, 10 (1): 14 - 23. https://doi.org/10.9734/jocamr/2020/v10i130153.

THE INFLUENCE OF ENVIRONMENTAL ENRICHMENT ON THE WELFARE AND BLOOD PROFILE OF BROILER CHICKENS

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ABSTRACT

The study evaluated the impact of environmental enrichments on the welfare, and blood profile of broiler chicken. The study was carried out with a total of 120 unsexed broiler chicks randomly assigned to four treatments. Each treatment was further replicated three times and each treatment contained 10 broiler chicks. T1 was the control with no environmental enrichment. T2 was enriched with Talinum triangulare (Water leaf), coloured balls were used as enrichments for T3 while Perches (plastic crates) were used as enrichments for T4. The results on the welfare of the broiler chickens indicated that birds in treatments 1 and 2 had mild lesions on their hocks, while those in T3 had moderate lesions on both feet. Broiler chickens in T4, however, had hocks with severe scabbing and extensive lesions. The results for serum biochemistry showed that environmental enrichment only had a significant effect ($p<0.050$ on serum creatinine and albumin in the broiler chicken. These findings, therefore, suggest that environmental enrichment only had a limited effect on broiler welfare, and blood composition.

KEYWORD: Welfare, Environmental Enrichment, Serum, Haematology.

INTRODUCTION

The subject of animal welfare has a range of understanding and regulation in different parts of the world. It is perceived as an important context in some parts of the world while in some other parts of the world it is ignored especially among farmers because such farmers are concerned about profit maximization and little about animal welfare. In some countries like Canada and Australia, the welfare laws have been reviewed extensively (Frazer et al., 2018; Morton et al. 2020 respectively) and the need for welfare in these parts of the world is accompanied by aggressive awareness for such binding legislations.

Although animal welfare is a difficult concept, it is defined because of animals' physical and physiological wellbeing (Coria-Avila et al., 2022). In farm animals, three broad bases for assessing animal welfare have been established. These include the normality of the animals' biological functioning, natural behaviour, and affective state. Coria-Avila et al. (2022), also outlines that an animal is only of good welfare when they are free from hunger, thirst, and malnutrition, free from discomfort, free from pain, injury, and diseases, free to express their natural behavioral repertoire, and free from fearful and distressful events.

Achieving these freedoms therefore has been the most concern of animal welfare studies. Specifically, in broilers' studies laws about animal welfare has been enacted in many European countries for the protection of broiler chicken especially regarding management practices with particular focus on stocking density, light regimen and air quality, training and guidance for people dealing with chickens, as well as monitoring plans for holding and slaughterhouse (Meluzzi and Siriri, 2009). Most of these efforts tackle freedom from hunger, distress, disease, pain and discomfort but not necessarily the freedom to express natural behaviours.

Among the so many approaches that have so far been studied, environmental enrichment stands out as a technique for improving the expression of broilers' natural behaviours. Environmental enrichment (EE) is defined by several authors in different ways. Belz et al. (2003) defined it as using various objects to improve quality of life and normal behaviour expression of animals which are kept in cages or in a limited space. It was also defined as addition of biologically relevant stimuli to animals' environment to encourage natural behaviours (Leone & Estevez, 2008). Furthermore, Newberry (1995) defined it as an improvement in the biological functioning of captive animals resulting from modifications to their environment.

When environmental enrichment is provided, animals are given a level of complexity that allows them to make decisions that improve their quality of life (Newberry, 1995). These advantages are especially pertinent to contemporary commercial systems for housing chickens as it translates into productivity and weight gain. Previous studies (Yildirim and Taskin, 2017; Zahor et al., 2022) have proven that blood profile of broiler chicken can be influenced by environmental enrichment. Nutritional enrichments have also influenced the blood profile of birds when compared to treatments with no environmental enrichment (Elsayed *et al.*, 2024) but there is scarcity of such studies in Nigeria. Accordingly, the objective of this study was to evaluate the impact of environmental enrichment on the overall behaviou/r, welfare and blood profile of broiler chickens in Uyo, Akwa Ibom State.

MATERIALS AND METHODS

Experimental Site

The research was conducted at the Poultry Unit of the Teaching and Research Farm in the Annex Campus of the University of Uyo, Akwa Ibom State, Nigeria. Uyo is located within the tropical rainforest zone of Nigeria. The average yearly rainfall in this area is between 2200 and 3500 mm. Uyo is situated between latitudes 4031 and 6030 north and longitudes 7030 and 8020 east of the equator. The area's temperature ranges from 26°C to 28°C. The average height above sea level is 38.1 meters. There are 1400–1500 hours of sunshine and 71%–80% relative humidity on a yearly basis (University of Uyo Meteorological Station, 2014).

Experimental Birds/ Design

This experiment was conducted with a total of one hundred and twenty nn(120) unsexed day-old Ross 308 broiler chicks. The study adopted a Completely Randomized Design (CRD) experimental design. The study comprised four treatments (T1-T4) and birds were randomly assigned to each treatment. Each treatment was replicated three times with each replicate containing 10 birds each (i.e 30 birds per treatment). T1 was the control with no environmental

enrichment. T2 was enriched with *Talinum triangulare* (Water leaf), coloured balls were used as enrichments for T3 while Perches (plastic crates) were used as enrichments for T4. In T2, the water leaves were tied with a rope and suspended in a way that the birds were able to reach them but not too low to touch the floor.They were replaced every day. Upward adjustments of the water leaf rope were made as the birds grew. In T3, 7 balls of different colours were kept in each replicate. The crates were positioned at the corner of the pen in each replicate in T4.

Management of Experimental Birds

The brooding pen and the rearing pen were thoroughly swept, washed, and disinfected before the arrival of the birds and wood shaving was used as the litter material on arrival, the initial weight of the birds was taken, and the average weight was derived by dividing the total weight by the number of birds. The birds were vaccinated according to the veterinary prescription and other preventive/curative drugs were administered as the needs arose. The birds were fed with commercial starter pellets from day 1-28 and commercial finisher pellets were introduced from day 29 until the end of the study. Feed and water were offered *ad libitum* throughout the experimental period which lasted for seven weeks (49 days).

Data Collection

1. **Gait score**

Data was collected during the last 3 days before termination. Five (5) random birds were selected from each replicate. The birds were kept on the poultry farm parthway and allowed to work from one end to another. The scoring of individual broilers took between 30 seconds and 2 minutes, and birds that did not walk away within 2 min were encouraged to walk by a person walking slowly behind them.

Birds were assessed for lameness using the six-point gait scoring system (Kestin, *et al.*, 2001). Birds with normal walking ability received a score of 0, birds with slight defects that were difficult to define received a score of 1, birds with defined defects that did not hinder their movement received a score of 2, birds with obvious gait abnormalities that affected their ability to move received a score of 3, birds with severe gait defects received a score of 4, and birds with complete lameness received a score of 5.

2. **Footpad dermatitis**

Five (5) randomly selected birds from each replicate had their footpad dermatitis assessed. For footpad dermatitis, both the left and right footpads were inspected, and grading was done at the slaughterhouse using palpation and visual inspection (McWard, *et al.* 2000). Birds with no lesions received a score of 0, while those with small lesions (less than 25% of the footpads) received a score of 1. Birds with moderate lesions (more than 25% but less than 50% of the footpads) on one or both feet received a score of 2, and those with extensive lesions (more than 50% of the footpads) on one or both feet received a score of 3.

3. **Hock burns**

A four-point scoring system was used for scoring the hock lesions. The scores for the hocks were as follows: 0 for the hocks without lesions, 1for the hocks with mild lesions, 2 when there

were moderate lesions on one or both hocks, and 3 for the shocks with severe scabbing and extensive lesions.

4. Blood Sample Collection

At seven weeks old, twelve (12) birds were selected at random, one picked per replicate of all 4 treatments. Blood samples were collected using a 10ml syringe via jugular into the laboratory test tubes. EDTA was used as anticoagulant for samples to be used for the analysis of the haematological parameters.

RESULTS AND DISCUSSION

1. Effect of environmental enrichment on the welfare of broiler chickens

The result of the effect of environmental enrichment on the welfare of the broiler chickens is present in Table 1. The results on the welfare of the broiler chickens indicate that birds in treatments 1 and 2 had mild lesions on their hocks, while those in T3 had moderate lesions on both feet. Broiler chickens in T4, however, had hocks with severe scabbing and extensive lesions. From the results on the table, broiler chickens in T1 and T3 had 25% but less than 50%-foot dermatitis, while T3 had small lesions with less than 25% of the footpad. Broiler chicken in the T4 group had more than 50%-foot dermatitis. The gait score showed that broiler chickens in T1 and T2 had normal walking ability, those in T3 had defunded defects that did not hinder their movements. Broiler birds in T3, however, had obvious gait abnormalities that affected their ability to move.

Recent research has reported positive effects of increased locomotion on the skeletal development of legs (Ruiz-Feria, 2013; Reiter *et al.*, 2009) which may improve animal welfare indicators. Locomotion can be increased through environmental enrichment using resources such as straw bales and platforms (O da Silva *et al.*, 2021). However, there are not such studies on the environmental enrichment on broiler gait and as such the poor gait observed in the treatment 4 broilers could be as a result of hock lesion and foot dermatitis recorded however, the treatment may not be traced to the hock and foot pad conditions. The litter quality may be a better explanation for these physical conditions.

Locomotion is an overly critical aspect of animal welfare assessment and their presence in any herd is often used as a marker. According to Garcia *et al.* (2012), many behavioural patterns depend on locomotion, such as exploring the environment, seeking food, water, and shelter, and escaping predators etc. However, easy access to resources such as water, food, and shelter, associated with monotonous environments, high body weight, and high stocking density, interfere in walking ability and reduce the exploratory behaviour and their well-being negatively (Dawkins *et al.*, 2004; Almeida *et al.*, 2010). Poor locomotion/evidence of lameness can be associated with several factors such as overweight, footpad dermatitis and suitability of the litter material. These causes also come with other challenges for instance, footpad dermatitis may lead to secondary infections and cause partial carcass condemnation and significant economic losses as chicken feet command high prices in the foreign market (Almeida *et al.*, 2010; Naas *et al.*, 2009).

Table 1: Effect of environmental enrichment on the welfare of broiler chickens

Parameter	T1	T2	T3	T4	SEM
Hock lesion	1	1	2	3	0.26
Foot dermatitis	2	1	2	3	0.19
Gait score	0	0	2	3	0.44

2. Effect of environmental enrichment on serum biochemistry in broiler chicken

The result on the effect of environmental enrichment on serum biochemistry of broiler chickens is presented in Table 2. The result showed that environmental enrichment significantly ($p<0.05$) affected the serum creatinine and albumin positively. Creatinine concentration of the control (32.33) was significantly higher ($p<0.05$) and different from all the treatment (25.00, 24.66, and 24.33). While creatinine concentration in the blood is known to increase with protein intake (Iyayi and Tewe, 1998), it has also been associated with increased protein catabolism during stress (Chikumba et al., 2013). When animals are enclosed in an environment where they have limited expression of natural behaviour, they may tend to spend more time feeding and this results in overfeeding and may explain the increase in creatinine concentration of the control birds.

Albumin concentration of the treatment birds was also found to be significantly improved ($p<0.05$) in T3 (28.00). While T4 (26.33), and T2 (24.67) were also higher than the T1 (22.33), the differences observed were not significant ($p>0.05$). The main functions of albumin as stated by Melilo (2013), are the transport of several molecules and the maintenance of blood osmotic pressure thus implying a healthier condition for the broiler chickens and this further explains the ability of environment enrichment to improve broiler's welfare. However, these were the only parameters influenced by environmental enrichment.

Table 2: Effect of environmental enrichment on serum biochemistry of broiler chicken

Parameter	T1	T2	T3	T4	SEM
AST	69.33	72.00	76.67	63.67	9.83
ALT	15.00	9.67	17.33	13.00	2.97
Cholesterol	2.27	2.10	2.60	2.43	0.26
Creatinine	32.33^{a}	25.00^{b}	24.67^{b}	24.33^{b}	2.24
Albumin	22.33^{b}	24.67^{ab}	28.00^{a}	26.33^{ab}	1.55
ALP	17.67	18.00	25.00	19.33	2.64
Total Protein	49.67	44.33	48.00	46.67	2.16

AST – Aspartate aminotransferase, ALT – Alanine aminotransferase, ALP – Alkaline phosphatase, SEM- Standard error of mean. Means with different superscripts are significantly different ($p<0.05$).

3. Effect of environmental enrichment on haematological profile of broiler chicken

The haematological profile of environmentally enriched broiler chicken is presented in Table 3. Environmental enrichment only had a significant effect ($p<0.05$) on the platelet concentration of the broiler chickens. As seen in the table, the effect was not consistent in all the applied environmental enrichment provided. However, the highest platelet count was recorded in the groups that were provided with perches while the lowest was found among the broilers that had balls of different colours. This findings from this study regarding haematology is consistent with Elsayed *et al.* (2024) who observed that the use of various environmental enrichment regimes did not affect the values of hemoglobin, red blood cell count, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration.

Platelet

Table 4.3: Effect of environmental enrichment on haematological profile of broiler chicken

Parameter	T1	T2	T3	T4	SEM
Haemoglobin	11.53	11.93	11.97	8.70	1-31
Red Blood Cells	2.23	2.33	2.33	1.67	0.26
White Blood Cells	125.93	129.57	126.93	91.43	15.94
MCV	131-33	128-67	136.67	130.67	2-33
MCH	51-33	50.67	52.00	51.67	1.04
MCHC	38.67	39.00	39.00	40.00	0.60
PLT	28.33^{ab}	26.00^{ab}	33.00^{a}	17.33^{b}	3.86

MCV: Mean cell volume, MCH: Mean cell haemoglobin, MCHC: Mean cell haemoglobin concentration. SEM- Standard Error of Means. Means with different superscripts are significantly different ($p<0.05$)

CONCLUSION

The findings of this study revealed that environmental enrichment's effect on welfare is inconsistent while exerting a limited effect on the blood chemical composition of broilers. As such the studied enrichments cannot be associated with improvement of broiler chickens.

RECOMMENDATION

Due to the findings from this study, it is recommended that some more studies can be carried out to confirm the inconsistencies and other studies can focus on the impact on stereotypic behaviour of broilers such as cannibalism.

REFERENCES

Almeida, Paz ICL, Garcia R. G., Bernardi, R, Na ¨a ¨s IA, Caldara FR, Freitas LW. (2010).Selecting appropriate bedding to reduce locomotion problems in broilers. Brazilian Journal Poultry Science. 12: 189–195.

Belz, E. E., Kennell, J. S., Czambel, R. K., Rubin, R. T., & Rhodes, M. E. (2003). Environmental enrichment lowers stress-responsive hormones in singly housed male and female rats. Pharmacology Biochemistry and Behavior, 76(3-4), 481-486.

Coria-Avila, G. A., Pfaus, J. G., Orihuela, A., Domínguez-Oliva, A., José-Pérez, N., Hernández, L. A., & Mota-Rojas, D. (2022). The neurobiology of behavior and its applicability for animal welfare: A review. Animals, 12(7), 928.

Dawkins MS, Donnelly CA, Jones TA (2004). Chicken welfare is influenced more by housing conditions than by stocking density. Nature. 427: 342–344.

Elsayed, Rana A.; Mohammed, Asmaa S.; Abou-Elnaga, Ahmed F.; Abou-Ismail, Usama A.; Darwish, Ragab A.; and Fouda, Mohammed M. (2024). Effects of different types of environmental enrichment on behaviour, performance, welfare, carcass characteristics and lipid profile of broiler chickens,"Mansoura Veterinary Medical Journal: 25(1):

Fraser, D., Koralesky, K. E., & Urton, G. (2018). Toward a harmonized approach to animal welfare law in Canada. The Canadian Veterinary Journal, 59(3), 293.

Garcia RG, Almeida Paz ICL, Caldara FR, Na ¨a ¨s IA, Pereira DF, Ferreira VMOS (2012). Selecting the most adequate bedding material for broiler production in Brazil. Brazilian Journal of Poultry Science 14: 121–127.

Kestin, S. C., S. Gordon, G. Su, and P. Sorensen. (2001). Relationship in broiler chickens between lameness, liveweight, growth rate and age. Veterinary Research. 148:195–197.

Leone, E. H., & Estévez, I. (2008). Economic and welfare benefits of environmental enrichment for broiler breeders. Poultry Science, 87(1), 14-21.

McWard, G. W., Taylor, D. R. (2000). Acidified clay litter amendment. Journal of Applied Poultry Research. 9:51829.

Melillo, A. (2013). Applications of serum protein electrophoresis in exotic pet medicine. The veterinary clinics of North America. Exotic animal practice, 16(1), 211.

Meluzzi A., Sirri F., 2009. Welfare of broiler chickens. Ital. J. Anim. Sci. 8, 161–173.

Morton, R., Hebart, M. L., & Whittaker, A. L. (2020). Explaining the gap between the ambitious goals and practical reality of animal welfare law enforcement: A review of the enforcement gap in Australia. Animals, 10(3), 482.

Naas IA, Almeida Paz ICL, Baracho MS, Menezes AG, Bueno LGF, Almeida ICL, (2009). Impact of lameness on broiler well-being. Journal of Applied Poultry Research; 18: 432–439.

Newberry, R. C. (1995). Environmental enrichment: Increasing the biological relevance of captive environments. Applied Animal Behaviour Science, 44(2-4), 229-243.

Reiter K, Bessei W. (2009). Effect of locomotor activity on leg disorder in fattening chicken. Berl Munch TierarztlWochenschr ; 122: 264–270.

Ruiz-Feria CA, Arroyo-Villegas JJ, Pro-Martinez A, BautistaOrtegaJ, Cortes-CuevasA, Narciso-GaytanC,(2014). Effectsof distance and barriers between esources on bone and tendon strength and productive performance of broiler chickens. PoultryScience; 93:1608e17

Webster, A. J., Main, D. C. and H. R Whay. (2004). Welfare assessment: indices from clinical observation. Animal Welfare Journal. 13:93– 98.

Yildirim, M., & Taskin, A. (2017). The effects of environmental enrichment on some physiological and behavioral parameters of broiler chicks. Revista Brasileira de Ciência Avícola, 19(2), 355-362.

Zahoor, M. S., Ahmad, S., Usman, M., Dawood, M., El-Sabrout, K., Hashmi, S. G. M. D., ... & Latif, H. R. A. (2022). Effects of mirror and coloured balls as environmental enrichment tools on performance, welfare and meat quality traits of commercial broiler. Tropical Animal Health and Production, 54(2), 151.

RESPONSE OF BROILER CHICKENS TO BLOOD MEAL - SANDBOX SEED MEAL MIXTURE AS REPLACEMENT FOR SOYA BEAN MEAL.

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Abstract

The effect of feeding varying dietary levels of blood meal sandbox seed meal mixture in place of soyabean meal in broiler chicken diets was investigated. One-hundred-and-fifty-day old broiler chicks were randomly allotted to five experimental diets at 10 birds per replicate. Soya bean meal was replaced with blood meal-sandbox seed meal mixture at 0,25,50,75 and 100% to represent Treatments 1,2,3,4 and 5 respectively. Feed and water were supplied ad-libitum throughout the 4 weeks starter and 4 weeks finisher phases. Birds fed control and 25% level of replacement of soya bean meal with blood meal-sandbox mixture (BMSBM) had similar (P>0.05) intake values that were significantly (P<0.05) lower than other levels of BMSBN. The feed cost/Kg. feed cost/bird and feed cost/kg weight gain(N) also decreased as the level of BNSBM increased in the diets. The final liveweight, average weight gains and feed efficiency were not significantly (p>.0.05) by the dietary treatment. The revenue per bird and the cost differential increased significantly as the level of BMSBM increased in the diets. It could be concluded that replacement of soya bean meal with BMSBN could give maximum economic returns in broiler bird production.

Keywords: Sandbox seed meal, soya bean meal, blood meal, broiler chickens

Introduction

Broiler production is one of the fastest means of providing animal protein in Nigeria and other developing countries, due to its rapid weight gain, short generation interval and efficient feed utilization (Nsa and Archibong 2019). However, the production of broiler birds being hampered by scarcity and exorbitant cost of conventional energy and protein ingredients like maize, sorghum, soya beans and groundnut cake (Ukoha *et al.*, 2019).

The cost of feed alone has been estimated to account for 70-80% of the total variable cost in most livestock production, in Countries like Nigeria) Olukosi *et al.*, 2018). This situation could be curb through inward search for plants that are adapt to our environment, high yielding potentials, easy to be processed and nit been competed for by man as food and industrial raw materials.

One of such plant is *Hura crepitans*, this plant has so much agronomic and nutritive potentials yet is underutilized because of pursy information on its utilization in livestock/poultry feeds. The woody segmented fruit shape is like that of a garden egg and when dry, bursts releasing several flattened circular seeds of about 18-20mm in diameter (Keay, 2010). The dry matter content of the seed (91-95%) is quite high, a good indicator of its high storage life that is devoid of mould growth (Keay, 2010). The seeds are also rich in oil, 35-55% ether extract, moderate in crude protein,32.00-35.43% (Nsa and Archibong, 2019). The seeds are also rich in

carbohydrates and minerals, especially sodium (Na), Potassium(K), Calcium (Ca), and trace minerals like Manganese (Mn), Iron (Fe) and Zinc (Esonu *et al.*, 2014). Among the amino acids content, arginine is most dominant, followed by leucine while Lysine is the most limiting amino acids (Yaakugh, 2001).

Therefore, for optimal utilization of sand box seed meal by livestock/ poultry bird, sand box seed meal-based diets as to be supplemented by crystalline lysine or by ingredients that are rich in lysine.

One of such ingredients is blood meal. It has a crude protein level of about 80% and also very rich in lysine to a tune of about 7% (Olukosi *et al.*, 2018).

Blood meal is very cost effective, it can be collected during the slaughter of various livestock species (cattle, pigs, chicken etc.) under a wide range of condition. It is usually dried and milled into blood meal (Crawford, 2004). Typical inclusion rates are2-5% with a maximum of 10-15% in poultry diets (Crawford, 2004).

This study was carried out with a view to determining the response of broiler chickens to blood meal supplemented sandbox seed meal as replacement for soya bean meal.

Material and methods

This study was carried out at the Poultry Unit of the Teaching and Research Farm, University of Calabar, Nigeria. One hundred and fifty unsexed day-old broiler chicks of arbor arcre strain were assigned to 5 treatment groups of 30 birds each, replicated thrice with 10 birds per replicate in a completely randomized design (CRD). Five (5) diets were formulated according to requirements of broiler chickens in the tropics (Olumu, 1995) fir each phase as shown in Tables 1 and 2. In each phase blood meal supplemented sand box seed meal BSMSM (0.5kg of blood meal + 10kg of sand box seed meal) was made to replace soya bean meal at 0, 25, 50, 75 100% levels representing treatments 1,2,3,4 and 5 respectively. Birds were vaccinated against infectious bursal disease (Gumboro) and New Castle Diseases during the starter phase. Both the starter and finisher phases lasted 4 weeks each, were water and feeds were given *ad-libitum*. Feed intake and body weights were taken daily and weekly respectively. Body weight gains and feed conversion ratio were calculated on a weekly basis. The prevalent prices of feedstuffs were used in calculating the cost of feed per kg(N), feed cost per weight gain(N) and cost differentials.

The economics of production was calculated as follows.

Feed cost/weight gain = cost/Kg x Feed Conversion ratio

Feed Cost/Bird = Cost/Kg x Av. Total Feed Intake

Feed Cost/Liveweight = Feed Cost per bird / Average Live Weight

Profit Margin = Revenue/Bird – Feed Cost/Bird

Cost Differential/Kg Weight gain = Feed Cost/ Weight gain of the control group – feed cost/ weight gain of each group.

All data obtained were subjected to analysis of variance (ANOVA) and significant means among variables were separated using Duncan Multiple Range Test (Duncan, 1955).

Table 1: Gross composition of experimental starter diets

Ingredients %	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Yellow Maize	54.00	54.00	54.00	54.00	54.00
Soya Bean Meal	30.00	22.50	15.00	7.50	0.00
BSBSM	0.00	7.50	15.00	7.50	0.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
Palm Kernel Cake	4.00	4.00	4.00	4.00	4.00
Fish Meal	3.00	3.00	3.00	3.00	3.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Oyster Shell	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vit/Min. Premixes	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Composition					
% Crude Protein	23.10	23.38	23.61	23.92	24.02
ME(Kcal/Kg)	2910.22	2937.51	2961.37	2986.00	2991.05
%CF	3.41	3.46	3.50	3.56	3.66

Table 2: Gross composition of experimental Finisher diets

Ingredients %	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Yellow Maize	56.00	56.00	56.00	56.00	56.00
Soya Bean Meal	28.00	21.00	14.00	7.00	0.00
BSBSM	0.00	7.00	14.00	21.00	0.00
Wheat offal	5.00	5.00	5.00	5.00	5.00
Palm Kernel Cake	5.00	5.00	5.00	5.00	5.00
Fish Meal	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Oyster Shell	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vit/Min. Premixes	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated Composition					
% Crude Protein	19.52	19.69	19.84	19.89	19.96
ME(Kcal/Kg)	3100.10	3105.92	3110.00	3116.92	3119.22
%CF	4.01	4.09	4.17	4.36	4.66

Results and Discussion

Table 3 shows the Nutrient composition of the experimental diets which agreed with that recommended by Olumu (1995) for broiler stater and finisher broiler birds. However, the fibre and protein content of the feed tended to increase significantly (P<0.05) as the level of dietary BSBSM increased in the diets. The high fibre and protein contents of the diets could be attributed to the high content of protein in blood meal and the high content of fiber in sand box seed meal. Aduku, (2005) had earlier reported crude protein content of blood meal and soya bean meal to be 80% and 43% respectively. While the crude fiber content of soya bean meal and sand box seed meal are 4.01 and 33.05% (Nsa and Archibong, 2019: Aduku, 2005).

Table 3. Proximate Composition of the experimental diets

Proximate Composition%	T_1	T_2	T_3	T_4	T_5	SEM
Dry Matter	94.05	94.13	94.09	94.18	94.00	2.33
Crude Protein	19.82	19.91	19.98	20.00	20.15	1.09
Crude Fibre	3.11c	4.27b	4.31b	4.36a	4.38a	0.32
Ether extract	3.04d	3.18c	3.36b	3.39b	3.46a	0.12
Ash	3.66	3.68	3.69	3.70	3.75	0.41
NFE	70.37	68.96	68.66	68.55	68.26	6.56

[Abc] Means on the same row having different superscripts were significantly (P<0.05) different

Table 4 shows the response of broiler chickens to blood meal supplemented sandbox seed meal BMSBM as replacement for soya bean meal. increase in dietary BMSSM had a significant effect on the feed intake, cost/Kg feed(N), feed cost/bird, Feed Cost/ Kg Live weight(N), Revenue/ Bird(N) and Cost Differential. While the Final live weight and Average weight gain Values were not Significantly (P.0.05) affected by dietary BSBSM.

Feed intake for the control and birds fed 25% BSBSN(T2) had similar Feed intake values that were higher (P,0.05) that of other treatment diets, tended to significantly (P<0.05) decreased as the level of BSBSM increased in the diets. The significant decrease in feed intake observed in groups fed high levels of BSBSM may be due to the high energy content of the diets (Table3). Birds were able to meet their energy requirements in the control and T2(25%) groups. According to Nsa *et al.*, 2016, birds eat to meet their energy requirements and when met intake of feed is drastically reduced. More so blood meal is known to hamper feed intake due to is low palatability (Ukoha *et al.*, 2019). Sand box seed meal is known to have some anti-nutritional factors such as saponins, phytate, tannins and hemagglutinin (Yaakugh, 2001). all these toxins are known to inhibit intake (Nsa and Archibong, 2019).

They non-significant (P>0.05) effect of the dietary treatments on feed efficiency, final live weight and average weight gain as observed in the experiment shows that fortified sandbox seed meal has the same potential as soya bean in terms of growth performance of broiler chickens.

The results of the economics of production as shown in table 4 reveals the cost of feed(N/Kg) decreased (P<0.05) with increase in the of BSBSM (N 825.20-720.92), cost of feed per bird (4,134-3435), Feed Cost per Kg Weight gain (N78.44-90.34). the cost deferential was best for birds fed 75 and 100% BSBSM as replacement for soyabean meal. the above observations could be attributed to the cost difference associated with the test ingredients BSSM and soya bean meal. soya bean is presently seventy-five thousand per 100kg bag while BSBSM costs twenty-two thousand per 100Kg. more so, sand box seed meal as fortified with blood meal was able to meet the nutrient requirements of broiler chickens just like soya bean meal. this is so because blood meal is not only high in crude protein but high in lysine which meet up with the one supplied by soya bean meal.

Table 4. Effect of the experimental diets on growth and economics parameters

Parameters	T_1 (0%)	T_2 (25%)	T_3 (50%)	T_4 (75%)	T_5 (100%)	SEM
AV. Initial WT(g)	49.82	49.91	49.71	50.00	50.00	2.67
AV. Final Body WT(g)	2612.15	2631.09	2638.91	2599.00	2502.30	11.35
AV. Weight gain(g)	25.33	2581.18	2589.20	2549.00	2452.23	11.88
Av. Daily Weight gain(g)	45.76	46.09	46.24	45.52	43.79	2.51
AV. Total feed intake(g)	5010a	4990a	4851b	4800c	4765c	11.54
AV. Daily feed intake(g)	89.46a	89.11a	86.63b	85.71c	85.09c	6.39
Feed Efficiency	1.96	1.93	1.87	1.88	1.94	0.21
Cost/Kg Feed(N)	825.20^a	800.91^b	785.62^c	741.20^d	720.92^e	3.90
Feed Cost/ Bird(N)	4134.01^a	3996.33^b	3811.00	3557.76^d	3435.00^e	8.91
Feed Cost/ Kg Weight Gain(N)	90.34^a	86.70^b	82.42^c	78.16^d	78.44d	5.00
Sales/Kg Live Weight	4000.00	4000.00	4000.00	4000.00	4000.00	-
Revenue/Bird(N)	10,448	10,524	10,556	10,396	10,008	11.81
Gross Margin(N)	6314	6528	6745	6839	6573	8.55
Revenue: Feed Cost Ratio	2.53^d	2.63^c	2.77^b	2.92^a	2.91^a	0.22
Gross Margin: Feed Ratio	1.53^d	1.63^c	1.77^b	1.92^a	1.91^a	0.11
Cost Differential	-	3.64^c	7.92^b	12.18^a	11.90^a	0.21

^{Abcde} Means on the same row having different superscripts were significantly (P<0.05) different

Conclusion

The study showed that soya bean meal could totally be replaced with blood meal supplemented sand box seed meal with much economic benefits without any deleterious effect on growth performance of broiler chickens.

References

Aduku, A. O. (2005). Tropical feedstuff Analysis Tables. Inc. Notes on feedstuff Analysis Table. ABU-Samaru, Zaria, Nigeria.

Crawford, R. (2014). Effect of blood meal on broiler growth. *Journal of Animal Science*, 92(5), 2241-2248.

Duncan, D. B. (1955). Multiple Range and Multiple. F. Tests. Biometrics, 11:1-42.

Esonu, B.O, Ozenda, E., Emenalon, O. O., Nnaji, C. and Onyeikegbulum, I. K. (2014). Nutritional value of sand box (*Hura crepitans*) seed meal. *Journal of Natural Science Research* 4(23):33-44. Jachem Publishers, Benin City PP320.

Keay, R.W.J. (2010). Trees of Nigeria. *Nordic Journal of Botany*, 11:322.

Khaksefids, A. and Ghoochi, T. (2006). Effect of blood on performance and immune competence in broiler chicks. *The Journal of poultry Science*, 42:296-300.

Nsa, E. E. and Archibong, E. E. (2019). Growth Response and hematological constituents of broiler birds fed raw sand box *(Hura crepitans)* seed meal based diets. *Nigerian Journal of Animal Production* 46(1), 91-96.

Nsa, E. E., Wogar, G. S. and Akpan L. (2016). Comparative evaluation of composite cassava root meal, palm oil and cray fish waste mixture as substitute for maize in broiler chickens diets. *American Journal of Experimental Agriculture*. 11(4). 1-7.

Olomu, J. M. 1995. Monogastrics Animal Nutrition. Principle and Practice.

Olukosi, O. A., Dansun, M. N. and Ubioha, N. A. (2018). Growth performance and carcass characteristics of broilers fed blood meal-based diets; Poultry Science, 97(10), 3411-3418.

Ukoha, O. A., Nsa, E. E., Onunkwo, D. N. and Ezike, J. C. (2019). Comparative evaluation of fish, cray fish waste, meat and blood meal for broiler production. *Nigerian Journal of Animal Production*. 46(1), 71-76.

Yaakugh, I. D., Tuleun, C.D. and Kaankuja, F. G. (2001). Nutrient composition of *Hura crepitans*. *Journal of Natural Sciences*. 8(2):342-348.

ECONOMICS OF BROILER PRODUCTION IN YOLA NORTH LOCAL GOVERNMENT AREA OF ADAMAWA STATE, NIGERIA

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ABSTRACT

This study was designed to carry out an economic analysis of broiler production in Yola North Local Government Area of Adamawa State. The specific objectives were to describe the socio-economic characteristics of the broiler farmers, estimate the cost and returns associated with broiler production, determine the socio-economic factors affecting broiler production, and identify the problems faced by the broiler farmers. A census of 150 broiler farmers obtained through snowballing was used for the study. Data was collected using a structured questionnaire. The results revealed that the majority of the respondents were male (75.33%), with an average age of 37 years and an average of 12 years of education. The gross margin per production cycle was ₦337,268.37 showing that broiler production is profitable. While farming experience, education, and access to credit were found to be statistically significant at 5%, 1% and 1%, respectively and positively influenced gross margin, high feed costs negatively impact it. The major challenge identified is the high cost of feed. The study concluded that broiler production is a profitable enterprise in the area studies despite the high cost of inputs. However, more returns could be realized if the farmers have access to credit and good education. The study recommended farmers should adopt more efficient feeding practices, including proper feed storage and accurate feed measurement, to minimize wastage and lower costs. Furthermore, they should be encouraged to adhere strictly to vaccination schedule.

Key words: Broiler, Cost and return, Multiple regression, Yola North

INTRODUCTION

Broiler production provides employment and regular income within the shortest time possible due to its fast growth and shorter production cycle, however reasonable returns can be guaranteed only when produced at minimum cost of production of production because net profit is a function of gross returns and cost of production (Adeoti & Simeon, 2013). Broiler birds are those kept and reared for meat from day old to about eight weeks of age for good quality tender meat and is a good source of animal protein for human diet.

Nigeria is currently facing a serious economic problem that affects businesses and consumers wellbeing. A vibrant agricultural sector presents an opportunity to increase export revenue and contribute to economic development.

Broiler production is predominantly practiced by smallholder farmers, who rely on it as a major source of livelihood. These farmers often operate under resource constraints but have demonstrated resilience and adaptability in managing their broiler enterprises. The economic framework of broiler production encompasses various aspects including the cost of inputs, such

as feed, medication, and labor, and the revenues generated from the sale of broiler meat. Studies have shown that efficient management practices and economies of scale significantly impact the profitability of broiler production in the region (Bamiro, 2020).

Despite numerous challenges, broiler production remains a viable economic activity due to the increasing demand for broiler products driven by population growth and urbanization (Adeniji *et. al.*, 2021). Government interventions and support programs aimed at improving broiler farming practices have also played a crucial role in sustaining the industry.

Broiler production in Yola North Local Government Area of Adamawa State faces several significant challenges that hinder its economic potential and sustainability. Despite the conducive environment for broiler farming, smallholder farmers encounter numerous obstacles that affect their productivity and profitability. Fluctuating feed prices, often driven by market instability and supply chain disruptions exacerbate the financial strain on farmers making it difficult to maintain consistent production levels (Akinwumi and Odunayo, 2020). Given the high operational cost in the midst of dwindling patronage due to eroding purchasing power of consumers, it is pertinent to investigate if broiler farmers in the study area are breaking even.

In view of the foregoing therefore, this study was designed to carry out an economic analysis of broiler production in Yola North Local Government Area of Adamawa state;

The specific objectives were to:

i. describe the socio-economic characteristics of broiler farmers;
ii. estimate cost and returns of broiler production;
iii. determine the socioeconomic factors affecting gross margin; and
iv. identify the problems faced by the broiler farmers.

This study provides valuable information to policy makers to formulate policy that will encourage more people to go into broiler production.

METHODOLOGY

The Study Area

The research will be carried out in Yola north local government area of Adamawa state. The study area lies between latitude 9° 13' N to 9° 19' N of the equator and longitude 12°19' E to 12°28' E of the Greenwich meridian with a land area of 111.85km^2 (Zemba *et. al.*, 2020).

The study area is typically marked by wet and dry season. The wet season commence in April and end in October, while the dry season start in November and ends in late march. The maximum annual temperature is around 41.8^{0}C and the average minimum temperature is 21.6^{0}C, while the average rainfall is 925mm (Zemba *et. al.*, 2020). The local government area (LGA) has a projected population of 282.785 in 2023.

Yola North LGA is bounded by Yola-South to the west, south, and east; and Girei local government to the north (Figure 1). The major occupation in the area is farming and rearing of animals. The predominant tribes in the local government area are Fulani and Laka.

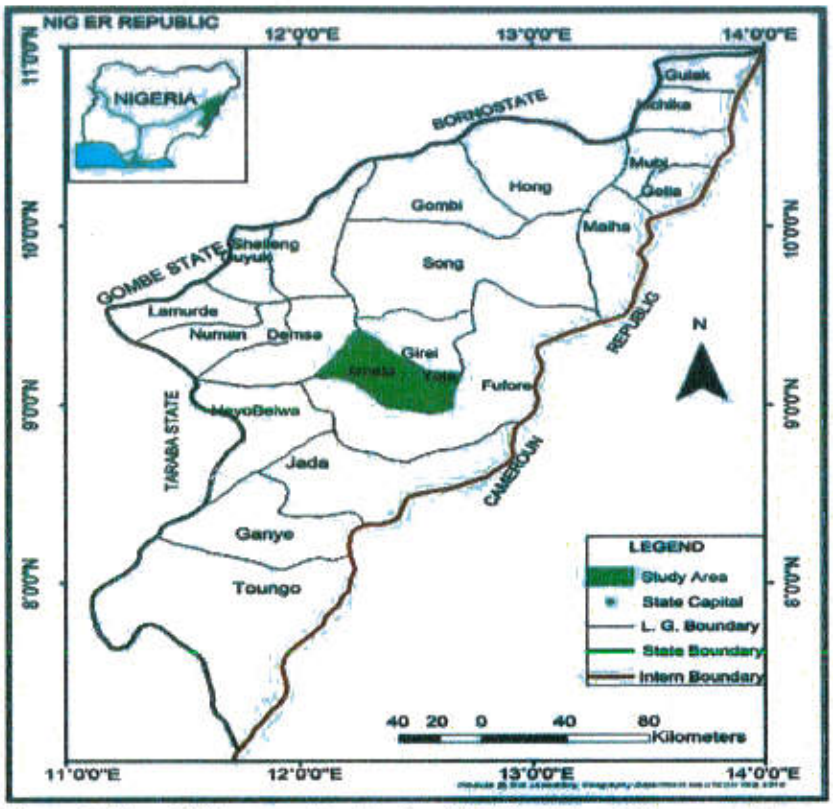

Figure 1: Map of Adamawa state showing Yola North Local Government Area

Source and methods of Data Collection

Primary data was used for this study. The data was collected with the aid of well- structured questionnaire administered to the respondents by the researcher and trained enumerators. Data was collected between May and June 2024

Sampling Techniques

A total of 155 broiler farmers were identified through snowballing sampling because no list could be obtained from the either from the Department of Agriculture and Natural Resources of the LGA or the Ministry of Agriculture. The entire list created was then used for the study. However, only 150 correctly filled questionnaires were analyzed. The remaining 5 were rejected owing to inconsistency in the responses.

Methods of Data Analysis

Descriptive statistics such as mean, percentage and frequency distribution were used to describe the socio-economic characteristics of broiler farmers (objective i) and the problems faced by the broiler farmers (objective iv).

Gross margin was used to determine the cost and returns of the broiler farmers (objective ii) in the study area. Gross margin is the difference between the total revenue and the total variable cost. The method will be calculated by equation 1

GM = TR-TVC .....(1)

Where;

GM = Gross Margin (₦)

TR = Total Revenue (₦)

TVC = Total Variable Cost (₦)

Multiple regression analysis was used to determine how socioeconomic characteristics of the respondent affect the gross margin of the broiler farmers (objective iii). The implicit form of the regression model as stated in equation 2

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, e)$ .....(2)

Where:

Y= Gross margin (Naira)

X_1 = Household Size (no of people in a household)

X_2 = Sex (Male =1, female= 0)

X_3=Age (years)

X_4 = farming experience (years)

X_5 = Access to credit (yes =1, No= 0)

X_6= Education (years spent in school)

X_7= Membership of Association (yes =1, No = 0)

X_8= Cost of feed (Naira)

e= Error term

The explicit forms of the regression model that were tried are as specified in equations (3) to (6)

i. Linear Model

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + e$ .....(3)

ii. Exponential Model

$\ln Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + e$ .....(4)

iii. Semi-log Model

$Y = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5\ln X_5 + \beta_6\ln X_6 + \beta_7\ln X_7 + \beta_8\ln X_8 + e$ ....(5)

iv. Double Log Model

$\ln Y = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5\ln X_5 + \beta_6\ln X_6 + \beta_7\ln X_7 + \beta_8\ln X_8 + e$.... (6)

Where:

β_0 is a constant term and β_1 to β_8 were estimated parameters of the variables; X_1 to X_8 are the independent variables, and e is error term.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

Table 1a above shows that the average age of the respondents is 37 years, with a standard deviation of 10.83, indicating that broiler farming in the area is primarily undertaken by middle-aged individuals. The minimum age of 17 and maximum age of 65 suggest that both younger and older individuals are involved, but the concentration around the mean age indicates that the sector may benefit from the energy and innovation typically associated with younger adults. The average years of education are 12, which is equivalent to secondary school education, suggesting that the respondents are reasonably educated. This level of education likely contributes to better decision-making and adoption of modern farming techniques, aligning with the study by Lawal et al. (2021), which found that education positively, influences the adoption of improved agricultural technologies in Nigeria.

Household size is another critical socio-economic factor, with an average of 7 people per household. A large household size can be beneficial in terms of labor availability, which is crucial in small-scale broiler production. However, it may also imply higher consumption needs, potentially placing a financial strain on households. The findings are consistent with the work of Adeoye et al. (2022), who reported that large households in rural Nigeria contribute to farm labor but also increase the dependency ratio.

The result in Table 1a further shows that the average farming experience is 3 years, indicating that most respondents are relatively new to broiler farming. This limited experience may explain

some of the challenges in optimizing production techniques, yet it also presents an opportunity for targeted training programs.

Table 1a: Socio-economic characteristics of the respondents (Quantitative)

Variable	Obs	Mean	Std. Dev	Minimum	Maximum
Age (years)	150	37	10.83	17	65
Education (years)	150	12	3.65	5	18
Household size (Number)	150	7	3.92	2	27
Farming experience (Years)	150	3	3.07	1	18

Source: Field survey 2024

Table 1b reveals that 75.33% of the respondents are male, indicating that broiler production is male-dominated in the study area. This gender disparity is common in agricultural activities across Nigeria, where men are often more involved in commercial farming than women. This aligns with the findings of Amusa et al. (2023), who noted that broiler production in Nigeria remains a male-dominated enterprise due to socio-cultural factors and resource ownership issues that limit female participation.

In terms of marital status, 49.33% of the respondents are married, while 44.67% are single. The higher percentage of married individuals suggests that broiler production may be more stable as married farmers are often more committed to long-term investment in farming activities. The results mirror those of Adeyanju et al. (2022), who found that married farmers in Kwara State were more likely to engage in broiler farming as a means of securing a stable income for their families.

A key finding from the table is that only 13.33% of respondents have access to credit, while majority (86.67%) do not. This lack of access to credit is a significant barrier to scaling up broiler production, as credit is essential for purchasing inputs such as feed and vaccines. Improving access to affordable credit would likely increase the scale and profitability of broiler production in the area.

Table 1b: Socio-economic characteristics of the respondents (Qualitative) (n=150)

Variable	Frequency	Percentage
Sex		
Female	37	24.67
Male	113	75.33
Marital status		
Single	67	44.67
Married	74	49.33
Divorced	5	3.33
Widowed	4	2.67
Access to credit		
No Access	130	86.67
Had access	20	13.33
Membership of Cooperative society		
Non member	133	88.67
Member	17	11.33

Source: Field survey 2024

Result in Table 1b also shows that 88.67% of the respondents do not belong to any cooperative societies, which limits their ability to access group benefits such as bulk input purchases, shared

knowledge, and better market access. Cooperative membership enhances farmers' access to resources and improving their bargaining power in the market.

Costs and Returns associated with Broiler Production

The result in Table 2 shows that the average return from one production cycle of broiler production enterprise was ₦ 814,992.60. The total variable cost for the same period was ₦ 477,724.30. The cost of feed accounted for about 82% of the total variable costs. This implies that feed is the highest cost component of the variable inputs used in broiler production. The gross margin was ₦ 337,268.37 suggestion a positive return to broiler production.

Table 2: Estimated Costs and Return of Broiler Production per 100 birds in a production cycle of 8 weeks

Variable	Values (₦)	%
Total Revenue (TR)	814,992.60	
Variable inputs		
Cost of feed	390,317.33	81.70
Cost of day old chicks	47,608.30	9.97
Cost of vaccine	15,432.67	3.23
Cost of litter materials	6,180.00	1.29
Cost of water	2,168.00	0.45
Cost of electricity	4,604.00	0.96
Cost of transport	1,990.67	0.42
Total Variable Cost (TVC)	477,724.30	100.00
Gross margin (GM)=TR-TVC	**337,268.37**	

Source: Field survey 2024

Socio-economic Factors Influencing Gross Margin in Broiler Production

The factors influencing gross margin of the respondents is presented in Table 3. The Cobb-Douglas function was chosen as the lead equation based on economic, statistical and econometric criteria. The R^2 was 0.416 suggesting that about 42% variation in the gross margin was explained by the independent variables included in the model. The model is generally a good fit given the significance of F-ratio ($P<0.000$). Based on the diagnostics, there was absence of problems of multicollinearity, autocorrelation, and heteroschedasticity given the values of variance inflation factor (VIF), Breusch Pagan, and Breusch Godfrey tests, respectively. From the results, four (4) out of eight (8) variables were statistically significant.

The coefficient of farm experience is positive and significant (Table 3) implies that the experience farmers has higher farm output than the less experienced farmers as they have better understanding of the production techniques that could increase their production. This entails that an increase in broiler farming experience by 1 year would also increase broiler profits by ₦ 0.26 other factors held constant. This is because broiler production experience implies more knowledge of better management regimes, resulting in an improved profit. The results agree with Esiobu *et al.*(2014) and Tuffour and Oppong (2014), who concluded that more years of business experience help farmers set cost targets and appropriate time to achieve their goals

Form Table 3, access to credit was significant ($p < 0.001$) with a coefficient of 0.45. With access to credit, farmers can potentially increase their profits by ₦ 0.45 while all other factors remain constant. This is in line with a study by Ali and Hossain (2010) on broiler production in Bangladesh, who reported a significant positive relationship between access to credit and profit levels in broiler production.

The coefficient of education significantly influences broiler profits at ($p < 0.000$) with a coefficient of 0.67 (Table 3). This means that acquiring education for farmers increases profit by ₦0.67. The results align with Phiri *et. al.* (2023), who revealed that education level significantly affect broiler production. The relationship between production and education level, could be attributed to the high need for sound knowledge and efficient management of the broiler business to ensure high output. This is also supported by Al-Fawwaz and AL-Sharafat (2013), who posits that education gives insight when farmers are trained in broiler production. This is based on the fact that an educated farmer will be knowledgeable, easy to train for managerial capacity and, as a result, will be able to manage production activities effectively and efficiently, thus increasing chances of obtaining better profits.

The coefficient of feed variable is statistically significant ($p<0.0000$) and has a negative influence on gross margin. The coefficient has a value of 0.749. This means that every one percent increase in feed cost for broiler chickens, the gross margin will be increased by 0.749 percent. This implies that if feed wastage is not reduced, broiler farmers may not be able to maximize profit.

Table 3: Socio-economics Factors Influencing Gross Margin in Broiler Production

Variables	Coefficient	Standard error	t-ratios	P > | t |
Log Household size ($LogX_1$)	0.0771043	0.1460123	0.53	0.598
Log Sex ($LogX_2$)	0.1036202	0.0693124	1.49	0.137
Log Age ($LogX_3$)	-0.3596696	0.3356031	-1.07	0.286
Log Farming Experience ($LogX_4$)	0.2636972*	0.1534495	1.72	0.088
Log Access to Credit ($LogX_5$)	0.4495062***	0.1597147	2.81	0.001
Log Education ($LogX_6$)	0.6683555***	0.2069623	3.23	0.000
Log Membership of Association ($LogX_7$)	0.0654885	0.0674832	0.97	0.334
Log Cost of Feed ($LogX_8$)	-0.7488994***	0.1056526	-7.09	0.000
Constant	1.771822	0.6107205	2.90	0.004
R^2	0.4165			
F-value	12.40***			0.0000
Mean VIF	1.50			
Ramsey RESET test	17.78			0.1572
Breusch Pagan (Chi2(1))	2.01			0.6641
Breusch-Godfrey LM test (Chi2)	0.138			0.7103

Source: Field survey 2024,
***significant at 1% and *significant at 10%

Challenges associated Broiler production in the study area

From the Table 4, the major challenge faced by the broiler farmers was high feed cost (82.00%. This is in line with the findings of Osuji (2019) who reported high cost of feed as the major constraint militating against broiler production in Imo state, Nigeria

Table 4: Challenges associated with Broiler Production

Challenges	Frequency*	Percentage
High cost of feed	123	82.00
Disease Outbreak	22	14.67
Lack of access to veterinary services	02	1,33
Poor market access	04	2.67

Source: Field survey 2024 * Multiple responses

CONCLUSION AND RECOMMENDATIONS

The study concludes that broiler production is a profitable enterprise in the study area, despite the high cost of inputs, particularly feed. To ensure the continued growth and profitability of broiler production, interventions that reduce feed costs, improve access to credit, and strengthen strict use of vaccination schedule should be pursued. Based on the findings of the study, the following recommendations are made:

1. Since feed costs represent 82% of the total variable costs, the farmers should adopt more efficient feeding practices, including proper feed storage and accurate feed measurement, to minimize wastage and lower costs. Furthermore the farmers can alternately use their own formulated feed and the conventional one.

2. Only 13.33% of respondents had access to credit, which limits the ability to expand and improve production, government should collaborate with financial institutions to offer low-interest loans specifically tailored for broiler farmers with flexible repayment plans.

3. Given that disease outbreak is one of the problems faced by broiler farmers, they should be encouraged to adhere strictly to vaccination schedule.

4. To address the issue of high feed costs, the teaching and research farm of Modibbo Adama University, Yola should as part of its community service undertake researches aimed at exploring alternative, cost-effective feed options using locally available materials. This can help reduce farmers' reliance on expensive commercial feeds.

REFERENCES

Adeniji, A., Ayodele, O.,& Olawuyi, J. (2021). Challenges and Prospects of Broiler Farming in Nigeria: A Study of Broiler Production in Southwest Nigeria. *Journal of Agriculture and Rural Development,* 9(1), 89-102.

Adeoti, A. and Simeon, O. (2013) Economic Analysis of Raising Different Broiler Strains. *Asian Journal of broiler Science* 7 (2) 75-82

Adeoye, O. J., Akinola, A. A., and Folorunso, T. J. (2022). Household size and labor availability in smallholder farming systems: Implications for food security in Nigeria. *Journal of Agricultural Extension and Rural Development,* 14(3),104-112

Adeyanju, O. A., Adeyemi, O. O.,and Ogunbiyi, M. A. (2022). Socio-economic characteristics and profitability of broiler production in Kwara State, Nigeria. *Agricultural Economics Research Review*, 35(2), 240-254.

Akinwumi, J. A., & Odunayo, M. E. (2020). Economic Challenges in Broiler Farming: A Study of Feed Cost Implications in Nigeria. *Journal of Agricultural Economics and Development,* 8(1), 45-52

Al-Fawwaz, T. M., and AL-Sharafat, A. (2013). Estimation of resource use efficiency in broiler farms: A marginal analysis approach. *Global Journal of Finance and Banking Issues*, 7:7, 1–8

Ali, M. S., and Hossain, M. M. (2010). Factors influencing the performance of farmers in broiler production ofFaridpur District in Bangladesh. *World's Broiler Science Journal*, 66, 123–131

Amusa, T. A., Ogunleye, I. O., and Olabisi, J. O. (2023). Gender disparities in broiler production in Nigeria: Socio-cultural influences and policy implications. *African Journal of Gender Studies,* 10(2), 98-108

Bamiro, O. (2020). Economic Analysis of Broiler Production in Nigeria: A Case Study of Small-Scale Broiler Farmers in Oyo State. *Agricultural Economics and Extension Research Studies*, 8(2), 123-134.

Esiobu, N. S., Onubuogu, G. C., and Okoli, V. B. (2014).Determinants of income from broiler egg production in Imo State, Nigeria: An econometric model approach. *Global Advanced Research Journal of Agricultural Science*, 3(7)

Lawal, M. O., Adewale, B. A., & Ibrahim, Y. (2021). The influence of education on the adoption of improved agricultural technologies among smallholder farmers in Nigeria. *Journal of Agricultural Education and Extension,* 27(2), 150-164

Phiri, P. T., Ruzhani, F., Madzokere, F., and Madududu, F. (2019) Factors affecting the profitability of smallholder broiler production in Mutare district, Manicaland Province, Zimbabwe: A quantile regression approach, *Cogent Economics and Finance,* 11: 2242660 1-6

Tuffour, M., & Oppong, B. A. (2014). Profit efficiency in broiler production: Evidence from greater AccraRegion of Ghana. *International Journal of Food and Agricultural Economics*, 2(1), 23–32

Zemba, A. A., Tukur, A. L. and Ezra A. (2020). Basic Geographic Information on Local Government Areas, PP 3-17 In Adamawa State in Maps (eds. A. A. Adebayo, A. L. Tukur, and A. A. Zemba, Paraclete Publishers, Yola-Nigeria.

GENETIC DIVERSITY OF RABBITS BASED ON COAT COLOUR IN SOUTH-SOUTH NIGERIA USING DISCRIMINANT FUNCTION APPROACH

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ABSTRACT

The study was to determine genetic diversity between rabbit strains (white, white-brown and black-white) monitored at three different locations - Cross River, Abia and Ebonyi states. Morpho-structural parameters measured were body weight (BW), body length (BL), ear length (EL), ear width (EW), chest circumference (CC), abdominal girth (AG), face length (FCL), foot length (FTL), tail length (TL), neck size (NS), fore limb (FL) and hind limb (HL). Statistical package for the Social Sciences (SPSS) was used for data analyses. The results revealed that coat colour had no significant (P>0.05) effect on parameters investigated. Genetic distance of rabbits based on coat colours indicated there was significant (P<0.05) difference between the coat colours of rabbits. Highest genetic distance was between white-brown and black-white coat colour (6.33), with the least observed between black-white and white coat colour (3.80) of rabbits. Two functions were used in discriminating against rabbits of the three coat colours due to n-1 (3-1 =2). Variance proportion was higher in function 1 than function 2 with values of 64.9 and 35.1 respectively. Total standardized canonical coefficients provided information on the importance and strength of each predictor and identified the most relevant traits in a population, it revealed neck size (NS) and hind limb (HL) as the most discriminant variables.

Introduction

The rabbit has been identified among animal species capable of contributing to the animal protein need of the constantly increasing human population. Studies have shown the rabbit to be highly prolific, exhibiting fast growth rate, expressing high genetic selection potential, high feed conversion efficiency and economic utilization of space (Hassan *et al.*, 2012), which makes them a viable option. Rabbit breeds are distinctively identified phenotypically by body size, shape and the coat colour (Lebas *et al.*, 1997).

Genetic diversity is essential for species to evolve. Healthy reproduction becomes increasingly difficult when genetic diversity within species is low. Genetic diversity of livestock species allows animal production to be practiced in a range of environments and with a range of different objectives. It provides the raw material for selective breeding programmes and allows livestock populations to adapt as environmental conditions change (FAO, 2015). In an attempt to exploit animal genetic resources, it is pertinent to have background knowledge of the amount of genetic variation that exists between and within the species (Dauda *et al.*, 2018). Morphometric animal selection can constitute an effective system for breed preservation and improvement (Sowande *et al., 2010*). There are several means to employ for the analysis of diversity which includes discriminant analysis (the method proposed by Anderson *et al.* (2003) or based on principal components); Measures of Dissimilarity - based on continuous,

multicategoric or binary phenotypic quantitative variables; Cluster analysis - Importance of traits by main components or the distance by Mahalanobis distance and canonical variable analysis (Smith *et al.*, 1936).

Generally, there is limited information on genetic diversity of rabbits with respect to coat colour of rabbit species commonly bred by rabbit farmers in the southern part of Nigeria. This research is designed to investigate genetic diversity (if it exists) between these rabbit species and provide adequate information from this study to enhance the productivity of rabbit producers within the study area.

Materials and methods

Study area from which rabbits were monitored and relevant data collected were Cross River State (CRS), Abia State (ABS) and Ebonyi State (EBS) all in the southern part of Nigeria.

A total of 180 rabbits were used for the study, comprising of 60 each of white, white-brown and black-white coat colours. Rabbits were managed under intensive system of management in cages with adequate spacing and ventilation. Hygienic conditions were observed on the various farms. Rabbits were raised on forage and concentrate. A top loader scale of 20kg capacity was used in obtaining the weights of the rabbits and tailor's measuring tape (cm) was used in taking linear body measurements.

Data were collected on the following parameters:
Body weight (BW): using a weighing scale in grams.
Body length (BL): from the base of the neck to where the tail begins.
Ear length (EL): from the tip of the ear to the base of the ear.
Chest circumference (CC): by placing the tape round the thoracic cavity.
Ear width (EW): placing the tape across the ear.
Abdominal girth (AG): measuring with tape around the abdominal cavity.
Neck size (NS): by measuring with tape around the neck.
Tail length (TL): from the tip of the tail to the base of the tail.
Hind limb (HL): from the beginning of the thigh to the feet
Fore limb (FL): from shoulder to foot
Face length (FCL): from the fore to the base of the mouth/ mandibular
Foot length (FTL): from the ankle to the end of the phalanges

The statistical analysis for the phenotypic traits of rabbits were obtained, the using SPSS (2011) application package to compute means (± standard error), coefficient of variation and canonical discriminant analysis. The general linear model employed is given as:

$Y_{ijkl} = \mu + \alpha_i + b_j + e_{ijkl}$

where,

Y_{ijk} = record of morphological traits of each animal

μ = overall mean

α_i = fixed effect of the i^{th} colour (i = white, white-brown and black-white)

b_j = fixed effect of the k^{th} location (k = Cross River, Abia and Ebonyi states)
e_{ijk} = random residual error associated with record of each animal.
The estimation of Mahalanobis squared distances (D^2) between different coat colours of rabbits were obtained using CANDISC procedure of SPSS 2011. Squared distance (D^2) between the different coat colours were estimated by the following relationship
D^2 (i/j) =(x_{ij}) cov-1 ($x_i - x_j$).
Where D^2 = genetic distance between populations,
I/j = the element of the i^{th} row and the j^{th} column of the inverse matrix,
x_i–x_j= mean sets of original variables
Cov = covariance of the original data set.

Results and Discussion

Mean and standard error of rabbits in the three study locations based on coat colour

Phenotypes are expressions of genetic characteristics modified by the environment. Discriminant analysis is used to determine which variable is best used for prediction of animal's phenotypic traits. It is also used to investigate how variables contribute to group separation and to what degree. Discriminant function analysis is used to determine which variable discriminate among or across natural occurring groups, it is used in separating two groups and if there are more than two groups as in this research then canonical discriminant analysis is obtained. Mean and standard error of rabbits in the three study locations based on coat colour are presented in Table 1. Across all three (3) locations there are similarities in values of morphometric traits investigated and it could be an indication that the rabbits share a common ancestry based on the data presented (Table 1) since location had no significant (P>0.05) effect on the parameters. The highest body weight (BW) of 1460.00g was recorded for white coat colour rabbits in Abia state, followed by white coat colour rabbits in Ebonyi state (1430.00g) and the least value (1260.00g) for black-white coat colour in Ebonyi state. The body length (BL) measurement of rabbits was highest (34.29±1.28cm) for white coat colour rabbits in Ebonyi state which was similar to the value of 34.27±2.93cm as reported by Setiaji *et al.* (2012), followed by 34.28±2.28cm for white coat colour rabbits in Abia state and the least value of 29.77±1.74cm for white-brown coat colour rabbits in Abia state. The results of the study are higher than reports of Hassan *et al.* (2012) and Tarek *et al.* (2017) who reported values of 25.58±0.19cm and 27.77±0.64cm, respectively for the same parameter. Abdominal girth (AG) measurement was highest for white coat colour rabbits (24.38±0.87cm) in Ebonyi state, followed by white coat colour rabbits (23.98±1.53cm) in Abia state with least measurement being (20.39±1.20cm) for white-brown coat colour rabbits in Cross River state. Hassan *et al.* (2012) reported higher AG value of 25.50±0.29cm which is relatively similar to the values obtained for white coat colour rabbits monitored in Ebonyi and Abia states. The chest circumference (CC) measurements of rabbits obtained in this study was least 20.02±0.88cm (white-brown coat colour) in Cross River state and highest for white coat colour rabbits (23.87±1.02cm) in Ebonyi state, followed by white coat colour rabbits (23.32±1.26cm) in Abia state. A similar pattern was also observed for white-brown and black-white coat colours for the three locations under evaluation. The tail length (TL) measurement of rabbits was least (8.30±0.42cm) in black-white coat colour rabbits of Ebonyi state and highest (9.21±0.21cm) for white coat colour rabbits of Abia state followed by 8.95±0.15cm for white-brown coat colour rabbits of Abia state. The neck size (NS)

measurements of rabbits was highest with the value of 15.78±0.80cm for white coat colour rabbits in Ebonyi state, followed by 15.68±1.11cm for white-brown coat colour rabbits in Ebonyi state and least value of 12.70±0.71cm for white-brown coat colour rabbits in Cross River state. The fore limb (FL) measurement of rabbits was highest (15.56±0.64cm) in white coat colour rabbits of Ebonyi state, followed by 15.44±0.82cm for white coat colour rabbits of Abia state with least of 13.41±0.43cm for white coat colour rabbits in Cross River state. Hind limb (HL) measurement was highest (26.20±0.60cm) for white coat colour rabbits in Abia state, followed by 25.31±0.83cm for white-brown coat colour rabbits in Ebonyi state and least (22.49±0.46cm) for white-brown coat colour rabbits from Cross River state.

Coefficient of variation (CV) values are presented in Table 1. Coefficient of variation (CV) has been used by researchers to describe the accuracy of their experiments (Dinardo-Miranda and Fracasso 2010 and Araújo *et al.* 2012), since it gives a general indication of the variation levels using the standard deviation as a fraction of the mean (Arnhold and Milani, 2011). Consequently, Pimentel-Gomes (1985) conducted a classification of the CVs obtained from agricultural studies, which were classified as low for values lower than 10%, moderate for values from 10 to 20%, high for values higher than 20 up to 30% and very high for values higher than 30%. The CV for BL was highest (20.42) for black-white coat colour rabbits in Cross river state and lowest (14.66) for black-white coat colour of rabbits in Cross river state. CV for BW was highest (54.44) in white coat colour rabbits in Cross river state and lowest (28.79) in white-brown in Abia state. CV for CC was highest (21.44) for black-white coat colour rabbits of Ebonyi state and lowest (12.03) in white-brown coat colour rabbits of Abia state. CV for AG was higher (28.47) in white coat colour rabbits of Cross river state and lowest (11.78) in white-brown coat colour rabbits in Abia state. CV for TL was highest (21.45) in white coat colour rabbits from Cross river state and lowest (4.90) in white-brown coat colour rabbits of Abia state. CV for FCL was highest (20.69) in black-white coat colour rabbits in Abia state and lowest (8.15) in white-brown coat colour rabbits in Abia state. CV for NS was highest (22.92) in white coat colour rabbits of Cross river state and lowest (15.45) in black-white coat colour rabbits of Cross river state.

The CV for EL, EW, FTL, FCL and HL were lower than 10% (these traits are not economic traits and need no room for improvement because farmers or purchasers of this animal will not use such trait as a measure of value), the CV for BL, CC, AG, TL, FL were at the range 10-20% suggesting that they are moderate and can be improved through selection, while BW was very high >30% which suggests that selection is effective for this trait because of wider genetic variability. Traits with high CV suggest that the traits are heterogeneous in nature, hence possessing more room for genetic improvement through selection while traits with less CV suggest that these traits are homogenous and possesses less room for improvement. Therefore, the variation that exists in the phenotypic traits of rabbits could be exploited for selection and improvement with respect to coat colour, since the characterization of local genetic resources depends on the knowledge of the variation of morphological traits, which have played a very fundamental role in classification of livestock based on size and shape (Yakubu *et al.*, 2010).

Table 1. Mean and standard error of rabbits in the three study locations based on coat colour

Parameters	Colour	Cross River			Abia			Ebonyi		
(cm)		Mean	SEM	COV	Mean	SEM	COV	Mean	SEM	COV
BL	White	31.44	1.42	16.89	34.28	2.28	19.94	34.29	1.28	14.94
	White-brown	32.01	1.61	19.48	29.77	1.74	17.49	31.67	2.09	19.84
	Black-white	32.21	1.18	14.66	30.77	1.81	20.42	32.40	2.52	17.40
CC	White	22.00	1.26	21.35	23.32	1.26	16.16	23.87	1.02	17.14
	White-brown	20.02	0.88	17.06	22.97	0.92	12.03	22.19	1.30	17.60
	Black-white	21.21	0.83	15.56	20.64	1.08	18.18	22.78	2.18	21.44
AG	White	22.92	1.74	28.47	23.98	1.53	19.16	24.38	0.87	14.21
	White-brown	20.39	1.20	22.76	23.79	0.93	11.78	22.99	1.28	16.72
	Black-white	21.79	1.05	19.23	20.85	1.18	19.62	22.30	2.11	21.19
EL	White	10.29	0.32	11.73	10.90	0.29	8.06	10.96	0.25	9.05
	White-brown	10.29	0.30	11.25	10.76	0.27	7.43	10.43	0.21	5.93
	Black-white	10.93	0.24	8.69	10.52	0.27	8.72	10.46	0.53	11.34
EW	White	5.28	0.20	14.49	5.39	0.19	10.43	5.49	0.16	11.88
	White-brown	5.28	0.13	9.42	5.54	0.18	9.92	5.24	0.32	18.29
	Black-white	5.42	0.12	9.00	5.13	0.16	1071	5.36	0.37	15.42
FTL	White	11.01	0.30	10.18	11.70	0.19	4.87	11.28	0.24	8.64
	White-brown	10.42	0.34	12.55	10.99	0.26	7.01	11.36	0.25	6.49
	Black-white	10.88	0.22	8.09	10.41	0.28	9.31	10.92	0.56	11.43
TL	White	8.75	0.50	21.45	9.21	0.21	6.90	8.48	0.21	10.11
	White-brown	8.71	0.39	17.13	8.95	0.15	4.90	8.62	0.17	5.85
	Black-white	8.36	0.28	13.24	8.74	0.34	13.58	8.30	0.42	11.40
FCL	White	11.29	0.48	15.96	10.80	0.50	13.80	11.99	0.28	9.19
	White-brown	10.99	0.28	9.84	11.13	0.30	8.15	11.18	0.44	11.76
	Black-white	11.03	0.28	10.32	10.24	0.61	20.69	11.90	0.74	13.96
NS	White	13.53	0.83	22.92	13.83	0.80	17.39	15.78	0.80	20.36
	White-brown	12.70	0.71	21.66	13.89	0.88	18.94	15.68	1.11	21.27
	Black-white	14.56	0.56	15.45	12.92	0.81	21.64	14.34	1.11	17.29
FL	White	13.41	0.56	15.69	15.44	0.82	15.83	15.56	0.64	16.56
	White-brown	13.65	0.68	19.40	14.24	0.73	15.43	15.21	0.65	12.77
	Black-white	13.89	0.56	16.15	13.82	0.43	10.81	14.80	1.42	21.40
HL	White	23.45	0.91	14.50	26.20	0.60	6.85	25.09	0.85	13.69
	White-brown	22.49	0.75	12.90	24.79	0.76	9.20	25.31	0.83	9.87
	Black-white	22.80	0.73	12.85	24.15	0.51	7.33	23.02	2.18	21.13
BW (g)	White	1180	0.17	54.44	1460	0.17	34.30	1430	0.11	29.98
	White-brown	1100	0.13	45.02	1200	0.12	28.79	1190	0.14	34.28

Black-white	1080	0.09	33.43	1100	0.15	45.66	1260	0.23	39.92

BW=body weight, BL=body length, CC=chest circumference, AG=abdominal girth, EL=ear length, EW=ear width, FCL=face length, TL= tail length, FTL=foot length, NS=neck size, FL=fore limb and HL=hind limb. CRS= Cross river state, ABS= Abia state, EBS= Ebonyi state, SEM= standard error of mean, CV= coefficient of variation

Canonical discriminant function of rabbits based on phenotypic traits

Canonical discriminant analysis is a multivariate technique that describes the relationship between two or more variable set through linear combinations that are maximally correlated and allows for discovering dominant gradients of variation among groups. The goal is to elucidate how variation among groups is maximized and variation within group is minimized and this helps in understanding genetic relatedness and diversity of rabbits in this study. The canonical discriminant function of rabbits based on phenotypic traits is shown in Table 2. Eigen values, variance proportion, canonical correlation, Wilk's lambda and Bartlett's test are presented in Table 2. Bartlett's test chi-square is presented in Table 2 with values of 53.16 and 19.56 for function 1 and function 2 at significant levels of $P<0.01$ and $P<0.05$ difference, respectively, for which provides validity for canonical discriminant analysis. The percentage of variance for function 1 (64.90) is higher than the value of function 2 (35.10) and accounts for 100% validity. The canonical correlation is also higher in function 1 with value of 0.54 and lower in function 2 with value of 0.42. The high percentage of shared variance (eigen value) for function 1 was 0.41 and function 2 was 0.22. The discriminant functions were tested with Wilk's lambda and values 0.57 and 0.81 obtained for function 1 and 2, respectively. The implication of this result is that two (2) functions were used in explaining the variations between rabbits of the three groups of coat colours (white, white-brown and black-white) due to n-1(3-1=2). On obtaining the weighing parameters for rabbits used in this study, the difference between the two functions could be attributed to the 3 groups of rabbit populations and evidence of high genetic variability among them may be environments (internal and external), knowing that this factor plays a vital role in phenotypic expressions due to genes. Function 1 creates maximum differences between the three groups while function 2 accounts for the three groups that aren't correlated with function 1. Canonical discriminant function obtained in this study could be used alongside the different economic traits in evaluating animals for management purposes. Canonical correlation measures the strength of the model and explaining variation that exists in grouping variables Gwaza *et al.*, 2015). Therefore, the second function which is lower than the first does not contribute significantly in the discrimination process.

Table 2. Canonical discriminant function of all rabbits measured

Function	Eigen value	Variance proportion	Canonical correlation	Λ	X^2	SIG
1	0.416	64.9	0.542	0.576	53.160	0.01
2	0.225	35.1	0.428	0.816	19.568	0.05

λ =wilk's lambda, $X2$ =barletts chi-square, SIG =significance

The total standardized canonical coefficient and total variance explained by each canonical variable

The total standardized canonical coefficient and total variance explained by each canonical variable is shown in Table 3. The first canonical variable (Can.1) or fisher linear discriminant function explains 64.90% of the total variation which can be considered high and the second

canonical function (Can.2) explained 35.10% of the total variation. The canonical discriminant analysis performed here helps in weighing each original trait contribution to the two canonical variables. Can.1 recorded highest for neck size (NS) 0.88, foot length (FTL) 0.78 and fore limb (FL) 0.65, while Can.2 recorded highest for hind limb (HL) 0.87, body weight (BW) 0.70 and chest circumference (CC) 0.63. Negative values demonstrated negative correlation among investigated traits as in the same way as positive correlation to reveal strength of traits. Can.2 recorded strong negative correlation for BL (-0.91) which means it is stronger inversely. This helps demonstrate their relevance in discriminating between coat colours (white, white-brown and black-white). Variables with high power of 0.30 or higher are considered to contribute significantly as discriminating variables. Given two or more groups, canonical discriminant analysis helps to determine the maximum multiple correlation called the first canonical correlation coefficient while the second canonical correlation is obtained by finding linear combination of unrelated traits with Can.1 variables. The standardized canonical discriminant coefficient provides information on the importance and strength of each predictor to the discriminant function (Meritexell *et al*., 2003). The above-mentioned traits are sufficient to be use in discerning and recognizing phenotypic variation between the populations of three coat colours of rabbits (white, white brown and black-white). Standardized canonical coefficient indicates the unique contribution of each trait in predicting group assessment. The variable defined by the first linear combination is the first canonical variable or canonical component or Fisher linear discriminant function, whose effectiveness increases in proportion to the percentage of the total variance attributed to it (Harris, 1975). The second canonical variable is obtained by defining the linear combination of the original variables, not correlated with the first canonical variable, which has the highest possible multiple correlation. These traits that loaded high in can.1 and can.2 demonstrate their relevance in separation of the three groups of rabbits.

Table 3. Total standardized canonical coefficient and total variance explained by each canonical variable

Variables	Function	
	CAN.1	CAN.2
BL	0.100	-0.919
BW	-0.494	0.709
CC	0.158	0.630
AG	-0.135	-0.340
EL	-0.361	-0.315
EW	-0.311	-0.228
FCL	0.332	0.058
TL	-0.437	-0.191
FTL	0.784	-0.146
NS	0.882	-0.102
FL	0.650	0.250
HL	-0.605	0.873

BW=body weight, BL=body length, CC=chest circumference, AG=abdominal girth, EL=ear length, BW=ear width, FCL=face length, TL=tail length, FTL=foot length, NS=neck size, FL=fore limb and HL=hind limb

Morphological variables selected by stepwise discriminant analysis to separate rabbits based on coat colour

Stepwise discriminant analysis showing Wilk's lambda, F-values, probability and tolerance statistics is as shown (Table 4). The discriminant analysis based on significant F-values showed that two steps were involved in the selection of the most discriminating values (HL and NS) that discriminate rabbits based on coat colour into their genetic groups. Tolerance is the proportion of variables difference not accounted for by other independent variables in the equation. F to remove is useful for describing what happens if a variable is removed from current model. Wilk's lambda showed that HL was the variable that discriminated against other traits with a value of 0.90 which dropped to 0.89 in NS with significant differences of $P<0.004$ (function 1) and $P<0.001$ (function 2) is presented in Table 4. This was further reaffirmed by the extraction of standardize canonical discriminant function coefficient as presented in Table 5. Only the important morphological variables that are relevant are selected while redundant variable are discarded (those that contribute less in the presence of other variables). In this research variables were selected based on Wilk lambda and F test and the result of HL (0.90) and NS (0.89) are worthy variables that are included into the discriminant function. This can only be concluded after each variable has been reviewed and evaluated to determine group separation of the three coat colours. The scale range of 0 -1 for Wilk lambda means where it is at 0 there is total discrimination and 1 means no discrimination. Smaller values of Wilk lambda indicated greater separation ability of the function $P<0.004$.

Table 4. Morphological variables selected by stepwise discriminant analysis to separate rabbit based on coat colour

Step	Variables selected	Wilk's lambda	F to remove	Tolerance	P-value
1	HL	0.908	5.979	1.000	0.004
2	NS	0.895	7.118	7.718	0.001

HL = hind limb and NS = Neck size

Standardized canonical discriminant function coefficients

Further explanation of the extraction of standardized canonical discriminant coefficients can be seen in Table 5. It shows that two functions were used to separate the two discriminating variables. Function 1 is higher in HL (1.22) while function 2 is higher in NS (0.72). These coefficients are used in calculating the discriminant score for a given case. It uses the standardized coefficient and standardized variables.

Table 5. Standardized canonical discriminant function coefficients

Variables	Function 1	Function 2
NS	-1.056	0.727
HL	1.228	0.369

HL = hind limb and NS = Neck size

Pairwise mahalanobis distance between coat colours of rabbits

Pairwise mahalanobis distance between coat colours indicates that there was significant ($P<0.05$) difference between white-brown coat colour and black-white coat colour rabbits (6.33), followed by white coat colour and white-brown coat colour rabbits (4.33) and the least which was between black-white and white coat colour rabbits (3.80) (Table 6). Pairwise mahalanobis distance is a measure of genetic divergence between species or populations within a species. Populations with many similar allele (number of alternative forms of the same gene occupying a particular position or locus) have smaller genetic distance. Genetic distance is the genetic difference (genomic difference) between breeds or populations which is measured by some numerical method (Dauda *et al.*, 2018). Genetic distance is important to determine the hybrid vigour (heterosis) expected during crossbreeding (Yunusa *et al.*, 2013). In order, to exploit animal genetic resources it is relevant to have background knowledge of the amount of genetic variation that exists between and within the species (Dauda *et al.*, 2018). The high genetic distance could be due to natural selection, artificial selection and adaptation to environmental conditions whereas the lower genetic distance could be due to genetic exchange that has taken place overtime and has reduced the genetic distance that would have theoretically described their differences. Thus, crossbreeding between white-brown coat colour rabbits and black-white coat colour rabbits may produce better heterosis because of the high genetic distance (6.33) that exits between the two colours, while the crossbreeding between white coat colour rabbits and black-white coat colour rabbits may produce less desirable heterosis due to the low genetic distance (3.80) that exists between the two coat colours with regard to traits of economic importance.

Table 6. Pairwise mahalanobis distance between coat colours of rabbit

Coat colour	White	White-brown	Black-white
White	0.000		
White-brown	4.372	0.000	
Black-white	3.802	6.327	0.000

Conclusion and recommendation

It was observed from this study that coat colour did not have significant ($P>0.05$) effect on the parameters investigated from the different study locations. Pairwise mahalanobis distance between the three coat colours was highest between white-brown and black-white coat colour rabbits (6.32) which has the advantage of being used for breeding purpose to bring about improvement of rabbit economic traits within the study locations. The white coat coloured rabbits are therefore recommended for breeding efficiency having showed superiority for a good number of traits. Overall performance from analysis has shown that there is higher genetic diversity between this rabbit specie than the others (used in the study), therefore they can be used for breeding purposes.

References

Ajayi B. A., & Oseni S.O. (2012). Morphological characterisation and principal component analysis of body dimensions in Nigerian population of adult rabbits. *World Rabbit Science Association Proceedings 10th World Rabbit Congress* Egypt, 229 – 233.

Anderson, T. W., Hoboken, N. J., & John W. (2003). *An Introduction to Multivariate Statistical Analysis,* 3rd edition, 334 – 339.

Arnhold, E., & Milani, K. F. (2011). Rank-ordering coefficients of variation for popping expansion. Acta Scientiarum. Agronomy, 33, 527-531. http://dx.doi.org/10.4025/actasciagron.v33i3.11911.

Dauda, A., Okon, B., & Ibom, L. A (2018). *Genetic diversity of Giant African Land Snails* (GALS). Proceedings of the 6th NSCB Biodiversity Conference; Uniuyo 2018, 144 -147).

Dinardo-Miranda, L. L., & Fracasso, J. V. (2009). Spatial and temporal variability of plant-parasitic nematodes population in sugarcane. *Bragantia*, 69(suppl), 39 - 52. http://dx.doi.org/10.1590/S0006-87052010000500006.

Food and Agricultural Organization (2015). Climate change and food security: Risks and responses.

Gwaza, D. S., & Igbayima, W. S. (2015). The use of morphological measurement for characterization of local chicken ecotypes populations. *Journal of Animal Production Resource*, 27:21- 26

Hassan H. E., Elamin, K. M., Yousif, I. A., Musa A. M., & Elkhairey, M. A. (2012). Evaluation of body weight and some morphometric traits at various ages in local rabbits of Sudan, *Journal of Animal Science Advances*, 2(4), 407- 415.

Lebas, F., Coudert, P., de Rochambeu, H., & Thebault, R.G. (1997). *The rabbit — Husbandry, Health and Production*. FAO Animal Production and Health Series No. 21. Food and Agriculture Organization of the United Nations, Rome.

Meritexell, R. E. A., Bredeweg, E. L., & Nagrete, O, C. (2003). A discriminant function for predicting sex in Belearic Sheawater. *Water birds*, 26(1),72-76

Pimentel-Gomes, F. (1985). Cursode estatísticaexperimental. Piracicaba: Nobel.

Setiaji, B., Sutopo k., & Kurnianto, E. (2012). Morphometric Characterization and Genetic Distance among Four Breeds of Rabbit (*Oryctolagus cuniculus*) *Journal of Animal Production*, 14 (2), 92-98.

Smith, H. F. (1936). A discriminant function for plant selection. *Annuals of Eugenics*, (7), 240-250.

Sowande, O. S., Oyewale, B. F., & Iyasere, O. S. (2010). Age and sex dependent regression models for predicting the live weight of West African goat from body measurements. *Tropical Animal Health Production*, 42, 969 – 975. DOI 10.1007/s11250-009-9515-4

Tarek, M. B., Radi, A. S., & Nermeen, S. E. (2017). Prediction of Californian rabbits body weight from their body characteristics in Egypt. *Life Science Journal*, 14, 11.

Yunusa, A. J., Salako, A. E., & Oladejo, O. E. (2013). Morphometric characterization of Nigerian indigenous sheep using multifactorial discriminant analysis. *International Journal of Biodiversity and Conservation*, 5(10), 661- 665.

COMPARATIVE ANALYSIS OF THREE FISH OIL EXTRACTION TECHNIQUES FROM VISCERA FAT OF CLARIAS GARIEPINUS AND HETEROCLARIAS

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ABSTRACT

Fish oil is a valuable nutritional resource with significant health benefits. The Catfish viscera fat constitute a significant and underutilized resource with huge potential for value addition through fish oil extraction. Fish viscera is often discarded as waste in the aquaculture industry, viscera fat are rich in lipids, including omega-3 fatty acid, offering a sustainable opportunity for fish oil production. The selection of appropriate and efficient method of oil extraction is the most critical factor in the efficient extraction of lipids. This study investigated oil extraction from the viscera fat of two fish species, Clarias gariepinus *and* Heteroclarias*, using three methods: oven-assisted, boiling-assisted, and enzyme-assisted (using papain) and compared oil yields across extraction methods in the two species. Heteroclarias had more fat content than Clarias gariepinus. Enzyme-assisted extraction yielded the highest oil percentages for both species, with C. gariepinus showing a range of 51.0% to 72.9% and Heteroclarias ranging from 53.3% to 54.2%. Oven-assisted extraction produced moderate yields, while boiling-assisted extraction had the lowest yields. Statistical analysis (ANOVA with Post-hoc analysis) confirmed the significantly higher efficiency of enzyme-assisted extraction ($P < 0.01$). Based on consistent high yields across both fish types, enzyme-assisted extraction with papain is recommended as the optimal approach for fish oil production from viscera fat.*

INTRODUCTION

Fish oil is a highly valued commodity derived from various fish species, widely known for its richness in omega-3 fatty acids, notably EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) (Mgbechidinma et al., 2023). These fatty acids have numerous health benefits to humans, ranging from cardiovascular health to improved cognitive function, making fish oil a popular nutritional supplement (Yashodhara et al., 2009). The rising demand for fish oil in recent years is due to its acknowledged importance in both animal nutrition, human nutrition and pharmacological uses (Shepherd & Jackson, 2013).

Viscera comprises 12-18% of the whole fish's body weight (Villamil et al., 2017), and occupy the highest portion of by-products from fish processing (Estiasih et al., 2021). However, Fish viscera, often discarded as waste in the aquaculture industry, constitute a reservoir of lipids, including valuable omega-3 fatty acids (Rohim et al., 2024) offering a sustainable opportunity for fish oil production. Among the diverse array of fish species, catfish, specifically *Clarias gariepinus* and its hybrid, *Heteroclarias*, have emerged as promising candidates for fish oil production (Adagha, 2024). These species exhibit remarkable attributes such as rapid growth rates, high fecundity, and adaptability to various

environmental conditions, rendering them well-suited for cultivation in aquaculture systems (Langi et al., 2024). The Catfish viscera fat constitute a significant and underutilized resource with huge potential for value addition through fish oil extraction (Mgbenka, 2014). The lipid composition and physical properties of the viscera fats, such as moisture content and tissue structure, can significantly impact the performance of extraction techniques (He et al., 2021). The differences in lipid composition and moisture content of *clarias gariepinus* and *heteroclarias* species could potentially affect the yield and quality of oil extracted using different extraction techniques (Ashley & Patience, 2020).

Studies have demonstrated the feasibility of extracting fish oil from catfish viscera fats using various techniques (Rahman et al., 2023). Oven-assisted extraction involves heating the viscera fats to facilitate lipid extraction, while boiling methods rely on thermal processing to release the oil. Enzyme-assisted extraction, on the other hand, utilizes enzymes to break down the cellular structure of the fat viscera, enhancing oil extraction efficiency (Hidayatiningtyas et al., 2020). Each method offers unique advantages in terms of efficiency, oil yield as well as the quantity of the extracted oil. Therefore, a thorough understanding of these methods is essential for tailoring extraction protocols to specific species and ensuring consistent and reliable results.

The availability of locally sourced fish oil from catfish fat viscera holds significant implications for food security and nutritional health, particularly in regions where access to marine-derived omega-3 fatty acids is limited (Crexi et al., 2010). By promoting domestic fish oil production, countries can reduce reliance on imported fish oil supplements and strengthen food sovereignty. The need for a sustainable fish oil production, underscores the importance of choosing the appropriate extraction method and fish species to maximize oil yield and quality, which can benefit the aquaculture and fish oil industries. Although a lot of research has been done on fish oil production but literature has shown that little work has been done on fish oil extraction from visceral fat. This study therefore aimed to compare oil yields across extraction methods for the two catfish species *Clarias gariepinus* and *Heteroclarias*.

METHODOLOGY

Raw Materials

Two fish species, *Clarias gariepinus* and *Heteroclarias* (a hybrid), were used for this study. Samples of *C. gariepinus* were sourced from the Institute of Oceanography fish farm, University of Calabar, which is geographically located within the historic peninsula between the Calabar River and the Great Kwa River with elevation of 41 meters above sea level. This area lies at Latitude of 04°55.9″N and longitude 08°26″E respectively with a total surface area of three hectares (3Ha). *Heteroclarias* was obtained from One-Sky fish farm in Calabar.\'\

Sample preparation

The fish was cut open and the fat around the internal organs (viscera) were collected. Visceral fat was collected as a composite from four individuals of each species, with a total weight of 5 kg. The visceral fats were washed to remove impurities, weighed, and homogenized to ensure consistency and efficient oil extraction.

Fish Oil Extraction

Three methods were used for oil extraction from the viscera fat of both species, with each method conducted in triplicate. For *Oven-Assisted Extraction*, homogenized viscera fat was spread on a stainless plate. It was then heated at a high power level (600 W, for 15 min). After
that, the plate was removed from the oven and the oil was extracted by squeezing followed by pressing manually through a cloth mesh and filtered. Extracted oil was collected, packaged in an airtight bottle

(Figure 1). The oil yield was measured as a percentage of the initial fat weight. For *Boiling-Assisted Extraction*, using liquefied petroleum gas (LPG), viscera fat was heated in a pot with water to boil for 30 minutes, ensuring uniform heating. After heating, it was allowed to cool and the oil was separated, measured, and yield calculated. Finally for the *Enzyme-Assisted Extraction* Papain enzyme obtained from unripe papaya latex was used to hydrolyze viscera fats at 50°C for 3 hours, after which the reaction was stopped by heating at 90°C.

Oil yield determination

The amount of oil from the viscera fat was calculated gravimetrically by applying the following formula.

$$\% \text{ Yield} = \frac{\text{Weight of oil obtained}}{\text{Weight of sample used}} \times 100$$

Oil yield was then measured as a percentage of viscera weight.

Data were analyzed using SPSS version, ANOVA test was used to identify significant differences in oil yield among the three extraction methods for each species, and Post-hoc analysis with Turkey HSD was done to identify pairwise mean difference in oil yield between all extraction methods with significance assessed at $p \leq 0.05$.

RESULT

Oil yield by different extraction methods

In *C. gariepinus*, oil yield varied across methods, with the enzyme-assisted extraction yielding the highest (up to 72.89%), followed by the oven-assisted (56.04%) and boiling-assisted methods (50.19%) (Table 1). Similarly, in *Heteroclarias*, the enzyme-assisted method produced the highest oil yield (up to 54.18%), while oven-assisted and boiling-assisted methods yielded lower values, with a maximum of 47.29% and 37.64%, respectively (Table 1).

One-way ANOVA indicated that there are significant differences in oil yield among the three extraction methods ($P < 0.01$) for both fish species (Tables 2 and 3). Following Post-hoc analysis with Turkey HSD each pairwise mean difference is greater than the HSD threshold of 0.57 and all p-values were < 0.01, the results showed statistically significant differences in oil yield between all extraction methods. However enzyme assisted extraction outperformed oven- assisted and boiling- assisted extractions.

Figure 1. Sample of oil extracted from Heteroclarias

Table 1. Oil production from *Clarias gariepinus* and heteroclarias viscera using three extraction methods.

Method	Replicates	Weight of fish (kg)	C.gariepinus Weight of viscera fat (g)	% Oil yield	Heteroclarias Weight of vicseca fat (g)	% Oil yield
Oven-assisted extraction	R_1	5	93.38	52.15	101.3	46.47
	R_2	5	98.53	49.93	101.5	47.29
	R_3	5	87.25	56.04	101.0	46.99
Boiling-assisted extraction	R_1	5	77.90	50.19	101.6	37.28
	R_2	5	101.98	39.69	102.0	37.62
	R_3	5	99.28	39.28	100.43	37.64
Enzyme-assisted extraction	R_1	5	74.50	72.89	100.9	53.29
	R_2	5	107.2	51.00	100.95	53.49
	R_3	5	98.53	55.11	100.23	54.18

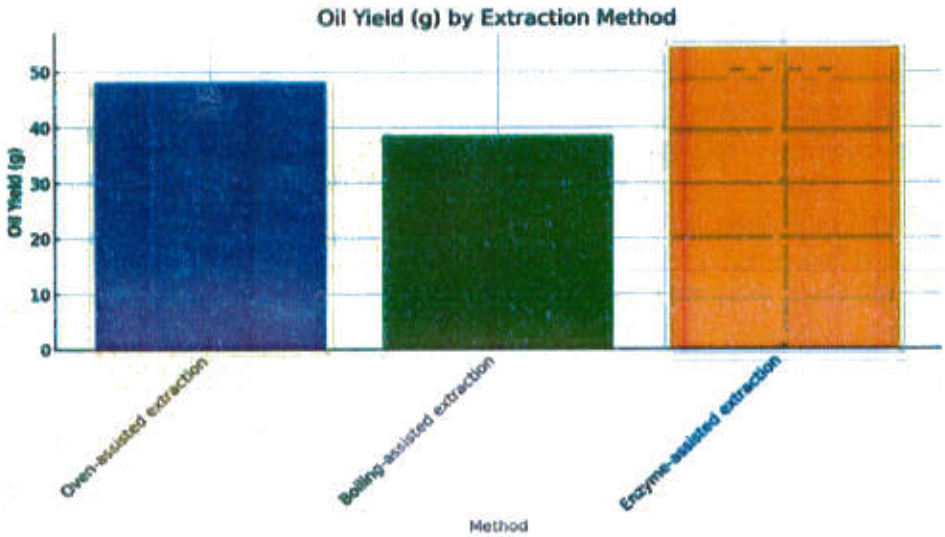

Figure 2: Bar graph showing Oil production from *Heteroclarias* viscera fat from the three extraction methods.

Table 2: One-way ANOVA evaluating the effect of three different extraction methods on oil yield from *Clarias gariepinus*.

Source of Variation	SS	df	MS	F	P-value
Between Groups	357.88	2.00	178.94	3111.96	<0.001
Within Groups	0.35	6.00	0.06		
Total	358.22	8.00			

Table 3: One-way ANOVA evaluating the effect of three different extraction methods on oil yield from Heteroclarias

Source of Variation	SS	df	MS	F	P-value
Between Groups	388.50	2.00	194.25	1575.00	<0.001
Within Groups	0.74	6.00	0.12		
Total	389.24	8.00			

DISCUSSION

This study investigated oil extraction from the viscera fat of two fish species, *Clarias gariepinus* and *Heteroclarias*, using three methods: oven-assisted, boiling-assisted, and enzyme-assisted (using papain) and oil yields was compared across extraction methods. The difference in oil yield across the three different extraction methods was statistically significant in the two species of fish. Enzyme-assisted extraction yielded the highest oil output, outperforming oven and boiling methods. Enzyme-assisted extraction consistently yielded the highest oil output in both fish species. This finding is consistent with prior research, confirming the effectiveness of enzyme-assisted extraction in breaking down lipid structures to release oil (Cheng et al., 2015; Yi et al., 2023). This method's high efficiency is due to papain's targeted enzymatic action, which facilitates lipid release without degrading temperature-sensitive compounds (Wang, 2020). Enzyme assisted extraction results in a reduction in extraction time in addition to the increased yield and quality of the product (Cheng et al., 2015). Furthermore, it is simple with no sophisticated instrument required however, the type of proteases used affects the fish oil yield (Saini et al., 2021). Other factors that affect the enzyme-assisted extraction of viscera oil include pH, time, and temperature as they influence enzyme activity. A study by Wang (2020) that compared oil extraction using different enzymes reported that the highest yield was obtained from papain-assisted extraction. The higher yield of the enzyme-assisted method, suggests that enzyme-based techniques are beneficial for maximizing oil extraction from fish viscera. The use of papain enzyme further offers many advantages as papain is readily available, cheap and is easily extracted and processed.

Oven-assisted extraction produced moderate oil yields, slightly lower than the enzyme-assisted method. Principally in this technique, the energy of a short electromagnetic wave disrupts the cell membrane and makes the oil easily leach out into the solvent (de la Fuente et al., 2022). This technique results in higher oil recovery in a shorter extraction time (Afolabi et al., 2018) The short duration of extraction is able to protect the sensitive compounds from heat degradation (Alara et al., 2018). There is paucity of data for direct comparison with the findings in the index work, however, the outcome is similar to studies that suggest that controlled heating can release oil effectively but may degrade lipid quality if the temperature is too high or the exposure is prolonged (Alara et al., 2018; Rohim et al., 2024). Low-temperature extraction of fish viscera oil has the advantage of preventing excessive peroxidation. Boiling-assisted extraction yielded the least oil across both species, highlighting its limited ability to effectively break down lipids, a finding supported by other studies indicating that high water content and direct heating can inhibit lipid release (Dave et al., 2024; Yi et al., 2023). In the boiling method, during heating, protein denaturation and coagulation will release the bound fats, and fats will be melted and released. The yield was smallest in this method across the two fish species compared to the other methods.

The fish oil raw material impacts the effectiveness of the extraction process (Yi et al., 2023). In this study, the fish species differences influenced the oil yield, with *C. gariepinus* demonstrating a higher yield across the three extraction methods particularly with enzyme-assisted extraction *despite the higher fat weight in Heteroclarias*. *Heteroclarias* is an inter-specific hybrid of *Clarias gariepinus* and *Heterobranchus bidorsalis,* the higher visceral fat weight findings on *heteroclarias* is consistent with research suggesting that hybrid species generally exhibit increased fat deposition, possibly due to enhanced growth rates and selective breeding (Adagha, 2024). However, *both fish species had a*

particularly high yield with enzyme-assisted extraction, indicating that both species are viable for oil production, especially when enzyme methods are used.

CONCLUSION

These findings highlight the efficiency and importance of Enzyme assisted extraction in fish visceral oil extraction. Oven-assisted extraction is also noted as an alternative technique of extraction to the conventional methods, while boiling-assisted method offered the least yield. Despite the higher fat weigh of *Heteroclarias,* the oil yield was found to give a lower oil yield than the visceral fat of *Clarias gariepinus*. This study underscores the importance of choosing the appropriate extraction method and fish species to maximize oil yield and quality, which can benefit the aquaculture and fish oil industries. By promoting domestic fish oil production from viscera fat, Nigeria can reduce reliance on imported fish oil supplements and strengthen food sovereignty. The findings from this study support the development of sustainable fish oil production practices, which are essential for meeting increasing demand and promoting public health. Future research should explore optimizing extraction parameter such as temperature, time and enzyme concentrations and combining enzyme-assisted techniques with mild heating to further enhance yield and efficiency.

RECOMMENDATIONS

We recommend that both *C. gariepinus* and *heteroclarias* are viable for oil production having demonstrated a particularly high yield with enzyme-assisted extraction. Based on consistent high yields across both fish types, enzyme-assisted extraction with papain is recommended as the optimal approach for fish oil production from viscera fat. Oven-assisted extraction is also noted as an alternative technique of extraction to the conventional methods.

REFERENCES

Adagha, O. (2024). Assessment of Growth and Nutrient utilization in Clarias gariepinus x Heterobranchus bidorsalis hybrid (Heteroclarias) fingerlings- fed Leuceana leucocephala (Lam . de Wit) seed Meal. *Dutse Journal of Pure and Applied sciences* 10(3b), 138–145.

Afolabi, H. K., Mudalip, S. K. A., & Alara, O. R. (2018). Microwave-assisted extraction and characterization of fatty acid from eel fish (Monopterus albus). *Beni-Suef University Journal of Basic and Applied Sciences*, *7*(4), 465–470.

Alara, O., Abdurahman, N., & Olalere, O. (2018). Optimization of microwave-as- sisted extraction of flavonoids and antioxidans from Vernonia amygdalina leaf using response surface methodology. *Food Bioprod. Process.*, *107*, 36–48.

Cheng, X., Bi, L., Zhao, Z., & Chen, Y. (2015). Advances in Enzyme Assisted Extraction of Natural Products. *3rd International Conference on Material, Mechanical and Manufacturing Engineering (IC3ME 2015)*, 371–375. https://doi.org/10.2991/ic3me-15.2015.72

Crexi, V. T., Monte, M. L., Soares, L. A. de S., & Pinto, L. A. A. (2010). Production and refinement of oil from carp (Cyprinus carpio) viscera. *Food Chemistry*, *119*(3), 945–950.

Dave, J., Kumar, N., Upadhyay, A., Purba, D. T., Kudre, T., Nukthamna, P., Sa-Nguanpuag, S., Ali, A. M. M., & Bavisetty, S. C. B. (2024). Sustainable fish oil extraction from catfish visceral biomass: A comparative study between high-shear homogenization and high-frequency ultrasound on wet rendering process. *Foods and Raw Materials*, *13*(1), 94–106.

de la Fuente, B., Pinela, J., Calhelha, R. C., Heleno, S. A., Ferreira, I. C. F. R., Barba, F. J., Berrada, H., Caleja, C., & Barros, L. (2022). Sea bass (Dicentrarchus labrax) and sea bream (Sparus aurata) head oils recovered by microwave-assisted extraction: Nutritional quality and biological properties. *Food and Bioproducts Processing*, *136*, 97–105. https://doi.org/10.1016/j.fbp.2022.09.004

Estiasih, T., Ahmadi, K., Ali, D., Nisa, F., Suseno, S., & LA, L. (2021). Valorisation of viscera from fish processing for food industry utilizations. *Earth Environ/ Sci. IOP Conf. Ser.:*, *924*(012024).

He, C., Cao, J., Bao, Y., Sun, Z., Liu, Z., & Li, C. (2021). Characterization of lipid profiling in three parts (muscle, head and viscera) of tilapia (Oreochromis niloticus) using lipidomics with UPLC-ESI-Q-TOF-MS. *Food Chemistry*, *347*, 129057. https://doi.org/10.1016/j.foodchem.2021.129057

Hidayatiningtyas, K., Bintari, S. H., & Iswari, R. S. (2020). The Effect of Papain Enzymes and Probiotic Addition on Feed Towards The Catfish Growth Performance, Feed Utilization Efficiency and Survival Rate in Biofloc Techniques. *Proceeding International Conference on Science and Engineering*, *3*(2), 419–423.

Langi, S., Maulu, S., Hasimuna, O. J., Kapula, V. K., Tjipute, M., Langi, S., Maulu, S., Hasimuna, O. J., & Kapula, V. K. (2024). Nutritional requirements and effect of culture conditions on the performance of the African catfish (Clarias gariepinus): a review. *Cogent Food & Agriculture*, *10*(1), 201-215

Mgbechidinma, C., Zheng, G., Buyagao Baguya, E., Zhou, H., Ukpong Okon, S., & Zhang, C. (2023). Fatty acid composition and nutritional analysis of waste crude fish oil obtained by optimized milder extraction methods. *Environmental Engineering Research*, *28*(2), 0–3.

Mgbenka, B. (2014). Clariid catfish Aquaculture: A Panacea for quality animal protein security. An Inaugural Lecture presented at the University of Nigeria Nsukka.

Patience, B. & Ashley O. (2020). Evaluating silage oil from rainbow trout (Oncorhynchus mykiss) viscera as a substitute for dietary fish oil on production parameters of juvenile African catfish (Clarias gariepinus) Co-supervisor: Mr Lourens de Wet. March.

Rahman, N., Hashem, S., Akther, S., & Jothi, J. S. (2023). Impact of various extraction methods on fatty acid profile, physicochemical properties, and nutritional quality index of Pangus fish oil. *Food Science and Nutrition*, *11*(8), 4688–4699.

Rohim, A., Estiasih, T., Susilo, B., & Nisa, F. C. (2024). Extraction of healthy oils from fish viscera by conventional and advanced technologies. *Grasas y Aceites*, *75*(2). https://doi.org/10.3989/gya.0751231.1999

Saini, R. K., Prasad, P., Shang, X., Keum, Y.-S., & Parinandi, L. (2021). Molecular Sciences Advances in Lipid Extraction Methods-A Review. *Int. J. Mol. Sci*, *22*, 13643.

Shepherd, C. J., & Jackson, A. J. (2013). Global fishmeal and fish-oil supply: inputs, outputs and markets. *Journal of Fish Biology*, *83*(4), 1046–1066.

Villamil, O., Váquiro, H., & Solanilla, J. (2017). Fish vis- cera protein hydrolysates: Production, potential applications and functional and bioactive prop- erties. *Food Chem.*, 224 (1), *160–171*

Yashodhara, B., Umakanth, S., Pappachan, J. M., Bhat, S. K., Kamath, R., & Choo, B. H. (2009). Omega-3 fatty acids: a comprehensive review of their role in health and disease. *Postgraduate Medical Journal*, *85*(1), 84–90.

Yi, M., You, Y., Zhang, Y., Wu, G., Karrar, E., Zhang, L., Zhang, H., Jin, Q., & Wang, X. (2023). Highly Valuable Fish Oil: Formation Process, Enrichment, Subsequent Utilization, and Storage of Eicosapentaenoic Acid Ethyl Esters. *Molecules*, *28*(2), 1–34. https://doi.org/10.3390/molecules28020672

EFFECTS OF DIFFERENT NATURAL EXTENDERS ON SPERM COUNT, MOTILITY AND FERTILITY OF *Clarias gariepinus* (Burchell, 1822) FOR ENHANCEMENT OF FINGERLING PRODUCTION

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ABSTRACT

The study assessed the effects of natural sperm extenders on the sperm count, motility and fertility of African mudfish (Clarias gariepinus) for artificial induced breeding and cryopreservation purposes. Three natural extenders were tested i.e. Coconut water, sugarcane water and soybean solutions were used. While the saline solution was used as a control. Semen samples (milt) were pooled from mature broodstock males weighing 600±100g and pre-extension qualities were evaluated for the fresh sperm. Extenders of sugarcane, coconut, soybean and saline water which was used as control were prepared and diluted with sperm to give a sperm extension ratio of 1:20 (1ml of sperm: 20ml of the extender) and 5ml of the prepared solutions were measured in different storage bottles and placed on crushed ice at about4°C which were used to fertilize ready isolated eggs at 0, 3 and 6hour intervals of exposure at 4°C to assess the fertility. In general, the fertilization rates decreased with increasing duration. With respect to natural extenders, the saline solution showed the highest fertility of 71%, followed by soybean milk (69%) while coconut water recorded the least fertility. There significant difference ($p<0.05$) in the percentage fertility of milt among the sperm extenders. The motility of the extended sperms was viewed under microscope at x400 magnification and calculated. Soybean milk showed the highest motility rate of 65% and sperm count $0.690\pm0.050x10^8$ after 6 hours exposure as compared with other natural extenders. However, sperm count, motility and fertility decreased progressively as the period of storage increased.

INTRODUCTION

Development of fish seed production has been identified as a rational way of augmenting the dwindling fish supply from the capture fisheries (Dada and Fagbenro (2008). To provide fish in the required quantities at reasonable prices to Nigerians, there is the need for adequate brood stock management for fish seed production (Francis, 2013). Fish produces high viscosity of

sperm and in some cases only small volume is produced. Extenders play a vital role in cryopreservation; they are needed for sperm dilution, and generally induce initial motility and increased fertilization of cryopreserved sperm. It is known that spermatozoa can be preserved for a day to years and their motility could be retained under low temperatures (Muchlisin, 2004; Akcay *et al.*, 1995; Bozkurt and Secer,2005). Ringer and physiology solutions are common practical extenders to dilute the milt, since these solutions are easy to prepare. The objectives of the study are to evaluate sperm motility of *C. gariepinus* from different sperm extenders, determine the sperm count of both extended and fresh milt of *C. gariepinus* and determine the fertility of *C. gariepinus* different sperm extenders.

MATERIAL AND METHODS

The study was carried out in Fisheries Laboratory of Modibbo Adama University of Technology, Adamawa State. Natural extenders used were grind, soaked and sieved for use. The parameters evaluated were:

Motile sperm cell (MC) = Whole sperm cells (WSC) – Immotile sperm cells (ISC)

$$\% \text{ Motile sperm cell (MC)} = \frac{\text{Motile sperm cell (MC)}}{\text{Whole sperm cells (WSC)}} \times 100$$

Total no of spermatozoa per ml = Average No. of counted spermatozoa x 104 of the extended semen

% Fertility = (No. of fertilized eggs / No. of inseminated egg) X 100%

Statistical Analysis

All measurements were done in duplicate for each sample and the data collected was analyzed using analysis of variance (ANOVA) and Duncan's multiple range tests to evaluate effects of types of extenders.

Results And Discussion

The study showed that motility (Table 1), progressively decrease as the period of storage increased. Sperm extended with soybean milk showed higher motility significantly different ($p>0.05$) with other extenders after 6hours of storage at 4°C. Therefore, soybean milk is a good extender for storing sperm for fairly long period of time, although, there was no significant difference ($p>0.05$) between the control solution and soy milk extender at the same exposure period.

The natural extender that had highest percentage fertility as seen in Table 2, was in the Soybean followed by sugarcane and coconut. Fertility decreased six hours after dilution, indicating that some of the sperms were dying at the time. Coconut water has been found to have higher fertility at the three hours exposure at 4°C of extenders. This result is in agreement with that of

Muchlisin and Mohammadar, (2002). The reason for the differences among extenders in fertilization rate can be explained with decrease in spermatozoa motility and sperm count. The higher the sperm count and motility rate, the higher the fertilization.

Table 1: Mean percentage motility rate after 0, 3, and 6 hours exposure at 40C in different extenders

Duration/h	Control	Sugarcane	Coconut	Soybean
0	84.445±4.445^{a}	76.780±1.780^{b}	75.520±6.290^{c}	82.215±0.395^{d}
3	68.335±1.665^{a}	88.690±2.980^{b}	41.765±3.685^{c}	79.000±1.000^{d}
6	42.220±2.220^{a}	38.095±4.765^{b}	29.715±6.645^{c}	65.000±1.002^{d}

Different superscripts in a row indicate significant differences at $p < 0.05$.

Table 2: Mean percentage fertility rate after 0, 3, and 6hours exposure at 40C in different extenders.

Duration/hr	Control	Sugarcane	Coconut	Soybean
0	97.000±1.000^{a}	89.000±1.000^{b}	81.000±1.000^{c}	94.000±2.000^{d}
3	92.000±2.000^{a}	81.000±1.000^{bc}	82.000±2.000^{bc}	91.000±1000^{a}
6	71.000±1.000^{b}	62.000±2.000^{c}	47.000±3.000^{cd}	69.000±1000^{b}

Different superscripts in a row indicate significant differences at $p < 0.05$.

Sperm count in the fresh sperm recording the highest spermatozoa cells 3.68 x 10^{8} and it recorded about 86.96% motility which was the prerequisite which qualifies the sperm for use (Mansour *et al.*,2002).

Among other extenders, soybean milk recorded the highest sperm count which is significantly different ($p>0.05$) compared with other extenders (Table 3).

Table 3: Overall mean percentage of motility and fertility and mean sperm count of *Clarias gariepinus*.

Treatment	Sperm count (x10^{8})	Motility	Fertility
Control	0.304±0.016^{a}	65.000±7.898^{a}	86.667±5.077^{a}
Sugarcane	0.415±0.035^{d}	67.855±9.978^{a}	77.333±5.103^{ad}
Coconut	0.385±0.035^{a}	49.000±9.036^{cd}	70.000±7.339^{d}
Soybean	0.690±0.050^{cd}	77.486±3.3221^{d}	84.667±5.024^{a}

The mean values in the same column followed by a different superscript indicate significant difference ($p<0.05$)

CONCLUSION

From the study, it showed that sperm of African catfish (*Clarias gariepinus*) survived more with the highest recorded of sperm count in soybean milk which also recorded the highest motility value, whereas, the control solution had the highest percentage fertility.

Although fertility value for soybean solution was also high there was no significant difference with that of the control solution. Therefore, it could be concluded that soybean milk extender can be a good replacement of saline solution which is a conventional solution in artificial breeding exercises.

Recommendations

1. I recommend that the synergistic effects of combining natural extenders be evaluated to identify potential additive benefits.
2. I recommend that natural extender concentrations be optimized based on individual fish variability.
3. I recommend that research investigate the effects of natural extenders on sperm DNA integrity.

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REFERENCES

Akcay, E., Tekin N., and Secer S., (1995). Preservation of Fish Semen. Ege University, Journal of Fisheries and Aquaculture Science. 12: 367-373.

Bozkurt Y, Secer S (2005). Effect of Short-Term Preservation of Mirror Carp (Cyprinus carpio) Semen on Motility, Fertilization, and Hatching Rates. Israeli Journal of Aquaculture Bamidgeh. 57(3):207-212.

Dada K, Fagbenro D (2008). Catfish fingerlings production in Nigeria. Proceedings of the 4th Annual Conference of School of Agriculture and Agricultural Technology, Federal Universityof Technology, Akure. 107 -110.

Francis O.M., Akinlolu A.A and Kehinde O.A (2013). Assessment of bitter leaf (Vernonia amygdalina) as fertility enhancer in the giant African Catfish (Heterobranchus bidorsalis) broodstock. Pages. 1 – 5.

Mansour, N, Lahnsteiner, F. and Patzner, R. A. (2002). The spermatozoan of the African Catfish: fine structure, motility, viability and its behaviour in seminal vesicle secretion. Journal of Fish Biology Vol. 60 (3): 545-560.

Muchlisin Z.A. (2004). Preliminary study on spermatozoa cryopreservation and evaluation of dietary protein on gonadal development of bagrid catfish (Mystusnemurus) female Broodstock. Thesis, University Sciences Malaysia, Penang.

Muchlisin Z.A. and Muhammadar. (2002). Long-term cryopreservation of baung spermatozoa, Mystusnemurus: Effect of various cryoprotectants on motility and fertility. Torani12 (4): 204-210.

Omitogun, G.O., Olaniyan, O., P. Amupitan, Oresanya,T, S. Aladele and W. Odofin (2012). Cryopreservation of the Sperm of the African Catfish for the Thriving Aquaculture Industry in Nigeria, Current Frontiers in Cryopreservation, Prof. Igor Katkov (Ed.),ISBN: 978-953- 51-0302-8.

WOMEN ENGAGEMENT IN FISH FARMING FOR SUSTAINABLE FOOD SECURITY IN CROSS RIVER STATE, NIGERIA

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ABSTRACT

Fish farming is a vital component of Nigeria's agricultural sector, contributing significantly to food security, employment, and economic growth. However, women participation in fish farming is limited. Hence, the study examined the strategies for enhancing women engagement in fish farming for sustainable food security. 220 female fish farmers in Cross River State were randomly selected. Structured questionnaire was used for data collection. Descriptive statistics and ANOVA were used to analyze the data collected. The findings lack of access to training, technology, and credit facilities among others as the major constraints hindering women involvement in fish farming. The study further identified enhancement measures such as provision of loans and grants to women fish farmers, training women on modern fish farming technique among others to encourage women fish farmers. In addition, the finding also revealed women engagement in fish farming to include provision of additional income, enhances women economic empowerment and independence, creates employment opportunities, contributes to better nutrition and health, enhances food security and availability among others. Based on the findings, it was concluded that enhancing women participation in fish farming is crucial for sustainable food production, employment creation and income generation among women in Cross River State. The study recommended among others that government of Cross River State should provide micro-credit facilities and grants for women fish farmers to boost their involvement and productivity; establish women-focused fish farming training programmes across different Local Government Areas and wards in the state among others.

Keywords: Fish farming, Women Engagement, Food Security, and Enhancement Measures, Cross River State.

Introduction

Food security is one of the critical and pressing global issues, with a significant proportion of the population not having reliable access to nutritious and affordable food. The global food security challenge has become increasingly pressing, with the United Nations estimating that the world's population will reach 9.7 billion by 2050 (United Nations, 2020). Food insecurity persists, particularly among vulnerable groups such low and average income earners in Nigeria. The country's agricultural sector, which employs approximately 30% of the workforce, has

significant potential for addressing food security concerns (Federal Ministry of Agriculture and Rural Development, 2020). Agricultural production has been identified as a crucial sector for enhancing food security (Food and Agricultural Organization (FAO), 2018).

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2021). It can also be regarded as the ability of individuals to obtain an adequate diet in terms of quality, quantity, and cultural acceptability, without compromising access to other basic needs and the ability to make food choices (Pinstrup-Andersen, 2012). Food security is the successful provision of sufficient, safe, nutritious, and culturally acceptable food for all individuals within a society, achieved through sustainable food systems that promote equity and resilience (FAO & WHO, 2019). It emphasizes the need for food systems that are not only productive but also inclusive and environmentally sustainable. On the other hand, food insecurity is the inability to have access to sufficient, safe, and nutritious food for an active and healthy life. Sharma et al. (2021) noted that food insecurity refers to barriers that prevent individuals from obtaining enough nutritious food to meet their dietary needs. This can result in hunger, malnutrition, and other health related issues due to lack of essential nutrients. Food insecurity challenges can be addressed by expanding agricultural productions both at local, state, national and global levels. Fish farming remains one of the vital areas of agricultural production which can help contribute to food security in Cross River State and Nigeria at large.

Fish farming has become an increasingly important economic activity in recent years. The State, located in the South-South geopolitical zone of Nigeria, is known for its rich aquatic resources and diverse fish species. Cross River State has immense potential for fish farming due to its abundant water resources, including rivers, streams, and wetlands (Ekweozor et al., 2018). The state is home to various fish species, including catfish, tilapia, and mudfish, which are in high demand both domestically and internationally (Nwaru et al., 2018).

Esor and Ekwueme (2018), stated that Cross River State has the potential to become a major player in the aquaculture industry due to its favorable climate, abundant water resources, and government support for the sector.

Fish are aquatic animals harvested for human consumption, providing a source of protein and essential nutrients (FAO, 2018). Fish are aquatic vertebrates that belong to the class Pisces, characterized by gills, fins, and scales (Nelson, 2018). Fish is an essential source of protein, micronutrients, and essential fatty acids, improving food security and nutrition globally (FAO, 2018).). Fish provides over 20% of animal protein intake in developing countries (FAO, 2018). Fish farming, also known as aquaculture, is the practice of breeding and raising fish in controlled environments such as ponds, tanks, or cages for commercial purposes (Tacon & Metian, 2018). According to (Ekweozor et al., 2018), fish farming is the cultivation of fish and other aquatic organisms in controlled environments, such as ponds, cages, or recirculating systems (Ekweozor et al., 2018). It involves the cultivation of fish for human consumption and

can help alleviate pressure on wild fish populations by providing a sustainable source of seafood (Villasante, 2018).

Fish farming is a rapidly growing industry that plays a crucial role in global food security by providing a reliable source of protein for a growing population (Troell, 2018). Fish farming also contributes significantly to food security, employment, income generation, and economic growth (Fadeyi et al., 2018). It helps maintain ecosystem services, reduce water pollution, and promote sustainable aquaculture practices (Intergovernmental Panel on Climate Change, 2018). Fish farming can help reduce pressure on wild fish stocks and promote sustainable aquaculture practices. By efficiently utilizing resources and adopting production methods, fish farming contributes to conservation efforts and helps protect marine ecosystems (Gentry et al., 2018). Although, fish farming plays crucial role in enhancing food security, its operations are mainly carried out by men with little involvement of women in Cross River, Nigeria.

Women have not participated fully in fish farming in Cross River State like men counterpart. A study by Etim et al. (2018) highlighted the importance of addressing gender disparities in fish farming to improve productivity and promote sustainable development. Abel et al. (2018) stated that women in the fish farming sector often lack access to technical support and training, which hinders their ability to improve their production practices and increase their yields. Also, poor extension services contribute to poor women engagement which also leads to lower productivity among female fish farmers in Cross River State (Abel et al., 2018). Etim et al. (2018) emphasized the need for targeted interventions to support women in accessing resources, training, and financial assistance in order to boost their involvement in fish farming. Similarly, Ogar et al. (2018) identified barriers to women participation in fish farming such as cultural norms and limited access to credit. Ogar et al. (2018) further stated that strategies such as providing technical training and creating women-friendly policies in the sector can help enhance increase women engagement in fish farming. Studies have shown that women participation in agriculture, including fish farming, can improve food security, reduce poverty, and enhance nutritional outcomes (FAO, 2018).

PROBLEM STATEMENT

However, in spite of the significant roles of women in promoting food security through fish farming, women participation in fish farming remains limited in Cross River State (Nwaru et al., 2018). Even when the state has immense potential for fish farming due to its abundant water resources (Ekweozor et al., 2018); yet women engagement in fish farming remains low, hindering the sector's growth and sustainability. This may be as a result of the numerous challenges, including limited access to training, technology, and credit facilities women face in the state (Adeoye et al., 2018). Addressing these challenges is crucial to enhancing women engagement in fish farming and promoting sustainable food security. Researchers in different parts of the world have carried out studies on the challenges of women engagement in fish farming in different places, but there is paucity of research findings on the ways of enhancing women engagement in fish farming for sustainable food security in Cross River State, Nigeria. This is the gap the study aimed to achieve.

Research Objectives

The primary objective of this study is to investigate ways of enhancing women engagement in fish farming for sustainable food security in Cross River State, Nigeria.
The specific objectives were:

1. Identify challenges militating against women engagement in fish farming in Cross River State;
2. Describe the strategies for enhancing women engagement in fish farming Cross River State.
3. Examine the benefit of women engagement in fish farming in Cross River State.

Hypotheses

1. There is no significant difference in the mean responses of women living in urban, semiurban and rural areas on the challenges militating against women engagement in fish farming in Cross River State.
2. There is no significant difference in the mean responses of women living in urban, semiurban and rural areas on the strategies for enhancing women engagement in fish farming in Cross River State.
3. There is no significant difference in the mean responses of women living in urban, semiurban and rural areas on the impacts of women engagement in fish farming in Cross River State.

Methodology

The study adopted a descriptive survey research design. It was carried out in three local government;

1) Calabar municipal, in the urban, (Okoro et al., 2020). These are characterised by high population density, economic activities and infrastructure development.
2) Biase in Semi-urban areas, (Udoakah et al., 2020). These area have moderate population density, economic activities and infrastructure development.
3) Ogoja in rural areas (Okon et al., 2020). of Cross River State. These areas are characterised by low population density, Limited economic activities and infrastructure development. Population for this study was 220 women fish farmers in Cross River State. The population consisted of 60 women fish farmers from urban area, 75 women fish farmers from semi-urban area and 85 women fish farmers from rural area randomly selected in the state and sampled. A structured questionnaire was used for data collection.

The questionnaire was administered to the respondents (women fish farmers) by the researcher and three research assistants. After the questionnaires were collated, it was observed that some were not properly rated or ticked and they were not used for the final analysis whereas few others were not retrieved from the respondents.
Only the responses of 210 respondents comprising 60 women fish farmers from urban area, 70 women fish farmers from semi-urban area and 80 women fish farmers from rural

area were used for data analysis. This implied that 10 of the questionnaire were not used for data analysis. Data collected from the study were analyzed using Mean, Standard Deviation and one-

way ANOVA. Descriptive statistics was used to answer the three objectives. The decision rule is that any mean response whose value is 2.50 and above was "agreed" by the respondents while any one whose mean value is below 2.50 was "disagreed" by the respondents. One-way ANOVA was used to test the three null hypotheses at 0.05 level of significance. The decision rule is that any null hypothesis whose p-value is less than 0.05 level of significance was rejected and regarded as significant, while any null hypothesis whose p-value is equal to or greater than 0.05 level of significance was accepted and regarded as not significant. All the analyses were carried out using Statistical Package for Social Sciences (SPSS) software version 25.

Results and Discussions:

CHALLENGES MILITATING AGAINST WOMEN

The result presented in Table 1 revealed fourteen (14) challenges militating against women engagement in fish farming in Cross River State. The findings further revealed that there was no significant difference in the mean responses of women living in urban, semi-urban and rural areas on the challenges militating against women engagement in fish farming in Cross River State.

The finding is in line with Philip (2018) who stated that women in Cross River State face challenges in accessing financial resources to invest in fish farming activities. Philip et al. (2018) also pointed that even with the availability of government programmes and microfinance institutions, many women in Cross River State still struggle to secure loans due to lack of collateral and high interest rates. Furthermore, the finding support Abel (2018) who stressed that women fish farmers in Cross River State often lack access to technical support and training, which hinders their ability to improve their production practices and increase their yields. The lack of extension services contributes to lower productivity among female fish farmers in Cross River State (Abel et al., 2018). In addition, the finding is in accordance with Adams (2018) who stated that women fish farmers in Cross River State face challenges in accessing quality inputs such as feeds, fingerlings, and equipment. This lack of access to essential resources hampers their ability to scale up their operations and compete effectively in the market.

Table 1: Mean Responses and ANOVA Analysis on the Challenges Militating Against Women Engagement in Fish Farming in Cross River State

	Items Statement				X	SD	Rmks	P-value
Rmks								
1	Gender-based discrimination	3.21	0.81	Agree	0.062	NS		
2	Inadequate extension services	3.20	0.80	Agree	0.860	NS		
3	Social stigma associated with women in fish farming	3.28	0.86	Agree	0.390	NS		
4	Limited access to credit facilities	3.10	0.89	Agree	0.099	NS		
5	High cost of inputs (fingerlings and fish feeds) and equipment	3.20	0.84	Agree	0.201	NS		

6	Limited market access and poor market prices	2.87	0.82	Agree	0.456	NS		
7	Inadequate financial support from government	3.13	0.76	Agree	0.110	NS		
8	Lack of modern fish farming technologies	2.98	0.84	Agree	0.071	NS		
9	Inadequate training on fish farming practices	3.18	0.80	Agree	0.130	NS		
10	Climate change and its impacts on fish farming	3.22	0.71	Agree	0.087	NS		
11	Water pollution and poor water quality	3.22	0.79	Agree	0.803	NS		
12	Poor waste management practices	3.17	0.77	Agree	0.055	NS		
13	Limited access to land and resources	3.15	0.80	Agree	0.063	NS		
14	Limited economic empowerment	3.00	0.79	Agree	0.391	NS		
	Grand Value			**3.14**	**0.81**	**Agree**	**0.269**	**NS**

Key: $\bar{X}$ = Mean; SD = Standard Deviation; Rmk = Remakrs; NS = Not Significant; Total respondents = 210
(60 urban women fish farmers, 70 semi-urban women fish farmers, 80 rural women fish farmers),

The data presented in Table 1 showed the mean responses and ANOVA analysis of women fish farmers on the challenges militating against women engagement in fish farming in Cross River State. The result revealed that all the 14 items obtained mean value above cut-off point of 2.50. This indicated that the respondents agreed that all the items are the challenges militating against women engagement in fish farming in Cross River State. The items on Table 1 also revealed the grand values of 3.14 ± 0.81, p-value = 0.269 ($P > 0.05$) which implies there was no significant difference in the mean responses of women living in urban, semi-urban and rural areas on the challenges militating against women engagement in fish farming in Cross River State. The null hypothesis is therefore upheld.

STRATEGIES FOR ENHANCING WOMEN ENGAGEMENT

The data presented in Table 2 showed thirteen (13) strategies for enhancing women engagement in fish farming in Cross River State. Again, the findings revealed that there was no significant difference in the mean responses of women living in urban, semi-urban and rural areas on the strategies for enhancing women engagement in fish farming in Cross River State.

The finding is in support of Ekweozor et al. (2018) who stressed that providing women with training on modern fish farming practices, technology, and business management enhances their productivity and efficiency. According to Afolayan (2018), capacity-building programmes have been shown to enhance women's participation in agriculture, including fish farming, by increasing their technical expertise and confidence. The finding also strengthens Adeleke (2018) who stated that women involvement in cooperatives and associations can provide them with networking opportunities, access to collective resources, and a platform for advocacy in fish farming. According to Adeleke (2018), women who are members of cooperatives tend to have higher levels of production and income in fish farming. The result further show support with Adeyemo (2018) who noted that access to finance is a key factor that can enable women to invest in fish farming. Providing women with access to credit

facilities can help them overcome financial constraints and expand their fish farming operations.

Table 2: Mean Responses, and ANOVA Analysis on the Strategies for Enhancing Women Engagement in Fish Farming Cross River State?

Items	Statement	X	SD	Rmks	P-value	Rmks
1	Training and capacity building programmes for women	3.15	0.84	Agree	0.301	NS
2	Access to credit facilities and microfinance	3.24	0.81	Agree	0.064	NS
3	Provision of modern fish farming technologies	3.12	0.74	Agree	0.087	NS
4	Functional extension services and mentorship programmes	3.22	0.89	Agree	0.813	NS
5	Formation of women fish farming cooperatives	3.10	0.67	Agree	0.035	NS
6	Market access and support for women fish farmers	2.95	0.80	Agree	0.083	NS
7	Gender-sensitive policies and legislation	3.02	0.99	Agree	0.131	NS
8	Women empowerment and leadership training	3.05	0.88	Agree	0.231	NS
9	Access to clean water sources and sanitation	3.01	0.86	Agree	0.070	NS
10	Provision of fish farming demonstration centres for women.	3.03	0.70	Agree	0.608	NS
11.	Collaboration with women organizations and NGOs	2.88	0.89	Agree	0.260	NS
12.	Fish processing and value addition training	2.94	0.92	Agree	0.017	S
13	Monitoring and evaluation of women engagement.	2.81	0.71	Agree	0.015	S
	Grand Values	**3.04**	**0.82**	**Agree**	**0.209**	**NS**

Key: $\bar{X}$ = Mean; SD = Standard Deviation; Rmk = Remarks; NS = Not Significant; S = Significant; Total respondents = 210 (60 urban women fish farmers, 70 semi-urban women fish farmers, 80 rural women fish farmers),

Table 2 results revealed the mean responses and ANOVA analysis of women fish farmers on the strategies for enhancing women engagement in fish farming in Cross River State. The data indicated that all the 13 items obtained mean values ranging from 2.81 to 3.24 with a grand value of 3.04 ± 0.82 which is above the cut-off point of 2.50. This implied that the respondents (women fish farmers) agreed that all the items are the strategies for enhancing women engagement in fish farming in Cross River State. Furthermore, Table 2 also recorded p-value of 0.209 ($P > 0.05$), this indicated that there was no significant difference in the mean responses of women living in urban, semiurban and rural areas on the strategies for enhancing women engagement in fish farming in Cross River State. The null hypothesis is therefore accepted.

BENEFITS OF WOMEN ENGAGEMENT

The result presented in Table 3 identified ten (10) benefits of women engagement in fish farming in Cross River State. In addition, The findings in Table 3 data indicated that there was no significant difference in the mean responses of women living in urban, semi-urban and rural areas on the impacts of women engagement in fish farming in Cross River State.

Kuba et al., 2018) who noted that women in Cross River State play a significant role in fish farming, which helps to improve household food security. By engaging in fish farming, women are able to produce nutritious food for their families, reducing reliance on costly food purchases and ensuring a steady food supply for their households. The finding is also in agreement with Udegbe et al. (2018) who pointed that women engagement in fish farming contributes to community development in Cross River State by creating employment opportunities, increasing economic growth, and promoting sustainable resource management practices. Women involvement in fish farming promotes community cohesion and allows for the sharing of knowledge and resources among community members. (Udegbe et al., 2018).

Table 3: Mean Responses and ANOVA Analysis on the benefits of women Engagement in Fish Farming in Cross River State.

Items	Statement	$\bar{X}$	SD	Rmks	P-value	Rmks
1	Women engagement in fish farming provides additional income for their households	3.17	0.59	Agree	0.089	NS
2	Fish farming enhances women economic empowerment and independence	3.11	0.88	Agree	0.160	NS
3	Women involvement creates employment opportunities them and for others	3.13	0.60	Agree	0.415	NS
4	Fish farming contributes to better nutrition and health	2.77	0.71	Agree	0.309	NS
5	Women involvement promotes sustainable fishing practices	2.44	0.78	Disagree	0.887	NS
6	Women engagement in fish farming helps conserve aquatic resources	Disagree	NS	2.48	0.80	0.892
7	Women participation in fish farming enhances food security and availability	3.25	0.80	Agree	0.981	NS
8	Women participation in fish farming leads to skill development among the women	Agree	NS	2.84	0.81	0.384
9	Women engagement in fish farming ensures access to protein-rich food	3.21	0.83	Agree	0.494	NS
10	It will enable women to connect with other fish farmers, expanding their networks	2.85	0.77	Agree	0.954	NS
11	Women engagement in fish farming contributes to community development	2.79	0.78	Agree	0.099	NS
12	Proper utilization of land	2.63	0.84	Agree	0.087	NS
	Grand Values		**2.89**	**0.77**	**Agree**	**0.479**

NS

Key: $\bar{X}$ = Mean; SD = Standard Deviation; Rmk = Remarks; NS = Not Significant; Total respondents = 210 (60 urban women fish farmers, 70 semi-urban women fish farmers, 80 rural women fish farmers).

Table 3 data the mean responses and ANOVA analysis of women fish farmers on the impacts of women engagement in fish farming in Cross River State showed that 10 items out of the 12 items got the mean values above cut-off point of 2.50. This implied that the respondents agreed that the 10 items are the impacts of women engagement in fish farming in Cross River State. Additionally, the items on Table 3 also revealed the grand value of 2.89 ± 0.77, and p-value of 0.479 ($P > 0.05$) which depicts that there was no significant difference in the mean responses of women living in urban, semi-urban and rural areas on the impacts of women engagement in fish farming in Cross River State. Hence, the null hypothesis is therefore upheld.

Conclusion

Fish farming in Cross River State holds great potential for economic development and food security. However, women engagement in fish farming in Cross River State remains low when in spite of the numerouscontributions of women in agricultural production and in ensuring food security. The low level of women engagement is due to many challenges such as gender-based discrimination, inadequate extension services, social stigma associated with women in fish farming, limited access to credit facilities, high cost of inputs (fingerlings and fish feeds) and equipment, limited market access and poor market prices, inadequate financial support from government, lack of modern fish farming technologies, inadequate training on fish farming practices among others. To overcome these challenges and to enhance women participation in fish farming, the study identified certain strategies to be adopted which include training and capacity building programmes for women, access to credit facilities and microfinance, provision of modern fish farming technologies, functional extension services and mentorship programmes, formation of women fish farming cooperatives among others. In conclusion, enhancing women participation in fish farming is crucial for sustainable food production, employment creation and income generation among women in Cross River State.

Recommendations

Based on the findings, the study recommended the following:

1. The Government of Cross River State through Ministry of Agriculture should establish women focused fish farming training programmes across different Local Government Areas and wards in the state to enable women to learn modern practices in fish farming and processing.
2. Cross River State Government through her Ministry of Finance should provide micro-credit facilities and grants for women fish farmers to boost their involvement and productivity.
3. There is need to strengthen extension services targeting women especially in fish farming. Government of Cross River State need to make extension services effective in the state.

4. Women fish farmers in Cross River State should be encouraged to form fish farming cooperative society so as to promote women participation in fish farming and to have easy access to collective resources.

References

Abel, W. (2018). Challenges of women's agricultural development and gender inequality in Cross River State, Nigeria. *International Journal of Science and Research, 7*(12), 766-771.

Adams, A. (2018). Gender disparities in fish farming practices and productivity in Cross River State, Nigeria. *Journal of Agricultural Research and Extension, 4*(2), 98-105.

Adeleke, A. (2018). The role of cooperatives in enhancing women's participation in agriculture. *Journal of Cooperatives and Rural Development, 15*(1), 34-48.

Adeoye, I. B., Opeyemi, J. A., & Olufemi, O. M. (2018). Analysis of women's participation in fish farming in Lagos State, Nigeria. *Journal of Agricultural Extension, 22*(1), 123-135.

Adeyemo, T. (2018). Access to credit facilities and women's involvement in agriculture. *Journal of Agricultural Economics and Development, 42*(1), 56-72.

Afolayan, O. (2018). Empowering rural women through agriculture: A focus on training, empowerment, and capacity building. *Journal of Agricultural Extension, 22*(2), 123-138.

Agriculture and Rural Development. (2020). *The national agricultural policy*. Federal Ministry of Agriculture.

Ekpenyong, A., Eftisom, A., & Bassey, C. (2018). Sustainable Fish Farming Practices in Cross River State, Nigeria. *Journal of Sustainable Agriculture, 7*(3), 24-32.

Ekweozor, I. K., Udeh, R. I., & Ogbonna, C. E. (2018). Fish farming in Cross River State, Nigeria: Prospects and challenges. *Journal of Fisheries and Aquatic Science, 13*(2), 145-155.

Esor, N., & Ekwueme, T. (2018). An Analysis of Fish Production in Cross River State, Nigeria. *Journal of Aquaculture Research & Development, 9*(2), 1-5.

Etim, C. P., Otu, M. S., & Etim, E. E. (2018). Gender dimensions of fish farming productivity in Akamkpa Local Government Area, Cross River State, Nigeria. *African Journal of Agricultural Research, 13*(33), 1759-1765.

Fadeyi, O., Oluwalana, S. A., & Omitoyin, B. O. (2018). Contribution of fish farming to food security in Nigeria. *Journal of Food Security, 6*(2), 34-42.

Food and Agriculture Organization (FAO). (2018). *The state of world fisheries and aquaculture.* Rome: FAO.

Food and Agriculture Organization of the United Nations & World Health Organization. (2019). *Sustainable healthy diets: Guiding principles.* FAO.

Food and Agriculture Organization of the United Nations (2021). *The state of food security and nutrition in the world 2021.* FAO.

Gentry, R. R., Froehlich, H. E., Grimm, D., Kareiva, P., Parke, M., & Rust, M. (2018). Mapping the global potential for marine aquaculture. *Nature Ecology & Evolution, 2*(5), 840- 849.

Intergovernmental Panel on Climate Change (IPCC). (2018). *Global warming of 1.5°C.* Cambridge University Press.

Kuba, O., Amusa, T.O., & Amodu, O. (2018). Women involvement in fish farming and food security in Cross River State, Nigeria: A case study of selected local government areas. *African Journal of Fisheries and Aquaculture, 6*(2), 85-92.

Nelson, J. S. (2018). *Fishes of the world (6th ed.).* Wiley.

Nwaru, J. C., Ugochukwu, A. I., & Onyia, C. C. (2018). Fish species diversity in Cross River State, Nigeria. *Journal of Fisheries and Aquatic Science, 13*(1), 1-9. doi: 10.3923/jfas.2018.1.9

Ogar, B. D., Ojukwu, I. C., & Acham, S. O. (2018). Women participation in aquaculture production a panacea for food security in rural households in Abia State, Nigeria. *Sci-Afric Journal of Scientific Issues, Research and Essays, 6*(2), 23-31.

Okoro, J.O., et al (2020). Urban planning and development in Calabar metropolitan area, Nigeria. Journal of urban planning and development 146(2), 1-10.

Okon, E,O.,et al (2020). Analysis of rural poverty and it determinants in Cross River State, Nigeria. Journal of poverty and social studies, 9(1), 1-12.

Philip, J. (2018). Access to credit facilities by women in fish farming in Cross River State, Nigeria. *African Journal of Agricultural Economics, 3*(2), 54-61.

Pinstrup-Andersen, P. (2012). Food security: Definition and measurement. *Food Security, 4*(2), 131-142.

Sharma, S., DePue, J., & Coberley, C. (2021). Understanding food insecurity and the role of the built environment in addressing social determinants of health. *Frontiers in Sustainable Food Systems, 5*. https://doi.org/10.3389/fsufs.2021.673167

Tacon, A. G. J., & Metian, M. (2018). Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: Trends and future prospects. *Aquaculture, 285*(1-4), 29-45.

Troell, M. (2018). Global aquaculture performance index (GAPI): The production, performance, and environmental impact of aquaculture. *Aquaculture, 292*(1-2), 1-17.

Udegbe, I. B., Nwosu, M. C., & Effiong, A. (2018). Women empowerment through fish farming for sustainable food security in Cross River State, Nigeria. *Journal of Agriculture and Rural Development in the Tropics and Subtropics, 119*(2), 177-188.

Udoakah N.E, et al (2020). Agricultural development and food security in Biase local government Area, Cross River State, Nigeria. Journal of Agricultural Extension 24(1), 1-12.

United Nations. (2020). *World population prospects 2019*. New York, NYFederal Ministry of Villasante, S. (2018). The global ocean darkening: A review of the state of knowledge on the causes, mechanisms, and implications of darkening. *Frontiers in Marine Science, 5*, 1-18.

MORPHOMETRIC DIVERSITY IN *PSEUDOTOLITHUS ELONGATUS* POPULATION FROM THE LOWER CROSS RIVER, NIGERIA: A MONTE CARLO SIMULATION APPROACH

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Abstract
Traditional morphometric studies often face challenges due to limited sample sizes, which can lead to incomplete or biased conclusions. This study aimed to simulate the morphometric diversity of Pseudotolithus elongatus using the Monte Carlo model. A total of 560 P. elongatus specimens, with an average total length of 25.03 ± 9.66 cm, were collected from the landings of artisanal fishermen between March and August 2024. Fourteen morphometric traits were measured, including total depth (TD), head length (HL), and orbital diameter (OD). The coefficient of variation (CV) for observed traits ranged from 26.50% (LPF) to 35.59% (LCP), while simulated CVs ranged from 27.47% (LPF) to 35.49% (LCP). The percent differences between observed and simulated CVs ranged from 0.27% (LCP) to 5.84% (HL). Root mean square error (RMSE) values were generally low, with OD showing no deviation (RMSE = 0.00) and mandibular depth (MD) having an RMSE of 0.10. T-tests indicated no significant differences ($p > 0.05$) between observed and simulated means. These findings suggest that Monte Carlo simulations are a reliable and effective tool for modeling the morphometric diversity of P. elongatus. This approach should be integrated into fisheries management practices to enhance population assessments and inform sustainable harvesting strategies.

Keywords: Morphometric Diversity, Monte Carlo modelling, *Pseudotolithus elongatus*, Fisheries Management

1. Introduction

The West African croaker, *Pseudotolithus elongatus*, is a demersal fish species widely distributed along the West African coast, particularly in the Gulf of Guinea and the estuarine and coastal waters of Nigeria. This species holds substantial ecological and economic value, contributing significantly to artisanal and commercial fisheries in the Cross River Estuary and beyond (Nwosu *et al.*, 2010, Asuquo & Ifon, 2022). Adapted to diverse habitats, especially brackish estuarine environments, *P. elongatus* plays a crucial role in trophic dynamics as a benthic feeder, consuming invertebrates and supporting the ecosystem's overall health (Asuquo & Ifon, 2019).

Understanding morphometric diversity, defined as the variability in measurable physical traits such as body length, fin dimensions, and head structure, is crucial for effective fisheries management and conservation. These traits provide valuable insights into population health, genetic diversity, and adaptability to environmental pressures, while also aiding in the identification of distinct population units and informing sustainable harvest levels (Ekpo *et al.*, 2021). Traditional morphometric studies, however, often face challenges such as limited sample sizes, constrained geographic coverage, and a lack of advanced computational tools. These limitations can lead to incomplete or biased conclusions. Research addressing these challenges, particularly for *P. elongatus*, is limited in the Cross River and its adjoining estuary, a region influenced by dynamic environmental conditions and anthropogenic pressures (Emeka *et al.*, 2023).

Monte Carlo simulation is an approach widely used to address the limitations of traditional morphometric studies. By generating synthetic datasets that mimic observed variability, it facilitates a detailed assessment of morphometric diversity under varying environmental and genetic scenarios (Fullman *et al.*, 2021). This method is particularly advantageous for species like *P. elongatus*, where large-scale field data collection is often hindered by logistical and financial constraints. Alternative approaches, such as resampling techniques, machine learning-based simulations, and Bayesian inference frameworks, are also employed for analyzing morphometric traits. However, these methods can be limited in capturing the full range of variability due to smaller datasets or oversimplified assumptions. In contrast, Monte Carlo simulation excels by integrating variability from multiple sources and offering flexibility in modeling hypothetical scenarios, making it a robust tool for fisheries research. Despite its proven utility, the validation of simulated datasets against real-world observations remains underexplored; a critical gap that this study aims to address.

In this study, *P. elongatus* serves as a model organism to investigate morphometric diversity using Monte Carlo simulations. This approach not only quantifies trait variability but also tests the reliability of simulated datasets by comparing them with observed measurements. The research addresses a key gap in fisheries science by providing a systematic methodology for simulation validation, offering insights into how environmental and genetic factors influence morphometric traits. These findings will enhance understanding of *P. elongatus* population dynamics and support sustainable fisheries management in the Cross River Estuary and beyond.

2. Materials and Methods

2.1 Study Area

The study was conducted in the lower Cross River, which flows into the Cross River Estuary, a vital ecological zone located in southeastern Nigeria, within Cross River State. This estuarine system is one of the largest and most biologically diverse in West Africa, supporting a wide range of aquatic and terrestrial species. Geographically, the lower Cross River is situated between latitudes 4°45' and 6°15' N and longitudes 8°00' and 8°55' E of the Greenwich Meridian (Fig. 1). The river originates as the Manyu River in the Mamfe region of Cameroon, approximately 74 km from the Nigerian border. It flows southward into Nigeria, where it

broadens into an extensive estuarine area before emptying into the Atlantic Ocean at the Gulf of Guinea (Zapfack *et al.*, 2001).

Figure 1: Map of Cross River Estuary showing sampling stations

Source: Ama-Abasi *et al.* (2022)

The estuary covers approximately 54,00 sq. km. serving as a navigational route to different ports (Calabar, Port Harcourt, Onne, Okrika, and Bonny) in Nigeria (Emaka *et al.*, 2023). The estuary's open connection to the Gulf of Guinea significantly influences its ecological dynamics. Marine and freshwater inputs create a gradient of environmental conditions along the estuary, with salinity levels ranging from nearly freshwater in the upper reaches to higher salinity near the mouth where it meets the Atlantic Ocean (Otogo *et al.*, 2023). This variation, along with tidal fluctuations and seasonal changes, creates numerous ecological niches that shape the distribution, growth, and behavior of fish populations.

Fringed by extensive mangrove forests, primarily composed of *Rhizophora* and *Avicennia* species, the estuary provides crucial habitats that support high biodiversity. These mangroves, interspersed with mudflats and sandy shores, serve as breeding, nursery, and feeding grounds for various fish and invertebrate species, each adapted to distinct habitats within the estuary. Local fishing communities depend heavily on the estuary for their livelihoods, with artisanal fishing being a predominant activity.

2.2 Data Collection

Five hundred and sixty (560) *P. elongatus* samples with average total length of 25.03±9.66 cm were collected systematically for six months (March to August 2024) from the landings of

artisanal fishers at eight sites, encompassing eight sites: Itu, Ayadehe, Uruan, Okobo, Oron, Nsidung, Atu, and Ibaka beaches and pooled for the study. These fishers employed gillnets and dragnets about 100m long with a stretched mesh size of 50 mm (Ama-Abasi *et al.*, 2022). Fish samples were preserved on ice and transferred to the laboratory, where they were measured.

2.3 Morphometric measurements

In the laboratory, 14 morphometric characters (Fig. 2), namely, Trunk Depth (TD), Head Depth (HD), Head Length (HL), Orbital Diameter (OD), Relative Eye Diameter (RED), Mouth Width (MW), Mouth Depth (MD), Trunk Thickness (TT), Length of the Pectoral Fin (LPF), Pectoral Fin Width (PFW), Length of the Caudal Peduncle (LCP) , Width of the Caudal Peduncle (WCP), Depth of the Caudal Peduncle (DCP), and Length of the Caudal Fin (LCF). Measurements were linear and made to the nearest centimetre with Vernier calipers and a measuring Board (Zelditch *et al.*, 2012). To ensure accuracy and minimize human error, each morphometric trait was measured three times per individual, and the average value was used in subsequent analyses to enhance reliability.

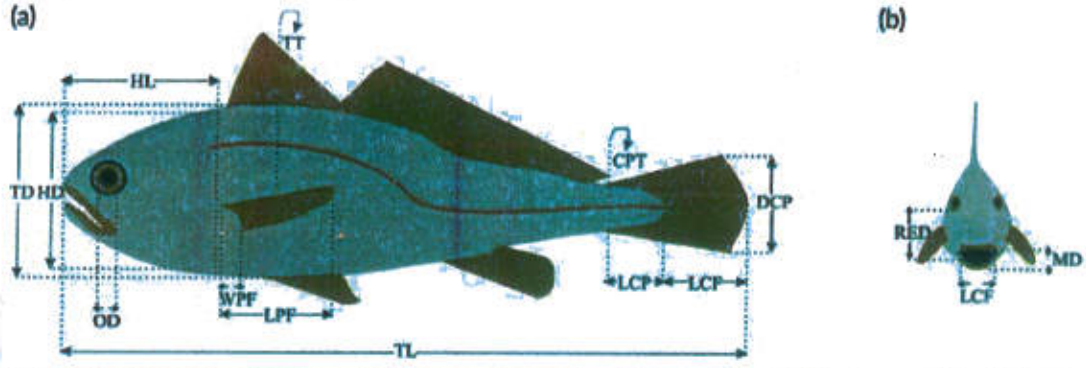

Figure 2: Schematic diagram of *P. elongatus*. Lateral (a) and front (b) views of the fish showing morphometric characters as well as total length

Source: Asuquo and Ifon (2021)

2.4 Monte Carlo Simulation of Morphometric Diversity

Monte Carlo simulation was used to model morphometric diversity in *P. elongatus*. This simulation technique generates a large number of random samples from defined probability distributions to estimate the potential range of values for each morphometric trait. For each morphometric trait, the mean (μ) and standard deviation (σ) were calculated from the observed data, assuming a normal distribution. The probability density function for each trait was defined as:

$$f(X) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(X-\mu)^2}{2\sigma^2}}$$

where: X represents the morphometric trait,

μ is the mean, and

σ is the standard deviation.

The Monte Carlo simulation involved 1000 iterations of bootstrap resampling for each morphometric trait. In each iteration, random samples (with replacement) of the same size as the original observed dataset (560 samples) were drawn from the observed data. This approach generated a total of $n_{observed} \times 1000$ simulated values for each trait yielding 560,000 simulated

values. The resampling ensured computational efficiency and preserved the variability inherent in the observed data (Pokropek *et al.*, 2019).

2.5 Morphometric diversity

Morphometric diversity was quantified using the coefficient of variation (CV) for each trait. The CVs for both the raw (observed) and simulated datasets were calculated as:

$$CV = \frac{\sigma}{\mu} \times 100$$

where: σ is the standard deviation of the simulated samples, and
μ is the mean of the simulated samples.

The percentage difference between the observed and simulated CVs was then computed using the following formula:

$$Percent\ Difference = \left|\frac{\text{Simulated CV} - \text{Observed CV}}{\text{Observed CV}}\right| \times 100$$

This approach provided a measure of how well the simulated values captured the variability observed in the observed data (Mulyasari *et al.*, 2023).

2.6 Statistical analysis

The variability in mean morphometric traits between the observed and simulated data was tested using a t-test for unequal sample sizes. The null hypothesis for the t-test stated that no significant differences existed between the means of the observed and simulated datasets for each studied trait. A p-value of less than 0.05 was considered statistically significant. All statistical analyses, including numerical operations and t-tests, were conducted using Python libraries such as NumPy and SciPy.

2.7 Validation of Simulation Results

To validate the simulation results, observed morphometric measurements were compared to simulated values generated using the Monte Carlo method. The goodness-of-fit was evaluated using the root mean square error (RMSE), calculated as:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i-1}^{n}(X - X')^2}$$

where: X_i is the observed morphometric measurement,
X_i' is the simulated morphometric measurement, and
n is the total number of observations.

Lower RMSE values indicate a better fit between observed and simulated data, supporting the reliability of the simulation approach.

3. Results

3.1 Morphometric Measurements

The observed morphometric measurements of *P. elongatus* in this study indicated notable variability in the physical traits of the species, suggesting population adaptability to fluctuating environmental conditions (Table 1). The mean total depth (TD) was 4.42 ± 1.31 cm, and the head length (HL) was 5.07 ± 1.47 cm, showing some variability, which is consistent with reports by Asuauo and Ifon (2021), who found similar variability in morphometric traits in fish populations in the Cross River Estuary. Other traits such as orbital diameter (OD) and mandibular depth (MD) showed smaller ranges of variation with observed means of 0.64 ± 0.20 cm and 1.38 ± 0.42 cm, respectively, aligning with previous research that highlighted a similar trend of low variation in these traits (Nwosu *et al.*, 2010). This variability in morphometric

traits suggests that *P. elongatus* is well-adapted to its habitat and capable of adjusting to minor environmental fluctuations, consistent with the findings of Asuquo and Asangusung (2019), who emphasized the role of morphometric diversity as a tool for understanding population health and adaptability in estuarine species.

Table 1: Comparison of observed and simulated mean morphometric traits of *Pseudotolithus elongatus*

Trait	Observed Mean	Simulated Mean	RMSE	T-Statistic	P-Value
TD	4.42±1.31	4.40±1.28	1.30	0.38	0.70
HD	4.06±1.22	4.07±1.18	1.80	-0.11	0.91
HL	5.07±1.47	5.08±1.43	2.60	-0.59	0.55
OD	0.64±0.20	0.64±0.19	0.00	0.59	0.55
RED	1.63±0.55	1.63±0.53	0.20	1.12	0.26
MW	1.16±0.38	1.16±0.37	0.50	0.56	0.57
MD	1.38±0.42	1.39±0.41	0.10	0.01	0.99
TT	2.24±0.68	2.24±0.66	0.90	0.29	0.77
LPF	3.84±1.02	3.84±0.99	1.50	0.69	0.49
PFW	0.65±0.22	0.65±0.22	0.00	-0.34	0.73
LCP	1.82±0.65	1.82±0.63	1.00	-0.70	0.49
WCP	0.68±0.24	0.69±0.23	0.10	0.23	0.82
DCP	1.29±0.37	1.30±0.36	0.20	-0.15	0.88
LCF	3.66±1.04	3.65±1.01	1.20	0.15	0.88

3.2 Monte Carlo Simulation of Morphometric data

The Monte Carlo simulation results mirrored the observed data closely, showing a high degree of accuracy in replicating the observed morphometric traits (Figure 2). The simulated mean values for traits such as TD and HL were 4.40 ± 1.28 cm and 5.08 ± 1.43 cm, respectively, which were almost identical to the observed data. The low RMSE values observed for OD (0.00) and MD (0.10) indicated an excellent fit between the observed and simulated data, supporting the reliability of the Monte Carlo approach for simulating morphometric variation in fish populations. The RMSE values of other traits, such as HD and MW, were also relatively low, indicating that the model provided accurate simulations. The t-statistics and corresponding p-values confirmed that there were no significant differences between the observed and simulated means, further validating the simulation's reliability. The p-values for HD (0.91) and LCP (0.49), which exceeded the 0.05 threshold for statistical significance, further suggested that the simulated data was a strong representation of the observed data. These findings align with studies by Fullman *et al.* (2021), who demonstrated the application of Monte Carlo simulations in ecological modeling.

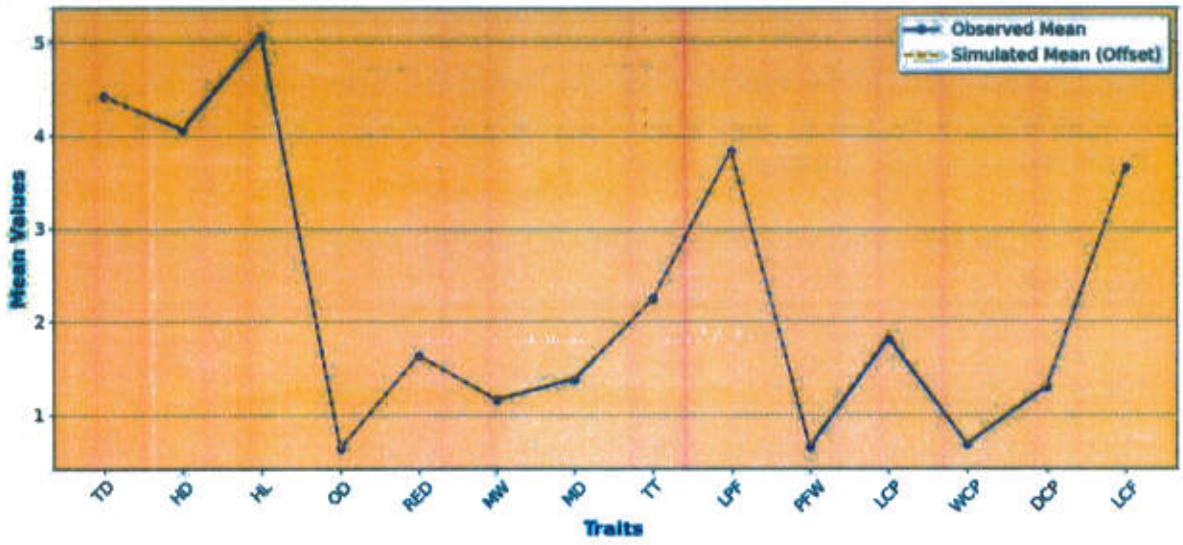

Figure 2: Trends in Observed and Simulated Means for Morphometric Traits of *Pseudotolithus elongatus*

3.3 Morphometric Diversity Using the Coefficient of Variation

The coefficient of variation (CV) was used to quantify morphometric diversity, providing a comparative measure of variability in observed and simulated data (Table 2). For example, the observed CV for TD was 29.71%, and the simulated CV was 28.69%, with a percent difference of 3.42%. Similar trends were observed for other traits, such as HD (observed CV = 29.97%, simulated CV = 29.00%), indicating a relatively high degree of consistency between the observed and simulated data. The largest percent difference was found for HL (5.84%), which suggests that, although the simulation accurately replicated most traits, some level of variability remains in certain characteristics. Conversely, traits such as LCP and MW exhibited minimal percent differences (0.27% and 0.61%, respectively), reflecting strong alignment between the observed and simulated data (Fig. 3). These findings confirm the effectiveness of the Monte Carlo simulation in replicating real-world variability while pinpointing areas where traits show greater divergence, in line with the observations of Opeh *et al.* (2023) and Cronin-Fine *et al.* (2013), who noted that variability in morphometric traits can reveal underlying ecological and genetic dynamics.

Table 2: Comparison of Coefficient of Variation (CV) Between Observed and Simulated Morphometric Traits of *Pseudotolithus elongatus*

Trait	Observed CV (%)	Simulated CV (%)	Percent Difference (%)
TD	29.71	28.69	3.42
HD	29.97	29.00	3.23
HL	28.98	27.29	5.84
OD	30.39	31.13	2.45
RED	33.39	32.64	2.24
MW	32.45	32.25	0.61
MD	30.59	30.50	0.32
TT	30.39	31.71	4.33
LPF	26.50	27.47	3.66

PFW	34.42	33.03	4.03
LCP	35.59	35.49	0.27
WCP	34.54	34.06	1.37
DCP	28.65	27.79	2.99
LCF	28.33	27.95	1.35

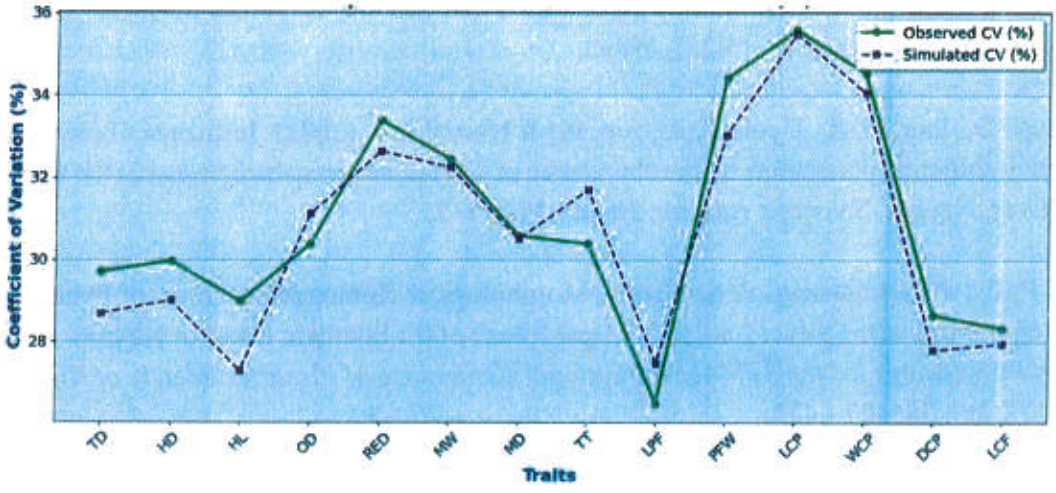

Figure 3: Trends in Observed and Simulated Coefficients of Variation (CV) for Morphometric Traits of *Pseudotolithus elongatus*

3.4 Validation of Simulation Results

The validation of the Monte Carlo simulation results was conducted through the root mean square error (RMSE) and statistical hypothesis testing. The generally low RMSE values across traits, such as HD (1.80) and MW (0.50), indicated that the simulation closely approximated the observed data, confirming its high accuracy. Additionally, the statistical tests (t-tests) yielded p-values greater than 0.05 for all traits, indicating no significant differences between the observed and simulated data. For instance, the p-value for HL was 0.55, while for TD it was 0.70, both supporting the model's accuracy. These findings are consistent with previous studies that have utilized Monte Carlo simulations in ecological modeling, demonstrating their ability to accurately replicate observed patterns in population characteristics (Mode & Gallop, 2007; Alawi & Dutta, 2023). The low RMSE values and non-significant p-values validate the robustness and reliability of the Monte Carlo simulation as an effective tool for simulating the morphometric diversity of *Pseudotolithus elongatus*.

4. Conclusion and Recommendations

This study successfully demonstrated the application of the Monte Carlo approach to simulate the morphometric diversity of *Pseudotolithus elongatus*. The close alignment between observed and simulated data, as validated through statistical testing, underscores the robustness and reliability of this simulation approach in modeling morphometric traits. The simulation approach effectively captured both observed and potential diversity within fish populations. Based on these findings, it is recommended that Monte Carlo simulations be integrated into fisheries management and conservation strategies to enhance assessments of population health and adaptability. Future research should explore incorporating genetic data into morphometric

simulations to offer a more comprehensive perspective on ecological and evolutionary dynamics. Also, continuous monitoring of morphometric traits in natural populations is critical for detecting shifts that may signal environmental changes or stressors.

References

Alawi, Y. A., & Dutta, S. (2023). Assessment of Seabream Fisheries Stock of Oman Using the Monte Carlo Catch Maximum Sustainable Yield and the Bayesian Schaefer Model Methods. *Sustainability*, *15*(22), 15692.

Ama-Abasi, D., Ibor, O. R., Uyoh, E. A., Job, B., & Uwalaka, S. (2022). Influence of physical environmental parameters on the abundance of *Chrysichthys nigrodigitatus* of the Cross River, Nigeria. *Scientific African*, *16* (e01247), 1–7.

Asuquo, P. E., & Asangusung, P. S. (2019). Morphological Homogeneity in some Estuarine Populations of the Silver Catfish in Major Rivers of the Southern Coast of Nigeria. *Book of Proceedings for the 33rd Annual national Conference of Fisheries Society of Nigeria (FISON)*, 78, 427 -.431.

Asuquo, P. E., & Ifon, H. T. (2019). Morphometric adaptation of bobo croaker, *Pseudotolithus elongatus* (Bowdich, 1825) (Sciaenidae) in the Cross-River estuary, Nigeria. *International Journal of Natural and Applied Sciences (IJNAS) 12*, 87 – 92.

Asuquo, P. E., & Ifon, H. T. (2021). Morphological discreteness of the estuarine croaker *Pseudotolithus elongatus* (Teleostei: Sciaenidae). *Journal of Fish Biology*, 100(3), 619 – 624.

Asuquo, P. E., & Ifon, H. T. (2022). The use of Python code scripting in revealing positive allometric growth of the Croaker fish (*Pseudotolithus elongatus*) in the Cross River Estuary. *International Journal of Natural and Applied Sciences (IJNAS)*, 15, 53 – 59.

Cronin-Fine, L., Stockwell, J. D., Whitener, Z. T., Labbe, E. M., Willis, T. V., & Wilson, K. A. (2013). Application of morphometric analysis to identify Alewife stock structure in the Gulf of Maine. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science*, 5, 11–20

Ekpo, P. B., Ekpo, I. P., Ifon, H. T., Eteng, F. J. (2021). Exploring Morphometric Traits of Farm-Reared African Catfish (*Clarias gariepinus*) in the University of Calabar Fish Farm, Nigeria. *International Journal of Natural and Applied Sciences (IJNAS),* 14, 149 – 155.

Emeka, C. N., Emeka, V. I., Akpan, E. B., Essien, N. U., & Nwosu, F. M. (2023). Dry season physicochemical characteristics of a tropical meso-tidal estuary: Cross River Estuary, Southeast Nigeria. *Global Journal of Geological Sciences*, 21, 183-200.

Fullman, T. J., Sullender, B. K., Cameron, M. D., & Joly, K. (2021). Simulation modeling accounts for uncertainty while quantifying ecological effects of development alternatives. *Ecosphere*, *12*(5), 1-24.

Mode, C. J., & Gallop, R. J. (2007). A review on Monte Carlo simulation methods as they apply to mutation and selection as formulated in Wright–Fisher models of evolutionary genetics. *Mathematical Biosciences*, *211*(2), 205–225.

Mulyasari, N., Subaryono, N., Utomo, B. S. B., Taufik, I., Kusmini, I. I., & Yosmaniar, N. (2023). Morphometric and Genetic Characterization of Dominant Fish Species in Progo River, Yogyakarta, Indonesia. *The Scientific World JOURNAL*, *2023*, 1–11.

Nwosu, F. M., Enin, U. I., & Holzlöhner, S. (2010). Assessment of Artisanal Fishery Impacts on West African Croaker Pseudotolithus elongatus in the Cross River Estuary, Nigeria, Using Length-Based Models. *North American Journal of Fisheries Management*, *30*(4), 860–865.

Opeh, P. B., Ifon, H. T., Idung, J. U., Ajang, R. O., & P. J. Asinde (2023). Morphometric Assessment of the Prawn Species (*Macrobrachium macrobrachion* and *M. vollenhovenii*) in the Calabar River, Nigeria. *Book of Proceedings for the 38th Annual national Conference of Fisheries Society of Nigeria (FISON)*, 140, 737 -.741.

Otogo, G. A., Enin, U. I., & Ndome, C. B. (2023). Trophic Modelling of the Cross River Estuary Ecosystem, Nigeria. *Journal of Marine Science Research and Oceanography*, *6*(1), 01–18.

Pokropek, A., Davidov, E., & Schmidt, P. (2019). A Monte Carlo Simulation study to assess the appropriateness of traditional and newer approaches to test for measurement invariance. *Structural Equation Modeling a Multidisciplinary Journal*, *26*(5), 724–744.

Zapfack, L., Ayeni, J. S. O., Besong, S., & Mdaihli, M. (2001). Ethnobotanical survey of the Takamanda forest reserve. https://www.yumpu.com/en/document/view/ Accessed 22nd March, 2024

ACUTE TOXICITY AND ACTIVE INGREDIENTS CONCENTRATION OF DATURA INNOXIA STEM ON CLARIAS GARIEPINUS JUVENILES

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ABSTRACT

Despite the widespread use of Datura innoxia stem in Nigeria for demarcation, gardening and medicine, its toxicity and effectiveness to aquatic species, notably fish, has received little attention. This study was carried out to determine the toxicity, phytochemical and proximate composition of Datura innoxia stem to Clarias gariepinus. The range-finding test was carried out and repeated twice to obtain credible results that could be used in the ultimate test .The toxicant (Datura_ innoxia stem) was introduced at varying concentrations of 300mg, 330mg, 360mg, 390mg and 420mg, respectively in the initial range-finding test; nevertheless, the toxicant was added at different concentrations of 320mg, 330mg, 340mg, 350mg, and 360 milligrams per liter of water (mg/l) in the final test. The median lethal concentration of Datura innoxia stem powder to Clarias gariepinus was determined to be 334.370 mg/L based on the conclusive test. The study found that young Clarias gariepinus exhibited erratic movement at first, rapid opercular movement, skin darkening, and absence of response. Furthermore, the results show that the local composition was within acceptable limits. Among the phytochemicals discovered were steroids, tannins, saponins, phenols, cardiac glycosides, and scopolamine. The water quality data were evaluated using one way Analysis of Variance (ANOVA) with temperature range of 25.27 to 25.35^{0}C, As a result, the study suggests that Datura innoxia stem is hazardous to Clarias gariepinus juveniles.

Keywords: ***Datura_innoxia*** **stem, Acute Toxicity, Lethal Concentration, and Active Ingredients**

INTRODUCTION

Human population is growing rapidly in this period of the green revolution. Construction of homes has taken place in forests, which has negatively impacted the environmental balance (Ullah, 2014). On the other hand, we are faced with a developing and growing problem of contaminants (Klumpp *et al.*, 2002). According to Abu-Darwish *et al.* (2011), these pollutants include household garbage, partially or completely treated industrial effluents, and different substances like pesticides used in agriculture or safety measures. These pollutants are supplemented with different chemicals, pesticides, organic compounds and heavy metals (Jabeen *et al.*, 2011). Many aquatic creatures live in water that has been altered by these compounds (Donohue *et al.*, 2006). These creatures are negatively impacted by the altered

water quality, which can even cause their mortality in situations of extreme exposure and acute concentrations (Sabae *et al.*, 2014). It is impossible to discount the possibility that deteriorating water quality is a significant cause of the drop in fish catches and aquatic productivity. The rise in agricultural operations is mostly to blame for the increased usage and use of pesticides and poisonous plants in Nigerian agriculture today, which significantly contributes to aquatic pollution; and consequently, a decline in water quality. Since fish are among the most widely spread species in aquatic environments, the degree to which environmental pollution in waters has biological effects on them may be indicated by the fish's susceptibility to environmental contamination (Ramesh *et al.,* 2009). Fish are frequently employed as indicators of environmental contamination because of the biochemical changes that they exhibit (Cavas and Ergene-Gözükara, 2005). Fish are also used to assess the health of aquatic ecosystems.

Datura innoxia is a highly toxic plant that belongs to the Solanaceae family. It contains a range of active compounds, such as hyoscyamine, scopolamine, and atropine, which are known to have hallucinogenic and toxic effects (Prado *et al.*, 2009). Understanding the effects of *Datura innoxia* on fish species is critical for maintaining and protecting aquatic environments and the organisms that live within them. *Datura innoxia* is a plant species with a variety of therapeutic characteristics. *Datura innoxia* has long been used in traditional medicine; however, it contains poisonous chemicals that can be harmful to both human and animal health. . *Datura innoxia* is a versatile plant found throughout the tropics; its leaves, seeds, stem, fruits, and roots are economically valuable for industrial and therapeutic purposes. Despite its widespread use in Nigeria for demarcation, gardening, and medicine, the toxicity and effectiveness of the *Datura innoxia* stem to aquatic species, notably fish, has received little study. Fish are frequently utilized as sentinel organisms in ecotoxicological research because they perform a variety of roles in the food chain, collect toxic compounds, and respond to low mutagen quantities (Cavas and Ergene-Gözükara, 2005). As a result, the use of fish biomarkers as indices of the impacts of pollution is increasingly important and can facilitate early diagnosis of aquatic environmental problems (Baser *et al.,* 2003). Acute toxicity experiments help to understand the limiting effects of various substances on organisms (Baser *et al.,* 2003; Svobodova *et al.,* 2003). Because chemical analysis cannot establish the effects of harmful substances on fish or ecological risks, mortality or bioassay trials are the preferred method for assessing their ecological impact. The objective of this study is to determine acute toxicity and active ingredients concentration of *Datura innoxia* stem on *Clarias gariepinus* juveniles.

MATERIALS AND METHODS

The Experimental Site

The experiment took place at the Fish Hatchery Laboratory, Department of Fisheries and Aquaculture, Bayero University, Kano, Nigeria. Kano is located between latitude $12^{0}00$N and 12.000^{0}N and between longitude $8^{0}31$'E and 8.517^{0}E in the Savanna, south of the Sahel. Kano is a major route of the trans-Saharan trade, having been a trade and human settlement for millennia. The State lies in North-West geopolitical zone of Nigeria and shares common borders with Katsina, Jigawa, Kaduna and Plateau State. Kano is a city in northern Nigeria and the capital of Kano State *(Encyclopedia Britannica, 2021).*

Experimental fish

One hundred and Eighty (180) species of *C. gariepinus* (mean weight, 19.56 ± 0.7g and 31.07±1.23g juveniles were used for the study, fish were purchased from a reputable fish farm from Kano, Kano State.

Source and Preparation of *Datura innoxia*

Fresh samples of *D. innoxia* plant were taken from Ankpa Local Government Area of Kogi State. The samples were separated into many components with special emphasis on the stems. The samples were allowed to air - dry to constant weight before being blended to fine powder. The resulting powder were sieved (0.2 mm sieve size)) and stored in air- tight wide mouth bottle for chemical analysis. Exactly 500g of each stored sample was dissolved in 2 litres each of distilled water at room temperature (27 ± 0.3°C) for 24 hours (Omoregie and Onuogwu, 2015). Afterwards, a vacuum pump was used to decant and filter the settled aqueous component via Whitman filter paper (No.1). To prepare them for usage, the filtrates were freeze-dried and kept in a refrigerator at 100°C.

Experimental Design

The experiment was conducted using a completely randomized approach design (CRD). Eighteen (18) plastics tanks, each measuring 60cm by 40cm by 40cm, were utilized. After a thorough cleaning, 20 litres of water were added to the plastic tanks. Each plastic tank has a label on it. Ten fish were allocated each tank after each fish was weighed. A total of 180 young *C. gariepinus* fish were randomized and placed into the aquariums in triplicates with 10 fish in each tank.

Phytochemical Screening of *Datura innoxia* stem powder

Phytochemical screening for key constituents was carried out on *Datura innoxia* stem powder in the Department of Plant Biology, Bayero University, Kano. The *Datura innoxia* stem powder was analyzed for the presence of active components such alkaloid, flavonoid, tannins, saponins, steroids, glycosides and terpenoids following the techniques of Ushie *et al.* (2013).

Range finding test

Following static bioassay, a preliminary 96-hour range finding test was carried out independently for *C. gariepinus* juveniles in order to ascertain the poisonous range of *Datura innoxia* stem to *C. gariepinus* juveniles in accordance with Parrish's (1985) description. In the course of the range finding test, 10 *C. gariepinus* juveniles were individually weighed using a sensitive electronic weighing scale (Mettler Toledo FB602 model) and stocked into the eighteen tanks that were filled with twenty litres of tap water. The stems of *Datura innoxia* weighing 300 mg, 330mg, 360mg, 390mg and 420 mg, respectively were used per litre of water. The LC_{50} of *Datura innoxia* stem was found when test fish were exposed to the plant for 96 hours. The fish's reaction to mild stimuli was utilized as an index of toxicity, and their inability to react to touch was used as an index of death.

Definitive Test

Result from range finding tests offered advice for the concentration level to be used in definitive test. A total of eighteen (18) plastic tanks were filled, each holding twenty litres of water, in order to conduct the final test. A concentration of *Datura innoxia* stem, previously identified through a range finding test, was used to conduct the definitive test. The amounts of *Datura innoxia* stem utilized were 320mg, 330mg, 340mg, 350mg and 360 mg respectively were per litre of water. The sensitive weighing balance was used to prepare the various concentrations. The fish's non-reaction to *Datura innoxia* stem powder was judged to be fatal at 50% of the test organism after 96 hours of exposure, whereas the fish's response to mild stimuli was employed as an indication of toxicity.

Statistical Analysis

Minitab 14 was used to analyze data on the water quality parameters. The mean lethal concentration (LC_{50}) for 96 hours was calculated using probit analysis (Finney, 1971).

Results and Discussion

Table 1 displys the result of water quality values following a 96-hour acute test in which juvenile *Clariasgariepinus* were exposed to *Datura innoxia* stems.

Table 1: Acute toxicity test criteria for experimental units' water quality of *Clarias gariepinus* exposed to *Datura innoxia* stem

S/N	Treatment Mg/L	pH	TEMP (^{0}C)	TDS (ppm)	EC (µS/cm)	DO (mg/L)
1	T0 (control)	6.57±0.01^a	25.27±0.03^{ab}	306.20±0.05^a	613.40±0.10^a	4.57±0.03^c
2	T1 (320)	6.63±0.03^a	25.30±0.06^a	314.52±0.17^b	620.03±0.35^b	4.47±0.01^d
3	T2 (330)	5.87±0.02^b	25.27±0.03^{ab}	320.00±0.05^c	635.00±0.10^c	4.42±0.01^e
4	T3 (340)	5.57±0.03^b	25.32±0.03^b	327.55±0.15^d	650.10±0.31d	4.37±0.00^e
5	T4 (350)	5.33±0.03^b	25.35±0.03^b	365.40±0.28^e	736.80±0.56^e	4.31±0.01^b
6	T5 (360)	4.67±0.02^c	25.27±0.03^{ab}	401.90±0.06^f	799.80±0.12^f	4.18±0.00^a
	P-Value	0.104	0.061	0.001	0.000	0.001

Means along the same column with different superscripts are significantly different *($p<0.05$)*

Dissolved oxygen (DO), total dissolved solids (TDS), temperature (Temp), hydrogen ion concentration (pH), and electrical conductivity (EC).

The test water's physico-chemical characteristics, as determined by the acute toxicity bioassay, fell within acceptable bounds that allowed *C. gariepinus* to survive and grow normally. Therefore, the test water's low water quality could not have caused the fish's behavioural abnormalities or eventual death. According to Badiru's (2005), the ideal pH scale for fish growth (6.67–7.02) used in this study matches the ideal range (6.5–9) for fish production. The dissolved oxygen range for this study (4.18–4.67 mg/L), however, fell within the range of reported by Badi (2005) on the dissolved oxygen scale for warm-water fishes, which indicates slow growth after prolonged exposure (1–5 mg/L). Similarly, Howerton (2001) indicated that the temperature range for this study (25.27°–25.32°C) fells within the typical tropical

temperature range to which fish get acclimated (25° – 32°C). It was noted that both the dissolved oxygen content and pH dropped. The impact of *Datura innoxia* stem powder on the quality of the water may be the cause of this. This is comparable to the *Datura innoxia* root extract research by Ayuba and Ofojekwu (2002); Ayuba *et al.* (2012). Total dissolved solids (TDS) and electrical conductivity (EC) levels were found to be within permissible limits, even though they differed from the control values significantly ($p<0.05$) (Ayuba *et al.*, 2012).

The lack of a statistically significant difference in temperature between the groups may have resulted from *Datura innoxia* not reacting as it would have in an exothermic or endothermic environment. Nevertheless, the concentration of *Datura innoxia* stem decreased with increased concentration, and in general, toxicity increased with reduced oxygen concentration. These findings are consistent with reports from Adigun (2003) and (Ayuba *et al.*, 2012) who reported on other toxicants. The aforementioned statement is consistent with the findings of Warren (1997), who reported that the introduction of a toxicant into an aquatic system may result in a decrease in dissolved oxygen concentration, which will impair respiration and cause asphyxiation. Raised temperature and other physiological states of the fish can be linked to acute fish death, according to Rahman *et al.* (2002), Mekkawy *et al.* (2013), and Isiyaku *et al.* (2015).

Table 2 shows the screening test for the presence of atropine, scopolamine, hyosyamine, alkaloids, saponins, and tannins.

Table 2: Phytochemicals in *Datura innoxia* stem

Parameters	Qualitative Analysis
Scopolamine	+
Steroid	-
Saponins	+++
Atropine	++
Flavonoid	+
Carboxylic acids	-
Terpenoids	++
Tannin	-
Coumarins	-
Essential Oils	+
Phenol	+
Valepotriates	-
Cardiac Glycoside	+

\+ = Present
\- = Absent

The active principles of many drugs found in plants are secondary metabolites (Okeke, (1998). Therefore, basic phytochemical investigation of these extracts for their major phyto constituents is also vital. The presence of saponin, flavonoids, tannin, steroid, cardiac glycosides, total phenol and terpenoids were detected in *Datura innoxia* stem. The presence of saponin which has sedative, anaesthetic as well as medicinal potency as evidenced in the various uses have been reported by Okeke (1998) and Ayuba and Ofojekwu (2005). Isiyaku *et al.* (2022) also reported the presence of some of these substances in the leaves and root bark of tamarind plant. The observed signs of toxicity, including the ultimate mortality in some of the exposed fish might have been due to these substances. This is because of the toxic nature of some of them (Bent, 2004). The observed mortality in some of the exposed fish might have been due to the saponins and tannin content of *Datura innoxia* stem.

Table 3 shows the behavioural changes in *Clarias gariepinus* juveniles after 96-hours exposure at different concentrations of *Datura innoxia* stem.

Table 3: **Behavioural changes in *Clarias gariepinus* juveniles after 96-hours exposure at different concentrations of *Datura innoxia* stem**

Behaviours	Concentration (mg/L)					
	0.00	320	330	340	350	360
Breathing in deeply	-	-	+	+	+	+
Deformation of Barbel	-	-	-	-	-	-
Discoloration	-	-	+	+	+	+
Swimming erratically	-	-	+	+	+	+
Rubbing against plastic tank	-	-	-	+	+	+
Leaping	-	-	+	+	+	+
Resting at bottom	-	+	+	+	+	+
Suspended vertically in water column	-	+	+	+	+	+
Fin deformation	-	-	+	+	+	+

\+ = Present

- = Absent

The behavioral changes found in this study are consistent with the findings of other authors. Fish in exposed groups exhibited hyperactivity for 12 to 24 hours, which may have been an attempt to flee the poisonous environment. When fish are exposed to an unfavorable environment, hyperactivity has been proposed as the key indicator of nervous system failure brought about by *Datura innoxia* poisoning, which impacts physiological and metabolic functions. According to Isiyaku *et al.* (2022), catfish exposed to tamarind exhibited similar behavioural responses, such as increased opercular movement, mucous secretion, jerky movement, floating on the sides, and hypersensitivity exhibiting violent, erratic, and fast swimming. The authors concluded that the fish's abnormal behavior is indicative of the tamarind's toxic effects on the cardiovascular and central nervous systems. The hyperactivity of *C. gariepinus* exposed to datura was also reported by Ayuba *et al.* (2007). This hyperactivity was characterized by rapid and erratic swimming or darting, partial loss of equilibrium, rapid movement of the pectoral fins and opercular, a decrease in feeding activity, bleeding from the fins, and loss of some skin parts. Similar clinical signs, including rapid breathing, were reported by Velisek *et al.* (2010) in rainbow trout poisoning cases involving metribuzin. Table 4 shows the juvenile *Clarias gariepinus's* mortality following 96 hours of exposure to various *Datura innoxia* stem concentrations during the acute test.

Table 4: Mortality of *Clarias gariepinus* juveniles exposed to *Datura innoxia* stem over the 96 hour period

Treatments/ Concentration (mg/L)	Log Concentration	Number Stocked	Mortality							Probit
			12 hrs	24 hrs	48 hrs	72 hrs	96 hrs	Total	%	
T0 (Control)	0	30	0	0	0	0	0	0	0	0
T1 (320)	2.51	30	0	0	3	3	2	8	26.67	4.39
T2 (330)	2.52	30	0	3	5	3	2	13	43.33	4.82
T3 (340)	2.53	30	3	4	5	3	3	18	60	5.25
T4 (350)	2.54	30	6	5	5	2	4	22	73.33	5.61

T5 (360)	2.56	30	9	7	4	3	3	26	86.67	6.13

Result showed that when the concentration of *Datura* stem increased, the mortality rates also became severe in this study. The first mortality was reported 178 minutes after the toxicant was added to the bowl with the greatest amount of mercuric chloride (360 mg/l). This is in line with the findings of Ayuba *et al.* (2007), who observed the first mortality occurring 30 minutes after a toxicant was introduced to *Clarias gariepinus* in an acute concentration of several *Datura innoxia* components. Three hours after the injection of the toxicant, Olaifa *et al.* (2004) reported the first mortality in *Clarias gariepinus* exposed to lethal and sub-lethal concentrations of copper. Datta and Kaviraj (2002); Fafioye *et al.* (2004) and Okomoda *et al.* (2010) reported the first fatality 36 hours after the acute toxicity treatment of *Clarias gariepinus* with synthetic pyrethyroid, Deltamethrin, *Raphia vinifera* extracts and formalin. Guedenon *et al.* (2011) reported the first mortality of *Clarias gariepinus* following 30 hours of treatment with 120 mg/l cadmium sulfate. In comparison to previous studies, the current study appears to have the shortest period of *Clarias gariepinus* resistance. *Clarias gariepinus* has shown high resistance to a number of toxicants (Datta and Kaviraj, 2002; Okomoda *et al.*, 2010; Guedenon *et al.*, 2011; Isiyaku *et al.*, 2015), although; it has extremely low resistance to mercuric chloride. The LC_{50} determined in this study was 334.37mg/l (Fig. 1), which is similar to the value reported by Isiyaku *et al.* (2011) when *Oreochromis niloticus* was exposed to an acute concentration of *Tamarindus indica* seed husk.

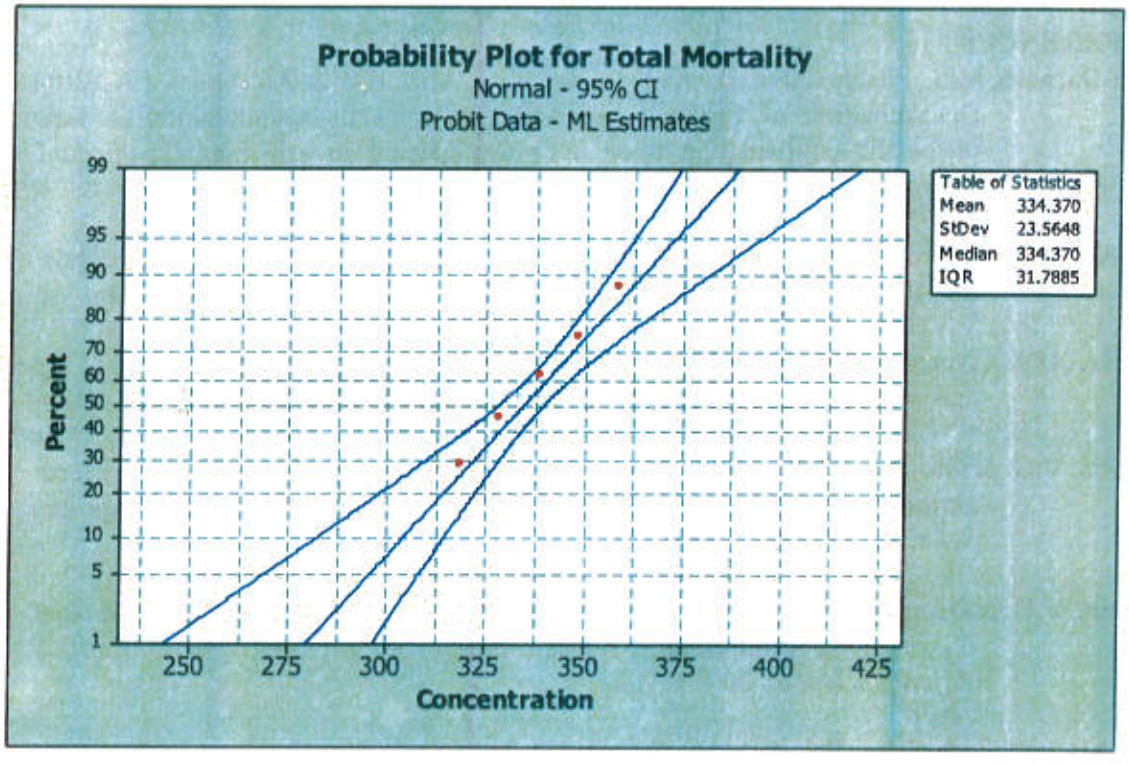

FIG. 1: A linear association exists between mean probit mortality and log concentration of Clarias gariepinus treated to various concentrations of Datura innoxia stem over 96 hours.

Ishikawa *et al.* (2007) determined that the LC_{50} for treating *Oreochromis niloticus* acute mercury toxicity was 0.22 mg/l. This study had the greatest median lethal concentration documented among those reported by earlier workers. Considering, that the chemical product is the same, the variation in the species employed may have contributed to the different outcomes. The LC_{50} discovered in the study, however, was significantly lower than those reported with *Clarias gariepinus* by Ayuba and Ofojikwu (2002); Ezike and Ufodike (2008); Lawson *et al.* (2011); Guedenon *et al.* (2011). These studies reported 204.17 mg/l for *Datura innoxia*, 334 mg/l for gasoline, 129 mg/l for Lindane (Gamma-Hexachloro-cyclohexane), and 46.11 mg/l for cadmium sulphate. The varied compounds and substances employed in the separate studies, as well as the unique ambient conditions, could be the cause of the variations.

CONCLUSION

i. Datura stem powder significantly induced anaemia, leukocytosis and lymphocytosis.
ii. Datura also inhibited the growth and nutrient utilization of *Clarias gariepinus* juveniles.
iii. Aquatic species experience increased stress when their environment is contaminated by toxic plants, whether as a result of acute or long-term events.

RECOMMENDATION

i. The use of Datura stem in agricultural fields should be controlled to prevent possible contamination by leaching into the aquatic environments. In this way aquatic organisms could be protected from these kinds of herbicides.
ii. The indiscriminate use of Datura as well as their use near water bodies should be discouraged. Instead, more environmentally friendly approaches to pest control (such as bio control) should be explored.

REFERENCES

Abu-Darwish, M.S., Al-Fraihat, A.H., Al-Dalain, S.Y.A., Afifi, F.U. & Al-Tabbal, J.A. (2011). Determination of essential oils and heavy metals accumulation in Salvia officinalis cultivated in three intra-raw spacing in ash-shoubak, *Jordanian International Journal of Agricultural Biology* 13(6), 981-985.

AOAC (2005). Association of Official Analytical Chemists. Official methods of Analysis of the AOAC. W. Hortwitz (ed.), 13 edn. Washington: D.C., AOAC, 858Pp

APHA (1998). American Public Health Association Standard methods for examination of water and wastewater. 13th Edition APHA Washington, D.C USA. pp.1254

Ayuba, V.O. & Ofojekwu, P.C. (2002). Acute toxicity of the root extracts of Jimsons Weed *Datura innoxia* to the African catfish *Clarias gariepinus*, *Journals of Aquatic Sciences.* 17(2), 131-133.

Ayuba, V.O. & Ofojekwu, P.C. (2007). Effects of sub-lethal concentration of *Datura innoxia* haematological indices of African catfish, *Clarias gariepinus. Journal Aquatic Sciences.* 20 (2): 113-116.

Ayuba, V.O., Ofojekwu, P.C. & Musa, S.O (2012). Haematological Response and Weight

Changes of the African Catfish *Clariasgariepinus Exposed*To Sub Lethal Concentrations of *Datura innoxia* Root Extract. *PAT December 8 (2): 134-143 ISSN: 0794-5213.* www.patnsukjournal.net/currentissue

Badiru, B. A. (2005). Water Quality Management in Aquaculture and Freshwater Zooplankton Production for Use in Fish Hatcheries. National Institute for Freshwater Fisheries Research, New Bussa, Niger State. Pp.567-678

Baser, K. H. C., Demici, B., Dekebo, A. & Dagne, E., (2003). Essential oils of some Boswellia SPP., Myrrh and Opopamax. *Flavour and Fragrance Journal,* 18, 153-156. DOI: 10.1002/ffj.1166.

Bent, S. (2004). Commonly used herbal medicines in the United States: A review. *The American Journal of Medicine* 116, 478–485.

Cavas, T. & Ergene-Gözükara, S. (2005). Micronucleus test in fish cells, a bioassay for in situ monitoring of genotoxic pollution in the marine environment. *Environmental and Molecular Mutagenesis*, 46, 64-70.

Datta, M. & Kaviraj, A. (2002) Acute Toxicity of Synthetic Pyrethroid Deltamethrin to Freshwater Catfish *Clarias gariepinus, Bulletin.Environment Toxicology,* 70, 296-29.

Ezike, C. &Ufodike.E.B.C (2008). Acute toxicity of petrol to the African catfish *Clariasgariepinus. Annals of research in Nigeria.* 6:1-4.

Fafioye, O. O., Adebisi, S. O. & Fagade, A. A. (2004). Toxicity of *Parkia biglobosa* and *Raphia vinifera* extracts on *Clarias gariepinus* juveniles. *African Journal ofBiotechnology,*3 (11), 137–142.

Finney, D.J. (1971). Statistical methods in biological assay, 2nd Ed. HafnerPub.Co. New York. N.Y. Cambridge University Press, London, England. 68p

Guedenon, P., Edorh, P.A., Hounkpatin, A. S.Y., Alimba, C. G, Ogunkanmi, A. & Boko, M. (2011) Acute Toxicity of Mercury (HgCl2) to African Catfish, *Clarias gariepinus. International Journal of Biology, Chemistry and Science,* 5(6),2497-2501.

Ishikawa, N.M., Ranzani-Paiva, M.J.T. & Lombardi J.V. (2007). Acute toxicity of mercury ($HgCl_2$) to Nile Tilapia, *Oreochromis niloticus, British InstitudePesca*, São Paulo. 33(1), 99 – 104.

Isiyaku, M. S., Laurat, H. T. & Maimunatu, A. (2022). Histopathology of gills and liver tissues of the freshwater fish *Oreochromis niloticus* (Linnaeus 1758) exposed to *Tamarindus indica* seed husk powder. The 37th Annual Conference of the Fisheries Society of Nigeria, held on 30th October to 4th November, 2022 at the Federal College of Education, Yola, Adamawa State.

Isiyaku, M. S., Annune, P. A. & Tiamiyu, L. O. (2015). Acute toxicity and histopathological changes in liver and gill epithelium of African Catfish (*Clarias gariepinus*) exposed to Mercuric Chloride. *Journal of Aquatic Sciences*, 30(2), 329-336.

Jabeen, G, Javed, M. & Azmat, H. (2011). Assessment of heavy metals in the fish collected from the River Ravi, Pakistan. *Pakistan Veterinary Journal*, 32(1), 107-111.

Klump, D. W., Hong, H. S., Humphrey, C., Wang, X. H. & Codi, S. (2002). Toxic contaminants and their biological effects in coastal waters of Xiamen, China. I. Organic pollutants in mussel and fish tissues. *Marine Pollution Bulletin*, 44(8),752-760. DOI: 10.1016/S0025-326X(02)00053-X.

Okeke, P. (1998). Zakami, Haukatayaro: Lataet Drug of Abuse. Drug Force (National Law Enforcement Agency Nigeria), 1st Quarter, 1998, P. 20

Okomoda, J, Ayuba, V. O. & Omeji, S. (2010). Haematological changes of *Clarias gariepinus* (Burchell, 1822), fingerlings exposed to acute toxicity of formalin. *Production Agriculture Technology,* 6,100-109.

Olaifa, F.E., Olaifa, A. K. & Onwude, T.E. (2004). Lethal and sub-lethal effects of copper to the African catfish *(Clarias gariepinus)* juveniles. *African Journal of Biomedical Research,* 8, 65 -70.

Omoregie, E. &.Onuogwu, M. A. (2015). Acute toxicity of water extracts of bark of the Neem plant, *Azadirachta indica* (Lodd) to the cichlid *Tilapia zillii* (Gervais). *Acta Hydrobiology,* 39, 47-51.

Parrish, P.R. (1985). Acute toxicity test. pp 31-57. *In:* M and Petrocelli S.R. (Eds.). Fundamentals of Aquatic Toxicity. Rand G Hemisphere, Publishing Corporation. Washington, DC.

Prado, R., Rioboo, C., Herrero, C. and Cid, A. (2009). The herbicide paraquat induces alterations in the elemental and biochemical composition of non-target micro-algal species. *Chemosphere*, **76:** 1440-1444. DOI: 10.1016/j.chemosphere.2009 .06.003.

Ramesh, M., Srinivasan, R. & Saravanan, M. (2009). Effect of Atrazine (herbicide) on blood parameters of common carp *Cyprinus carpio. African Journal of Environmental Science and Technology,* 3(12), 453 – 458.

Sabae, S.Z., El-Sheekh, M.M., Khalil, M.A., Elshouny, W.A.E. & Badr, H. M. (2014). Seasonal and regional variation of physico-chemical and bacteriological parameters of surface water in El-Bahr ElPherony, Menoufia, Egypt. *World Journal of Fish and Marine Science*, 6(4), 328-335.

Svobodova, Z., Luskova, V., Drastichova, J., Svobodova, M. & Zlabek, V. (2003). Effect of deltamethrin on haematological indices of common carp (*Cyprinus carpio* L.). *Acta Veterinaria Brno*, 72, 79-85. DOI: 10.2754/avb200372010079.

Ullah, R., Zuberi, A., Ullah, S., Ullah, I. & Dawar, F. U. (2014). Cypermethrin induced behavioural and biochemical changes in mahseer, *Tor putitora*. *The Journal of Toxicological Sciences*, 39(6), 829-836.

Ushie, O. A., Adamu, H. M., Abayeh, O. J. & Chindo, I. Y. (2013). Antimicrobial activities of *Chrysophyllum albidum* l eaf extracts. *International Journal of Chemical Sciences,* 6(1), 69-76.

Ushanandini, S., S. Nagaraju. Kumar, K.H., Gowda, V. & Girish, K. S. (2006). The anti.snake venom properties of *Tamarindus indica* seed extract. *Phytotherapy Research*, 20 (10), 851-858.

Velisek, J., Sudova, E., Machova, J.& Svobodova, Z. (2010). Effects of sub-chronic exposure to terbutryn in common carp *(Cyprinus carpio* L.). *Ecotoxicology and Environmental Safety,* 73, 3 84-390.

FOOD, FEEDING HABIT AND CONDITION FACTOR OF *POMADASYS JUBELINI* FROM NSIDUNG BEACH, CALABAR RIVER, NIGERIA.

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ABSTRACT

A Study of the food, feeding habit and condition factor of Pomadasys jubelini, was carried out between the months of August 2023 - October 2023 at Nsidung Beach a tributary of Calabar estuary, Cross River State, Nigeria. The stomach contents of thirty samples caught from the Beach by Artisanal fishermen were examined. 13 specimens of P. jubelini were purchased 10 August, 10 in September and 7 in October. Morphometric parameters (length and weight) were measured. The total mean value for the fish length was 13.20±12.50 cm with the mean weight of 51.20±23.31 g. The largest fish with a length of 19.70 cm (TL) and weight of 86.1 g, was purchased in September, while the smallest fish purchased in October had a length of 7.90 cm (TL) and weighed 19.70 g. The stomach contents of all P. jubelini fish examined revealed that 19 samples (63%) contained food items while 11 samples (36%) had empty content. According to the importance of food index (IRI), the food items identified were; Sardinella sp. (230%), Callinectus amnicola (22.4%) and Macrobranchium sp. (22.6%), Sand grains (17.2%), Ethmalosa fimbriata (11.0%), unidentified plant part (1.4%), hermit crab (0.9%) and Litorrina sp. (0.9%) were the secondary load items consumed by P. jubelini. Macrobranchium sp., sand grain, Sardinella sp. and Callinectus amnicola were frequently observed in the stomachs of the fish samples throughout the study period. E. fimbriata, unidentified plant parts, hermit crab and Littorina sp. were sparingly observed in the stomach of P. jubelini. Condition factor (KF) for P. jubelini ranged between 1.1 and 4.60 with a mean±SD of 2.49±1.14. The highest values were obtained for fish with 8.5 cm length and 28.5 g weight.

Keywords: *P. jubelini*, Stomach content, Food, Condition factor

Introduction

Polymadasys jubelini is a target species exploited by artisanal fishing due to increased indiscriminate fishing, habitat destruction and environmental pollution in Nigeria (Adebola and Mutsert, 2019). The annual catch of the family - *Hacmilldae* increased from 4,902 tonne in 2010 to 8,721 tonne in 2014 and decreased slightly in 2015 to 8,362 tons in Nigeria waters (Olopade *et al.* 2020). Food and feeding habit of fish species is an important process for

aquaculture. *P. jubelini* is important in the riparian community of the Delta of Niger due to its abundance, availability, tasteful flesh, economic and nutritional values (Assan *et al* 2021). The condition factors are important biological parameters for fishes, to assess the health of the fish stock population. Information involving the feeding habit of a fish community is necessary for understanding the feeding ecology of a fish community, food and feeding habit of fish species is an important process for aquaculture (Oribhabor *et al.* 2019).

The present study will advance and enhance our knowledge on the food and feeding habit, condition factor and catch rate of the trophic structure of fish community in the Nigerian coastal ecosystem and contribute valuable information, which is very important for a successful fishery management and aquaculture of *P. jubelini*.

Materials and methods

Description of the study area

The study area, Calabar River (Nsidung Beach), is located approximately at 04°54' 1 5" N and 008'160" E and takes its rise from the Oban Hills. The Calabar River has a shallow depth ranging from 1.0m to 10.Om at flood tide in the navigational channels dredged by the Nigerian Port Authority for sea-going vessels. The river lies in the humid tropical rainforest belt (Aminigbo *et al.* 2022). The area has been reported to be characterized by two major rainfall seasons, the dry season (typically from November to March) and the rainy season (typically from April to October) (Ibebuchi and Abu, 2023).

Sample collection

Freshly caught fish samples were collected from the artisanal fishermen at Nsidung Beach upon landing. They were stored immediately in an ice-chest to prevent the breakdown of consumed diet components due to autolysis (self-cell eating and putrefaction), and then transported to the laboratory for further analysis. Samples were collected for three months between the period of August - October 2023).

Plate 1: Picture of *P. jubelini* (Source: Field survey, 2023).

Laboratory studies

Measurement of the fish length

In the laboratory, measuring board calibrated in cm was used to measure the standard length of each fish to the nearest 0.1cm, beginning from the tip of the snout to the end of caudal peduncle. Each fish length measured were arranged in tabular forms for purpose of marching each correspondence weight of the sampled fish.

Measurement of weight of fish

UNICON top-loaded weighing balance calibrated in grams (RS232 model) to the nearest 0.1g was used to measure each of the weight of the fish.

Extraction and preservation of fish gut

Each sampled specimen guts were removed by cutting open the abdomen of the fish from rectum to oesophagus, with an aid of a pair of pointed nose dissecting scissors. Two ends of the gut were tied up with thread to prevent the discharging of the diet components. Each sampled specimens were preserved separately in 10% formaldehyde solution in sample bottle of 50ml capacity for 3 days prior to analysis.

Analysis of gut content

On the third day, after preservation each gut was cut open and its content washed with tap water and emptied into a petri-dish. The unaided eyes were used to identify macroscopic food items, while a hand lens and a light binocular microscope with magnification of x 10 and x40 objectives were used to identify the microscopic diet components.

Numerical occurrence

The total number of an individual food item in each gut was counted and summed up. This was expressed as the percentage of the total number of all the food items from all the guts examined using formula:

$\%Ra = n/N(I00)$.

Where %Ra is the relative occurrence of each diet component and n is the number of each diet component, while N is the total number of all diet components from all guts examined.

Volumetric occurrence

The food items found in the gut of *P. jubelini* were mixed with specific amount of water in a measuring cylinder to determine the food volume of each gut.

Relative frequency

The number of fish stomachs containing one or more individual food items were recorded to determine the number of stomachs containing a particular food item.

Condition factor (K)

Fulhon's condition actor (C.F) was estimated for individual fish specimens using the formula:

$CF = 100(w)/L^3$ (Ricker, 1971, 1973)

Where CF= condition factor

W = ungulted weight (g)

L^3 = the cubed value of the standard length.

Statistical analysis

Data collected were analyzed using Microsoft Excel (2016 Version). Descriptive statistics determined the Mean ± SD of length (cm), weight (g) and condition factor (K_f) of fish samples collected, while one way Analysis of variance (ANOVA) tested for significant difference in the quantity of food items observed during the sampling period.

Results and discussion

A total of thirty (30) specimens of *P. jubelini* were purchased from the artisanal fishermen during the study period (August - October, 2023). 13 were purchased in August, 10 in September and 7 in October. All 30 fish samples were measured, the morphometric parameters (length and weight) were measured. The total mean value for the fish length was 13.20±12.50 cm with the mean weight of 51.20±23.31 g. The largest fish with a length of 19.70 cm (TL) and weight of 86.1 g, was purchased in September, while the smallest fish purchased in October had a length of 7.90 cm (TL) and weighed 19.70 g. Condition factor (KF) for *P. jubelini* ranged between 1.1 and 4.60 with a mean±SD of 2.49±1.14. The highest values were obtained for fish with 8.5 cm length and 28.5 g weight. The condition factor seemed to increase with decrease in length.

Table 1: Mean±SD of length, weight and condition factor of *P. jubelini* from the study area

Parameters	N	Min	Max	Mean±SD
Total length (cm)	30	7.90	19.70	13.20±12.50
Weight (g)	30	20.20	86.10	51.20±23.31
Condition factor (K_F)	30	1.10	4.60	2.49±1.14

The stomach contents of all *P. jubelini fish* examined revealed that 19 samples (63%) contained food items while 11 samples (36%) had empty content. According to the importance of food index (IRI), the food items identified were; *Sardinella sp.* (230%), *Callinectus amnicola* (22.4%) and *Macrobranchium sp.* (22.6%), Sand grains (17.2%), *Ethmalosa fimbriata* (11.0%), unidentified plant part (1.4%), hermit crab (0.9%) and *Litorrina sp.* (0.9%) were the secondary load items consumed by *P. jubelini. Macrobranchium sp.*, sand grain, *Sardinella sp.* and *Callinectus amnicola* were frequently observed in the stomachs of the fish samples throughout the study period. *E. fimbriata*, unidentified plant parts, hermit crab and *Littorina sp.* were sparingly observed in the stomach of *P. jubelini.* while *E. fimbriata,* unidentified plant parts, hermit crab and *Littorina sp.* were sparingly observed in the stomach of *P. iubelini* (Table 2). Generally, it can be inferred that, these fishes have various degree of selectivity as regards food items. Also, eating food containing both plants and animals makes a species more likely to be omnivorous.

Therefore, the stomach content of *P. jubelini,* reveals this fish species is omnivorous (Oronsaye and Nakpodia, 2005). The wide range of diets for this fish species revels trophic level flexibility, which aids the fish with ecological advantage of effectively foraging in different categories based on food availability (Abiaobo *et al.,* (2020).

Table 2: Percentage composition of various food items found in the stomach of *P. jubelini* in the study area (August – October, 2023)

Food items	RF	%RF	Vo	%Vo	No	%Ra	IRI	%IRI
Sardinella Sp.	6	25.00	3.70	7.90	6	22.20	725.5	23
Littorina sp.	1	4.16	1.50	3.20	1	3.70	28.7	0.9
Macrobranchium sp.	4	16.66	9.60	20.49	6	22.20	711.2	22.6
Callinectus amnicola	4	16.66	11.45	24.43	5	18.50	715.2	22.7
Ethmalosa fimbriata	3	12.50	7.80	16.65	3	11.10	346.9	11.0
Hermit crab	1	4.16	1.71	3.65	1	3.70	30.6	0.9
Unidentified plant part	1	4.66	2.80	5.98	1	3.70	45.1	1.4
Sand grains	4	16.66	8.30	17.70	4	14.80	541.5	17.2
Total	24	100	46.86	100	27	100	3144.7	100

***RF – Relative frequency, V – Volumetric occurrence, No – Numerical occurrence, Ra – Relative occurrence, IRI - Importance of food index.**

Different fish fall into different trophic levels and the ability of *P. jubelini* to expand its dietary spectrum can be to reduce competition (Abiaobo *et al.,* 2024). Analysis of variance (ANOVA) showed there was no significant difference (P>0.05) in the quantities of food items observed during the study period (August – October 2023).

References

Abiaobo, N. O., Akpan, I. I., Asuquo, I. E. & Polycarp, N. A. (2024). Evaluation of dietary choices and feeding behavior of *Pseudotholithus elongates* (B0b0 Croaker) from Jaja Creek, Niger Delta, Nigeria.

Abiaobo, N. O., Asuquo, I. E., Ejiogu, I. N. & Umoren, U. J. (2020). Diets and trophic niches of an amphibious fish from Jaja Creek South Eastern, Nigeria. *American Journal of Biology and Life Science,* 2(5), 122 – 134.

Assan, D., Huang, Y., Mustapha, U. F., Addah, M. N., Li, G. & Chen, H. (2021). Fish feed intake, feeding behavior, and the physiological response of Apelin to fasting and refeeding. 10.3389/fendo.2021.798903

Oronsaye, C. G. & Nakpodia, F. A. A, (2005). Comparative study of the food and feeding habits of *Chrysicthys nigrodigitatus* and *Brycinus nurse* in a tropical river. *Pak. J. Scilnd. Res,* 48(2), 118 – 121.

Ricker, W. E. (1973). Computation and Interpretation of biological statistics of fish populations. *Bulletin of fisheries Board of Canada*, 191, 209 - 210.

Ricker, W.E. (1971). *Methods for assessment of fish production in fresh waters* (2nd Edn), Bluckwell Scientific Oxförd.

Adebola, T. & de Mutsert, Kim. (2019). Investigating Fishing Impacts in Nigerian Coastal Waters Using Marine Trophic Index Analyses. *Marine and Coastal Fisheries Dynamics, Management and Ecosystem Science,* 11(4), 287 - 294.

Olopade, O.A., Dienye, H. E. & Okonkwo, C. C. (2020). Biometric Indices and Condition factors of Pomadasys jubelini (Cuvier, 1830) from Obuama Creek, Nigeria. *ILMU KELAUTAN Indonesian Journal of Marine Sciences,* 25(2), 45 – 52.

Oribhabor, B. J., Akpan, A. E. & David, G. S. (2019). The Food and Feeding Habits of Fishes of a Coastal Nigeria River. *Scientific Research Journal (SCIRJ),* 7(9), 43 – 63.

Aminigbo. L. M. O., Abali, T. & Inko-Tariah, I. (2022). Comparative analysis of Climate and Land use change patterns in Calabar River Basin, South-eastern Nigeria. *Journal of Social Sciences Advancement,* 3(1), 20 – 32.

Ibebuchi, C. C. & Abu, I. O. (2023). Rainfall variability patterns in Nigeria during the rainy season. *Scientific Reports,* 13(7888), https://doi.org/10.1038/s41598-023-34970-7

FOOD SECURITY: ACCELERATED FISHERIES DEVELOPMENT AND PRODUCTION PROGRAMME IN NIGERIA

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ABSTRACT

Fish as an important source of protein to man and livestock is explained and articulated. Fisheries activities have been a major service of income and livelihood for many especially people in rural areas. Fisheries activities as originally developed in Nigeria have their peculiar characteristics. The problems, constraints and likely solutions are highlighted. Recommendations are made for sustainable fisheries activities in Nigeria. It is known that fisheries activities and business are capable of increasing the wellbeing of individual fishers and the Gross Domestic Product (GDP) of Nigeria to achieving substantially the country's unemployment problems and support Federal Government's agenda on food security for all Nigerians.

Keywords: Nigeria fishing industry, artisanal fishery, industrial fishery, aquaculture.

INTRODUCTION

FAO (2020) Annual report stated that Nigerian's current fish production stands at 0.8 Million metric tons with a deficit of 1.9 Million metric tons as local demand for fish is 2.7 Million tons annually, and according to CBN (2021) $1.2 Billion worth of fish is being imported into the country annually. The FAO Country Profile (2017) stated that Nigeria with an estimated annual *per caput* fish consumption of 13.3kg in 2015, fish is an important dietary element and one of the sources of animal protein available to many Nigerians. In 2015, the total fisheries production was estimated at 1,027,000T, in which marine catches contributed 36%, inland waters catches (33%) and aquaculture (31%) (FAO, 2017). Ozigbo *et. al.* (2014) and Amosu *et. al.* citing FDF (2008) showed that fishery sector projected a contribution of 0.5% of national GDP in 2015 and with fish demand of 2,055.000T whereas the projected fish supply was 671.492T, leaving a deficit of 1.444.700T (Table 1). This assertion was further explained by FAO Country Profile (2017) that with total fish imports amounting to about USD 1.2 billion and exports valued at USD 284390 million in 2013, Nigeria is a net importer of fishery products. In 2014, about 713,036 fishers were engaged in inland fisheries of which 21% were women, while 15% of the total of 764,615 people engaged in other fisheries were women, suggesting fishing as a major source of livelihood. More than 80 percent of Nigeria's total domestic production is generated by artisanal small-scale fishers from coastal, inshore, creeks of the Niger Delta, lagoons, inland rivers and lakes. National Food Security in Nigeria suggests that Nigeria has some development plans towards fishery but the manner and nature of the development is the critical factor for discussion. FAO/UNDP (1984) and Motwani (1990) had already explained the importance of fish as food and source of animal protein to man. Ajayi and Talabi (1984) observed that fish will continue to be important to man in view of the deterioration in the livestock production due

to feed scarcity, Sahelian drought, desert encroachment, rinderpest and other animal disease outbreaks, and most recently the devastating banditry and insecurity situation in the North East and North West Nigeria and other areas. the short fall greatly impacted to many Nigerians. Concerted efforts made by Government, International /Local organizations and Fisheries Professional including Artisanal Fisheries Development Project; National Accelerated Fish Production. These efforts were made, quite laudable but with poor conception and implementation, could not achieve their objectives. Consequently, fisheries development has remained at a very low level, fishing and fishing communities are amongst the Nigeria's poorest population. This situation has persisted because artisanal fishers are getting low income for their production and are paying higher prices for the goods and services. The fishing communities being in the remote places, their settlement is difficult to access, same to credit and markets outlay. Inflation has further affected the fishing community as cost of fish is not proportion as the commodities which the fishers buy. Most recently, the globally acclaimed climate change leading to unprecedented upwelling phenomena has resulted in severe damage to fish-breeding, nursery and fishing grounds. This results to depletion of fish stock and consequently reduction of the limited income available to the fishers. Many fishers are not able to repair or replace their tools due to lack of financial resources limiting the activities of the fishers and leading to reduction in fish production. Consequently, the income generating capacity of the entire fishing communities is affected, the fishers remain in perpetual poverty circle. To break this circle, there is need for greater efforts and attention by all stakeholders needs no emphasize

Table 1: Projected Human Population, Fish Demand and Supply in Nigeria (2000 – 2020)

Year	Projected Population (Million)	Projected Fish Demand (Tonnes)	Projected Domestic Fish Supply (Tonnes)	Deficit (Tonnes)
2000	114.4	1,430.00	467.098	962.902
2001	117.6	1,470.00	480.163	984.836
2002	121.0	1,412.50	507.928	1,004.572
2003	124.4	1,555.00	522.627	1,063.082
2004	128.0	1,600.00	536.917	1,063.072
2005	131.5	1,643.75	552.433	1,091.317
2006	135.3	1,691.25	567.948	1,23.301
2007	139.1	1,732.75	583.872	1,154.873
2008	143.0	1,782.30	600.612	1,186.887
2009	147.1	1,838.75	617.353	1,221.397
2010	151.2	1,810.00	634.500	1,255.440
2011	155.5	1,943.75	652.606	1,291.143
2012	160.0	2,000.00	689.958	1,328.508
2013	164.0	2,113.75	709.683	1,365.042
2014	169.1	2,175.00	730.248	1,404.067
2015	174.0	2,055.00	671.492	1,444.752
2016	178.9	2,200.00	678.500	1,521.500

2017	183.1	2,410.00.	690.400	1,719.600
2018	188.9	2,500.00	710.200	1,789.800
2019	193.2	2,610.00	750.105	1,859.859
2020	198.5	2,700.00	770.950	1,929.050

Source: (FDF, 2008) (Tonnes x 1000) (Culled from Ozigbo *et al.*, 2014).

THE STRUCTURE AND FEATURES OF THE NIGERIAN FISHING INDUSTRY

Fishery Development (General Nature of Fishing Business)

Business enterprises vary in needs and mode of operation. Fishing business especially at the artisanal level has some peculiarities which distinguish it from most agricultural enterprise. The majority of fishers are well down below the poverty line, Resources available are mobile and seasonal, Production circle is very short, Operational base is usually in remote areas, Resources are easily affected by change in the environment, Production outputs are difficult to predict, Cost of operational inputs do not commensurate with cost of output. Therefore, attention should be given to fishers keeping with their generally weak economic position and special needs, the poverty in fishing communities and general low level of education. This means that a considerable

development component including education, rural infrastructure and extension services especially those aimed at providing social services are inevitable. Hence, the institutional assistance to be offered to the fishers should be need-oriented, flexible, timely and simple.

Artisanal Fishery

This consists of small sub-sector fisheries in the riverine, lacustrine, lagoon and inshore canoe fisheries. With reference to its nature, the following are its peculiarities and the problems limiting investment in the sub-sector.

Inadequate Information: Lack of accurate and reliable statistical information about the potential in the sub-sector limits banks financial exposure to the sub-sector, unlike the crops and livestock sub-sectors or the manufacturing sectors of the economy, were information is readily available. The dearth of information makes it difficult to estimate the return on fishery investment. Similarly, updated fishery statistics and stock potential is not known, hence projection becomes difficult and long-term investment is discouraged.

Mobility: Artisanal fishers are itinerant in nature because they migrate with the seasons, water movement and schools of fish. This makes it difficult for banks to get them settled for the purpose of credit delivery. The high mobility also creates the fear of high risk of default since it will be difficult to serve a demand note on a fisher whose loan is due for repayment.

Remoteness of Fishing Villages: Fishing villages are mostly found along the coastlines and riverine areas, without social and economic infrastructures which could attract establishment of bank branches in the areas. Until these villages are opened up, the cost and risk of establishing bank branches, will be too high for conventional banks to bear.

Lack of Collateral: Artisanal fishing is characterized by low level of operations, low income and saving which limit capital formation for acquisition of fixed asset as collateral for loans. Without collateral, bank loans and advances carry a high risk and create a discouraging environment for banks to operate. The fisher's equipment (boat and engines) are highly mobile and bear high risk of loss which render them unattractive for institutionalized supplier of credit as a form of collateral.

Monitoring of Loans: Fishers are dispersed in rural and remote areas making monitoring making monitoring of loans difficult and costly in terms of administrative expenses.

Industrial Fishery

With reference to its nature, the following are its peculiarities and the problems limiting investment in the sub-sector.

Resource Information: Nigeria has access to a 200 nautical miles Exclusion Economic Zone (EEZ) in addition to its territorial water (Ajayi, 1992). The 200 nautical miles Exclusive Economic Zone within which Nigeria has absolute jurisdiction over all the resources covers a 332 miles (667km) coastline, about 192,000km^{2}in area. Ajayi and Talabi (1984), Onwuka (1988) observed that adjourning this 667km coastline are the Niger Delta and extensive brackish waters through which the numerous rivers and their tributaries drain into the Gulf of Guinea. However, there is no accurate information about the resources available in these waters. This dearth of information is a disincentive to investment in trawler fishery especially where financial institutions are expected to contribute substantial proportion of the capital required. For instance, in the past few years, there are conflicting reports on the resource stock of the territorial waters and the EEZ. There is no reliable data on Maximum Sustainable Yield and fishing effort in the water to guide investment, Gulland and Carroz (1968). The subsector is characterized by high capital outlay on vessels, nets and cold storages, effective and efficient market distribution network, advanced technology application requiring the employment of highly trained and experienced manpower, high maintenance and operational costs, foreign exchange outflow and generation, local and foreign market oriented.

Lack of Manpower: Deep Sea Fisheries Project is a sophisticated operation requiring high capital outlay and high caliber of multi-disciplinary management for efficient performance. Credit analysis for loan purpose requires bankers who are specialists in sea fisheries management.

Provision of Security: The high cost of fishing trawlers calls for multi-million naira loans to finance deep-sea fishery projects, hence syndication among banks. However, clients benefiting from such loans often find it difficult to float adequate security to secure such loans. Thus banks have no option other than take a lien on the vessels procured with such loans, in spite of the attendant problems in such arrangement.

Aquaculture

Tobor (1990) stated that fish culture has not hitherto been classified as a major sector of the Nigerian fishing industry presumably because of three reasons:

v. Low contribution to domestic fish production averaging only 24,000 tonnes annually (Okpanefe, 1982).

vi. Slow growth rate and development efforts in spite of the fact that the first attempt at the culture of fish started in 1942 (Longhurst, 1961).

vii. Until recent years, in the late 1980s, studies in fish culture practices in Nigeria have not been able to demonstrate convincingly the economic viability of this sector either to attract potential entrepreneurs or make impact on the rural economic. Despite this, Tobor (1984, 1985 and 1990) and Ozigbo *et al.* (2014) stated that fish culture has the potential of contributing not only to the food security agenda of Government but also a major source of foreign exchange earnings and employment generation. Ozigbo *et al.* (2014) presents a critical review of aquaculture production and management in Nigeria and explains that it is essential to implement and follow good aquaculture management practices to ensure quality and quantity yield. The report also showed that in aquaculture there is the problem of shortage of pond construction engineers to undertake pond construction and landscaping of fish farms. Fish-seed propagation system is poor and fish-feed is very expensive. Hence, aquaculture is an expensive business in Nigeria. Again Ozigbo *et al.* (2014) quoting Olagunju *et al.* (2007) made a case for greater attention for aquaculture development in Nigeria and showed that in terms of economic and trade, aquaculture makes a minor contribute to overall fish and protein supply, and the country's GDP, attributing this to emerging nature of the sector when compared with agriculture and fisheries. Ozigbo *et al.* (2014) also observed that agriculture's contribution to GDP between 1999 and 2002 was 34% while aquaculture contributed only 0.154% within the same period.

GENERAL CHARACTERISTICS OF RURAL FISHERY DEVELOPMENT

As opposed to the advanced urban economies, fishery projects in rural economies are characterized by:

i. Less priority by the government

– This means that the policy set-up is not conducive for rural development. There is an inadequate financial support from government and in most cases, a bureaucratic tendency and misappropriation of funds hinder the achievement of the intended goals at grass root level.

a. Illiteracy – this means lack of needed basic managerial skills to sustain projects that are initiated, technological and entrepreneurial skills to maximize production, expand the markets and maximize profit.

iii. Subsistence farming – this relates to farming that is good only for family consumption and is done with less technology if not totally in manual labour.

iv. Poorer or complete lack of infrastructure/facilities – this means lack of communication facilities, transportation facilities (e.g. roads, rail, etc.).

v. Donor Dependency Syndrome – this means the people are dependent on donation and do not have capital on their own which minimizes quality and quantity and hence deterioration in profit.

vi. Poor quality of life – this means poor/lack of health facilities, education, clean water and sometimes poor food and feeding habits.

vii. Unfavorable market conditions – products are sold in a raw state without further processing, which may result to less income.

viii. Inferiority complex – this means that some rural people do not take their own initiative to develop themselves but they only wait for somebody because they believe they cannot

do it even if they can. They rely mostly on middlemen for exchange of goods and services.

ix. Resistance to change – this means they do not want to adopt new ideas, methods/ technologies which are for the betterment of their lives but rather stay on the old and obsolete way of living and doing things.

These characteristics continue to cause economic imbalance between the urban and rural areas, causing vicious circle of poverty in the rural areas and influx of people in the urban areas. This influx to urban areas leads to lack of jobs, homeless people, increase in crime, health hazards.

PROBLEMS OF FISHERIES DEVELOPMENT

Under-Utilization of Research Findings and Developed Technologies:

There are research findings with great potentials for the development of the fisheries and increase in fish production and availability to consumers. Private sector inertia to take up and use some of these findings is a major setback. Some of these findings are in the areas of unexploited fishery resources like tuna and tuna-like fishery, the production of fish meal and feeds, and other fishery products, propagation and transportation of fish seed, fish preservation and fishing gear designs and fabrication. There are also other factors including: Weak and ineffective extension services for transfer of research results to end users, existence of weak linkage between researchers and end users. Researchers and development officers who interact regularly with end users are under the control of different government agencies and approximately 80-90% of end users of research results and new technologies have no access to published information.

Wrong Investment Decisions:

There was disproportionate emphasis on the development of capture fisheries at the expense of fish culture in allocation of funds. This situation probably arose out of the ignorance of the fact that fish culture has a greater potential than capture fisheries in rapidly achieving increase in fish production. Post-harvest loss is negligible in fish culture since the fish farmer controls the time and quantity of fish he wants to harvest from his ponds as dictated by market situation. Equally neglected were riverine fisheries both in research and development efforts; a situation which has led to lack of adequate scientific knowledge of the fisheries of many rivers in Nigeria.

Faulty Implementation Machinery: Fisheries development projects are mostly components of rural development, but their implementation machinery is heavily concentrated in the hand of officers based at State capitals (Talabi, 1984). Since rural communities are the focus of fisheries development, they should be involved fully in the planning and implementation of projects that affect their well-being. Rural communities are at present regarded only as recipients of fisheries inputs with little or no responsibility of the implementation of fisheries development plans.

Shortage of Trained Manpower: There is acute shortage of trained manpower for successful implementation of key projects in aquaculture, fishing technology, resources management and administration. Experienced and trained personnel are also lacking in vessels operation and maintenance.

Shortage of Funds: Most development projects were not completed before the flow of funds dried up. The resultant unanticipated disruption of project execution limits the level of achievement of plan objective. In no time, the project dies a natural death.

Poor Statistics: Available data on the extent of resources in the vast inland waters and on catches, number of fishers, boats and gear types are not reliable enough to permit formulation of realistic development projects for the achievement of the needed level of increased fish production.

Escalating Cost of Fishing Inputs and Vessels: The fishing industry relies heavily on imported inputs including fishing nets and accessories, out-board and in-board engines and their spare parts. Inflation has escalated prices far beyond the reach of entrepreneurs. Maintenance of vessels presents an acute problem as spare parts must be imported at great costs by importers. Since inputs are not available locally, there is also long delay before they are brought into the country. The delay results in heavy loss of fishing days thereby contributing to reduced production of fish. The small scale fishers who contribute over 96% to domestic fish production are hardest hit. They can no longer afford new out-board engines or replace their old and worn-out nets. Coupled with reduced government subsidy, the small-scale industry is slowly experiencing a decline.

Fish Depletion in the Inland Waters:

Indiscriminate fishing methods e.g. use of non-selective traps, set nets and poisons in the inland waters have led to serious depletion of fish stocks (Abowei and Davies, 2009, Abowei *et al.*, 2010). The case of dams and effect on fish resources are cases for mention. Most dams were built with no provision of fish to and from breeding and feeding grounds located on either side of the dams. Species which are unable to adjust to the pattern of behaviour will naturally be unable to respond positively to natural and fishing mortalities (NEDCO, 1961; NDES, 2002; IUCN, 2013; Osuamkpe, 2014). The fish may eventually become extinct. The cases of Kainji Lake and Lake Chad are reference points. Shallow Lake Chad has lost most of its fishing grounds subjecting fishers to constant migration in search of fish. Efforts to stock reservoirs with fish fingerlings have not been successful. In aquaculture, inadequacy of fish seeds, scarcity of fish feed, cost of hiring bull-dozers and non-availability of suitable land are the major problems of fish farmers.

SOLUTIONS TO IMPROVED FISHERY DEVELOPMENT

The implementation of the following measures can achieve rapid increase in fish production.

1. Encourage fish farmers to acquire skills for artificial propagation of fish seeds, collection and transportation of fish fry and fingerlings from the wild to fish farms. The idea is to make fish farmers less dependent on official sources of fish fingerlings and feeds and aggressive aquaculture programme all over the country. Already, FDF and ADP have done remarkably well by creating awareness in rural communities of the great potentials of aquaculture for increased fish production, employment and revenue generation. This will make for the encouragement and use of local government for development plans and of the great potentials of aquaculture for increased fish production, employment and revenue generation. This will make for the encouragement and use of local government for development plans and implementation of aquaculture programmes.

Intensify research into cage and pen culture of fish nation-wide.

ii. Promote and encourage investments in fish meal and fish feed production. Acute shortage of feeds is a major problem in aquaculture in the country.

iii. Promote the expansion of industrial fishing from inshore to offshore waters for the exploitation of under or un-exploited fishery resources and the promotion and establishment of large scale subsidiary industries for the manufacture of netting materials of various specifications, floats, sinkers, engine spare parts, etc.

iv. Encourage private sector investment in small scale fisheries e.g. in Bonga and *Sardinella* fisheries. Bonga and Sardinella can be canned as demonstrated at the Nigerian Institute of Oceanography and Marine Research, Lagos. In time of glut, several tones of the Bonga are lost to spoilage. This can be prevented by canning the fish.

v. Promote the designs of suitable small fishing crafts which can be motorized and made capable to accommodate ice for inland fisheries. The use of ice will reduce spoilage of catch before landing.

vi. Intensify manpower training and development, at all levels for the fishing industry

vii. Intensify research into fish preservation and utilization to increase supply to consumer

viii. Establish fresh water fish sanctuaries in perennial bodies of water to preserve important fish species such as *Gymnarchus niloticus, Malapterurus* spp, *Clarotes* spp, *Heterobranchus bidorsalis, Lates niloticus, Labeo* spp, *Distichodus niloticus, Ophiocepalus obscurus, Heterotis niloticus, Bagrus* spp. and *Hydrocynus* spp.

PROSPECTS

The reports of Ozigbo *et al.* (2014) showed that Nigeria is a nation endowed with good natural resources which can enhance aquaculture development to a greater extent. Fisheries benefit to man are numerous: it fulfills protein demand both at individual and national levels, helps prevent food insecurity, creates jobs which settle the unemployment issue, generate income for individuals, serves as recreation centers for relaxation, can attract foreign exchange capable of increasing the country's GDP. Government has introduced many intervention schemes including National Accelerated Fish Production, the Bank of Agriculture for provision of credit to fish farmers at subsidies rate, Infrastructural Rural Development for access to fish farm. All these schemes are geared towards sustainability of the fisheries subsector.

CONCLUSION AND RECOMMENDATION

The development of fishery in Nigeria should be given urgent attention by all stakeholders

especially, the government through proper policy thrust and budgetary allocations; the organized private sector by way of direct investment through jointventures, and banks through increase investment by way of equity participation, loan and advances. In order to solve the problem of inadequate information which presently limiting the extent of bank's participation in fishery development, the research institutes should intensify the reach-out activities and make available to banks the results of their finding to guide in investment decision making. The government through the Central Bank of Nigeria should direct Commercial Banks to open rural branches in the fishing villages.

It is suggested that banks should design special credit delivery packages to serve the interest of artisanal fishers. It is our contention that the Bank of Agricultural should be strengthened to further enhance its performance in the fishery sub-sector. This could be done through federal government Anchor-Borrowers loan scheme to the practitioners in the fishery business. The problem of shortage of manpower could be solved if banks recruit fisheries specialists who are trained in the art of banking. This is necessary in view of the difficulty in perfecting bank loans in fisheries activities. The efforts of the banks in this respect can be complemented by getting the institutions that train fisheries personnel to introduce courses in banking and related fields in their programmes. Implementation of these recommendations will ensure sustainability of fisheries development in Nigeria.

REFERENCES

Abowei, J. F. N. and Davies, O. A. (2009). Aspects of *Sphyraena barracuda* (Wallbaum, 1992). Population Dynamics from the fresh water Reaches of Lower Nun River, Niger Delta, Nigeria: Current Research *Journal of Biological Sciences* 1(1): 21 – 27 (2009).

Abowei, J. F. N; George, A. D. I. and Davies O. A. (2010). Mortality, Exploitation Rate and Recruitment Pattern of *Callinectes amnicola* (De Rochebrune, 1883) from Okpoka Creek, Niger Delta, Nigeria. *Asian Journal of Agricultural Sciences,* 2(1): 27 – 34.

Ajayi, T. O. (1992). The maximum sustainable yield of the inshore fish and Shrimp resources of the Nigerian continental shelf, *J. Fish Biol*, 20: 571-577.

Ajayi, T. O. and Talabi, S. O. (1984). The Potentials and Strategies for optimum utilization of the Fisheries Resources of Nigeria. NIOMR Tech. Pap. No. 18 (1984).

Amosu, A.O; Hammed, M; Adenyi, K.T; Olabode, O.J (2017): Possible Aquaculture development in Nigeria: for Commercial Prospects. Journal of Agricultural Science and Technology B7 (3) DIO:10.17265/2161-6264/2017:03.007

FAO(2017). Food and Agricultural Organization of the United Nations (Fishery and Aquaculture Country Profile, Nigeria). 2017

FAO/UNDP (1984). Food and Agricultural Organization/United Nations Development Programme. Paper Presented at the Expert Consultation on the Regulation of Fishing (Effort Mortality): A Preparatory Meeting for the FAO World Conference on Fisheries Management and Development. *FAO Fish. Rep.* (289)2: 214.

FDF (2008). Federal Department of Fisheries. Fisheries Statistics of Nigeria Projected Human Population; Fish Demand and Supply in Nigeria from 2000 – 2020. 56p.

Gulland, J. A. and Carroz, U. T. (1968). Advance in Marine Biology Volume 6: Management of Fisheries Resources (pp 1- 71).

Longhurst, A. R. (1961). Report on the fisheries of Nigeria. Ministry Economic Development, Lagos.

Motwani, M. P. (1990). FAO Report to the Government of Nigeria at the Fishery investigations on the Niger and Benue Rivers within the Northern area and improvement of a programme of riverine fishery management and education. FAO/UNDP Rep. No TA 2771, Rome, 196Pp

NDES (2002). Niger-Delta Environment Survey: Part 2 Report: Biological characteristics.

NEDECO (1961). Netherlands Engineering Consultant: the waters of the Niger-Delta, Report of an investigation by NEDECO, the Hague, Netherlands, Pp 210-228.

Okpanefe, M. O. (1982). Demand analysis for Nigerian Fisheries. Proc. 2nd Ann. Conf. FISON. 25-27 January 1982 Pp 193 – 206.

Olagunju, F. I., Adesiyan, I. O. and Ezekiel A. A. (2007). Economic viability of Cat Fish Production in Oyo State, Nigeria. *J. Hum. Ecol.*, 21(2):121 – 124.

Ozigbo, E., Anyadike, C., Adegbite, O. and Kolawole, P. (2014). Review of Aquaculture Production and Management in Nigeria. *American Journal of Experimental Agriculture*, 4(10): 1137-1157

Talabi, S. O. (1984). Management of Nigeria's fishery resources towards self – sufficiency (An individual development project submitted to ASCON, Topo Badagry as part of the Advanced Management Course AMC 9/84.

Tobor, J. G. (1984). A review of the fishing industry in Nigeria and status of fish preservation methods and future growth pre-requisites to cope with anticipated increase in production NIOMR Tech. Pap. No. 17.

Tobor, J. G. (1985). A review and appraisal of fisheries development efforts in Nigeria. 1985 Conference proceedings of FISON, pp 78 – 88.

Tobor, J.G. (1990). The Fishing Industry in Nigeria-Status and Potential for Self Sufficiency in Fish Production. NIOMR Technical Paper No. 54.

IMPACT OF COMMERCIAL AGRICULTURE ON THE PRODUCTIVITY OF RURAL FARMERS IN NIGERIA: AN EVALUATION OF COMMERCIAL AGRICULTURAL DEVELOPMENT PROJECT.

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Abstract

This study examined the impact of the Commercial Agriculture Development Project (CADP) on the productivity of farmers in Nigeria. Specifically, it estimated the determinants of productivity among households and the impacts on beneficiaries and non-beneficiaries of the project, Using multi-stage sampling technique, secondary data were collected in the five participating states (Cross River, Enugu and Lagos in the South; Kaduna and Kano States in the North). The tools used for data analysis included descriptive statistics, Total Factor Productivity (TFP), and Tobit regression models. The Average Treatment Effect on the Treated (ATT) had a positive coefficient of 0.375. The mean TFP for CADPB at the endline (2016) is 0.922 with a standard deviation of 2.106, while that of NCADPB at the same point in time is 0.615 with a standard deviation 1.449. The study recommends that policy measures should be oriented towards improving access of farmers to land and credit facilities as well as encourage the optimal use of resources provided to farmers as grant but in real terms, it is loan to the state and federal government.

Key words: Total Factor Productivity, Commercial Agriculture

Introduction

Agriculture remains the bedrock of developing economies, contributing about 4.3 percent of global gross domestic product (GDP), 17.3 percent to Sub-Saharan GDP and 23.7 percent to the GDP of Nigeria, World Bank (2023). Based on this, development practitioners are comfortable to say that the sustainable growth of agriculture remains one of the most effective tools to achieve the SDG goals of ending extreme poverty, boost shared prosperity and feed a projected 9.7 billion people by 2050, World Bank, (2019). Worrisomely, the productivity in agricultural sector has continued to fall short of expectations (Food & Agricultural Organization FAO 2002). Evidence from the Global Agricultural Productivity Report (2023) shows that, the global productivity index is 1.14 percent against a projected annual Total Factor Productivity (TFP) growth of 1.73 percent. while that of Sub-Saharan Africa and low-income countries (where Nigeria is categorized) is 0.18 percent and 0.11 percent respectively within the 2011-2021 period, USDA Economic Research Service (2023).

The agricultural sector has lagged behind even though the sector employed about two-thirds of Nigeria's total labor-force (a key production resource). Over the years however, the performance of this important sector had been characterized by sluggish productivity growth

due to multiple factors. Some of these factors are; under-investment in new technology, slow adoption of improved technologies, constraints associated with the investment climate, and poor infrastructure.

As a result, most developing countries including Nigeria, have considered it a top priority in their development plans to include activities that can bring about increase productivity of the agricultural sector. In this light, there have been many large-scale commercial investments in the sector by well- meaning governments, donor organizations and even the private sector. One of these interventions is the Commercial Agricultural Development Project (CADP) funded by the World Bank in Nigeria. The development objectives of CADP as reflected in the CADP Project Appraisal Document (2009) had specific information on targeted value chains: i) to strengthen agricultural production systems, ii) to facilitate access to markets for small and medium scale commercial farmers engaged in targeted agricultural value chains which include aquaculture, cocoa, dairy, fruit trees, maize, palm oil, poultry and rice in the participating states. The states that participated in the Project were: Cross River, Enugu, Kaduna, Kano and Lagos; each state representing different geo-political and ecological zones to demonstrate the practicability of commercial agriculture in Nigeria.

As highlighted above, agricultural productivity is germane for the enhancement of economic growth and development as well as poverty reduction of any country with huge rural population. Thus, this may have informed studies on socioeconomic and institutional triggers of agricultural productivity to enhance development policies and growth options. A review of relevant literature shows that, there are studies on the determinants of crop productivity in Nigeria (Verter, 2015; Samson and Obademi, 2018), impact of commercialization of agriculture on agricultural productivity and welfare measures such as food security, poverty reduction etc. (Ochieng, Knerr, Owuor and Ouma, 2015; Cazzufi, McKay and Perge, 2018; Matenga and Hichaambwa (2017); Olanrewaju 2015; Ele, Omini and Adinya 2013). These studies are useful as they show the state of programmes aimed at improving agricultural productivity and their impact on poverty reduction in the different countries and in Nigeria in particular. However, none of them explored the impact of commercialization on agricultural productivity. Thus, this study attempts to answer the questions: has the CADP increased the productivity of beneficiaries? What was the impact of socioeconomic variables on the productivity of CADP beneficiaries? The main objective of the study therefore, was to determine the impact of CADP on the productivity of farmers in Nigeria. Specifically, it determined the level of productivity of beneficiaries and non-beneficiaries; and examined the socioeconomic determinants of productivity of CADP beneficiaries and non-beneficiaries; and the impact of the CADP on the productivity of project beneficiaries' non-beneficiaries

Methodology

The Study Area

The CADP, a World Bank assisted project, was implemented in Nigeria in five (5) States as a pilot project. These States were: Cross River, Enugu and Lagos in the South; Kaduna and Kano in the North (Fig 1). The project supported outputs per State as follows: Cross River (Oil Palm, Cocoa, and Rice), Enugu (Fruit Trees, Poultry, and Maize), Kaduna (Fruit Trees, Dairy,

and Maize), Kano (Rice, Dairy, and Maize) and Lagos (Poultry, Aquaculture, and Rice). The basis of choice of enterprise by these states was their respective comparative advantages and contributions to agricultural growth. Based on an evaluation of market equivalents during appraisal, selected value chains were expected to have high demand and markets with capacities to absorb additional production. The five States were considered due to availability of relevant data for the study.

Fig 1: Map of Nigeria showing states participating in the CADP

Fig. 1: Map of Nigeria showing States participating in CADP

Data for the Study

The study used secondary data that were collected in the five participating states (Cross River, Enugu and Lagos in the South; Kaduna and Kano States in the North) in 2017 by the Project. Multi-stage sampling was used in selecting the sample. In determining the sample size and distribution for each State, a few significant strata were considered, as it relates to the design and implementation of the CADP. These include (i) types of value chains, types of Commodity Interest Group (CIG), size of operation (small or medium) and gender. For the beneficiary category, the list of commodity interest group (CIG) beneficiaries in the various strata (producer, processor & marketer) provided by the State CADP office formed the sampling frame for the study. Beneficiaries were then randomly selected. The non-beneficiary category was purposively selected based on their willingness to participate in the survey.

Analytical Techniques

The tools for data analysis included descriptive statistics, Total Factor Productivity (TFP), and Tobit regression models.

Total Factor Productivity

The Total Factor Productivity (TFP) analysis was used to to analyse the level of productivity of beneficiaries and non-beneficiaries. According to Key and McBride, (2003), total factor productivity can be measured as an inverse of unit variable cost. Since TFP is defined as the ratio of total output to the total variable cost in a production process, let total output be given by Y (kg) and total variable cost (TVC) in naira, then TFP is:

$$TFP = Y/TVC \quad (1)$$

Alternatively,

$$TFP = Y/\sum PiXi \quad (2)$$

Where:

Pi= unit price of ith variable input,

Xi= quantity of ith variable input

The advantage of this methodology is that it does not consider Total Fixed Cost (TFC) since it does not affect profit maximization and resource-use efficiency; besides it is fixed and a constant (Bamidele *et al.*, 2008).

Total Factor Productivity (TFP) analysis was employed to analyze the data for the study.

From the Theory of Costs;

$$AVC=TVC/Y \quad (3)$$

Where:

AVC= Average Variable Cost (₦)

However, $TFP = Y/TVC = 1/AVC$ (4)

TFP is the inverse of AVC

Total Factor Productivity (TFP) in this study was computed using the model as used by Ali and Byerlee (2014) and Odok (2018).

$$V_{To}/V_{Tn} = \frac{\sum_{i=1} P_{\alpha i} Q i}{\sum_{t=1} PxtXt}$$

Where V_{To} = value of total output in naira/ha

V_{Tn} = value of total input in naira/ha

P_{α} = price per unit of output in naira

Q = Quantity of output

i = Type of output (i ranges from 1 - nth output type)

p = price per unit of input in naira

X = Quantity of input

t = type of input (t ranges from 1 - nth input type)

It measures how technically efficient respondents utilized available inputs to produce the respective outputs. The value is on a scale of 0 to 1; a value tending to one implies increase in productivity; the higher the value, the higher the productivity to measure productivity performance we, therefore, need to specify the price and quantity of each output and input. We need to accurately specify quantities because productivity is essentially a weighted average of the change in output quantities divided by a weighted average of the change in input quantities. Once the productivity is obtained for both beneficiaries and non-beneficiaries, the differences in productivity of CADP and non-CADP households were analyzed using ATT described in equation (5).

Tobit Regression Model

This was used to examine the socioeconomic determinants of productivity of CADP beneficiaries and non-beneficiaries. The Tobit model was developed by James Tobin (1958). It is an extension of the probit model. In the Tobit model, the data sample is divided into two groups of n_1 about which there is information on the regressors and the regressands and another

group n_2 about which there is information only on the regressors but not on the regressands. A sample in which information on regressands is available only for some observations and not for others is known as a censored sample. Therefore the Tobit model is known as a censored regression model. Censored models are typically applied when the data set has a meaningful proportion (say 5% or higher) of data at the boundary of the sample support. The censoring process may be explicit in data collection, or it may be a by-product of economic constraints. The Tobit model is estimated by the maximum likelihood method because the ordinary least square method is unsuitable because the parameters are biased and inconsistent. According to Greene, (2003) the Tobit model is specified as:

$$y_i^* = x_i'\beta + \varepsilon_i \qquad 5$$

$$y_i = \begin{cases} 0 & if \quad y_i^* \leq 0 \\ y_i^* & if \quad y_i^* > 0 \end{cases}$$

Where y_i^* the censored is variable, β is the parameter to be estimated, x is a vector of explanatory variables and ε is the error term. The dependent variable is productivity while the independent variables are: sex, age, level of education, household size, Area of land cultivated/farm size, receipt of credit, land ownership. These variables were selected based on review of related studies (Ajibefun, Battese, & Daramola, 2002; Adeoti 2002). The general functional form of the model is as follows:

$$Yi=\beta_0 + \beta_1X_1+\beta_2X_2 + \beta_3X_3+ \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7+\varepsilon i \quad - \quad (6)$$

The variables are defined as follows:

X_1= Sex
X_2= Age
X_3= Level of Education
X_4= Household Size (number)
X_5= Years of farming experience
X_6= Area of land cultivated (ha)
X_6= receipt of credit
X_7= Landownership
βis are unknown parameters to be estimated.

ε_i= error term

Results and Discussions

Productivity level of CADP Beneficiaries and Non-CADP Beneficiaries

This section discussed the level of productivity of CADP beneficiaries and non CADP beneficiaries; the results are as presented in Table 2. The results show that the mean TFP for CADPB at the endline (2016) is 0.922 with a standard deviation of 2.106, while that of NCADPB at the same point in time is 0.615 with a standard deviation 1.449. This shows that the TFP of CADPB is higher compared to that of NCADPB. The fact that the beneficiaries had access to grants from CADP might have affected their productivity. The use of TFP as a tool of analysis shows how resources are efficiently utilized by beneficiaries of Project interventions. This result is in consonance with the findings of Salisu (2016) who found that the productivity of CADP participants in Kaduna state was higher than that of non-participants.

Table 2: Level of Productivity of Beneficiaries and Non-Beneficiaries

Variable	Obs	Mean	Std. Dev.	Min	Max
Mean TFP pooled (beneficiaries and non-beneficiaries) 2016	1,198	0.7487494	1.770955	0.0008358	27.68626
Mean TFP for beneficiaries 2016	521	0.9219527	2.10612	0.0008358	27.68626
Mean TFP for non-beneficiaries 2016	677	0.6154571	1.449284	0.0354304	27.61178

Source: Author's own estimation using CADP Nigeria Data, 2020

Determinants of Productivity among Households

The result of the determinants of productivity among households is shown in Table 3. The log likelihood for the Tobit model is -2359.98 and the chi-square is 48.17 and strongly significant at 5% level. With this, the overall model is significant and has a good fit to the data. The result shows that out of the 8 explanatory variables captured in the model, only three were found to significantly influence productivity. The variables that did not significantly influence productivity of respondents are: sex, age, years of schooling, farm experience and land ownership. While the variables that were significant in influencing productivity are: household size, farm size and credit.

However, the results showed a negative relationship between productivity and household size which is negatively significant at 10% level. This negative relationship is surprising as it is incongruent with a'priori expectation. Nevertheless, it is consistent with the findings of Fawole and Rahji 2016. This negative relationship between productivity and household size might be as a result of many factors. On the other hand, farm size significantly and positively influenced productivity at 5% significant level. The result suggests that a 1% increase in farm size increases productivity by 12.87% thus corresponding with the findings of Oyekale (2007) and Verter (2015) who also find a positive relationship between agricultural production and land expansion in Nigeria. This refutes the inverse-farm size hypothesis which is said to be due to market failures.

Also positively significant at 10% level is receipt of credit. The result shows that access to credit by farmers impact positively on productivity. It suggests that one unit increase in credit results in 29.6% increase in productivity. This corroborates the works of Samson and Obademi, (2018) who also find that the amount of credit received by farmers in Ibarapa, Oyo State, Nigeria has a positive impact on productivity. It however contradicts the findings of Verter (2015) whose findings indicated an inverse relationship between commercial loans to agriculture and crop performance in Nigeria.

Table 3: Estimates of Tobit Regression for the determinants of productivity among households

Variables	Coefficient	Std. Err.	t	P>t
sex(male)	0.1437376	0.1410196	1.02	0.308
Age	-0.0049301	0.0052134	-0.95	0.345
Years of schooling	-0.0047403	0.0118538	-0.4	0.689

Household size	-0.0189126*	0.0102729	-1.84	0.066
Farm experience	0.0073769	0.0062943	1.17	0.241
Farm Size	0.1287495**	0.0227008	5.67	0.000
Credit (Yes)	0.2963973**	0.1100997	2.69	0.007
Landownership(Yes)	0.1750108	0.1142356	1.53	0.126
_cons	0.1025454*	0.3066863	0.33	0.738
Sigma	1.734982	0.0354442		
Prob>chi2	0.000			
LR chi2 (8)	48.17			
Pseudo R2	0.0101			
Log likelihood	-2359.98			

**p<0.05,* p<0.1

Source: Author's own estimation using CADP Nigeria Data, 2020

Impact of CADP on Productivity of beneficiaries and non-beneficiaries

The impact of CADP on beneficiaries is presented in Table 4 which shows the Average Treatment Effect on the Treated (ATT). The ATT of 0.375 is positive and significant at 5% level implying that the CADP has positive impact on the productivity of participants who experienced a 37.5% increase in their productivity. The Average Treatment Effect on the Untreated (ATU) shows the spillover effect of the Project on non-participants, while the Average Treatment Effect (ATE) is the intention to treat which excludes the spillover. The results corroborate the findings of Elias *et al.* (2013) who established that participation in agricultural cooperatives increases productivity of smallholder farmers in Ethiopia, and that of Martey *et al* (2015) whose results through the estimation of ATT revealed that participation in farmer mentorship project impacts positively on farm technical efficiency by 28 percent.

Table 4: Impact of CADP on Productivity of Beneficiaries and Non-Beneficiaries

Variable	Sample	CADP Beneficiaries	Non-CADP Beneficiaries	Difference	S.E.	T stat
TFP	Pooled	0.92195273	0.61517198	0.30678075	0.10279687	2.98
	ATT	0.88833213	0.51287476	0.37545737	0.12855028	2.92
	ATU	0.62188994	0.69496391	0.07307397		
	ATE			0.20202381		

Source: Author's own estimation using CADP Nigeria Data, 2020

Conclusion and Recommendation

This study examined the impact of the Commercial Agriculture Development Project (CADP) on the productivity of farmers in Nigeria. The study revealed that the CADP increased productivity of farmers by 37.5% and impacted positively on their commercialization though minimally. Socioeconomic factors that were significant determinants of productivity are: household size, farm size and receipt of credit. This study has contributed to knowledge by carrying out an independent assessment of the CADP with the secondary data from the Project using a counterfactual approach.

Arising from the findings of this study and conclusion drawn, the following policy recommendations are made:

- though farmers benefit from grants which are "free", they should be made to maximize such resources which are not free to the state. For such Projects like CADP which operated on loans by the federal government there should be optimal use of resources.
- Farm size and access to credit among other factors significantly influenced productivity; policy measures should be oriented towards improving access of farmers to land and credit facilities.
- The CADP was implemented in 5 states of the federation in its pilot phase. If it is to be continued, the Project should be scaled up and its targeting mechanism should be reviewed as well as some of its operations.

References

Abass, A., Amaza, P., Bachwenkizi, B., Wanda, K., Agona, A. & Cromme N. (2017) The impact of mechanized processing of cassava on farmers' production efficiency in Uganda, *Applied Economics Letters, 24:2, 102-106*

Adenegan, K.O. (2015). Smallholder Cassava Commercialization: Implication for Household Income among farmers in Oyo State, Nigeria. *App Trop Agric Journal* 121-127.

Adeoti, A. I. (2002). *Economic analysis of irrigation and rainfed production systems in Kwara State, Nigeria.* Unpublished PhD thesis, Dept. of Agricultural Economics, University of Ibadan.

Ajibefun, I. A., Battese, G. E., Daramola. (2002). Determination of Technical Efficiency in Smallholder Crop Farming in Oyo State, Nigeria. *Quarterly Journal of International Agriculture*, 41 (3): 226-240.

Coelli, T. J and G. E. Battesse. (1996). Identification of factors which influence the technical efficiency of Indian farmers. *Australian Journal of Agricultural Economics* 40(1), pp103-128

Ele, I. E., Omini G., and Adinya B. E., 2013: Assessing the Extent of Commercialization of Smallholding Farming Households in Cross River State, Nigeria. *IOSR Journal of Agriculture and Veterinary Science* (IOSR-JAVS) e-ISSN: 2319-2380, p-ISSN: 2319-2372. 4(2) (Jul. - Aug. 2013), PP 49-55

FAO 2002: The Role of Agriculture in the Development of Least-Developed Countries and their Integration into the World Economy. Food and Agriculture Organization of the United Nations. Rome, 2002

Fawole W.O and Rahji M.A.Y. 2016. Determinants of Productivity among Farmers in Ondo State of Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology 9(4): 1-7, 2016.*

Global Agricultural Productivity Report (2023)

Govereh, J., Jayne, T.S and Nyoro, J. (1999). Smallholder Commercialization, Interlinked Markets and Food Crop Productivity: Cross Country Evidence in Eastern and Southern Africa, the *Department of Agricultural Economics and the Department of Economics, Michigan State University.*

Heckman, James J., and Edward J. Vytlacil. 2000. "Local Instrumental variables." *NBER Technical Working Paper 252, National Bureau of Economic Research, Cambridge, MA.*

Jaleta, M., Gebremedhin, B., and Hoekstra, D. (2009). 'Smallholder Commercialization: Processes, Determinants and Impact'. ILRI *Discussion Paper 18. Nairobi: ILRI. Available at:* https://cgspace.cgiar.org/handle/10568/27

Key, N. and McBride, W. (2003). Production Contracts and Productivity in the US Hog Sector. *Am. J. Agric Econ.*, 85 (1): 121-133.

Mellor, J. 1999. Faster, More Equitable Growth – The Relation Between Growth in Agriculture and Poverty Reduction Agricultural Policy Development Project (*Research Report No. 4). Washington, D.C.: United States Agency for International Development.*

Ochieng, J., Knerr, B., Owuor, G. & Ouma, E. 2015. "Agricultural commercialization and household food security: The case of smallholders in Great Lakes Region of Central Africa". 2015 Conference, August 9-14, 2015, Milan, Italy 212588, *International Association of Agricultural Economists.*

Odok, G. N. (2018). Technology Adoption, Productivity and Commercialization of Cassava in the South-South States of Nigeria. *Unpublished PhD, Dept. of Agricultural Economics, Fed. Univ. of Tech. Owerri.*

Olanrewaju, E. (2015). Agricultural Commercialization: Effect on Food Security among Smallholder Farming Households in Southwestern Nigeria. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Oni, O. A. and Olaniran, O. T. (2008). An analysis of Poverty Status of Fadama II and Non Fadama II Beneficiaries in Rural Oyo State, Nigeria. *Journal of Rural Economics and Development 17(1), 55-74.*

Pingali, P. L., and Rosegrant, M. W. (1995). 'Agricultural commercialization and diversification: processes and policies'. *Food Policy, 20*(3), 171–85.

Samson, A., & Obademi, O. (2018). The determinants and impact of access to agricultural credit on productivity by farmers in Nigeria; Evidence from Oyo State, Nigeria. *Advances in Social Sciences Research Journal, 5(3)* 252-265.

Strasberg P.J, T.S. Jayne, T. Yamano, J. Nyoro, D. Karanja and Strauss J (1999). Effects of agricultural commercialization on food crop input use and productivity in Kenya. *Michigan State University International Development Working Papers No. 71. Michigan, USA.*

Verter, N. (2015). Determinants of crop productivity in Nigeria in the era of agribusiness.

Von Braun J, Kennedy E (eds.) (1994). *Agricultural commercialization, economic development and nutrition, IFPRI*, Johns Hopkins University Press, Baltimore Maryland.

Von Braun. (1994). *Agricultural commercialization, economic development, and nutrition* (pp. 3–8). Baltimore, Maryland: Johns Hopkins University.

USDA Economic Research Service (2023)

Wasseja, M.M., S. N. Mwenda, M. Sammy, J. Josephine & P. Ochieng. 2016. An Empirical Analysis of Commercialization of Smallholder Farming: Its Inclusive Household Welfare Effects. *Journal of Economics & Commerce Management 1: 1-10.*

World Bank. 2008. Project Appraisal Document For Commercial Agriculture Development in Nigeria, Project Report No: 46830-Ng

EXPLORING THE POTENTIALS OF FINANCIAL TECHNOLOGY (FINTECH) IN ENHANCING FINANCIAL INCLUSION FOR FARMERS IN RURAL NIGERIA: IMPLICATIONS FOR FOOD SECURITY AND SUSTAINABLE AGRICULTURAL PRODUCTIVITY

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ABTRACT:
This study was designed to assess the potentials of Fintech in enhancing financial inclusion and access for farmers in rural Nigeria with Obudu in Cross River State as a case study. While many studies on financial inclusion have not considered Fintech as an alternative platform, this study fills the gap by espousing the unrealized benefits of this platform. Specifically, the study sought to assess the level of financial inclusion among farmers in the study area, identify the specific Fintech services currently available and utilized by farmers in the study area, analyze the potential benefits of Fintech adoption for farmer's financial inclusion, analyse the level of adoption of Fintech in the study area, investigate the impact of Fintech adoption on farmer's income levels in the study area, evaluate challenges and barriers hindering effective use of Fintech services among farmers in the study area, and analyse the potential risk and vulnerability associated with the use of Fintech by farmers in the study area. 140 farmers were selected for the study. Data obtained were analyzed using both descriptive and inferential statistics. The results showed among others that the income of male farmers, older farmers, and married farmers increased with the use of Fintech services. Again, having a household size of ≥ 6 increased income with Fintech services used, and the bigger the farm size, the greater the possibility of making more income when a farmer uses Fintech services. However, the study also found that using Fintech services alone in itself, may not increase income. Therefore, the study recommends that the problem of poor internet connectivity and high cost of data should be addressed to increase Fintech services use.

KEYWORDS: Fintech, Financial Inclusion, Financial services, Food security, Nigeria.

INTRODUCTION

Agriculture is a vital sector of the Nigerian economy, employing a significant portion of the population and contributing to food security and economic growth (Adegbola, 2018). However, farmers in many regions of Nigeria including Cross River State face challenges in accessing financial services, hindering their productivity and economic well-being. The availability and usage of affordable financial services is a crucial factor for farmers' economic empowerment, resilience, and a step towards sustainable practices and growth (Demirguc-Kunt *et al.*, 2018). This availability, which is generally term 'financial inclusion' allows farmers to access savings, credit, insurance, and payment systems, enabling them to manage their finances effectively. In

Nigeria, however, a large portion of the rural population remains unbanked or underserved by formal financial institutions (Ibukun and Adebayo, 2019), and this void, created by this exclusion, limits farmers' access to financial services and particularly credit, constraining their ability to invest in modern farming practices and expand their operations. This situation has compounded the food security problem of the country, making it really difficult for most families.

Access to credit is particularly essential for farmers as it provides the necessary capital to invest in farm inputs, machinery, and technology, leading to increased productivity and income (Minten *et al.,* 2019), and many rural farmers are known to access their credit needs from informal or traditional sources. However, most traditional sources have stringent credit access requirements and limited outreach, making it challenging for farmers in these areas (Omoyefa *et al.,* 2020). There are many instances where farmers are willing to borrow irrespective of the stringent conditions and high interest rates but the limited amount and outreach will always be a barrier. This credit gap hampers farmers' ability to adopt improved practices, acquire essential inputs, and mitigate risks, thereby limiting their potential for growth and development.

In recent years, Financial Technology (FINTECH) has emerged as a promising solution to address the financial inclusion and credit access challenges faced by farmers. Fintech leverages technological innovations including mobile banking, digital platforms, and online lending, to provide accessible and cost-effective financial services (Allen *et al.,* 2018). Fintech solutions offer farmers convenient channels to access credit, make payments, save, and manage their finances, bypassing the limitations of traditional banking systems (Acharya *et al.,* 2019). By leveraging fintech, farmers can overcome the barriers to financial inclusion and credit access, leading to improved productivity, income stability, and overall rural development.

Cross River State exhibits a diverse agricultural landscape with farmers engaging in various farming activities such as crop farming, livestock rearing, and fisheries. However, farmers in the state face significant challenges in accessing formal financial services, limiting their potential for growth and development. These challenges hinder their ability to invest in modern farming techniques, access quality inputs, and expand operations. The limited access to financial services and credit constrains agricultural productivity and rural development in the state. Therefore, for these problems to be addressed, there is need to try alternative platforms like fintech since the conventional financial institutions have done very little to tackling these challenges.

It is on record that many rural farmers in the State lack access to affordable and appropriate financial services such as savings accounts, insurance, and payment systems (EfinA, 2023). The lack of financial inclusion hampers farmers' ability to effectively manage their finances, save for the future, and cope with unexpected shocks (Demirguc-Kunt *et al.,* 2018). The problem lies in the limited outreach of formal and informal financial institutions to rural areas and the lack of tailored financial products for farmers. Farmers in the State also struggle to access formal credit, hindering their ability to invest in productive assets and expand their operations (Omoyefa *et al.,* 2020). Therefore, this study aims to explore the potentials of

fintech in enhancing financial inclusion for farmers in the state. By examining the level of financial inclusion among farmers, the specific fintech solution available and utilized by farmers, and their impact on farmers' financial well-being, as well as barriers to fintech use, this study seeks to provide valuable insights to alternative and innovative means of access to financial services which will build farmers' financial resources, expand production, and ensure availability and affordability of food for the growing populace.

MATERIALS AND METHODS

Study area

The study area is Obudu Local Government Area in Cross River State, Nigeria. It is located in longitude 66694°N" and latitude 91622°E" of the equator. It has a land area of 415.6 km and a population of 245,900 (city population, 2022). Obudu local government area is bordered to the north by Vandeikya in Benue state, to the east by Akwaya community in the republic of Cameroon, and to west by Boki and Bekwarra local governments. It has a total of 10 wards, with the dominant language being Bette. The people of the area are largely farmers who deal in food crops such as yam, cocoyam, cassava, plantain, maize and pumpkin, and cash crops such as, oil palm, cocoa, cashew and rubber. Apart from farming, Obudu people also engaged in palm wine tapping and processing of wild palm fruits (Agnes Ingwu, 2017).

The choice of Obudu for this study is because of the expansive internet connectivity made possible by the famous Obudu cattle ranch. As a consequent, many farming communities enjoy this benefit and should, ordinarily, be hooked to many financial technology services.

Sample size/Sampling technique

Using a sample size calculator at 99% confidence level, 10% error margin and a proportion of 70%, a sample size of 140 was arrived at. This was used because the population of study is undefined. Consequently, since Obudu LGA is made up of 10 wards and 47 farming communities, the sampling technique was based on internet/network connectivity in the villages. Arising from this, therefore, the distribution of respondents used for the study is as shown on Table 1.

Data Collection

Quantitative data was elucidated using the structured questionnaire administered to selected respondents in the study area.

Qualitative data was also collected through in-depth interviews with key stakeholders, including farmers, Fintech providers, government officials, and representatives from financial institutions. Focus Group Discussion was also employed for data collection.

Table 1. Sampled communities and number of sampled respondents per community

Urban 1 ward	Urban 2 ward	Ipong ward	Begiading ward	Anglaba/begiaka ward	Ukpe ward	Alege/ubang	Otugwang north ward	Otugwang south ward	Otuguwang central ward
*Abonkib 7	*Okambi 7	* Kakum 6	* Ohong 6	* Bedia 6	* Ikong 6	*Amukwong 6	Ukutia	*Ukpada 6	Nkeriria
Bebuabong	*Ukwumikwo 7	* Bebuagbong 6	Igwo	Okorshie	Kari	Araru	Ukworutung	Okwurogung	* Morrison 6
*Atiekpe 7	*Ukwelobudu 7	* Bebuabie 6	Kutia	Kubongbette	Kigbor	Okikwo	*Egbe egre 6		
*Bebuagah 7		*Bebuasuan 6	* Betukwel 6	*Begiaka or Ibong 6	Kagbang	Ngorkpu			
*Bebuasuan 7			Kutiang		*Ashikpe 6	Biuhe			
			Begiaba		Bayatung	*Okordem			
					Owong	Ebuasu			
					Bayobri	Okwenseng			
						*Ofambe 7			
						Okiro			
28	21	24	12	12	12	13	6	6	6

*sampled communities

Models Specification

To investigate the effect of Fintech adoption on farmers' agricultural productivity proxied by income levels, the following model was used:

$Y = f(X_1, X_2, X_3, \ldots X_n)$

The explicit form of the model is given as;

$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + e$

Where,

Y = farmer's income (naira earn)

X_1 = Gender (male =1, Female =0)

X_2 = Age (year)

X_3 = Marital status (married =1, otherwise =0)

X_4 = Level of education (years of schooling)

X_5 = Household size (number)

X_6 = Farm size (hectares)

X_7 = Experience (years)

X_8 = Fintech adoption (yes =1, no =0), defined in terms of the use of Automated Teller Machines, Banks' USSD codes, Mobile banking apps, etc.

RESULTS AND DISCUSSION

Use of Fintech services

The results revealed that majority (56.43%) of the respondents had adopted Fintech services, while 43.57% had not. The fact that over half of the respondents had adopted fintech services suggests a growing acceptance of digital financial solutions among farmers. This trend aligns with global patterns where fintech adoption has surged due to technological advancements and increased internet penetration (Alhajjaj and Ahmad, 2022; Mothobi and Kebotsamang, 2024). Addressing the needs of the non-adopting segment is crucial for achieving comprehensive financial inclusion. Tailored strategies that consider the unique challenges faced by these farmers will be necessary.

Level of financial inclusion among farmers in the study area

The result showing level of financial inclusion among farmers in the study area is presented in Table 2. The findings of this study indicate that in terms of level of financial inclusion; 43.9 % of the respondents made convenient transactions, 23.7 % had access to credit/loans, and 32.4 % had access to market information. The level of financial inclusion among farmers in the study area reveals a mixed picture, with significant opportunities for improvement in areas such as market access and information dissemination. By addressing these gaps through targeted interventions and leveraging technology, stakeholders can enhance the overall financial well-being of farmers, leading to improved agricultural productivity and economic stability within rural communities. Financial inclusion is a critical factor for enhancing agricultural productivity and improving the livelihoods of farmers. Recent findings indicate varying levels of financial inclusion among farmers in the study area, with notable statistics regarding convenient transactions, access to credit, market access, and information availability.

A significant portion of farmers (43.9%) reported having access to convenient transaction methods, which is crucial for managing day-to-day financial activities. This access often includes mobile banking and digital payment systems that simplify transactions and reduce the time and costs associated with traditional banking methods. Studies have shown that convenient transaction methods enhance financial literacy and encourage savings behavior among farmers.

Access to relevant agricultural information is reported by 32.4% of respondents. Information regarding market trends, weather forecasts, and best farming practices is critical for making informed decisions that can enhance productivity and profitability.
The lack of information can hinder farmers' ability to adapt to changing conditions and optimize their operations. The World Bank (2014) argues that access to and use of essential financial services can help the poor move out of poverty by economically and socially empowering them.

Table 2: Level of financial inclusion among farmers

	Frequency	Percent
Convenient transactions	76	43.9
Access to credit/loans	41	23.7
access to market information	56	32.4
Total	173	100

** Multiple responses were used for frequency
Source: Field survey, 2024

Fintech solution available and utilized by farmers in the study area

The result showing adoption of Fintech solution is presented in Table 3. The results indicated that majority (41 %) of respondents utilized it for Mobile money transfer using USSD while 12.8 % utilized it for Digital banking (Use of Bank Apps). The adoption of fintech solutions among Nigerian farmers reflects a growing trend towards digitalization in agriculture. While significant progress has been made in areas such as mobile money transfers and agricultural insurance, challenges remain in enhancing digital banking usage and market access through innovative platforms. By addressing these gaps through targeted interventions and education initiatives, stakeholders can further promote financial inclusion and empower farmers to improve their livelihoods.

The integration of Fintech solutions in agriculture is transforming the way farmers in Nigeria access financial services, information, and markets. The result further showed that 21.4 % of respondent used it for Agricultural insurance. Agricultural insurance is critical for mitigating risks associated with farming, such as crop failure due to adverse weather conditions.

Table 3: Fintech solution available and utilized by farmers in the study area

	Frequency	Percent
Agricultural insurance	25	21.4
Agricultural information/advisory services	20	17.1
Mobile money transfer using USSD	48	41
Trading through WhatsApp	9	7.7
Digital banking (Use of Bank Apps)	15	12.8
Total	117	100

** Multiple responses were used for frequency
Source: Field survey, 2024

Level of adoption of Fintech in the study area

The result indicating the level of adoption of Fintech in the study area is presented in Table 4. A weighted mean value of 3.0 was used as a benchmark to assessed if Fintech had improved farmers' access to financial services and also to assessed whether Fintech had increased farmers income levels. From the results, the extent to which Fintech has improved farmers' access to financial services had a weighted mean score of 3.48, while the extent to which Fintech has increased farmers' income levels had a weighted mean score of 3.49. Overall, the results implies that the level of adoption of Fintech in the study area was high.

Table 4: Level of adoption of Fintech in the study area

Variable	VH	H	M	L	VL	Sum	Mean

To what extent has Fintech services improved farmers access to financial services	29(145)	27(108)	34(102)	13(26)	9	390	3.48
To what extent has Fintech services increased farmers income levels	26(130)	24(96)	29(87)	12(24)	8	345	3.49

Source: Field Survey, 2024
benchmark = 3.0; VH = very high, H = high, M = moderate, L = low, VL = very low

Effect of Fintech adoption on Farmers' income level

The determinants of Fintech adoption on farmers' income level is presented in Table 5. The model was specified in four functional forms (linear, semi- Log, double- log and exponential functions). Based on economic theory, the semi-log form was choosen as the lead equation. The semi-log form was choosen because it has the highest number of significant variables, correct signs of coefficient and the highest R^2 value and lowest standard error. Result shows that gender, age, marital status, household size, and Fintech adoption were the significant variables that determined farmers' income.

The positive coefficient for gender suggests that the more a farmer is male the higher the tendency to have higher income levels compared to female farmers. This finding is consistent with previous studies that highlight gender disparities in agricultural access and resources (Fowowe, 2020). In many regions, men often have better access to credit and market opportunities, which can enhance their income potential.

The coefficient for age is positively related with income levels at 10 % significant level. This implies that older farmers will earn more income than new ones. This aligns with findings from studies that age is positively related with income (Obisesan and Adeyonu, 2018).

Similarly, marital status was positively related with income. The significant positive impact of marital status suggests that married farmers benefit from shared resources and labor, leading to higher income levels. This supports previous research indicating that household dynamics play a crucial role in agricultural productivity and financial stability (Jisha *et al.*, 2023).

Both household size and farm size have positive coefficients and were significantly related with income. The results indicate that larger households may provide more labor and larger farms yield more produce, contributing to higher incomes. This is consistent with literature emphasizing the importance of land access and labor availability in agricultural success (Fowowe, 2020).

The negative coefficient for fintech adoption is particularly noteworthy, suggesting that increased adoption may correlate with lower income levels among farmers in this study area. This could reflect several underlying issues: farmers might be adopting fintech solutions without fully understanding their implications or benefits, initial costs or learning curves associated with new technologies may temporarily impact income negatively and may be a

dependency on credit facilitated by fintech without adequate financial literacy, leading to unsustainable debt levels (Seluhinga, 2023).

Table 5: Effect of Fintech adoption on Farmers' income level

	Linear		Double log		+Semi-log		Exponential	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
C	-3353840	-1.090	10.334	5.264***	12.214	15.997***	-6417536.0	-0.817
Gender	2727664	2.938***	0.364	1.536	0.409	1.776*	2500720.0	2.638**
Age	13559.09	0.301	0.710	1.326	0.020	1.790*	521707.9	0.244
Marital status	1822698	3.183***	0.312	2.087**	0.368	2.589**	1735460.0	2.897***
Education	-72068.63	-0.907	0.018	0.145	0.014	0.726	-323020.3	-0.668
Household size	518367.2	2.616**	0.301	0.996	0.087	1.769*	2246921.0	1.856*
Farm size	-204215.6	-1.847*	0.309	2.034**	0.083	3.037***	520018.2	0.856
Experience	-12713.86	-0.142	0.042	0.175	-0.019	-0.868	272387.8	0.282
Fintech adoption	-2960853	-3.095***	-0.583	-2.392**	-0.655	-2.758***	-2698619.0	-2.766***
R-squared	0.38		0.42		0.50		0.42	
Adjusted R-squared	0.34		0.39		0.47		0.39	
S.E. of regression	5214190		1.33		1.29		5321921	
F-statistic	3.61		2.48		3.54		2.81	
Prob(F-statistic)	0.000803		0.015644		0.000959		0.00663	
Durbin-Watson stat	1.94		1.94		1.96		1.952095	

Source: Computed from field survey, 2024

Note: *** represents significant at 5% and 1%. (+) = Lead equation.

IMPLICATIONS FOR FOOD SECURITY AND AGRICULTURAL PRODUCTIVITY

The potentials of Fintech services in improving the food security status of Nigerians cannot be overemphasized as it has been proven in other African countries of the benefits of Fintech use. In Kenya for instance, the use of this service led to 85 percent reduction in payment leakages, 80 percent cost savings and 48 percent increase in earnings. Access to Fintech services also increased the consumption levels over a six year period enabling an estimated 186,000 families or 2 percent of Kenyan household move out of poverty. Also, One-Acre Fund (OAF), a non-profit organization leverage on the services provided by M-Pesa (A Fintech company) to provide farmers with agricultural inputs such as seeds and fertilizers on credit on 'pay-as you-go' basis and to make repayments through the same medium. (Agbelusi, 2018). In Nigeria, very many individuals and businesses are already accessing credit through many Fintech platforms,

which can be perfected and adopted by government and other organisations to reach many farmers in the rural communities. Achieving this will cut-off the bottlenecks experienced by these farmers in accessing conventional loans. Like Kenya, this will not only increased farmers productivity on a sustain level but will ensure the affordability and availability of food in the country.

REFERENCES

Aboki, E., Jongur, A.A.U. & Onu, J. I. (2013). Productivity and Technical Efficiency of Family Poultry Production in Kurmi local Government Area of Taraba State, Nigeria. *Journal of Agriculture and Sustainability*, 4(1): 52-66.

Acharya, V., Allen, F., Bartlett, R., Berentsen, A., Bharath, S. T., Biswas, R. & Qian, Y. (2019). Fintech: The Impact on Consumers and Systemic Risk. *SSRN Electronic Journal,* 1-39.

Adegbola, O. (2018). The Role of Agriculture in the Nigerian Economy. *Journal of Agricultural Science,* 10(12), 173-185.

Agbelusi, M. O. (2018). FinTech as a tool for promoting financial and economic development in Nigeria. *Bullion*, Central Bank of Nigeria, 42(1):61-68

Alhajjaj, H., & Ahmad, A. (2022). Drivers of the consumers' adoption of Fintech services. *Interdisciplinary Journal of Information, Knowledge, and Management*, 17, 259-285. https://doi.org/10.28945/4971.

Allen, F., Carletti, E., Cull, R., Qian, J., Senbet, L., & Valenzuela, P. (2018). The African Financial Development and Financial Inclusion Gaps. *Journal of African Economies*, 27(5), 1-16.

Allen, F., Carletti, E., Cull, R., Qian, J., Senbet, L., & Valenzuela, P. (2018). The African Financial Development and Financial Inclusion Gaps. *Journal of African Economies*, 27(5), 1-16.

Citypopulation: Population of Obudu (2024). Retrieved from: https://www.citypopulation.de>admin.

Demirguc-Kunt, A., Klapper, L., Singer, D., Ansar, S., & Hess, J. (2018). The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. *World Bank Policy Research Working Paper*, (1), 1-91.

Fowowe, B. (2020), "The effects of financial inclusion on agricultural productivity in Nigeria", *Journal of Economics and Development*, Vol. 22 No. 1, pp. S 61-79. https://doi.org/10.1108/JED-11-2019-0059

Ibukun, O., & Adebayo, A. (2019). Financial Inclusion and Poverty Reduction in Nigeria: Evidence from Selected States. *African Journal of Economic Review*, 7(2), 46-60.

International Telecommunication Union (ITU) & World Bank. (2017). The State of Broadband: Broadband Catalyzing Sustainable Development. Available at: https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.17-2017-PDF-E.pdf

Jisha, K K & Palakkeel, Prashobhan, 2023. Availability of agricultural credit: determinants, marginal effect, and predicted probability, Agricultural and Resource Economics: International Scientific E-Journal, vol. 9(4),

Minten, B., Tamru, S., & Taffesse, A. S. (2019). Impact of Credit Constraints on Smallholder Farmers' Productivity in Ethiopia. World Development, 116, 15-30.Omoyefa, V., Ogunleye, O., & Adetunji, A. (2020). Determinants of Credit Access and Utilization among Smallholder Farmers in Nigeria. *African Development Review*, 32(3), 466-480.

Mothobi, O., Kebotsamang, K. (2024). The impact of network coverage on adoption of Fintech and financial inclusion in sub-Saharan Africa. *Economic Structures* 13, 5 (2024). https://doi.org/10.1186/s40008-023-00326-7.

Obisesan, A. &Adeyonu, A. (2018).Financial Inclusion of Arable Crop Farmers in Nigeria. Paper Presentation at the 30th International Conference of Agricultural Economist held atVancouver July 28- August 2, 2018

Omoyefa, V., Ogunleye, O., & Adetunji, A. (2020). Determinants of Credit Access and Utilization among Smallholder Farmers in Nigeria. *African Development Review*, 32(3), 466-480.

Pothula, S. R. (2023). Review and analysis of FinTech approaches for smart agriculture in one place. *Journal of Agriculture Science & Technology*, 22 (1), 60-69

Seluhinga, N.S. (2023). Factors Influencing Smallholder Farmers' Access to Formal Financial Services in Morogoro Region, Tanzania. *Tanzania Journal of Agricultural Sciences*, 22(2), 434-443.

World Bank, (2003). Inequality Measurement and Decomposition, World Bank Poverty Net.

DETERMINANTS OF CASSAVA COMMERCIALIZATION IN SELECTED STATES OF NIGER DELTA REGION OF NIGERIA

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Abstract
This study examines the determinants of cassava commercialization among smallholder farmers in the selected States in the Niger Delta region, Nigeria. Despite Nigeria's position as the world's largest cassava producer, the commercialization of cassava remains limited in states such as Akwa Ibom, Rivers, and Edo States. This study applies the Cassava Commercialization Index (CCI) to quantify commercialization levels and assess the impact of key socio-economic and production factors. Data was collected using structured questionnaires administered to 282 farmers selected from Akwa Ibom, Rivers and Edo States through random sampling. From the results, the distribution of cassava farmers according to their commercialization levels, were categorized into ranges (25-35%, 36-46%, etc.) with the peak distribution within the 58-68% commercialization range, with approximately 36.9% of farmers. This suggests that a substantial proportion of farmers are moderately commercialized, selling more than half of their cassava production. However, relatively few farmers exceed an 80% commercialization rate, indicating a limit to high commercialization levels among farmers in the study area, potentially due to barriers such as market access, production costs, or lack of processing facilities. The results further averred that a large portion of the sample (60.9%) reported moderate levels of commercialization between 58-68%. On the contrary, factors such as age and education level exhibited minimal impact on commercialization rates. However, addressing infrastructural, economic, and policy barriers are crucial for achieving higher commercialization levels by leveraging on the region's comparative advantage in cassava production and implementing targeted interventions, the Niger Delta can emerge as a major player in global cassava markets. The study concludes with appropriate policy recommendations such as facilitating access to market, promote technology adoption, and provide input support to farmers, with the drive to transform cassava from a mere subsistence crop to a viable commercial product in the Niger Delta Region of Nigeria, ab initio.

Keywords: Cassava Commercialization, Niger Delta, Cassava Commercialization Index, Agricultural Policy

1.0 Introduction
Cassava commercialization refers to the shift from subsistence farming to market-oriented production, where cassava is grown primarily for sale rather than consumption. The Cassava Commercialization Index (CCI), a quantitative measure, evaluates the proportion of cassava production sold relative to total production. A higher index indicates greater market orientation (Govereh *et al.*, 1999; Strasberg *et al.*, 1999). Cassava, as a staple root crop, plays a critical role in food security balance sheet and rural livelihood in Nigeria, which is the world's largest cassava producer, contributing about 21% of global cassava output (FAOSTAT, 2016). Despite high production rates, much of Nigeria's cassava is produced by smallholder farmers and

directed toward subsistence rather than commercial markets (Akinwumi, 2012). The Niger Delta region, encompassing Akwa Ibom, Rivers, and Edo States, exemplifies the potential of cassava commercialization, as the region has favourable agro-climatic conditions and high cassava yields. However, barriers such as limited market access, inadequate input supply, and lack of improved technology adoption hinder full commercialization potentials (Nweke, 2004). This study seeks to examine factors influencing cassava commercialization in the three selected states vis-à-vis the Niger Delta Region of Nigeria by employing the Cassava Commercialization Index (CCI), whose specific objectives include to:

(a) assess the current extent of cassava commercialization, its ratio and other crop ratios in the region;
(b) identify key socio-economic variables and production factors influencing cassava commercialization in the region;

1.1 Relevance of Cassava Commercialization in Niger Delta

Commercialization enhances household income, employment opportunities, and rural economies (Nweke, 2004). Industrially, cassava is a key raw material for industries producing ethanol, starch, and animal feed (IITA, 2005). On the basis of food Security, increased market participation ensures the availability of processed cassava products such as garri, fufu, and tapioca. Studies show that moderate commercialization levels are attributed to small farm sizes and limited access to markets. In Akwa Ibom State, the average CCI is approximately 60%, indicating a substantial portion of cassava production is sold (Agwu *et al.*, 2012).

Cross River State is known for high cassava production, although farmers face challenges in accessing processing facilities, thereby reducing the CCI to about 55% (Sanni *et al.*, 2014). Edo state demonstrates the highest commercialization level among the other two states, with a CCI exceeding 65%, due to better road networks and access to market (Elemo, 2013).

This research addresses critical knowledge gaps in cassava commercialization, offering insights for policy development and intervention programmes to boost rural economic growth through cassava market integration.

2.1 Some Empirical Review

2.1.1 Cassava Commercialization: Global and Regional Trends

Recent studies underscore cassava's role in food security and economic transformation, especially in sub-Saharan Africa. Cassava has shifted from a subsistence crop to an increasingly commercialized crop in many regions due to rising demand for industrial uses (Maziya-Dixon *et al.*, 2017). Globally, cassava's diversification into biofuel, starch, and animal feed markets, particularly in Southeast Asia, demonstrates the economic potential of commercializing this root crop (Scott *et al.*, 2020). However, in Africa, the commercialization process remains impeded by structural issues, such as poor infrastructure, limited processing capacity, and reliance on traditional cultivation methods (FAO, 2021).

2.1.2 Determinants of Cassava Commercialization

1. **Farm Size and Output Levels**: Studies by Carletto, Savastano, and Zezza (2013) and others affirm that larger farm sizes enable farmers to scale production, making commercialization

more feasible. Small-scale farms face constraints in reaching marketable surplus due to lower yields and limited access to inputs.

2. Market Access and Infrastructure: Adeoti *et al.* (2021) highlight the significance of road networks and market proximity in promoting commercialization. Market distance has a direct impact on transportation costs, discouraging farmers from selling in larger, urban markets (Atagher, 2013).

3. Adoption of Improved Varieties and Technology: Martey, Kuwornu, and Omotoso (2020) found that adopting improved cassava varieties can significantly enhance yields and marketability. Improved varieties are often more resilient to pests and diseases, allowing for consistent and high-quality output that appeals to commercial markets (Nweke, 2013).

4. Household Labour and Size: Family labor is essential in smallholder cassava production. Studies by Osondu *et al.* (2014) suggest that larger household sizes contribute to labour availability, which supports both cultivation and commercialization activities. However, the dependency ratio within households can affect how much labor is allocated to cassava versus other economic activities.

5. Price Incentives and Input Costs: Pricing structures for cassava impact farmers' willingness to commercialize. Studies have shown that high input costs and low farm-gate prices reduce the incentives for smallholder farmers to invest in commercial cassava production (Elemo, 2018).

3.1 Methodology

Study Area

This study focuses on Akwa Ibom, Rivers, and Edo States in the Niger Delta. These states are among Nigeria's top cassava-producing regions and exhibit varying levels of cassava commercialization influenced by socio-economic, environmental, and infrastructural conditions.

3.2 Sampling Procedure and Sample Size

Sampling Procedure: A multi-stage sampling technique was employed. Firstly, states and local government areas were purposively selected based on farm size. Primary data was gathered through structured questionnaires covering socio-economic characteristics, farm size, input use, technology adoption, and market access. From each state,94 farmers were randomly selected using list of farmers provided by the selected states giving a total of 282 farmers (farmers with 3 hectares of farmlands and above were selected randomly using random number generator) to represent diverse socio-economic backgrounds.

Data analysis

Cassava Commercialization Index (CCI)

The CCI measures commercialization as the ratio of gross value of cassava sales to gross value of cassava output. This index enables quantification of the commercialization rate and has been successfully applied in other studies, such as by Govereh *et al.* (1999) and Strasberg *et al.* (1999) (see formula 1).

Formula: $CCI = \frac{\text{Output sold}}{\text{Total harvested}} \times 100$ (1)

A multiple regression analysis was undertaken using four functional forms: linear, double log, semi-log and the exponential to examine the factors influencing commercialization of the cassava in the area of study.

4.1 Results and Discussion

Key variables, including farmer age, household size, education level, farm size, and distance to market, were summarized (Table 1). A large portion of the sample (60.9%) reported moderate levels of commercialization, between 58-68%.

Table 1: Descriptive statistics on the socio-economic variables in the area

Variable	Mean	Std Dev	Min	Max
Farmer Age	45.2	12.1	20	70
Household Size	5.8	2.4	2	10
Farm Size (hectares)	2.5	1.3	0.5	8
Distance to Market (km)	12.3	5.6	3	25
Adoption of Improved Varieties (%)	64.7	15.8	20	100

Source: Fieldwork (2023)

Distribution of Cassava Farmers by Commercialization Extent

The chart shows the distribution of cassava farmers according to their commercialization levels, categorized into ranges (25-35%, 36-46%, etc.). The peak distribution falls within the 58-68% commercialization range, with approximately 36.9% of farmers (Fig.1). This suggests that a substantial proportion of farmers are moderately commercialized, selling more than half of their cassava production. However, relatively few farmers exceed an 80% commercialization rate, indicating a limit to high commercialization levels among farmers in the study area, potentially due to barriers like market access, production costs, or lack of processing facilities.

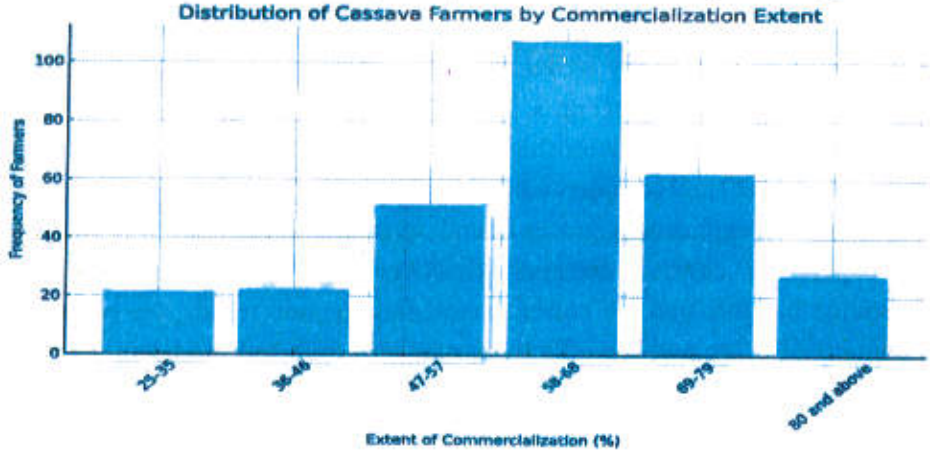

Fig. 1: Distribution of Cassava Farmers by Commercialization in the Region

Cassava commercialization Ratio and ratios for Other Crops

This chart compares the commercialization ratios for different crops. Cassava stands out with a commercialization ratio of 60.9%, much higher than other crops such as maize (21.7%), yam (15.5%), melon (12%), and cocoyam (11.7%) (Fig.2 and Table 2). This indicates that cassava is the most commercially viable crop among those studied, likely due to its demand and versatility in the region. The significant drop-off in commercialization ratios for other crops underscores cassava's unique role in the local agricultural economy, suggesting it could be a focal point for policy and market interventions aimed at commercialization.

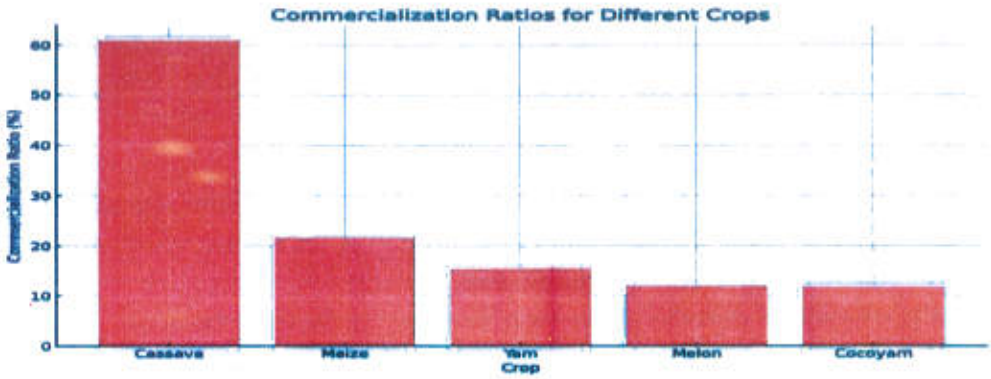

Fig. 2: Commercialization Ratios for Different Crops

Table 2: Commercialization ratios for Cassava and other crops in the study area

Crops	Gross Value of Crop Sales (₦)	Gross Value of All Crops Produced (₦)	Commercialization Index (%)	Category
Cassava	127859.6	209950	60.9	High
Maize	45550	209950	21.7	Low
Yam	32600	209950	15.52	Low
Melon	25170	209950	11.99	Low
Cocoyam	24640	209950	11.74	Low

Source: Authors Field Data (2023)

R Squared Values for Different Regression Functional Forms

This chart compares the R-squared values across four different functional forms used in the regression analysis. The double-log model yields the highest R-squared value (0.884), indicating that it explains approximately 88.4% of the variability in cassava commercialization, making it the best fit among the models (Fig. 3, Table 3). This suggests that the double-log form is the most suitable for capturing the relationships between the independent variables (e.g., farm size, household size, input use) and commercialization extent. The high R-squared values across models also indicate strong explanatory power overall, reinforcing the identified determinants' significance in explaining cassava commercialization rates in the study area. These interpretations provide insights into the current commercialization trends, the prominence of cassava as a commercial crop, and the effectiveness of the selected model in analyzing the determinants of commercialization.

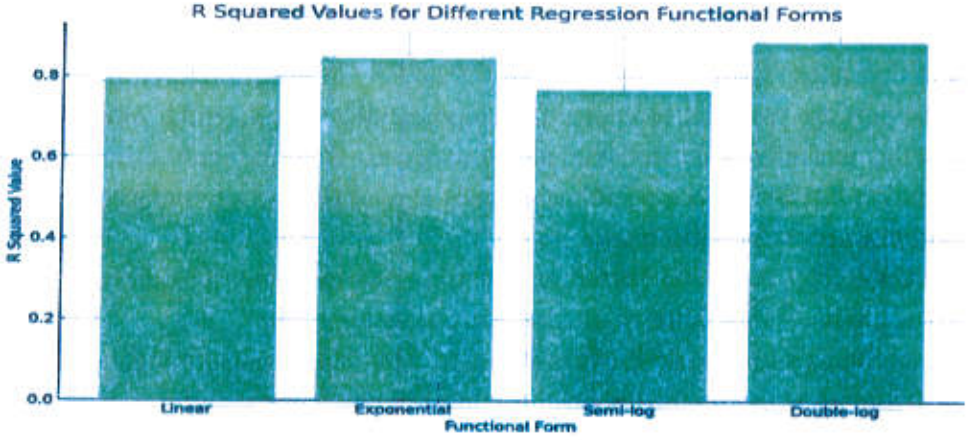

Fig.3: R- Squared Values for different regression functional forms

An Ordinary Least Squares (OLS) regression model was used to assess determinants of commercialization. Results indicate that farm size and household size (implying labour availability enhances commercialization potential) were positively significant at the 5% level except for the adoption of improved varieties that was significant at 1% level, suggesting that adoption enhances yields and market availability. Besides, distance to market indicated negative impact, signifying that distance to market is a barrier to commercialization while external input use indicated highly significant positive effect. Thus, emphasizing that access to inputs such as fertilizers and pesticides facilitates higher yields and marketability of the commodity in the region under consideration.

Table 3: Factors influencing cassava commercialization in the study area

Functional Forms	Linear	Exponential	Semi-log	Double-log
Constant	-28145.2	10.476	-62301.7	7.596
Adoption Level (X1)	125.168	0.002	69715.55	0.5
Farm Size (X2)	1373.881	0.008	1061.657	0.01
Household Size (X3)	3913.851	0.042	57383.05	0.541
Age of Farmer (X4)	2227.061	0.006	1295.885	0.015
Education Level (X5)	341.752	0.012	25139.21	0.17
Distance to Market (X6)	-131.013	-1.003	-2337.69	0.009
Age of Cassava (X7)	-5004.08	-0.048	-2352.24	-0.035
External Inputs Used (X9)	17185.2	0.055	8455.977	0.28
Price of Cassava (X10)	31209.17	0.045	2284.993	0.632
R Squared (R^2)	0.791	0.844	0.767	0.884
F-value	105.467	150.714	225.588	210.47

Source: Computed from Authors Field Data (2023)

Conclusion and Policy Recommendations

The analysis indicates that farm size and technology adoption are critical for commercialization, aligning with previous studies (Carletto *et al.*, 2013). The negative effect of market distance underscores the need for improved rural infrastructure, which could reduce transaction costs and enhance market participation. The positive impact of household size on commercialization reflects labor availability's importance, supporting Zekeri and Tijani's (2013) assertion that

family labor can drive productivity. Based on the results, it was therefore, concluded that factors such as farm size, market access, and technology adoption significantly influence commercialization rates. Targeted policies and investments in infrastructure, input provision, and market support are essential to realize the commercialization potential of cassava in the region. Given this scenario, policy recommendations arising from the study were to:

1. Enhance Market Access: Develop and maintain rural road networks to reduce transportation costs and facilitate access to urban markets.
2. Promote Technology Adoption: Increase extension services and subsidies for improved cassava varieties to boost productivity and commercialization rates.
3. Expand Input Support Programs: Provide access to affordable inputs through government or cooperative support, addressing the financial barriers to input adoption.
4. Develop Cassava Value Chains: Encourage investments in processing facilities to expand cassava's value-added market, thereby creating more commercial opportunities for smallholder farmers.

References

Adeoti, A. I., Awoyemi, T. T., & Kuponiyi, T. F. (2021). Market accessibility and cassava commercialization among smallholder farmers in Nigeria. Journal of Agricultural Economics and Rural Development.

Agwu, N. M., Anyanwu, C. I., & Mendie, E. I. (2012). Cassava value chain development in Nigeria.

Atagher, A. (2013). Determinants of commercialization among cassava farmers in Benue State.

Carletto, C., Savastano, S., & Zezza, A. (2013). Smallholder commercialization and farm productivity.

Carletto, G., Savastano, S., & Zezza, A. (2013). Land size and productivity in African agriculture: empirical evidence from the literature. World Bank.

Elemo, F. (2013). Challenges of cassava commercialization in Nigeria.

FAO (2021). The Future of Food and Agriculture: Drivers and Trends. Rome.

FAOSTAT (2016). Global cassava production statistics.

IITA (2005). Cassava in the Nigerian economy.

Martey, E., Hassan, R. M., & Kuwornu, J. K. (2012). Commercialization and agricultural technology adoption.

Martey, E., Kuwornu, J. K. M., & Omotoso, A. (2020). The role of technology adoption in agricultural productivity and commercialization. African Journal of Agricultural Economics.

Nweke, F. I. (2004). New challenges in cassava transformation in Nigeria.

Odok, G. N. (2018) Technology Adoption, Productivity and Commercialization: Unpublished PhD Thesis, Federal University Technology Owerri, Imo state, Nigeria.

Osondu, C. K., *et al.* (2014). Socio-economic determinants of commercialization in Nigeria.

Oyewole, S., Sanni, L., & Ogunjobi, O. (1996). The role of cassava processing in Nigeria.

Sanni, L. O., Christiana, O., & Silifat, A. (2014). Cassava commercialization in Cross River State.

Scott, G. J., Rosegrant, M. W., & Bokanga, M. (2020). Roots and tubers in the global food system: challenges and opportunities for the 21st century.

PRELIMINARY EVALUATION OF THE PERFORMANCE OF BENE SEED (*SESAMUM INDICUM* L.) IN CALABAR

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ABSTRACT

Appropriate time of sowing and suitable varieties have been reported to be the major constraints experienced by sesame farmers in Nigeria. Therefore sesame genotypes were pre-evaluated in Calabar between August 6th 2023 and January 3rd 2024, in a 4 x 4 factorial experiment in RCBD consisting four varieties namely; Variety 04E, Variety 05E, Variety E8 and Mbok-1 Local that was used as a check variety; and 4 planting times beginning from August 6th, August 20th, September 3rd and September 17th. Randomized Complete Block Design (RCBD) replicated 3 times was used. Plant height, branching, leaf area index, number of pods, number of seeds pod^{-1} and pod yield ha^{-1} were assessed. Results from the study indicate that Sesame variety NCRIBEN E8 sown on August 20th had the highest pod yield ha^{-1} amongst all the genotypes tested, and recommends this for farmers in the study area desirous of optimizing sesame yields.

Keywords: Climate change, Variability, Genotypes, Temporal dispersion, yields

Introduction

Sesame (*Sesamum indicum* L.), family Pedaliaceae, is a flowering plant with broad leaves, growing to a height of 1-2m. It is a warm season crop and considered drought tolerant, but needs good soil moisture to thrive. Geremew (2012) maintained that, Sesame requires temperature of 25 to 370C throughout its growth period, however, temperature of 25 to 270C encourages germination and early growth. A rainfall of 300 to 800mm all the year round is necessary for reasonable yields, the soil pH of 5 to 8 is required for optimum performance of sesame and a well-drained sandy loam soil, which allows for smooth root penetration, waterlogging soil and heavy clay soil are not encouraged for sesame production. Sesame is valued for its high quality oil that is rich in vitamins required for the body's wellness (Vasantrao *et al.*, 2015). Nigeria is one of the major producers of sesame in Africa and cultivation in this country is concentrated in the guinea savanna agro-ecological zone. The increasing demands for Sesame as alternative source of cooking oil and for baking activities in Nigeria and export market is a wake-up call for the introduction of Sesame production into different agro ecological zone in Nigeria.

There is paucity of information on sesame production in the study area, importantly the best time to introduce the crop is not known, being a neglected crop. Time is a determinant of agronomic activities, thus a key factor that helps the farmer decide when to start and end operations. It is upon this premise this research examined the efforts whether or not time of planting have any positive effects or impact on Sesame in Calabar, Eastern Rainforest Zone. The study determined the effects of time of planting on the growth and yield of sesame genotypes in Calabar, Nigeria.

Materials and methods

The study was conducted in Calabar (4.5-5.2°N, 8.0-8.3°E), Cross River State, from August, 2023 to January 3rd 2024, within the South Eastern rain forest Agro-ecological Zone of Nigeria, 39m above sea level. Calabar receives 3000–3500mm rainfall per annum, has a mean annual temperature of 27-35°C and relative humidity of between 75–85% (CRBDA, 2008). The plot was manually tilled and levelled into a fine tilth, mapped out into plots/units to meet the experimental design specification. Soil was sampled randomly at 0-30cm depth, from different portions of gross plot using soil auger, bulked, air dried, grinded, sieved and later analysed for physico-chemical properties according to Udo *et al.* (2009) method. The 4 x 4 factorial experiment was laid out in Randomized Complete Block Design (RCBD) replicated three times. Four planting dates (August 6th and 20th; September 3rd and 17th), four varieties of sesame namely NCRIBEN (04E, 05E, and E8); and Ex-Mbok (a local land race), giving it a total of 16 treatments. The gross plot size for the experiment was 16m x 20m^2, plant spacing of 0.5m x 0.2m was maintained. Seed beds were constructed to the dimension of 4m x 1m with 0.25m row spacing between beds.

Varieties NCRIBEN (04E, 05E and E8) were sourced from National Cereal Research Institute Badegi Niger State, while the local land race Ex-Mbok sourced from out-growers field at Mbok village Ogoja, served as a check. Seeds were planted at a distance of 50cm by 20cm between plants. Three seeds were planted per hole and later thinned to one stand per hole, maintaining a total of 32 plants per plot, which translated to 100, 000 plants per hectare. Fertilizer NPK 15:15:15 was procured from Ministry of Agriculture and Natural Resources, Calabar, Agro input store and was applied only at 200kg/ha, 2-weeks after planting. Although, fertilizer was not part of the treatment, it was only applied to boost the soil nutrient status, at onset of the study. Data for agronomic and yield variables were collected from net plots for plant height, leaf area, number of leaves per plant, number of branches, percentage germination, number of seeds per pod and pod yield ha^{-1}.

Results and discussion

The soil properties at the experimental site (Table 1) indicate that pH was slightly acidic (5.4) and suitable for cropping. Total nitrogen of 0.17 % was a bit higher than the critical value of 0.12%. Soil of the experimental site is described as sandy loam characteristic of soils in the immediate environment of the experimental site. With a base saturation of 70.39 %, minor fertilization sufficed to help the crop's initial growth (Table 1).

Effects of planting date on growth and yield metrics

Growth and yield metrics of sesame (Table 2) specifically plant height was highest (74.71 cm) for August 6th sown plants ($P<0.05$), which decreased among plants sown on August 20th and September 3rd, which were statistically at par but significantly higher than sesame sown on September 17th. Significantly higher branching occurred among plants sown on 6th and 20th August, significantly higher than other planting dates. Same phenomenon was observed for leaf area index. Highest number of pods and seeds per pod (40.67 and 70.75) were observed in sesame sown on 6th August, whereas pod yield ha^{-1} was highest ($P<0.05$) when sesame was sown on August 6th. Other planting dates ranked under the former (Table 2). This could be attributable to the effect of prolonged photoperiod resulting in assimilates production and consequent partitioning of such to capsules and seeds. Similar results were reported by Alam Sarkar *et al.* (2007) who recorded higher (57) number of seeds/capsule in early sown as compared to late sown sesame. Early sown sesame crops have been reported to produce significantly higher number of capsules per plant than the mid and the late sown crops while delayed sowing severely reduced the period of capsule setting and development (Ahmed, 1992; and Ibrahim *et al.*, 2016).

Variety effects on performance of sesame

Apart from plant height, other growth and yield metrics were significant. Branching, number of pods and number of seeds per pod were highest ($P<0.05$) in Ex-Mbok (4.33, 29.75 and 69.25) while other varieties were sub-ordinate in ranking. For pod yield however, variety E8 had significantly higher pod yield values 3.89 t ha^{-1}, followed by 05E (2.64 t ha^{-1}), higher than both 04E and Ex-Mbok (2.38 and 2.36 t ha^{-1}) which were statistically at par ($P>0.05$). The higher yielding variety E8 would seem to have weightier seeds than Ex-Mbok. This could be the reason for higher pod yields. The varieties showed differences in their response to the environment they were subjected to, in the study area. Ibrahim *et al.* (2016) reported varietal differences in performance and yield among sesame genotypes studied under Sahelian conditions.

Interactions

Non-significant interactions between date of planting and sesame varieties were observed ($P>0.05$).

Summary and conclusion

Field experiment was carried out in Calabar during the late cropping season of 2023 into early 2024 for preliminary evaluation of sesame performance in Calabar. Four genotypes of sesame NCRIBEN 04E, 05E and E8 were evaluated at four different planting periods. Interaction effects were not significant. Results showed that variety E8 yielded highest pods amongst the varieties sown on the 20th of August. The study concludes that sowing in mid-August is the most appropriate sowing date for sesame and variety E8 is suitable for high yields in Calabar.

References

Ahmed, M. A. (1992). Effect of Sowing Date and Genotype on Growth and Yield of Rain-fed Sesame (*Sesamum indicum* L.). M.Sc. Thesis, University of Khartoum, Sudan.

Alam Sarkar, M. N., Salim, M., Islam, N., & Rahman, M. M. (2007). Effect of sowing date and time of harvesting on the yield and yield contributing characters of sesame (*Sesamum indicum* L.) seed. *International Journal of Sustainable Crop Production*, 2(6): 31-35.

CRBDA (Cross River Basin Development Authority) (2008).
Geremew, T., Adugna, W., Muez B., & Hagos, T. (2012). Sesame Production Manual. EIAR

Ibrahim, A., Mohammed, Z. H., Gambo, B. A., Muhammad A., & I. U. Abubakar (2016). Effects of sowing date on performance of sesame (*sesamum indicum* l.) varieties in Maiduguri, Borno State-Nigeria. *FUW Trends in Science & Technology Journal*, 1 (2): 563 – 566.

Vasantrao, N., Lale, R. G., Deshumukh, K. E., & Nikhil, M. (2015). Sesame (*Sesamum indicum* L.) importance and its high quality see oil: A Review Article.

Udo, E. J., Ibia, T. O., Ogunwale, I. A., Ano, A. O., & Esu, I. E. (2009). Manual of Soil, Plant and Water Analysis. Festac Lagos: Sibon Book Limited. p. 183.

Table 1: Physico-chemical properties of the soil used for the experiment

Physical Composition	
Sand (g/kg)	876
Clay (g/kg)	54
Silt (g/kg)	70
Chemical composition	
pH	5.4
Organic matter (%)	1.18
Total Nitrogen (%)	0.17
Available P (mg/kg)	23.04
Na (cmol/kg)	0.21
K (cmol/kg)	0.18
Ca (cmol/kg)	2.88
Mg (cmol/kg)	1.2
H^+ (cmol/kg)	1.48
Al^{+3} (cmol/kg)	0.4
ECEC (cmol/kg)	6.35
Base Saturation (%)	70.39
Exchangeable Acidity	0.06

Table 2: Growth and yield components of sesame at the study site

Treatments	Plant height (cm)	Branching	Leaf area index	Number of pods	Number of seeds pod^{-1}	Pod yield ha^{-1}
Planting date						
August 6th	74.91^{a}	3.50^{a}	1.42^{a}	40.67^{a}	70.75^{a}	3.03^{b}
August 20th	57.97^{b}	4.42^{a}	1.52^{a}	36.25^{c}	62.83^{bc}	4.45^{a}
September 3rd	55.90^{b}	3.12^{b}	1.09^{c}	27.91^{d}	50.25^{cd}	2.85^{b}
September 17th	40.78^{C}	2.50^{c}	1.25^{c}	37.17^{b}	67.58^{b}	3.89^{b}
Variety						
04E	56.58^{a}	3.25^{b}	1.27^{c}	25.00^{b}	58.17^{b}	2.38^{c}
05E	58.97^{a}	2.92^{c}	1.35^{b}	25.92^{b}	65.00^{ab}	2.64^{b}
E8	57.84^{a}	3.08^{b}	1.80^{a}	25.33^{b}	59.00^{b}	3.62^{a}
Ex-Mbok	56.17^{a}	4.33^{a}	1.35^{b}	29.75^{a}	69.25^{a}	2.36^{c}
Interactions (Date x Variety)	ns	ns	ns	ns	ns	ns

IMPORTANCE OF POLLINATORS IN CHANGING LANDSCAPE FOR CROPS: A REVIEW

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ABSTRACT

Pollinators play a crucial role in maintaining ecosystem health, food security, and global economic stability. However, their populations are declining due to habitat loss, agricultural intensification, climate change, and agrochemical use. This review examines the critical importance of pollinator diversity in ensuring crop yields and quality, preserving native plant communities, ecosystems, and human well-being. It discusses the causes and consequences of pollinator decline, including reduced crop yields, decreased biodiversity, and ecosystem disruption as well as the effects of habitat loss, agricultural intensification and climate change on pollinator diversity and abundance. The review also explores strategies for conserving and promoting pollinator populations in changing landscapes including reintroducing pollinator micro-habitats, pollinator-friendly farming practices, enhancing floral biodiversity through habitat restoration, and adopting ecosystem management strategies that integrate environmental services, social-cultural benefits, and biological control. Effective pollinator conservation requires a multifaceted approach recognizing the intricate relationships between pollinators, ecosystems, and human well-being. By synthesizing existing knowledge, this review emphasizes the urgent need for pollinator conservation to safeguard crop production and ecosystem services in a rapidly changing world.

Keywords: pollinator, pollinator diversity, conservation, floral biodiversity, habitat loss, agricultural productivity

Introduction

Pollinators are fundamental to maintaining global biodiversity, playing a pivotal role in ecosystem functioning through processes like pollination (Potts *et al.*, 2010). The symbiotic relationships between plants and pollinators underpin food production and provide essential ecological services that support biodiversity worldwide (Ollerton, 2017). A staggering 87.5% of flowering plants rely on animal pollinators for fertilization (Olleton *et al.*, 2011), with animal pollination essential for 87 key agricultural crops and 35% of global cultivation (Klein *et al.*, 2007).

Insects comprise the majority of pollinators, with Lepidoptera, Coleoptera, and Hymenoptera exhibiting remarkable diversity (Wardhaugh, 2015). Diptera and Thysanoptera are notable insect pollinator families (Orford *et al.*, 2015), although Thysanoptera's role in pollination remains understudied. Hoverflies, specifically Syrphinae and Eristalinae, have been identified

as pollinators (Rotheray and Gilbert, 2011). Further research is needed to uncover additional pollinators among invertebrate groups (Wagner *et al.*, 2021).

Ecosystem services, including pollination, are vital for human well-being but face threats (Ghazoul, 2005). Crop pollination is frequently cited as a vulnerable ecosystem service (Ghazoul, 2005). Many crops and indigenous plants rely on animal pollination for reproduction, impacting human nutrition (Wagner *et al.*, 2021). The decline of pollinator species may have far-reaching consequences for plant diversity (Biesmeijer *et al.*, 2006). Given the critical importance of pollination for human well-being, particularly in terms of food security and micronutrient intake, it is essential to revisit and update our understanding of agricultural pollination processes. This review aims to provide a comprehensive overview of the current state of knowledge on pollinators and their role in maintaining ecosystem services.

Pollinator and their roles in maintaining ecosystem services

Pollinators, primarily insects, play a vital role in maintaining biodiversity and ecosystem health by facilitating plant reproduction through pollen transfer (Ollerton *et al.*, 2011). Bees, particularly, are renowned for their effectiveness as pollinators due to their reliance on pollen as a primary food source (Winfree *et al.*, 2011). However, a diverse array of animals, including stingless bees, solitary bees, hoverflies, butterflies, wasps, moths, beetles, midges, honeybees, bats, squirrels, parrots, hummingbirds, and primates, contribute to pollination services (Klein *et al.*, 2007). While domestic honeybees have historically received attention, recent research highlights the significant contributions of wild pollinators to global agricultural pollination (Klein *et al.*, 2007). Vertebrates, such as birds and bats, also serve as important pollinators. With over 1000 species, birds are the most diverse pollinator group (Ollerton, 2017), while bats, specifically pteropodid and phyllostomid bats, pollinate around 528 plant species, including crops like durian and jackfruit (Fleming *et al.*, 2009; Lim *et al.*, 2018).

Less-studied pollinator groups, including reptiles, rodents, lemurs, and marsupials, also contribute to pollination, albeit to a lesser extent (Pastor *et al.*, 2021). Notably, reptile pollination remains understudied, despite reports of lizards consuming nectar (Wester, 2019). The dependence of both cultivated and natural plants on diverse pollinators underscores the need to address knowledge gaps in pollination, particularly among under-researched pollinator groups.

Importance of Pollinators

Pollination is a crucial ecological service supporting human well-being, wildlife, and flora. Animal pollination is essential for one-fifth of the world's principal agricultural crops, including fruits, vegetables, nuts, edible oils, and protein sources (Klein *et al.*, 2007; Maxim and Van der Sluijs, 2013). Pollinators also pay crucial role in the following:

i. **Economic and Cultural Significance:** Pollinators enhance crop quality, longevity, and economic value, contributing to food diversity, health benefits, and cultural heritage (Klein *et al.*, 2007). Approximately 40% of the global population relies on agriculture for livelihood, and pollinator declines threaten significant losses in culturally and financially important crops.

ii. **Nutritional Importance:** Pollinator-mediated crops provide vital nutrients, including: Over 90% of vitamin C, lycopene, and antioxidants; 74% of lipids; 70% of vitamin A and related carotenoids; 58% of calcium; 62% of fluoride as well as 55% of folic acid (Maxim and Van der Sluijs, 2013)

iii. **Wildlife Support:** Pollination maintains food sources for wildlife, including fruits, nuts, and seeds, supporting herbivores and other species.

iv. **Environmental Indicators:** Pollinators serve as environmental markers, reacting to pollutants and contaminants (Azam *et al.*, 2015; Skorbiłowicz *et al.*, 2018). Bees, butterflies, and bats can indicate ecological changes and monitor seasonal variations in urban environments.

v. **Disease and Pest Control:** Pollinators help control agricultural pests and disease vectors through biological control, reducing pesticide consumption and benefiting the environment and public health (Whitby *et al.*, 2020; Brock *et al.*, 2021).

vi.

Pollinator Diversity and its Effects

a. Enhancement of Plant Productivity and Recruitment

Pollinator diversity plays a vital role in the reproductive success of flowering plants (Blitzer *et al.*, 2016). Research has demonstrated a positive correlation between pollinator functional diversity and plant reproductive success in natural communities (Fründ *et al.*, 2013). Specifically, plants visited by a diverse range of pollinators tend to produce larger, high-quality seeds (Celep *et al.*, 2020). Moreover, increased pollinator diversity has been shown to enhance plant species richness in communities (Fontaine *et al.*, 2006). Conversely, restricting pollinator access to flowers can lead to decreased seedling recruitment and plant species richness (Lundgren *et al.*, 2015). These findings suggest that pollinator diversity contributes to the persistence of plant communities by promoting seed development and seedling recruitment. Further long-term studies are necessary to explore the relationships between pollinator diversity and plant community dynamics.

b. Minimization of Pollen Limitation

Pollen limitation poses significant risks to ecosystem function, threatening plant species' population dynamics and dispersal (Bennett *et al.*, 2018). Specialized plants are particularly vulnerable in the face of environmental change (Bennett *et al.*, 2020). Maintaining pollinator diversity is crucial to mitigate these risks. Low pollinator species richness contributes to pollen limitation (Gomez *et al.*, 2010). Diverse pollinators increase overall pollination success, as different plants occupy distinct pollination niches (Pauw, 2013). Varied pollinator assemblages prevent pollen limitation due to differences in foraging distances and flower-visiting behaviors. Pollinator species diversity, rather than flower visitor abundance, drives pollen limitation in natural plant communities (Gomez *et al.*, 2010). Preserving pollinator diversity is essential for healthy and resilient plant communities.

c. Importance in Agricultural Productivity

Pollinator diversity significantly enhances crop yields and quality. Studies demonstrate that diverse pollinators promote genetic diversity, gene flow, and climate resilience. For instance,

coffee weight increases with diverse pollinators (Philpott *et al.*, 2006), while mango and cotton yields improve with high pollinator richness (Rafique *et al.*, 2016; Cusser *et al.*, 2016). Additionally, loquat fruits pollinated by multiple species exhibit better quality and antioxidant characteristics (Ahmad *et al.*, 2021). Pollinator diversity also influences fruit set in various crops, including coffee (Geeraert *et al.*, 2020), almonds (Wietzke *et al.*, 2018), pumpkin (Hoehn *et al.*, 2008), and apples (Blitzer *et al.*, 2016). Preserving taxonomically diverse pollinators may be crucial for maintaining crop quality in the face of climate change.

The Causes and Consequences of the Decline of Pollinators

The global decline of insects and arthropods, including uncontrolled insect pollinators, has been catastrophic (Biesmeijer *et al.*, 2006). Reduced pollination leads to lower food yields and species diversity. The main drivers of this decline include: The intensification of agriculture, leading to habitat loss, and the widespread use of agrochemicals, nitrogen deposition, climate change, invasive species, pathogens as well as increased roads and traffic (Biesmeijer *et al.*, 2006).

i. **Loss of Habitat, Foraging, and Nesting Resources:** Agricultural intensification has led to environmental changes, including the conversion of natural areas to cultivated lands and the transformation of diversified crops to monoculture (Winfree, 2010). Urbanization has the greatest negative impact on insect flower visits (Deguines *et al.*, 2012). Modern agriculture has reduced wild flower availability and diversity (Klein *et al.*, 2007).
ii. **Depletion of Floral Resources:** Reactive nitrogen pollution from fertilizer and manure production, and fossil fuel burning, supports the decline of pollinators. Nitrogen buildup in soils alters ecosystem composition and reduces blooming plants (Biesmeijer *et al.*, 2006).
iii. **Climate Change:** Climate change contributes to habitat degradation, altering climate zones and disrupting pollinator-plant interactions (Potts *et al.*, 2010). Earlier blooming due to climate change may create gaps in pollen supply during honeybee foraging seasons.

Proposed Solutions

The UN Convention on Biodiversity's Strategic Plan (2011-2020) lacks specific pollinator conservation strategies. Instead, it focuses on ecosystem services and habitat restoration (CBD, 2010). The FAO oversees the Conservation and Sustainable Use of Pollinators project (2002).

Critics argue that emphasizing economic benefits neglects pollinator diversity, resilience, and intrinsic value (Wyss Institute, 2016). A more comprehensive approach should incorporate biological, moral, and cultural arguments. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) addresses pollinator conservation. Its thematic assessment on pollinators, pollination, and food production was released in 2016. Hence some proposed national, regional, and state-level solutions include:

i. Conserve and reintroduce pollinator micro-habitats to offset land use changes.
ii. Enhance floral biodiversity through ecosystem restoration.
iii. (Re)introduce hedgerows, field margins, and microhabitats in agricultural landscapes.
iv. Incorporate blooming trees in meadows for shade and floral resources.

v. Create pollinator-friendly urban spaces, including floral resources and nesting sites.
vi. Manage road margins and urban green areas to promote pollinator-friendly design.
vii. Ban neonicotinoids, fipronil, and prophylactic agrochemical use.
viii. Support food security through phenologically linked crop blossoming and pollinator manipulation.
ix. Technological solutions include robotic pollinators, chemical-induced fruit set, and genetically engineered crops.

Summary and Conclusion

Research consistently highlights the vital role of pollinators relationship in maintaining native plant communities, ecosystems, and the global economy, particularly in food production. However, the actual number of species in most biomes is outdated. Agricultural intensification since the 1940s has led to significant habitat losses, threatening pollinator populations.

Pollinators are essential for the reproduction of most cultivated and native plants, and their decline jeopardizes ecosystem stability. Pollinator diversity preserves native plant groups which controls ecosystems. Emerging research underscores the unique ecosystem services provided by pollinator variety, crucial for food security and environmental safety through ecological monitoring.

Beyond ecological benefits, pollinators contribute to human welfare through aesthetic and socio-cultural benefits. To effectively protect pollinator diversity, ecosystem management strategies must integrate environmental services, social-cultural benefits, and biological control of agricultural pests and disease vectors. Effective conservation requires a multifaceted approach, recognizing the intricate relationships between pollinators, ecosystems, and human well-being.

References

Ahmad, S., Khalofah, A. and Khan, S. A. (2021). Effects of native pollinator communities on the physiological and chemical parameters of loquat tree (*Eriobotrya japonica*) under open field condition. *Saudi Journal of Biological Science.* 28, 3235-3241. https://doi.org/10.1016/j.sjbs.2021.02.062.

Azam, I., Afsheen, S. and Zia, A. (2015). Evaluating insects as bioindicators of heavy metal contamination and accumulation near industrial area of Gujrat, Pakistan. *BioMedical Resources International.* 942751. https://doi.org/10.1155/2015/942751.

Bennett, J. M., Steets, J. A. and Durka, W. (2018). Glopl, a global data base on pollen limitation of plant reproduction. *Science Data* 5, 1-9. https://doi.org/10.1038/sdata.2018.249.

Bennett, J. M., Steets, J. A. and Burns, J. H. (2020). Land use and pollinator dependency drives global patterns of pollen limitation in the Anthropocene. *National Communication*. 11, 1-6. https://doi.org/10.1038/s41467-020-17751-y.

Biesmeijer, J. C., Roberts, S. P. M., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., Schaffers, A. P., Potts, S. G., Kleukers, R. and Thomas, C. D. (2006). Parallel declines

in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science.* 313, 351–354.

Blitzer, E. J., Gibbs, J. and Park, M. G. (2016). Pollination services for apple are dependent on diverse wild bee communities. *Agricultural Ecosystem and Environment.* 221, 1-7. https://doi.org/10.1016/j.agee.2016.01.004.

Brock, R. E., Cini, A. and Sumner, S. (2021). Ecosystem services provided by aculeate wasps. *Biology Revised.* 96, 1645-1675. https://doi.org/10.1111/brv.12719

CBD (2010). Strategic plan for biodiversity 2011–2020 and the Aichi biodiversity targets. Convention of biological diversity http://www.cbd.int/decision/cop/?id=12268. Accessed 22nd October, 2023.

Celep, F., Atalay, Z. and Dikmen, F. (2020). Pollination ecology, specialization, and genetic isolation in sympatric bee-pollinated Salvia (Lamiaceae). *International Journal of Plant Science.* 181, 800-811. https://doi.org/10.1086/710238.

Cusser, S., Haddad, N. M. and Jha, S. (2021). Unexpected functional complementarity from non-bee pollinators enhances cotton yield. *Agricultural Ecosystem and Environment.* 314, 107415. https://doi.org/10.1016/j.agee.2021.107415.

Deguines, N., Julliard, R., de Flores, M. and Fontaine, C. (2012). The whereabouts of flower visitors: Contrasting land-use preferences revealed by a country-wide survey based on citizen science. PLoS One, 7, e45822.

FAO (2016). FAO's global action on pollination services for sustainable agriculture. http://www.fao.org/pollination/projects/en/. Accessed 22nd October, 2023.

Fleming, T. H., Geiselman, C. and Kress, W. J. (2009). The evolution of bat pollination: a phylogenetic perspective. *Annual Botany.* 104, 1017-1043. https://doi.org/10.1093/aob/mcp197.

Fontaine, C., Dajoz, I. and Meriguet, J. (2006). Functional diversity of plant pollinator interaction webs enhances the persistence of plant communities. *PLoS Biology.* 4, 129-135. https://doi.org/10.1371/journal.pbio.0040001

Fründ, J., Dormann, C. F. and Holzschuh, A. (2013). Bee diversity effects on pollination depend on functional complementarity and niche shifts. *Ecology.* 94, 2042-2054. https://doi.org/10.1890/12-1620.1.

Geeraert, L., Aerts, R. and Berecha, G. (2020). Agriculture, ecosystems and environment effects of landscape composition on bee communities and coffee pollination in Coffea arabica production forests in southwestern Ethiopia. *Agricultural Ecosystem and Environment.* 288, 106706. https://doi.org/10.1016/j.agee.2019.106706

Ghazoul, J. (2005). Buzziness as usual? Questioning the global pollination crisis. *Trends of Ecology and Evolution.* 20, 367-373. https://doi.org/10.1016/j.tree.2005.04.026

Gomez, J. M., Abdelaziz, M. and Lorite, J. (2010). Changes in pollinator fauna cause spatial variation in pollen limitation. *Journal of Ecology.* 98, 1243-1252. https://doi.org/10.1111/j.1365-2745.2010.01691.x.

Hoehn, P., Tscharntke, T. and Tylianakis, J. M. (2008). Functional group diversity of bee pollinators increases crop yield. *Proceedings of Royal Society of London.* 275, 2283-2291. https://doi.org/10.1098/rspb.2008.0405

Klein, A. M., Vaissière, B. E., Cane, J. H., Cunningham, S. A., Steffan-Dewenter, I., Kremen, C. and Tscharntke, T. (2007). Importance of crop pollinators in changing landscapes for world crops. *Proceedings of Royal Society of London.* 274, 303–313. https://doi.org/10.1098/rspb.2006.3721.

Lim, V. C., Ramli, R. and Bhassu, S. (2018). Pollination implications of the diverse diet of tropical nectar-feeding bats roosting in an urban cave. *Peer Journal.* 6, e4572. https://doi.org/10.7717/peerj.4572.

Lundgren, R., Lazaro, A. and Totland, Ø. (2015). Effects of experimentally simulated pollinator decline on recruitment in two European herbs. *Journal of Ecology.* 103, 328-337. https://doi.org/10.1111/1365-2745.12374.

Maxim, L. and van der Sluijs, J. P. (2013). Seed-dressing systemic insecticides and honeybees. In Late lessons from early warnings: science, precaution, innovation. 401–438, ed. European Environment Agency. European Environment Agency (EEA) report 1/2013, Copenhagen.

Ollerton, J. (2017). Pollinator diversity: distribution, ecological function, and conservation. *Annual Revised Ecology and Evolution System.* 48, 353-376. https://doi.org/10.1146/annurev-ecolsys-110316-022919

Ollerton, J., Winfree, R. and Tarrant, S. (2011). How many flowering plants are pollinated by animals? Oikos 120, 321–326. https://doi.org/10.1111/j.1600-0706.2010.18644.x

Orford, K. A., Vaughan, I. P. and Memmott, J. (2015). The forgotten flies: the importance of non-syrphid Diptera as pollinators. *Proceedings of Royal Society of Bees.* 282, 2014-2934. https://doi.org/10.1098/rspb.2014.2934.

Pastor, J. F., Muchlinski, M. N. and Potau, J. M. (2021). The tongue in three species of lemurs: flower and nectar feeding adaptations. *Animals* 11, 2811. https://doi.org/10.3390/ani11102811.

Pauw, A. (2013). Can pollination niches facilitate plant coexistence? *Trends in Ecology and Evolution.* 28, 30-37. https://doi.org/10.1016/j.tree.2012.07.019.

Philpott, S. M., Uno, S. and Maldonado, J. (2006). The importance of ants and higheshade management to coffee pollination and fruit weight in Chiapas. Mexico. *Biodiversity Conservation.* 15, 487-501. https://doi.org/10.1007/s10531-005-0602-1.

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O. and Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology and Evolution.* 25, 345–353. https://doi.org/10.1016/j.tree.2010.01.007

Rafique, M. K., Quratulain, M. R. and Stephen, E. (2016). Pollination deficit in mango orchards at Multan, Pakistan. *Pakistan Journal of Zoology.* 48, 35-38.

Rotheray, G. E. and Gilbert, S. F. (2011). The Natural History of Hoverflies. Forrest Text, Tresaith, UK.

Skorbiłowicz, E., Skorbiłowicz, M. and Ciesluk, I. (2018). Bees as bio indicators of environmental pollution with metals in an urban area. *Ecological Engineering.* 19, 229-234. https://doi.org/10.12911/22998993/85738.

Wagner, D. L., Grames, E. M. and Forister, M. L. (2021). Insect decline in the Anthropocene: Death by a thousand cuts. *Proceedings of National Academic Science. U.S.A.* 118, e2023989118. https://doi.org/10.1073/PNAS.2023989118

Wardhaugh, C. W. (2015). How many species of arthropods visit flowers? *Arthropod Plant Interactaction.* 9, 547-565. https://doi.org/10.1007/s11829-015-9398-4.

Wester, P. (2019). First observations of nectar-drinking lizards on the African mainland. *Plant Ecology and Evolution* 152, 78-83. https://doi.org/10.5091/plecevo.2019.1513.

Whitby, M. D., Kieran, T. J. and Glenn, T. C. (2020). Agricultural pests consumed by common bat species in the United States corn belt: the importance of DNA primer choice. *Agricultural Ecosystem and Environment.* 303, 107105. https://doi.org/10.1016/j.agee.2020.107105.

Wietzke, A., Westphal, C.and Gras, P. (2018). Insect pollination as a key factor for strawberry physiology and marketable fruit quality. *Agricultural Ecosystem and Environment.* 258, 197-204. https://doi.org/10.1016/j.agee.2018.01.036.

Winfree, R. (2010). The conservation and restoration of wild bees. *Annual New York Academic Science.* 1195, 169–197.

Winfree, R., Gross, B. J. and Kremen, C. (2011). Valuing pollination services to agriculture. *Ecological Economics.* 71:80–88

Wyss Institute (2016). The RoboBees project and colony collapse disorder. http://wyss.harvard.edu/viewpage/536. Accessed 22nd October, 2023.

EVALUATION OF NPK APPLICATION RATES AND PHENOLOGICAL STAGE EFFECTS ON VEGETATIVE GROWTH OF FISH BEAN

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ABSTRACT

One-year field experiment was conducted in 2019 at Akpabuyo Local Government Area of Cross River State, South-eastern rainforest to study the effects of NPK 20.10.10 rates and time of application on the vegetative growth of T. vogelii. The design consisted of three rates of N.P.K 20.10.10. (0, 100 and 200 kg/ha); and two fertilizer application periods (pre-anthesis and early pod commencement), giving a combination of 3 x 2 x 3 = 18 treatments. Randomized Complete Block Design (RCBD) with three replications was used to disperse all treatments in the field. Results showed that Tephrosia vogelii plants that were fertilized before the commencement of anthesis with 200 kg/ha N.P.K. 20.10.10 had better growth and yield performance, outstripping plants that received 0 and 100 kg/ha NPK. Interactively, 200 kg/ha of NPK fertilizer at early pre-anthesis gave the best performance of the plant during the study. The study has shown that T. vogelii can be propagated in the study area. N, P, and K are very essential to plant growth, development and seed yield performance as well as support photosynthesis and root system formation. NPK fertilizer at 200 kg/ha is optimum for basal fertilization of T. vogelii for optimum yields as demonstrated.

Key words: Soil fertility, fish bean, phenology, temporal application, Photosynthesis.

INTRODUCTION

A candidate plant species for development as a non-food, pesticidal crop is *Tephrosia vogelii* Hook F. Also known as fish bean, fish-poison bean, or vogel's tephrosia, *T. vogelii* is native to tropical Africa, and belongs to the family *leguminosae*, sub family papilionaceae. It is a small leguminous tree which can be used to improve soil fertility, owing to its nitrogen fixing ability. In agroforestry, it may be used as green manure, wind breakers and temporary shade crop in cocoa, coffee, tea, rubber, coconut and cinchona plantations (Jama *et al.*, 2000). Because of its dense growth, it is suitable as a hedge plant and for firewood. It can also be used as a medicine for skin diseases and internal worms.

The poisonous leaves and seeds of *T. vogelii* have been used as a fish poison, (although this is now illegal in many countries), and because livestock do not graze it, this plant may be useful in solving the problem of clashes between herders and farmers in Nigeria and elsewhere. The 'poisonous substances' contained in *T. vogelii* is mainly rotenone, but also deguelin, both of which are the most toxic rotenoids. Rotenone is classified by the World Health Organization (WHO) as a moderately hazardous or Class II pesticide, which can be used for the control of

pests in the field, in storage or domestic animals (Koigi, 2011). Because of its high rotenone content, large size, rapid growth and adaptation to a wide range of growing conditions, *T. vogelli* was selected in the United States of America for study and development as a new, non-food crop species, prior to the emergence of synthetic pyrethroids (USDA, 2015). A study in East Africa, found that farmers ranked *T. vogelli* as the most efficacious and preferred pesticidal plant species (USDA, 1970; Mkindi *et al.*, 2017). In Nigeria, field studies have shown that extracts of *T. vogelii* are effective in the management of insect pests of cowpea (Alao *et al.*, 2011), Roselle (Olaniran, 2013), Water Melon (Alao and Adebayo, 2015), amongst others, while Mafongoya *et al.* (2003) found that the plant is useful in improving fallows in Southern Africa. *T. vogelii* has also been found useful in the control of livestock pests (Isabirye and McCleod, 2015).

Inspite of the economic importance of *T. vogelii,* its agronomy scarcely reported in literatures, therefore this study was carried out to evaluate the effects of inorganic fertilizer on growth and biomass yield of *T. vogelii* in Akpabuyo Local Government Area of Cross River State, Nigeria.

MATERIALS AND METHODS

Experimental Location

The experiment was conducted under rain-fed conditions at CROSPIL ESTATE, Akpabuyo (Tropical High Forest; 8° 27' E; 4° 28' N), in 2019. Akpabuyo is characterized by humid tropical climate and a bimodal rainfall pattern ranging from about 2500-3000 mm per annum. The ambient temperature ranges from 23-35° C, while relative humidity is 87 % (NIMET, 2011).

Experimental design and treatments

The experiment was a 2 x 3 factorial laid out in RCBD, replicated three times. NPK 20:10:10 was applied at 0, 100 and 200 kg/ha, at two stages of plant growth (seedling stage, immature pod stage). Specifically, the following treatment combinations were evaluated:

i) No fertilizer application at seedling or any other stage a_3b_1
ii) 100 kg/ha NPK 20:10:10 applied at Seedling stage a_1b_1
iii) 200 kg/ha NPK 20:10:10 applied at Seedling stage a_2b_1
iv) No fertilizer application at immature pod or any other stage a_3b_2
v) 100 kg/ha NPK 20:10:10 applied at Immature pod stage a_1b_2
vi) 200 kg/ha NPK 20:10:10 applied at Immature pod stage a_2b_2

RESULTS AND DISCUSSION

The effects of applying NPK 20:10:10 fertilizer at different rates, phenological growth stage at time of fertilization and their interaction on height of *T. vogelii* plants are presented in Table 1. At all periods of sampling, plants to which fertilizer was applied grew significantly taller than others, although those that received the relatively higher rate of 200 kg/ha were taller, the difference in plant height was statistically similar to those that received 100 kg/ha.

Similar to the effect of fertilizer rate, the stage of plant growth at which fertilization was done also affected plant height significantly, since in general, seedling application resulted in significantly taller plants compared to application at the immature pod stage. The effect on plant

height of the interaction of fertilizer rate and stage of plant growth when application was done was significant at all sampling periods except 7 WAP. The tallest plants were produced in the plots to which 200 kg/ha NPK 20:10:10 fertilizer was applied at the seedling stage, while the shortest plants were obtained in the control plots. The other treatment combinations were at the borderline between the tallest and the shortest.

At 7 WAP, the application of NPK 20:10:10 at the different rates and plant growth stages evaluated did not affect the number of branches borne per plant in the 2019 cropping season, just like the interaction of the two factors. However, at subsequent periods of sampling, all fertilized plant produced significantly more branches than unfertilized ones, with 200 kg/ha 20:10:10 bearing significantly more branches than 100 kg/ha 20:10:10 at 9, 11 and 15 WAP (Table 2). Seedling stage fertilization consistently performed better than immature pod stage, and in general, significantly more branches were borne by those plants that were fertilized at the seedling growth stage.

The effects of fertilizer rate and time of application, and their interactions on number of leaves of *Fish bean* at 7 – 15 WAP in 2019 are presented in Table 3. The effect of fertilizer rates on the number of leaves of *Fish bean* was significant at all sampling periods except at 7 WAP. When N.P.K. 20:10:10 fertilizer was received at 200 kg/ha, it resulted in significantly ($P \leq 0.05$) higher number of leaves than the control and 100 kg/ha NPK 20:10:10 fertilizer rate at 9 to 15 WAP. The number of leaves increased significantly ($P \leq 0.05$) as fertilizer rate increased from 0 to 200 kg/ha NPK 20:10:10.

The effect of time of fertilizer application was significant at all sampling periods, except at 7 WAP. *Fish bean* plants that received NPK 20:10:10 fertilizer at seedling stage produced more leaves at 9 – 15 WAP, ($P \leq 0.05$) than those that received fertilizer applications at early/immature pod stage of development.

DISCUSSION

The superior vegetative and yield performance of Fish bean, in the plots that received NPK 20:10:10 fertilizer relative to those without fertilizer application suggests that the compound fertilizer had provided nutrients to the plant which possibly had enhanced the general wellbeing of the plant resulting in a better vegetative growth and superior yield. The macro elements N, P and K are essential for the growth, development and seed yield of tree legumes. Nitrogen is needed for protein production, leaf growth, and supports metabolic processes such as photosynthesis (Ali and Wulan, 2018). While phosphorus plays a role in stimulating root growth and the formation of a good root system in young plants, as a constituent material for nuclei (nucleic acids), fats, and proteins (Djumaeva et al., 2010). Potassium plays a role in the formation of proteins and carbohydrates, increasing plant resistance to pests and diseases, and improving the quality of crop yields (Glover et al., 2012). Soil is one of the media in giving nutrients to plants. Giving fertilizers containing nitrogen to the soil can increase immediate nutrient availability for plants (Subhan *et al.*, 2009). This finding is in consonance with the results earlier reported by Abayomi *et al.* (2008) and Omotoso (2014).

The better vegetative and yield performance of Fish bean in the plots treated with NPK fertilizer at seedling stage relative to those treated with NPK at flowering is evidence that the time of applying NPK fertilizer had significant effect on the growth and yield of Fish bean, regardless of NPK fertilizer rates. The poor performance of Fish bean in the plots treated with NPK fertilizer rates after flowering suggest that late application of fertilizer was not beneficial to plant growth and yield. The superiority of Fish bean plants in the plot treated with 200 kg/ha NPK 20:10:10 fertilizer rate at seedling stage relative to those treated with 100kg/ha NPK 20:10:10 fertilizer rate at flowering indicates that timing of fertilizer application is very important in Fish bean production. Even when, the NPK fertilizer rate is increased, improper timing will make it far less beneficial for plants. Similarly, Ndor and Faringoro (2020), while working on the effect of time of application of NPK fertilizer on the performance of cowpea observed that plots that received NPK fertilizer earlier at 2 WAP were superior in both vegetative and yield performance relative to when NPK fertilizer was applied prior to flowering. The better vegetative and yield performance of Fish bean in the plots treated with 200 kg/ha NPK fertilizer rate at seedling stage relative to application at flowering shows that the application of NPK fertilizer at the right time and dose had positive influence on growth and yield of Fish bean. This corroborates the report of Amujoyegbe and Alofe (2003), that the application of NPK fertilizer in appropriate time and amount will increase the availability of nitrogen in the soil. This availability of nitrogen will in turn be used for processes such as protein formation. Having the ability to produce adequate protein which is used in the process of cell division and differentiation will result in, rapid growth of tissue and organ.

CONCLUSION

Application of higher NPK 20:10:10 at the rate of 200kg /ha fertilizer at seedling stage gave higher vegetative growth of fish bean than lower fertilizer rate of 100kg/ha at flowering stage. The study therefore recommends that the application of basal fertilizers should be done at the early stages of crop growth before the onset of flowering for high yields. Further studies on the plant should be encouraged to discover more of its characteristics, being a somewhat novel plant.

REFERENCES

Abayomi, Y. A., Ajibade, T. V., Samuel, O. F. & Sa'adudeen, B. F. (2008). Growth and yield responses of cowpea (*Vigna unguiculata* (L.) Walp) genotypes to nitrogen fertilizer (N.P.K.) application in the Southern Guinea Savanna zone of Nigeria. *Asian Journal of Plant Sciences,* 7:170-176.

Alao, F. O. & Adebayo, T. A. (2015). Comparative efficacy of *Fish bean* and *Moringa oleifera* against insect pests of water melon (*Citrullus lanatus* Thumb). *International Letters of Natural Sciences* 35, 71-78.

Alao, F. O., Adebayo, T. A. & Olaniran, A. O. (2013). On-farm evaluation of natural toxicants from *Fish bean* and *Petiveria alliacea* on *Megalurothrips sjostedti* and *Apion varium* of cowpea *Vigna unguiculata* (L) Walp. *Bangladesh Journal of Agricultural Research* 36(4): 575-582.

Ali, M., & Wulan, W. (2018). Effects of sand and sugar concentration rosella (*Hisbiscus sabdariffa* Linn) against quality of jelly candy. *Teknoboyo*, *2*(1) 223 – 229.

Amujoyegbe, B. J. & Alofe, C. O. (2003). Influence of poultry manure and inorganic nitrogen fertilizer on grain yield and proximate component of two cultivars of cowpea (*Vigna unguiculata* L. Walps). *Moor Journal of Agricultural Research*, 4:37-45.

Djumeva, D., Lamers, J. P. A. Martins, C., Khamzina, A., Ibragimov, N. & Vlex, P. L. G. (2010). Qualification of symbolic nitrogen fixation by *Elaeagnus angustifolia* L. on salt affected irrigated crop lands using tried 15 N isotopic methods. *Nutrient Cycling in Agroecosystem*, 88, 3, 329 – 339.

Glover, J. D., Reganold, J. P. & Cox, C. M. (2012). Plant perennials to save African soils. *Nature*, 489, 359 – 361.

Isabirye, R. A. & Mecleod, E. (2015). *Fish bean* for control of fleas in free-range poultry. *Uganda Journal of Agricultural Science* 16(1), 29-41.

Jama, B.., Swinkel S. R. A., & Buresh, R. J., (2000). Agronomy and economy evaluation of organic and inorganic resources of phosphorus in West Kenyia. *Agronomy Journal* 89 (4); p. 597 – 604.

Koigi, Bob (November 2011). *"Fish bean* Leaf Offers Low-Cost Tick Protection" (http://www.new-ag.info/en/focus /focusItem.php?a=2267). *New Aghculturalist.*

Mafongoya, P. L., Chintu, R., Chirwa, T. S., Matibini, J. & Chikale, S. (2003). *Tephosia* species and providences for improved fallows in southern Africa. *Agroforestry System*, 59, 3, 279 – 288.

Mkindi, A., Mpumi, N., Tembo, Y., Stevenson, P. C., Ndakidemi, P. A., Mtei, K., Machunda, R. & Belmain, S. R. (2017). Invasive weeds with pesticidal properties as potential new crops. *Industrial Crops and Products*. Available online at: http//dx.doi.org/10.1016/j.indcrop.2017.06.002.

Ndor, E. & Faringoro, U. D. (2020). Response of Cowpea (*Vigna unguiculata* L. Walp) to time of application and nitrogen fertilizer on the degraded soil of southern guinea savanna zone of Nigeria. *Asian Soil Research Journal*, 3(1): 36-42.

NIMET (Nigerian Meteorological Agency) (2020). Monthly weather data sheets: 2019-2020. University of Calabar meterological services, Calabar, Cross River State, Nigeria.

Olaniran, O. A. (2013). Control of foliage pests of Roselle (*Hibiscus sabdariffa* L) using plant extracts of *Fish bean* and *Azadirachta indica* in Ogbomosho, Nigeria. *Transnational, Journal of Science and Technology* 3(6): 51-62.

Omotoso S. O. (2014). Influence of NPK 15-15-15 fertilizer and pig manure on nutrient dynamics and production of cowpea, *Vigna unguiculata* L. Walp. *American Journal of Agriculture and Forestry*, 2(6):267- 273.

Subhan, N. Nurtika, D. & Gunadi, N. (2009). Tomato Plant Response to the use of NPK compound fertilizer 15-15-15 in latosol soil in the dry season. *Journal of Horticulture,* 19, (1):40-48.

USDA (2015). Tephrosia vogelii (https://plants.usda.gov/core/profile?synibol=JEy02). Natural Resources Conservation Service PLANTS Database. USDA. Retrieved 8 December 2015.

TABLE 1
Effect of NPK fertilizer rate and plant growth stage at application on plant height of fish bean in 2019 cropping season

Treatment	Plant height (cm)				
	7WAP	9WAP	11WAP	13WAP	15WAP
Fertilizer rate (kg/ha)					
0	40.43^{ab}	49.20^{ab}	63.80^{b}	75.50^{b}	116.90^{b}
100	43.65^{a}	53.70^{a}	71.20^{a}	86.80^{a}	126.90^{a}
200	38.77^{b}	45.50^{b}	54.90^{c}	61.80^{c}	109.70^{c}
TOA					
Seedling	40.42^{a}	54.20^{a}	70.30^{a}	82.40^{a}	126.00^{a}
Pod	41.48^{a}	44.70^{b}	56.30^{b}	67.00^{b}	109.70^{b}
Interaction					
100kg x seedling	38.7^{a}	55.50^{ab}	71.30^{a}	82.90^{b}	124.80^{ab}
100kg x pod	42.13^{a}	42.80^{c}	56.30^{b}	68.20^{cd}	109.00^{cd}
200kg x seedling	43.77^{a}	59.40^{a}	82.10^{a}	98.60^{a}	134.80^{a}
200kg x pod	43.53^{a}	48.00^{bc}	60.20^{b}	75.10^{bc}	119.00^{bc}
0kg x seedling	38.77^{a}	47.70^{bc}	57.30^{b}	65.80^{cd}	118.40^{bc}
0kg x pod	38.77^{a}	43.30^{c}	52.40^{b}	57.80^{d}	101.00^{d}

In a column, means followed by the same letter are not significantly different by DNMRT at 5 % probability level. TOA = stage of application, A_1 = 100 kg / ha NPK 20:10:10, A_2 = 200 kg / ha NPK 20:10:10, A_3 = control, B_1 = seedling stage; B_2 = immature pod stage.

TABLE 2
Effect of NPK fertilizer rate and growth stage at application on number of branches/plant of fish bean in 2019 cropping season

Treatment	Number of branches				
	7WAP	9WAP	11WAP	13WAP	15WAP
Fertilizer (kg/ha)					
0	1.60^{a}	4.07^{b}	5.62^{b}	8.82^{a}	13.00^{b}
100	2.08^{a}	4.85^{a}	6.92^{a}	10.17^{a}	14.45^{a}
200	2.33^{a}	3.25^{c}	4.20^{c}	7.15^{b}	9.48^{c}
TOA					
Seedling	2.09^{a}	4.91^{a}	6.91^{a}	10.23^{a}	13.50^{a}
Pod	1.92^{a}	3.20^{b}	4.24^{b}	7.19^{b}	11.12^{b}
NPK x stage					
100kg x seedling	1.40^{a}	4.77^{b}	7.23^{b}	10.40^{b}	14.57^{b}
100kg x pod	1.80^{a}	3.37^{c}	4.00^{c}	7.23^{c}	11.43^{c}
200kg x seedling	1.90^{a}	6.43^{a}	9.07^{a}	13.07^{a}	16.53^{a}
200kg x pod	2.27^{a}	3.27^{c}	4.77^{c}	7.27^{c}	12.37^{c}
0kg x seedling	2.97^{a}	3.53^{c}	4.43^{c}	7.23^{c}	9.40^{d}
0kg x pod	1.70^{a}	2.97^{c}	3.97^{c}	7.07^{c}	9.57^{d}

In a column, means followed by the same letter are not significantly different by DNMRT at 5 % probability level. TOA = stage of application, A_1 = 100 kg / ha NPK 20:10:10, A_2 = 200 kg / ha NPK 20:10:10, A_3 = control, B_1 = seedling stage, B = immature pod stage.

TABLE 3

Effect of NPK fertilizer rate and growth stage at application on number of leaves of fish bean in 2019 planting

Treatment	Number of leaves				
	7WAP	9WAP	11WAP	13WAP	15WAP
Fertilizer (kg/ha)					
0	6.18[a]	8.53[b]	10.17[b]	11.78[b]	14.80[b]
100	6.75[a]	9.47[a]	11.30[a]	13.97[a]	17.00[a]
200	6.12[a]	7.77[c]	8.38[c]	10.13[c]	11.88[c]
TOA					
Seedling	6.32[a]	9.31[a]	10.99[a]	13.59[a]	16.12[a]
Pod	6.38[a]	7.87[b]	8.91[b]	10.33[b]	13.00[b]
NPK x stage					
100kg x seedling	5.77[a]	9.30[b]	11.57[a]	13.23[b]	16.57[b]
100kg x pod	6.60[a]	7.77[b]	8.77[b]	10.33[c]	13.03[cd]
200kg x seedling	6.97[a]	10.93[a]	13.17[a]	17.13[a]	19.43[a]
200kg x pod	6.53[a]	8.00[b]	9.43[b]	10.80[c]	14.57[bc]
0kg x seedling	6.23[a]	7.70[b]	8.23[b]	10.40[c]	12.37[cd]
0kg x pod	6.00[a]	7.83[b]	8.53[b]	9.87[c]	11.40[d]

In a column, means followed by the same letter are not significantly different by DNMRT at 5 % probability level. TOA = time of application, A_1 = 100 kg / ha NPK 20:10:10, A_2 = 200 kg / ha NPK 20:10:10, A_3 = control, B_1 = seedling stage; B_1 = immature pod stage.

CONJUGAL EFFECT OF D.I.GROW BIO-ORGANIC FERTILIZER AND ORGANO-MINERAL FERTILIZER ON THE GROWTH AND YIELD OF CUCUMBER (*Cucumis sativus L.*) IN SOUTH EASTERN RAINFOREST ZONE OF NIGERIA

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ABSTRACT

A 3 x 4 factorial nutrient experiment on cucumber (Cucumis sativus L.) was conducted in 2022 and 2023 cropping season at the Crop Research Farm of the Department of Crop Science, University of Calabar, Calabar to evaluate the conjugal effect of varying concentrations of foliar applied D.I. Grow bio-organic fertilizer (D) at 0, 50 and 100 ml/L and organo-mineral fertilizer rates at 0,3, 6 and 9 t/ha on the productivity of cucumber. Treatments were factorially combined and laid out in a Randomized Complete Block Design replicated thrice. Data were presented as an average of two years and mean (±SE) of three replicates. Data generated were subjected to statistical analysis of variance (ANOVA) and significantly different means were compared using Fisher's least significant difference (FLSD) while interactions were compared using New Duncan's Multiple Range Test Method (DMRT). Results obtained showed that foliar sprayed D-Grow bio-organic fertilizer significantly ($P \leq 0.05$) and potentially enhanced vine length, number of leaves and leaf area at high levels but was not significant on yield indicators irrespective of the rates. However, a synergy between D.I. Grow fertilizer at higher rates (100 ml/L) in conjunction with lower rate (3 t/ha) of organo-mineral fertilizer significantly ($P \leq 0.05$) produced higher growth and yield indices as well as fruit yield per hectare and is therefore suggested for recommendation and adoption by vegetable farmers in Southeastern agro-ecological zone of Nigeria.

Key Words: Cucumber, D.I. Grow fertilizer, organo-mineral fertilizer, conjugation and yield.

Introduction

Cucumber *(Cucumis Sativus L.)* is one of the major fruit vegetable crops grown worldwide. It is a creeping vine that roots deep in the ground and grows on other supporting frames, wrapping around supports with thin, spiraling tendrils (Mariod, Mirghani and Husscin 2017; Hemphill 2014). It belongs to the cucurbitaceae family to which fluted pumpkin and fluted gourd also belong. Cucumber fruits are roughly cylindrical, elongated, with tapered ends and may be as large as 60cm long and 10-12cm in diameter. The demand for cucumber as a fruit vegetable has tremendously increased owing to its nutritional and medicinal values (Okoli and Nweke 2015; Otie *et al.* 2024; Rivers *et al.* 2024). It supplies vitamins (A, C, K and B_6), potassium, panthothenic acid, Mg, Cu and Mn), minerals and anti-oxidants to the body. It also supplies thiamine, niacin, iron, calcium and other nutritional characters (Gopalan,Rama and Balasubramanian 2015). In addition to its delicious taste it has high medicinal value. It is well

known for natural diuretic and thus, can serve as an active drug for secreting and promoting the flow of urine. Due to its high potassium content (50 – 80mg /100g), cucumber can highly be useful for both high and low blood pressures (Khan *et al.* 2015). It is also an excellent source of dietary fiber that massages the teeth and gums (Adeoye and Batogun 2016). Daily consumption of fresh cucumber also helps to control digestive disorders such as heat burn, gastritis and ulcers. Its high water content flushes away toxins from the digestive system and hence aid nutrient assimilation and absorption in the body.

Organo-mineral fertilizers release nutrient slowly and steadily and besides being rich sources of macro and micro nutrients, act as chelating agents and regulate the plant growth by providing nutrients in the available forms. It also contains active metabolites particularly gibberellins, cytokinins, auxins and group B vitamins.

D.I. Grow bio-organic fertilizer is a natural liquid fertilizer formulation developed to ensure the enhancement of crops and boost agricultural productivity both in quality and quantity. Its potential productivity is thrice that of synthetic or chemical fertilizer. Foliar applied fertilizers have properties which enable them penetrate the cellular barrier to enter into plants more easily, synergise at cellular and sub-cellular level to stimulate plant biomass accumulation, improve plant stress resistance (El-Shetehy *et al.* 2021) as well as promote photosynthesis for enhanced crop yield (Du *et al.* 2022; Binang *et al.*, 2024). It also enhances the efficiency of nutrient uptake by plants and stabilizes the soil ecosystems (Perea-velez, Carillo-Gonzalez and Gonzalez-Chave 2021). Before application, it is usually diluted as follows:

1 Liter D.I. Grow	=	1 application
1 Drum (200L) of water		Hectare

Mineral composition of D.I. Grow (ml/L)

- Nitrogen (N) 3.19 %
- Phosphorus ($P_2 0_5$) 1.15 %
- Potassium ($K_2 0$) 1.21 %
- Magnesium (Mg0) 0.21 %
- Calcium (Ca) 0.008 %
- Sulphur (S) 0.61 %
- Iron (Fe) 5mg
- Iodine (IoD) 3mg
- Zinc (Zn) 1 mg

Fertile soils are used for the cultivation of cucumbers. Infertile soil results in bitter and mis-shaped fruits which are often rejected by consussmers (Nweke and Nsoanya 2015). Despite the economic potentials of the crop, its full production potentials in Nigeria have not been realized. This tremendous decline in cucumber productivity may be due to the intensification of agricultural land which has resulted in degradation of soil and water resources, diminishing biodiversity exacerbated by deforestation and increasing environmental pollution. These challenges have unequivocally placed farmers and agronomist at a cross-road. The need of fertilizing crops as well as improvement in environmental conditions and public health are important reasons for advocating the concept of agriculture due to realization of inherent advantages. Since cucumber is a short duration crop, combined application of organ-mineral fertilizers and foliar applied D.I. Grow bio-organic fertilizer has been found to be one of the quickest and easiest strategies for increasing the yield of cucumber per unit area.

Materials and Methods

A 4 x 3 factorial experiment was conducted during the early raining season of 2020 and 2021at the teaching and research farm of the Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar. (04^0 27'N, 07^0 25' E and 37 meters above sea level) and 37m above sea level, located in the tropical rain forest zone of Nigeria.

Treatments comprised four rates of organo-mineral fertilizer (O) at 0, 3, 6 and 9 t/ha and three rates of foliar applied D.I. Grow bio-organic liquid fertilizer (D) at 0, 50 and 100 ml/L replicated thrice. A gross plot size of 22.1m x 17.3m (382.33_m^2 or 0.0382 ha) was used for the experiment. Composite soil samples were obtained for determination of soil physio-chemical properties. Organo-mineral fertilizer was applied two weeks after emergence in a ring method according to treatments while the foliar applied Di-Gro bio-organic fertilizer was also administered in two splits: at two and eight weeks after emergence respectively, according to treatments using a knap sack sprayer.

Data collection and analysis

Data were presented as an average of two years and mean (±SE) of three replicates from three weeks after emergence. Agronomic parameters assessed included: vine length (cm), number of leaves and leaf area (cm^2) (length x Breath of terminal leaf x 1.8). Yield indices measured were: number of fresh fruits/ plant, fruit length, fruit diameter, weight of fresh fruit per plant and fruit yield (t/ha). Data generated were analyzed statistically using analysis of variance (ANOVA) and significantly ($p \leq 0.05$) different means compared using Fisher's Least Significant difference (FLSD) (Gomez and Gomez, 1984) at 5% level of probability and interactions using Duncan's Multiple Range Test Method (DMRT) as described by Duncan (1995).

Results and Discussion

In this study, soil textural class revealed sandy loam with pH; slightly acidic and relatively low levels of organic matter, total nitrogen, available P as well as exchangeable bases which transcends to low fertility (Table 1). This relatively poor nutrient status of the soil could be due to the inherent adverse physical conditions and erosive forces accompanied by intensive cultivation as well as excessive use of chemical fertilizers according to Ning *et al.* (2017).

Findings revealed that foliar sprayed D.I. Grow bio-organic fertilizer applied at high levels significantly ($p \leq 0.05$) and potentially influenced vine length, number of leaves (Table 2) and leaf area (Table 3) at 4, 6 and 8 weeks after sowing (WAS), respectively. There was a consistent increase in these growth indicators with increasing rate of D.I. Grow fertilizer up to 100 ml/L. However, as plant growth progresses up to 10 WAS, application of D.I. Grow fertilizer produced plant growth indices which were statistically at par and showed a plateau effect irrespective of the rates. This result is not surprising as previous studies revealed that D.I. Grow bio-fertilizer application can affect the morphological, physiological and molecular characteristics of plants as observed in enhanced growth indices (Ekanayake *et al.* 2015; Awobana *et al.* 2020; Khan *et al.* 2020).

Conversely, the effect of organomineral fertilizers was not significant on growth parameters studied. Although, it potentially stimulated the growth of cucumber at low levels but showed an inhibitory effect at high levels (Table 2 and 3). However, plants treated with 3 t/ha organomineral fertilizer produced longer vines, higher number of leaves and leaf area which reduced with further increase in application. This retarded development of growth indices at higher rates of organomineral fertilizer above 3 t/ha could have been attributed to soil salinization and increased accumulation of heavy metal by the crop as well as soil nutrient

imbalances thus, impairing effective uptake of essential nutrients for crop development as reported by Hao and Chang (2003). Findings have also shown that photosynthetic pigments are decreased by salinity stress possibly due to accumulation of Na^+ and ROS (Wang *et al.* 2016; Gad *et al.* 2018; Li *et al.* 2019). Interaction between foliar applied D.I. Grow and organomineral fertilizer significantly ($p \leq 0.05$) has a conjugating, prominent and promotional impact on vine length at 6,8 and 10 WAS (Table 2). Results showed that higher rates of organomineral fertilizers reduce the efficacy of D.I. Grow fertilizer as observed in shorter vines, and lower number of leaves. Conjugal effect of foliar sprayed D.I. Grow and organomineral fertilizer significantly ($p \leq 0.05$) influenced leaf area at 4, 6 and 8 WAS (Table 3). Leaf area; a measure of the photosynthetic efficiency of the crop was simultaneously wider as D.I. Grow fertilizer rate increases. At 10 WAS application of D.I. Grow fertilizer produced similar leaf area which were statistically at par. This may not be unconnected with the fact that at this growth stage, partitioning of photo-assimilates is geared towards fruit yield production as opined by Ekinya (2013); Ekinya *et al.* (2017) and Elemi *et al.* (2021).

The effect of foliar applied D.I. Grow fertilizer on yield indices was not significant. This behavioural pattern of response in yield indices to D.I. Grow fertilizer exhibited by cucumber in this study were not surprising as essential nutrients may have been washed or leached out due to excessive rainfall and become unavailable to crops after application as reported by Moyin-Jesu, (2015). Interaction between D.I. Grow and organomineral fertilizers were significant on all yield components and fruit yield except fruit length. Synergistic effect of both foliar and soil applied organic fertilizers was significant on all yield components and fruit yield implying that both factors can combine favourably to produce cucumber on a sustained basis. This conforms with the findings of Du *et al.* 2022 who reported that foliar applied fertilizers synergises with soil applied organic substances and penetrate the cellular and sub cellular barrier to stimulate plant biomass accumulation, improves plant stress resistance (Chinatu, Onwuchekwa and Okoronkwo 2017; Awobana *et al.* 2020; El-Shetehy *et al.* 2021) as well as promote photosynthesis for enhanced crop yield.

Table 1: Physico-chemical Properties of Soil at the Experimental Site

Physical Properties	**Values**
Ph	5.80
Sand %	74.60
Silt %	7.00
Clay %	18.40
N %	0.12
Organic Carbon (%)	2.00
Av. O. (Mg/Kg)	23.60
Exchangeable Bases (Cmol/Kg)	
Na (Cmol/Kg)	0.15
K (Cmol/Kg)	0.09

Ca^{+} (Cmol/Kg)	5.6
Mg (Cmol/Kg)	1.20
H^{+} (Cmol/Kg)	0.48
Al^{3+} (Cmol/Kg)	0.36
ECEC (Cmol/Kg)	7.88
Base Saturation (%)	88.70

Table 2: Effect of D.I. Grow Bio-organic fertilizer and Organomineral fertilizer on the Vine Length (cm) and number of leaves of Cucumber at 4, 6, 8 and 10 weeks after sowing.

	Vine lengths (cm)				Number of leaves			
Treatments	4	6	8	10	4	6	8	10
D.I. Grow fertilizer (ml/L)								
0	12.72	56.99	96.72	119.52	5.18	14.27	34.18	47.1
50	12.61	66.75	93.32	119.37	5.33	14.9	34.87	47.87
100	16.93	72.26	101.57	123.95	5.55	15.62	39.45	48.1
LSD$_{0.05}$	4.07	*8.32*	4.08	*NS*	*0.22*	*1.27*	*1.22*	*NS*
Organomineral Fertilizer (t/ha)								
0	14.01	68.01	92.56	118.88	5.24	15.51	35.27	47.31
3	13.91	69.57	97.59	123.47	5.62	15.62	35.29	47.22
6	12.92	62.53	96.02	123.00	5.31	14.07	34.30	47.00
9	11.50	61.21	94.66	117.47	5.24	14.51	34.00	46.91
LSD$_{0.05}$	*NS*	*NS*	*NS*	*NS*	NS	*NS*	*NS*	*NS*
Interactions								
D_0*O_0	12.21_a	67.24_{ab}	97.19_a	114.21_{ab}	5.27_{bcde}	15.20_{ab}	33.27_{ab}	46.80_a
D_0*O_1	14.23_a	62.46_{abc}	82.63_a	123.49_{ab}	5.13_{cde}	15.07_{ab}	35.13_{ab}	48.07_a
D_0*O_2	11.79_a	44.63_c	102.37_a	124.47_{ab}	5.27_{bcde}	11.87_c	35.80_a	46.67_a
D_0*O_3	12.66_a	53.62_{bc}	104.66_a	115.91_{ab}	5.07_{de}	14.93_{ab}	32.53_b	46.87_a
D_1*O_0	14.37_a	62.97_{abc}	108.21_a	119.33_{ab}	4.93_e	14.40_{abc}	35.33_a	45.53_a
D_1*O_1	14.81_a	71.90_{ab}	83.92_a	125.01_{ab}	5.73_{ab}	16.27_{ab}	34.73_{ab}	48.20_a
D_1*O_2	10.57_a	71.31_{ab}	77.45_a	124.21_{ab}	5.60_{abc}	15.53_{ab}	34.47_{ab}	49.33_a
D_1*O_3	10.68_a	60.81_{abc}	103.71_a	108.92_b	5.07_{de}	13.40_{bc}	34.93_{ab}	48.40_a
D_2*O_0	15.46_a	76.83_a	78.58_a	123.11_{ab}	5.53_{abcd}	16.93_a	34.73_{ab}	49.60_a

D_2*O_1	12.69_a	76.94_{ab}	111.12_a	121.91_{ab}	6.00_a	15.53_{ab}	35.93^a	49.60_a
D_2*O_2	12.15_a	71.27_{ab}	112.95_a	120.19_{ab}	5.07_{ab}	14.80_{ab}	35.60^a	46.67_a
D_2*O_3	15.42_a	69.21_{ab}	103.64_a	120.00_a	5.60_{abc}	15.20_{ab}	35.53_a	46.53_a

Means within a column having the same letter(s) are not significantly different using Duncan's New Multiple Range Test at 95% Confidence Limit.
NS= Not Significant. $LSD_{0.05}$ = Fisher's least significant difference at 95% confidence limit.

Table 3: Effect of D.I. Grow Bio-organic fertilizer and Organo-mineral fertilizer on leaf area (cm^2) 4, 6, 8 and 10 weeks after sowing, Yield indices and Fruit yield (t/ha) of Cucumber.

	Leaf area (cm^2)				Yield indices and fruit yield (t/ha)				
Treatment	4	6	8	10	No of fruits/plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (kg)	Fruit yield (t/ha)
D.I. Grow fertilizer (ml/L)									
0 (D_0)	36.45	86.7	112.21	154.55	14.42	20.73	56.95	2.55	19.62
50 (D_1)	41.26	94.24	128.9	155.78	15.00	20.80	55.32	2.81	21.62
100 (D_2)	47.97	107.84	138.52	161.67	17.17	20.93	55.62	2.85	21.92
$LSD_{0.05}$	*9.8*	*9.40*	*9.02*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Organomineral Fertilizer (t/ha)									
0 (O_0)	39.92	89.63	132.32	163.72	14.22	20.47	55.93	2.60	18.07
3 (O_1)	46.33	100.06	133.6	161.37	15.22	20.85	55.92	2.63	20.00
6 (O_2)	40.92	89.57	122.82	153.97	14.78	20.81	56.63	2.35	20.23
9 (O_3)	40.41	88.45	138.75	150.27	17.89	20.62	55.38	3.35	25.77
$LSD_{0.05}$	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*0.52*	*4.00*
Interactions									
D_0*O_0	29.31_b	78.13_{bc}	143.92_a	167.21_{ab}	16.00_{ab}	20.83_a	58.94_a	2.96_{abcd}	22.77_{abcd}
D_0*O_1	43.22_{ab}	111.35_a	133.34_a	164.67_{ab}	10.33_b	20.72_a	55.87_{ab}	2.41_{bcde}	18.54_{bcde}
D_0*O_2	35.96_{ab}	87.38_{abc}	131.78_a	159.06_{ab}	13.33_{ab}	20.80_a	57.17_{ab}	1.65_e	12.69_e
D_0*O_3	37.31_{ab}	69.93_c	119.78_a	127.25_b	18.00_{ab}	20.57_a	55.83_{ab}	3.17_{abc}	24.38_{abc}
D_1*O_0	35.79_{ab}	87.63_{abc}	124.07_a	154.60_{ab}	13.00_{ab}	20.97_a	53.86_b	2.87_{abcd}	22.08_{abcd}
D_1*O_1	48.77_{ab}	105.20_{ab}	142.26_a	162.31_{ab}	17.33_{ab}	20.54_a	55.28_{ab}	2.22_{cde}	17.08_{cde}
D_1*O_2	42.40_{ab}	83.50_{abc}	143.81_a	161.54_{ab}	15.33_{ab}	20.91_a	57.42_{ab}	2.74_{abcd}	21.08_{abcd}
D_1*O_3	38.10_{ab}	100.650_{ab}	105.44_a	144.68_{ab}	14.33_{ab}	20.78_a	54.72_b	3.41_{ab}	15.23_{de}
D_2*O_0	54.65_a	103.15_{ab}	148.27_a	169.35_{ab}	13.67_{ab}	19.60_a	54.98_{ab}	1.98_{de}	26.85_a
D_2*O_1	46.99_{ab}	83.63_{abc}	121.35_a	157.13_{ab}	18.00_{ab}	21.29_a	56.62_{ab}	3.25_{ab}	25.00_{ab}
D_2*O_2	44.42_{ab}	97.82_{abc}	125.20_a	141.31_{ab}	15.67_{ab}	20.73_a	55.30_{ab}	2.67_{abcd}	20.53_{abcd}
D_2*O_3	45.82_{ab}	94.76_{abc}	143.24_a	178.89_a	21.33_a	20.51_a	55.59_{ab}	3.49	20.53_{abcd}

Means within a column having the same letter(s) are not significantly different using Duncan's New Multiple Range Test at 95% Confidence Limit.
NS= Not Significant. $LSD_{0.05}$ = Fisher's least significant difference at 95% confidence limit.

Conclusion

From the foregoing, it is hereby concluded that cucumber can sustainably be cultivated by applying foliar sprayed D.I. Grow bio organic fertilizer at the rate of 100 ml/L in combination with organomineral fertilizer at 3 t/ha for enhanced yield production in an ecologically friendly environment.

Disclosure statement

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REFERENCES

Adeoye I. B., and O. L. Balogun. 2016. Profitability and efficiency of cucumber production among small holder farmers in Oyo State. *Journal of Agricultural Science.* 61 (4): 387-398.

Awobona T, J. O. Adedapo, O. W. Bolaji, A. A. Ijah, J. A. Ogunsanwo, E. J. Zakka, and A. H. Ridwan. 2020. Evaluation of water use efficiency, growth and yield of cucumber (*Cucumis sativus* L.) under greenhouse conditions. *Proceedings of 38th Annual Conference of Horticultural Society of Nigeria.* 362-367.

Binang, W. B., M. A. Itah, E. E. Obok, E. B. Effa, and E. S. Bassey. 2024. Improving the yield and nutritional quality of cassava (*Manihot esculenta Crantz)* in the rainforest agro-ecolological zone of Southeast Nigeria through agronomic biofortification with micro-nutrients. *Journal of Plant Nutrition,* DoI, 10.1080/01904167.2024.2338.

Chinatu L. N., C. B. Onwuchekwa, and C. M. Okoronkwo. 2017. Assessment of yield and yield components of cucumber (*Cucumis sativus* L.) in South Eastern Nigeria. *International Journal of Earth Science and Agriculture.* 3 (1):35 - 44.

Du, J., B. Liu, T. Zhao, X. Xu, H. Lin, Y. Ji, Z. Lii, C. Lu, P. Li, H. Zhao, Y. Li, Z. Yin, and X. Ding. 2022. Silica nanoparticles protect rice against biotic and abiotic stresses. *Journal of Nanobiotechnolo.* 20 (1): 197, https//doi.org/10.1187/s12951-922.

Duncan, D. B. 1995. Multiple Ranges and Multiple F. Test. *Biometrics.* 11: 1- 42.

Ekanayake, L. J., D. Thavarajah, E. Vial, B. Schatz, R. Mcgee, and P. Thavarajah. 2015. Selenium fertilization on Lentil (*Lens culinaris Medikus)* grain yield. Seed selerium concentration and antioxidant activity. *Field Crops Res.* 177: 9 – 14.

Ekinya, E. E. 2013. Preliminary Evaluation of different Sources of organic manure on the productivity of okra (*Abelmoschus esculentus L.* Moench) in Bauchi, Nigeria. *Journal of Environment, Technology and Sustainable Agriculture.* 2(1): 54- 60

Ekinya, E. E., A. S. Fagam, N. Vonir, A. A. Garba, and M. D. Garba. 2017. Growth and yield of Soybean (Glycine max (L.) merr.) as affected by Nitrogen levels and cropping system in Gombe Northeastern Nigeria. *Journal of Science and Technology Research.* 14 (3): 27-32.

Elemi, E. E., P. O. Ukatu, G. E. Uwak, and L. J. Agah. 2021. Effect of Nitrogen, phosphorus and variety on physiological indices and Nutrient composition of living stone potato (*Plectranthus esculentus* N.E.Br,) in Gombe, Northern Guinea Savannah, Nigeria. *Journal of Experimental Agriculture International.* 180-188, ISSN: 2457 – 0591.

El-shetehy, M., A. Moradi, M. Maceroni, D. Reinhard, A. Petri-fink, B. Rothen-Rutishauser, F. Mauch, F. Schwab. 2021. Silica nomoparticles enhance disease resistance in arabidosis plants. *Nat. Nanotechnol.* 16 (13): 344-353. https://doi.org/10.1038/s 41565-020-00812-0.

Gad, N., M. R. Abdel-Moez, A. M. Ferky, and S. D. Abuo-Hussein. 2018. Increasing salt tolerance in cucumber by using cobalt.

Gomez, K. A., and A. A.Gomez. 1984. Statistical Procedures for Agricultural Research; 2nd Edition, John Wiley and Sons. New York. 207-215.

Gopalan, C., S. B. V. Rama, and S. C. Balasubramanian. 2015. Nutritive value of Indian Foods. *Indian Council of Medical Research, National Institute of Nutrition*, Hyderabad, India.

Hao, X. Y., and C. Chang. 2003. Does long term heavy cattle manure application increase salinity of a clay loam soil in Semi-arid southern Alberta? *Agriculture Ecosystems and Environment* 94: 89 – 103.

Hemphill, D. 2014. Cucumbers, Greenhouse, *Extension Horticulture,* Oregon State University.

Khan, A., M. Numan, A. L. Khan, I. L. Lee, M. Imran, S. Asaf, and A. Alttarasi. 2020. Melatonin: Awakening the defense mechanisms during plants oxidative stress. *Plants.* https://doi.org/10.3390/plants9040407.

Khan, Z, A. H. Shah, R. Gul, A. Majid, U. Khan, and H. Ahmad. 2015. Morpho-agronomic characterization of cucumber germplasm for yield and yield associated traits; *International Journal of Agronomy and Agricultural Research.* 6 (1): 1-6.

Li, J., J. Liu, Z. Zhu, C. Zhao, L. Li, and M. Chen. 2019. The role of melatonin in salt stress responses. *Int. J. Mol. Sci.* https://doi.org/10.3390/ijms 20071735..

Mariod, A. A., M. E. Mirghani,and I. H. Hussein. 2017. Cucumber (*Cucumis sativus* L.), 145-151 Unconventional oil seeds and oil sources. *Academic press.* 26-32 ISBN 9780134337

Moyin-Jesu, E. I. 2015. Efficacy of different organic fertilizers on soil fertility improvement, growth and fruit parameters of cucumber (*Cucumis sativus* L.). *Journal of Agriculture and Food Technology.* 5 (2): 1-7.

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REFERENCES

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Binang, W. B., M. A. Itah, E. E. Obok, E. B. Effa, and E. S. Bassey. 2024. Improving the yield and nutritional quality of cassava (*Manihot esculenta Crantz)* in the rainforest agro-ecolological zone of Southeast Nigeria through agronomic biofortification with micro-nutrients. *Journal of Plant Nutrition,* DoI, 10.1080/01904167.2024.2338.

Chinatu L. N., C. B. Onwuchekwa, and C. M. Okoronkwo. 2017. Assessment of yield and yield components of cucumber (*Cucumis sativus* L.) in South Eastern Nigeria. *International Journal of Earth Science and Agriculture.* 3 (1):35 - 44.

Du, J., B. Liu, T. Zhao, X. Xu, H. Lin, Y. Ji, Z. Lii, C. Lu, P. Li, H. Zhao, Y. Li, Z. Yin, and X. Ding. 2022. Silica nanoparticles protect rice against biotic and abiotic stresses. *Journal of Nanobiotechnolo.* 20 (1): 197, https//doi.org/10.1187/s12951-922.

Duncan, D. B. 1995. Multiple Ranges and Multiple F. Test. *Biometrics.* 11: 1- 42.

Ekanayake, L. J., D. Thavarajah, E. Vial, B. Schatz, R. Mcgee, and P. Thavarajah. 2015. Selenium fertilization on Lentil (*Lens culinaris Medikus)* grain yield. Seed sclerium concentration and antioxidant activity. *Field Crops Res.* 177: 9 – 14.

Ekinya, E. E. 2013. Preliminary Evaluation of different Sources of organic manure on the productivity of okra (*Abelmoschus esculentus L.* Moench) in Bauchi, Nigeria. *Journal of Environment, Technology and Sustainable Agriculture.* 2(1): 54- 60

Ekinya, E. E., A. S. Fagam, N. Vonir, A. A. Garba, and M. D. Garba. 2017. Growth and yield of Soybean (Glycine max (L.) merr.) as affected by Nitrogen levels and cropping system in Gombe Northeastern Nigeria. *Journal of Science and Technology Research.* 14 (3): 27-32.

Elemi, E. E., P. O. Ukatu, G. E. Uwak, and L. J. Agah. 2021. Effect of Nitrogen, phosphorus and variety on physiological indices and Nutrient composition of living stone potato (*Plectranthus esculentus* N.E.Br,) in Gombe, Northern Guinea Savannah, Nigeria. *Journal of Experimental Agriculture International.* 180-188, ISSN: 2457 – 0591.

El-shetehy, M., A. Moradi, M. Maceroni, D. Reinhard, A. Petri-fink, B. Rothen-Rutishauser, F. Mauch, F. Schwab. 2021. Silica nomoparticles enhance disease resistance in arabidosis plants. *Nat. Nanotechnol.* 16 (13): 344-353. https://doi.org/10.1038/s 41565-020-00812-0.

Gad, N., M. R. Abdel-Moez, A. M. Ferky, and S. D. Abuo-Hussein. 2018. Increasing salt tolerance in cucumber by using cobalt.

Gomez, K. A., and A. A.Gomez. 1984. Statistical Procedures for Agricultural Research; 2nd Edition, John Wiley and Sons. New York. 207-215.

Gopalan, C., S. B. V. Rama, and S. C. Balasubramanian. 2015. Nutritive value of Indian Foods. *Indian Council of Medical Research, National Institute of Nutrition*, Hyderabad, India.

Hao, X. Y., and C. Chang. 2003. Does long term heavy cattle manure application increase salinity of a clay loam soil in Semi-arid southern Alberta? *Agriculture Ecosystems and Environment* 94: 89 – 103.

Hemphill, D. 2014. Cucumbers, Greenhouse, *Extension Horticulture,* Oregon State University.

Khan, A., M. Numan, A. L. Khan, I. L. Lee, M. Imran, S. Asaf, and A. Alttarasi. 2020. Melatonin: Awakening the defense mechanisms during plants oxidative stress. *Plants.* https://doi.org/10.3390/plants9040407.

Khan, Z, A. H. Shah, R. Gul, A. Majid, U. Khan, and H. Ahmad. 2015. Morpho-agronomic characterization of cucumber germplasm for yield and yield associated traits; *International Journal of Agronomy and Agricultural Research.* 6 (1): 1-6.

Li, J., J. Liu, Z. Zhu, C. Zhao, L. Li, and M. Chen. 2019. The role of melatonin in salt stress responses. *Int. J. Mol. Sci.* https://doi.org/10.3390/ijms 20071735..

Mariod, A. A., M. E. Mirghani,and I. H. Hussein. 2017. Cucumber (*Cucumis sativus* L.), 145-151 Unconventional oil seeds and oil sources. *Academic press.* 26-32 ISBN 9780134337

Moyin-Jesu, E. I. 2015. Efficacy of different organic fertilizers on soil fertility improvement, growth and fruit parameters of cucumber (*Cucumis sativus* L.). *Journal of Agriculture and Food Technology.* 5 (2): 1-7.

Ning, C, P. Gao, B. Wang, W. Lin, N. Jiang, and K. Cal. 2017. Impacts of chemical fertilizer reduction and organic amendments supplementation on soil nutrient, enzyme activity and heavy metal content. *Journal of Integrative Agriculture.* 16 (8): 1819-1831.

Nweke, L. A., and L. N. Nsoanya. 2015. Effect of cow dung and urea fertilization on soil properties, growth and yield of cucumber (*Cucumis sativus* L.). *Journal of Agriculture and Ecology Research International.* 3: 81-88.

Okoli, P. S. O., and Nweke, I. A. 2015. Effect of Poultry manure and mineral fertilizer on the growth performance and quality of cucumber fruits; *Journal of Experimental Biology and Agricultural Sciences.* 3 (4): 362-367.

Otie, V., A. Ping, I. Ali, J. Akpan, A. Yahya, D. Olim, D. Iyamah, V. Akpan, and A. E. Eneji. 2024. Soil physic-chemical properties and yield response of cucumber (*Cucumis sativus* L.) to 2, 4-Epibrasinolide under water stress. *Journal of Plant Nutrition.* https://doi.org/10.1080/01904167.2024.2378224.

Perea-velez, Y. S., R. Carrillo-Gonzalez, and M. D. C. A. Gonzalez -Chavez. 2021. Interaction of metal nanoparticles plants–microorganism in agriculture and soil remediation. *J. Nanopart.Res*: Interdiscip. *Forum Nanoscale Sci. Technol.* 23(9): 206. https//doi.org/10.1007/s11051-021-05269-3.

Rivers, E. U., P. O. Ukatu, U. C. Nwune, I. Okoroafor, U. N. Nwaosu. 2024. Comparative efficacy of organic mulching and organic neem oil in the control of spotted and stripped cucumber beetles affecting the growth and yield of cucumber in Uyo, Akwa Ibom State. *International Journal of Life Science and Agriculture Research.* 3(6): 473-478.

Wang, L. Y., J. L..Liu, W. X. Wang, and Y. Suin. 2016. Exogenous melatonin Improves growth and photosynthetic capacity of cucumber under salinity-Induced stress. *Photosynthetica.* 54: 19-27 https://doi.org/10/1007/s11099-015-0140-3.

AGRONOMIC PERFORMANCE AND ASSOCIATION BETWEEN YIELD AND RELATED ATTRIBUTES OF SOME CUCUMBER GENOTYPES (*CUCUMIS SATIVUS* L) IN CALABAR.

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ABSTRACT

A field experiment was conducted at Crop Science Teaching Research Farm, from May to June 2024 to study the agronomic performance and association between yield and related attributes of some cucumber genotypes in Calabar. The experiment was laid out in a randomized complete block design (RCBD) with 3 replications. A total number of five genotypes was used for this study. Data was collected on morphological and reproductive traits. The results showed that there were significant differences (P<0.05) among genotypes for number of leaves, vine length both at 5 and 7 weeks after planting (WAP) and number of nodes at 7 WAP. The correlation analysis from the study showed that vine length, number of leaves, number of fruits within the range of 0.20 to 0.97 were significant and positively correlated with yield and other attributes. This suggests that an increase in one character will simultaneously lead to an increase in the other. SairaF1 and Akabuyo were significantly better in performance than the other genotypes hence, recommended for further evaluation.

Key words: Agronomic performance, Association, Cucumber, Yield.

Introduction

Cucumber (*Cucumis sativus* L.) plant is a member of the Cucurbitaceae family widely cultivated for its edible fruit. In this family, different types of melon such as bitter melon and squash are also included. Cucumber is Asia's fourth most important vegetable after tomato, cabbage, and onions (Onuwa *et al.*, 2021) and is Western Europe's second-most important vegetable crop after tomatoes (Wilcox *et al.*, 2015). Cucumbers provide many nutrients and are low in calories, sodium and cholesterol and the flavour is also is very good. Cucumbers are very popular for salads, small fruits of cucumber are often pickled (Chakraborty and Rayalu, 2021). The silica in cucumber helps to give strength to connecting tissue thereby providing relief from joint pain. Its production continues to gain popularity in Nigerian communities because of its nutritional, economic and health benefits (Abdulkadir *et al.*, 2020).

Evaluating genotypes in different ecology and soil types is important for continuous cultivation of this crop thereby meeting the needs of the populace (Ivandro *et al.*, 2003). There is a need to

screen cucumber germplasm for the identification of genotypes with improved quality and yield which may be directly used as varieties after extensive evaluation or as parents in the hybridization programme. (Kumar *et al.*, 2011). While selecting for yield, one should take into account the improvement of yield contributing traits, provided the association of such traits with yield is known.

Correlation coefficient assesses the association among several attributes and aids in identifying which trait to select for crop improvement. A study on morphological analysis of cucumber was also conducted and results showed that there was a moderate positive correlation between the length of fruit and the thickness of flesh and the length of stem.

The aim of this study was to assess the growth and yield traits of some cucumber genotypes in Calabar and also to assess the association between growth and yield attributes.

Materials and Methods

The experiment was carried out at Crop Science Teaching and Research Farm University of Calabar, between May –July 2024. Calabar is located at the Southeastern rainforest agro-ecological zone of southern Nigeria (4.5°N-5.2 °N, 8.3 °E; about 39 m above sea level), and has a bimodal annual rainfall distribution that ranges from 3,000 to 3,500 mm with mean annual temperature range of 27 - 35 °C and relative humidity of 75 % to 88 %.

The genotypes used were Saira F1, Market more, Cucumber marketer, Akampka local and Akpabuyo local. The experiment was laid out in randomized complete block design (RCBD) with three (3) replications. Each plot size was 2 m × 2 m (2 m^2) the planting distance was 50 cm by 50 cm. The blocks were separated by 1m pathway while, the plots within each block was separated by 0.5m pathway. The plot was mapped out with pegs into uniform plots to meet the design specification, and beds were made. Two seeds were planted per hole, which was later thinned to one, giving a plant population of 40,000 plants / ha. Weeding was done at 3 weeks and 5 weeks after planting (WAP), while staking was done at 4 WAP.

Data were collected from four plants in the net plot at three sampling periods (3, 5 and 7 WAP). Data were collected on number of leaves, vine length, number of nodes, number of fruits and yield.Data collected were subjected to analysis of variance (ANOVA) and significant means were separated using the least significant difference (LSD) at 5% probability level. Pearson's correlation coefficient was used to determine the association between growth and yield attributes.

Results and Discussion

The results showed that genotypes varied significantly in number of leaves at 5 and 7 WAP but showed no significant at 3 WAP (Table 1). At 5 and 7 WAP, Akabuyo and SairaF1 had the highest no of leaves with mean value of 51.50 and 47.25, and 67.42 and 57.17 respectively. Akamkpa had the lowest number of leaves 27.08.

Similarly, there was also a significant difference in vine length at 5 and 7 WAP but there was no significant difference at 3WAP (Table 1). At 5 and 7 WAP SairaF1 and Akabuyo had the longest vine with mean value of 105.22 and 141.03 followed by Akampka 138.77. Marketer had the shortest vine length at both sampling periods.

Number of nodes was significant at 7 WAP only. It was not significant at the other sampling periods (Table 1). Akabuyo had the highest number of nodes with mean value of 61.92 followed by SairaF1 (47.25). Market more had the lowest number of nodes with mean value of 25.08. Genotypes varied significantly in number of fruits. SairaF1 had the highest numbers of fruits with mean value of 12.67 followed by market more 10.67. Marketer did not produce much fruits.

The fruit yield was highly significant (P<0.001). SairaF1 had the highest yield, followed by Market more and Akampka (Table 2). Although Akpabuyo performed well in terms of growth attributes, the yield was low.

The results from correlation analysis showed that yield was positively correlated with all other attributes, but not significant except for vine length at 7 WAP (0.601**). Number of leaves at 5WAP had positive and significant correlation with number of leaves7WAP (0.946**) vine length 5WAP (0.878**) and number of nodes 7WAP (0.957**).

This study reveals that there was variation in cucumber genotypes for most of the attributes studied. This result is in accordance with the findings of Hamid *et al.* (2002). The high number of leaves recorded in SairaF1 and Akpabuyo could be attributed to the genetic variation and adaptability to the study area. This result agrees with the findings of Khan *et al.*, 2015; Ranjan *et al.*, 2015; Pal, *et al.*, 2017; who also reported that number of leaves varied significantly among the

Table 1: Number of leaves, vine length (cm) and number of nodes of cucumber genotypes

Genotypes	Number of leaves			Vine length (cm)			No of nodes		
	3	5	7 WAP	3 WAP	5	7	3	5	7 WAP
Akpabuyo	17.80	51.50	67.42	65.33	141.03	202.81	13.58	42.67	61.92
Akamkpa	17.00	27.08	40.00	131.28	97.84	138.77	11.92	22.08	28.33
Marketer	13.00	21.92	28.92	26.85	60.63	71.49	6.17	18.25	25.83
Market more	13.50	23.67	29.92	55.30	81.97	112.97	7.75	19.67	25.08
SairaF1	18.60	47.25	25.17	59.40	105.22	156.25	11.58	40.17	47.25
Significance	NS	*	**	NS	*	***	NS	NS	**

S.e.d.	3.34	92.40	9.40	58.22	18.65	19.05	2.35	10.01	9.11
CV (%)	25.60	33.60	25.80	105.40	23.50	17.10	28.30	42.90	29.60
LSD	7.71	21.61	21.68	134.25	43.02	43.93	5.43	23.09	20.99

NS = Non significant, S.e.d Standard error of difference, CV coefficient of variation, LSD Least Significant difference * = P<0.05, ** = P<0.01, *** = P<0.001

Table 2: Number of fruits and yield of cucumber genotypes

Genotype	Number of fruits	Yield (t / ha)
Akpabuyo	8.67	9.09
Akamkpa	9.00	9.48
Marketer	6.67	8.25
Market more	10.67	13.96
SairaF1	12.67	18.47
Significance	***	***
S.e.d.	0.823	1.193
CV (%)	10.6	12.3
LSD	1.898	2.750

NS = Non significant, S.e.d Standard error of difference, CV coefficient of variation, LSD Least Significant difference * = P<0.05, ** = P<0.01, *** = P<0.001

Table 3: Correlation of growth and yield attributes of cucumber genotypes

	Yield	NL5WAP	NL7WAP	VL5 WAP	VL7WAP
NL5WAP	0.302				
NL7WAP	0.206	0.946**			
VL5 WAP	0.713	0.856**	0.878**		
VL7WAP	0.601**	0.878**	0.830**	0.594	
NN7WAP	0.267	0.957**	0.970**	0.836	0.772

NL5WAP = Number of leaves 5 weeks after planting
NL7WAP = Number of leaves 7 weeks after planting
VL5 WAP = Vine Length 5 weeks after planting
VL7WAP = Vine Length 7 weeks after planting
NN7WAP = Number of node 7 weeks after planting

accessions and this was due to genetic variation. A good leaf cover is essential for producing high quality fruit. Lack of leaf cover will expose fruit to high level of radiation and cause excessive heating of the fruit surface. This can lead to variety of disorder including sunburn, sunscald, yellowing of fruit, cracked and shriveled fruit. Genotypes also varied significantly in vine length at 5 and 7 WAP. Generally, more vigorous vine brings about better yield in cucumber. Similar results were reported by (Shukla *et al.*, 2010; Veena *et al.*, 2012; Pal *et al.*, 2017). The vines allow the plant to raise themselves up towards sunlight and hold tightly to structures such as trellises.

Number of nodes showed no significance at 5 WAP but was significant at 3 and 7 WAP, SairaF1 and Akabuyo had the highest number of nodes and this results corresponds with the findings of (Pal *et al.*, 2017; Bhagwat *et al.*, 2018; Deepa *et al.*, 2018). The result from this study showed that number of fruits and yields were highly significant which agrees with the findings of (Pal *et al.*, 2016; Sharma *et al.*, 2018 and Bhagwat *et al.*, 2018).

The correlation analysis from the study showed that some of the traits were significant and positively correlated with each other. This suggest that an increase in one character will simultaneously lead to an increase in most of the other traits. Yield had positive and correlation vine length at 7 WAP and other attributes. The positive and significant correlation indicate a strong association of these traits with yield.

Cconclusion and Recommendation

The result obtained from the study showed that genotypes varied significantly in most of the growth and yield characters. SairaF1 performed better with respect to various growth and yield traits, this was closely followed by Akpabuyo. On the association between traits, yield positively correlated with all the morphological and reproductive attributes. This clearly shows that an increase in one character will bring about a simultaneous increase in the other. The two high performing genotypes are recommended for further evaluation.

References

Abdulkadir, S.U., Mahmoud, B.A, and Kashere, M.A. (2020). Effects of fertilizer management on growth and yield of Cucumber (*Cucumis sativus* L). In Proceedings of 38th Annual Conference of Horticultural Society of Nigeria, Hall of Fame, University of Nsukka, Nigeria: 79-82.

Bhagwat, A., Srinivasa, V., Bhammanakati, S. & Shubha, A. S. (2018). Evaluation of Cucumber (*Cucumis sativus* L.) Genotypes under Hill Zone of Karnataka. *International Journal of Current Microbiology and Applied Sciences*, 7(09): 837–842.

Chakraborty, S. and Rayalu, S. (2021) Health Beneficial Effects of Cucumber. Intechopen Book Series. DOI: 10.5772/intechopen.96053.

Deepa, S. K., Hadimani, H. P., Hanchinamani, C. N., Ratnakar, S. & Sumangala, K. A. (2018). Estimation of genetic variability in cucumber (*Cucumis sativus* L.). *International Journal of Chemical Studies*, 6(6): 115-118.

Hamid, A.J.D., Bloch and Naeemullah, K. (2002). Performance studies on six cucumber genotypes under local conditions of Swat. *Int. Journal of Agricultural Biology* 4: 491-510.

Ivandro, B., Fernando, I. F., de-Carvalho1, A. & de Oliveira C. (2003). Parental Selection Strategies in Plant Breeding Programs. *Journal of Crop Science and Biotechnology,* 10(4): 211-222.

Khan, Z., Shah, A.H., Gul, R., Majid A., Khan, U., Ahmad, H. (2015). Morpho-agronomic characterization of cucumber germplasm for yield and yield associated traits. *International journal of Agronomy and Agricultural Research* 6(1):11-6

Kumar, S., Kumar, R., Gupta, R.K., Sephia, R. (2011). Studies on correlation and path coefficient analysis for yield and its contributing traits in cucumber. *Crop Improvement.* 38(1):18-23.

Onuwa, G.C., Okeke-Agulu, K.I., Birma, J., and Alamanjo., (2021). *Technical Efficiency.*

Pal, S., Sharma, A. K. & Bhardwaj, R. I. (2016). Genetic variability, heritability and genetic gain for yield and quality traits in cucumber (*Cucumis sativus L.*). The *Bioscan*, 11 (3): 1985-1190.

Pal, S., Sharma, H. R., Das, A. & Pandav, A. (2017). Character association and path analysis for fruit yield and it's contributing traits in cucumber (*Cucumis sativus* L.). *International Journal of Agriculture, Environment and Biotechnology*, 10 (2): 163-170.

Ranjan, P., Gangnopadhyay, K., Bag, M.K. and Roy, A. (2015). Evaluation of cucumber (*Cucumis sativus*) germplasm for agronomic traits and disease resistance and estimation of genetic variability. *Indian Journal of Agricultural Sciences*. 85(2): 23-49.

Sharma, S., Kumar, R., Chatterjee, S. & Sharma, H. R. (2018). Correlation and path analysis studies for yield and its attributes in cucumber (*Cucumis sativus* L.). *International Journal of Chemical Studies*, 6(2): 2045-2048.

Shukla, I.N., Shunder, S., Singh, N., Pandey, R., Awasti, P.N. (2010). Genetic variability and selection parameters for fruit yield in cucumber (*Cucumis sativus L.*) *Current advances in agricultural sciences,* 2(2) 107-108

Veena, R., Sidhu, A.S. Pitchaimutuy, M., Souravi, K. (2012). Genetic evaluation of some cucumber (*Cucumis sativus L.*) genotypes for some yield and related traits. Electronics. *Journal of plants Breeding Development,* 21(1): 3437-3443.

Wilcox, G. I., Offor, U. S. & Omojola, J. T. (2015). Profitability of cucumber (*Cucumis sativus* L.) Production in Tai Local Government Area of Rivers State, Nigeria. *Lancet,* 2(3): 2394-2606.

ANALYSIS OF POVERTY STATUS AMONG COOPERATIVE AND NON-COOPERATIVE CASSAVA FARMERS HOUSEHOLDS IN AKPABUYO LOCAL GOVERNMENT AREA OF CROSS RIVERSTATE, NIGERIA.

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ABSTRACT

The study was conducted to analyze the poverty status of cooperative and non-cooperative cassava farmer's households in Akpabuyo local government area of Cross River State, Nigeria. A multi-stage sampling procedure was adopted in the selection of 125 cassava farmers. Data was analysed using descriptive and inferential statistics. The results showed that most farmers were female (61.6%), married (52.0%), and had secondary education (64.0%). The mean age was 37 years, the mean household size was 6, the mean farm size was 2.64 and the mean farming experience was 8 years. The Foster Greer Thorbecke Poverty index showed that non-cooperative members who were not poor had a mean income of ₦ 946,520, while those who were poor had a mean income of ₦6,007.8. Cooperative members who were not poor had a mean income of ₦1,150,880, while those who were poor had a mean income of ₦8,020.62. The study identified inadequate loan facilities, untimely release of funds, and high interest rates as significant constraints affecting cassava production. Based on the findings, it was recommended that cassava farmers join cooperative societies to access affordable and timely credit facilities with flexible repayment terms to enhance productivity.

Key words: Poverty status, cooperative, non- cooperative, Cassava.

Introduction

Agriculture is the major economic activity of developing economies and in Nigeria, it provides food for the increasing population, supplies adequate raw materials to growing industrial sector, serves as a major source of employment, generates foreign exchange earnings and provides market for the products of the industrial sector. Agriculture employs about two-third of Nigeria's total labour force, contributed 42.2% of Gross Domestic Products (GDP) and provides 88% of nonoil earnings (Yakubu and Akanegbu, 2015). The contribution to agricultural GDP is in the following proportion: crops (85%), livestock (19%), fisheries (4%) and forestry (1%). Also, more than 90% of the agricultural output is accounted for by small-scale farmers with less than two (2) hectares under cropping (Akerele *et al.,* 2018). Among the crops that contribute to 85 per cent of Nigeria's GDP, is cassava. Cassava (Manihot spp.) is recognized together with yam, rice, maize, sorghum, and millet as the main staple food crops in Nigeria (NEEDS, 2004). Cassava has a high poverty reduction potential for Nigeria due to its low production cost (Apata, 2019). Cassava is Africa's food insurance crop with stable yield, even with low rainfall, low fertility and low inputs (FAO, 2008).

Despite the contribution of cassava to the economy, Nigeria's agricultural sector faces many challenges which impact on productivity. These include poor land tenure system, low level of irrigation farming, climate change and degradation, low technology, high production, limited

financing, high post-harvest losses and poor access to markets (FAO 2018). To solve some of these issues, donor agencies and governments have re-emphasized co-operatives as a strategy to promote collective action to strengthen small holder farmers' livelihood by linking them to national and international markets. A co-operative is an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly owned democratic enterprise. An agricultural cooperative is a form of cooperative formed by farmers or agriculturists who have combined their resources together for the production and marketing of their produce. Cooperatives play a role in providing financial services to farmers who have limited access to formal banking systems. This includes providing credit, savings, and insurance services.

Poverty refers to a state or condition of deprivation or lack, typically characterized by a lack of material resources or basic necessities needed to meet one's basic human needs. It is a multifaceted concept that encompasses various dimensions, including income, education, health, access to resources, and overall well-being. Poverty is often measured in monetary terms, using income or consumption-based indicators, which assess the extent to which individuals or households fall below a defined poverty line. The poverty line is typically set at a level considered necessary to meet basic needs, such as food, shelter, healthcare, education, and clothing (Ogunyinka, 2019). The alleviation and eradication of poverty has remained a critical issue among countries of the world and has also become the central goal and the top priority of the international development agenda (United Nation, 2015).

According to Ravallion and Datt, (2019), increasing agricultural production can reduce poverty through a variety of channels, including changes in real income, the creation of jobs, multiplier effects on rural non-farm businesses, and effects on food prices. Agricultural cooperative impact on poverty is both direct, flowing immediately from growth in agriculture by raising real incomes of poor farm (and non-farm) households, and indirect by increasing agricultural outputs which induces job creation in upstream and downstream non-farm sectors as a response to higher domestic demand. Messiah and Maryam (2018) showed that Cooperative societies enable farmers to pool their resources and negotiate better deals for their produce. By selling collectively, farmers can often secure higher prices for their crops, reducing the income volatility that individual farmers might face and this improved bargaining power is instrumental in lifting farmers out of poverty. However, this study seeks to investigate the contribution of co-operative societies to cassava farmers' poverty status in Akpabuyo local government area of Cross River State, Nigeria with reference to the following objectives: to describe the socio-economic characteristics of cassava farmers in the study area, estimate and compare the poverty status of cooperative and non-cooperative cassava farmers in the study area and to identify the major constraints that hinder cassava farmers from optimizing the benefits from co-operative societies in the study area.

Research Methodology

Study Area

This study was carried out in Akpabuyo local government area of Cross River state, Nigeria. Akpabuyo has its headquarters at Ikot Nkanda, It is also within the vegetative belt of Southern

Nigeria and shores of the Atlantic seashore with Bakassi to the East and the Republic of Cameroon to the West. It is located between Latitude 405' North and 504' and Longitude 8025' West and 8032' East of the equator. It has a population of over 271,325 (NPC 2006).

There are twenty-eight villages in Akpabuyo, and the primary economic activities are farming and fishing, it is known as the food basket of Cross River State (Itam, Ajah and Agbachom, 2014). The most important crops grown are cassava, cocoyam, kola nut, oil palm, maize, etc. other economic activities include palm wine tapping, processing of wild palm fruits, tailoring, welding, trading and processing of Cassava into garri and fufu for sale.

Sampling Procedure

A multi- stage sampling procedure was used in selecting the respondents. The first stage was purposive sampling of five town/communities from Akpabuyo local government area each based on the presence of large number of cooperative and non-cooperative cassava farmer. The second stage involved the proportionate use of random sampling technique in selecting twenty five (25) cassava farmers from each of the 5 communities/town which amount to 125 respondents for the study.

Method of Data Analysis

Foster-Greer-Thorbeck (FGT) poverty index: The Foster-Greer-Thorbeck (FGT) poverty index is used to analyze and quantify poverty status. It combines three components: the headcount ratio, the poverty gap, and the poverty severity. The FGT index allows for a more comprehensive assessment of poverty by considering both the incidence and the depth of poverty.

The FGT poverty index is calculated using the following formula:

FGT Index (α) = $(1/n) \times \Sigma [(Z - Y)/Z]^{\alpha}$ ..... Equ 1

Where:

1. n: Total population
2. Z: Poverty line (threshold)
3. Y: Income/Consumption of each individual
4. α: Parameter that determines the poverty aversion or sensitivity to income/consumption shortfall (commonly set at 0, 1, or 2)

Results and discussion

Socioeconomic Characteristics of Respondents

Table 1 revealed the Socio-economic characteristics of the respondents. The results showed that majority (61.6%) of the farmers were female while male constituted (38.4%.) The results implied that female respondents dominate cassava production in the study area. This result agrees with the findings of Emeka and Adanna (2017) which observed women as major stakeholders in the provision of food. Majority of the respondents (37.6%) were within the age bracket of 42-49 years old, (28.0%) of the respondents aged between 26-33 years old. The results implied that the respondents are in their active age and have active strength to carry out cooperative activities and cassava production activities. This result agrees with Ma *et al* (2018) who reported age range of 46-55 years old for cassava farmers. (52.0%) of the cassava farmers

in cooperative society are married while (14.4%) of the respondents were single. This result also agrees with Amao *et al.*, (2018) who reported that majority 71.43% of the respondents were married. Majority of the respondents had secondary school level of education, of (64.0%). This suggests that there is a diverse educational background among the respondents, Ravallion and Datt, (2019), viewed formal education as means of facilitating farmers use of written information sources and increasing their knowledge and comprehension of new farm practices. Majority of the farmers utilized leasehold of (43.2%), and (26.4%) of the respondents inherited their farmland, and (30.4%) of the respondents bought their farmland. Majority (51.20%) of the respondents had quarterly meetings with extension agent, (30.40%) met with extension agent monthly. This frequency of meeting suggests a structured and regular exchange of information, advice, and assistance, enhancing farmers' capacity to address challenges and adopt best practices in cassava cultivation (Ogunyinka, 2019).

The results showed that (20.8%) of the respondent use family labour in cassava production, (56.8%) of the respondents used hired labour and (22.4%) of the respondents used both family and hired labour. The predominance of both family and hired labour, reflects the reliance on household resources and traditional labour arrangements within the local community.

The results showed that (24.8%) of respondents had members ranging from 1 to 4 members, while (57.6%) of the respondents being ample majority ranging from 5 to 8 members. The large household sizes of the farmers were mainly as a result of the extended family system common in the country. The results revealed that majority (50.40%) of the respondents had 11 to 20 years of farming experience, (24.0 %) of the respondents had 6 to 10 years of experience, this signifies a moderate level of agricultural expertise and tenure within the community. This suggests that the majority of farmers have acquired substantial knowledge and skills over a considerable period, enabling them to navigate the challenges and opportunities inherent in cassava cultivation (Kaine 2019). The results showed that (27.2% of the respondents cultivate 0.5 to 1 hectare of land and (5.6%) of the respondents cultivate 3 to 6 hectares of land in the study area. This indicates that there was a normal distribution of farm sizes among the respondents, with majority having small sized farms. This is in line with Nlebem *et al.*, (2019) that the farmers were into small scale farming due to lack of resources and poverty with majority being small scale farmer were 6%

Table 1: Socioeconomic characteristics of the respondents

Variable	Frequency	Percentage	Mean
Sex			
Male	48	38.4	
Female	77	61.6	
Marital status			
Married	65	52.0	
Single	18	14.4	
Divorced	16	12.8	
Separated	26	20.8	
Age			

18-25	9	7.2	
26-33	35	28	
34-41	47	37.6	36.64
42-49	28	22.4	
50-58	6	4.8	
Farm size(hectares)			
0.5 -1	32	25.6	2.64
1.1-3	80	64.0	
4-7	13	10.4	
Household size			
1-4	31	24.8	
5-8	72	57.6	6.33
9-12	22	17.6	
Farming experience			
1-5	18	14.4	
6-10	30	24.0	
11-20	63	50.4	8.17
21-30	14	11.2	
Level of Education			
Primary	16	12.8	
Secondary	80	64.0	
Tertiary	29	23.2	
Land acquisition			
Bought	38	30.4	
Leasehold	54	43.2	
Inheritance	33	26.4	
Meeting with extension agents			
No meeting	8	6.4	
Monthly	38	30.4	
Quarterly	64	51.2	
Yearly	15	12.0	
Source of labour			
Family	26	20.8	
Hired	71	56.8	
Both	28	22.4	

Source: Field survey, 2024

Contribution of Co-Operative Society to Farmers

The results in Table 2 showed that only (88.0%) of the respondents were member of cooperative society and (12.0%) of the respondents are not member of cooperative society. The results showed that (92.8%) of the respondents obtained assistant and (7.2%) of the respondents were without assistance. The results also showed that majority (84.8%) of the respondents reported improved standard of living and (15.2%) of the respondents expressed no improvement in

standard of living. The majority, (92.8%) of cassava farmers in the study area receiving assistance from cooperative societies thus, highlighting the significant effect of collective action and community support mechanisms on farmers' livelihoods. This high percentage suggests that cooperative societies play a pivotal role in providing essential resources, such as access to credit, inputs, and market linkages, which are crucial for enhancing productivity and profitability in cassava farming (Nzeh, *et al.*, 2017). Furthermore, the widespread availability of assistance indicates the effectiveness of cooperative structures in pooling resources and leveraging economies of scale to benefit individual farmers. The reported improvements in the standard of living among the majority of respondents further demonstrate the tangible outcomes of cooperative initiatives in alleviating poverty and promoting socio-economic development within the farming community. This enhanced standard of living may manifest in various aspects, including increased household income, better access to healthcare and education, and improved housing and infrastructure (Nlebem *et al.*, 2019).

Table 2: Contribution of co-operative society to farmers

Variable	Yes		No	
	Freq.	Percentage	Freq.	Percentage
Cooperative membership	110	88	15	12.0
Obtained assistance	116	92.8	9	7.2
Improved standard of living	106	84.8	19	15.2

Source: Field survey, 2024.

Poverty Status of Respondents

The results of the poverty status of respondents is shown in Table 3, the results showed that non-cooperative society who were not poor had a mean income of ₦946,520 while those who were poor had mean income of ₦6,007.8. The cooperative member who were not poor had mean income of ₦1,150.880 and those who were poor had mean income of ₦8,020.62. The head count ratio (proportion poor) for non-cooperative member was 0.42655 and cooperative member was 0.60822. The normalized poverty gap was 0.1157 among non-cooperative member and 0.1499 among cooperative members. The disparity in income between cooperative and non-cooperative members, underscores the tangible benefits and economic advantages associated with cooperative participation in the cassava farming sector (Messiah and Maryam, 2018). Cooperative societies provide members with access to collective resources, including bulk purchasing discounts, shared infrastructure, and coordinated marketing efforts, which can significantly reduce production costs, enhance market access, and improve price negotiation power. Additionally, cooperative members may benefit from economies of scale and enhanced efficiency in production and distribution processes, resulting in higher yields, better-quality products, and increased profitability (Messiah and Maryam, 2018). In contrast, non-cooperative members may face greater challenges in accessing inputs, markets, and support services, leading to lower productivity, higher costs, and reduced competitiveness in the marketplace

Table 3: Poverty Status of Respondents

	Cooperative members			Non-cooperative members		
	Share in population	Mean Income	Mean poor	Share in population	Mean Income	Mean poor
	0.3946	1150,880	8,020.62	0.46054	946,520	6,007.8

	Cooperative members	Non-cooperative members
Headcount ratio (proportion poor)	0.60822	0.42655
Normalized poverty gap	0.1499	0.1157

Field survey, (2024)

Constraint faced by cassava farmers in the study area

The constraints identified, includes inadequate loan, untimely release of funds, high interest rates, insufficient loan availability, unpredictable prices of inputs, and high costs of leasing farmland, collectively pose significant challenges to cassava production in the study area. Inadequate access to loans limits farmers' ability to invest in essential inputs, such as seeds, fertilizers, and machinery, hindering productivity and yield potential. The untimely release of funds exacerbates this issue, disrupting farmers' cash flow and delaying crucial agricultural activities, such as land preparation, planting, and harvesting. High interest rates further compound financial burdens, increasing the cost of borrowing and reducing farmers' profitability (Emeka and Adanna 2017). Insufficient loan availability restricts farmers' capacity to expand operations, adopt new technologies, and mitigate production risks, constraining their ability to capitalize on market opportunities and improve competitiveness. Moreover, unpredictable prices of inputs, such as fertilizers, pesticides, and machinery, create uncertainty for farmers, making it challenging to plan and budget effectively. Fluctuations in input prices can erode profit margins, reduce investment incentives, and deter farmers from making long-term commitments to cassava production. Additionally, the high cost of leasing farmland adds to the financial burden faced by farmers, particularly smallholders with limited resources (Emeka and Adanna 2017). High land rental fees reduce profitability and diminish the economic viability of cassava cultivation, especially in areas where land tenure systems are insecure or land markets are dominated by large-scale operators. These constraints collectively undermine the sustainability and resilience of cassava production systems, limiting farmers' ability to harness the full potential of this vital crop for food security, income generation, and rural development.

Table 4 : Constraint faced by cassava farmers in the study area

Constraint	Mean	Standard deviation
Inadequate loan	3.43*	0.67
Untimely release of funds	3.18*	0.63
High interest rate	3.15*	0.73
Insufficient loan	3.15*	0.65
Too many people on queue	2.98	0.92
Poor management	2.80	0.79

Cases of corruption	2.63	0.97
Lack of training	2.98	0.76
Non-remittance of dividends	2.80	0.64
Unpredictable prices of inputs	3.08*	0.79
Shortage or high cost of labour	2.83	0.93
Poor access to water/irrigation system	2.65	0.92
Lack of fund	2.80	0.82
Natural disaster	2.68	0.88
Animal invasion	2.63	1.02
Weed control issues	2.58	0.98
Poor or no access to fund	2.70	0.99
Theft of cassava produce	2.60	0.77
Insecurity	2.90	0.87
High cost of leasing farmland	3.08*	0.85
Poor access to farm land	2.60	0.70
Insufficient land for farming	2.75	0.80
Access to extension agents	2.60	0.89

Field survey, (2024). Mean above 3.0 were constraints. Mean below 3.0 were not serious constraint

Conclusion and Recommendations

The findings reveal a demographic profile of cassava farmers in the study area, with a majority being female (61.6%), married (52.0%), and having attained secondary education. Cooperative membership was high (88.0%) and associated with improved living standards, increased income, and satisfaction with various support services. Cooperative members reported higher incomes compared to non-cooperative members, with a significant income difference between the two groups. The Foster Greer Thorbecke Poverty index showed that non-cooperative society who were not poor had a mean income of ₦946,520 while those who were poor had mean income of ₦6,007.8 The cooperative member who were not poor had mean income of ₦1,150,880 and those who were poor had mean income of ₦8,020.62 Constraints affecting cassava production included inadequate access to loans, untimely release of funds, high interest rates, insufficient loan amounts, unpredictable input prices, and high farmland leasing costs.

The study recommends that cooperative society should enhance access to affordable and timely credit facilities tailored to the needs of cassava farmers and collaborating with financial institutions to develop special loan packages with flexible repayment terms and lower interest rates specifically for agricultural purposes. Government agencies and financial institutions should streamline processes to ensure the timely disbursement of funds to farmers, the loan amounts should be increased to cassava farmers to meet their diverse financing needs.

REFERENCES

Akerele E.O., Idowu, A.O., Oyebanjo, O., Ologbon, O.A and Oluwasan (2018). Economic Analysis of Cassava Production in Ogun State, Nigeria. Acta Scientic Agriculture, 2(8).

Apata, G. T. (2019). Analysis of cassava value chain in Nigeria: pro-poor approach and gender perspective. International Journal of Value Chain Management. Vol. 10, No. 3. DOI: 10.1504/IJVCM.2019.10022069.

Emeka E. O and Adanna H (2017). Determinants of Poverty among Arable Crop Farmers Using Sustainable Soil Management Techniques in Imo State, Nigeria. International Journal of BioSciences, Agriculture and Technology, Volume 8, Page(s):55-63

Food and Agriculture Organization (2018). The state of world fisheries and aquaculture. Food and Agriculture Organization, Rome, Italy

Kaine, A.I.N, (2019). Economics of traditional cassava processing technology among small-holder female cassava processors in Delta North Agricultural Zone, Delta State Nigeria. *Bangladesh Journal of Agricultural Economics, Bangladesh Agricultural University*, 39(1&2) 234-265

Messiah A J and Maryam U. D (2018). Effect of Agriculture on Poverty Reduction in Nigeria: A Multifaceted Approach Using Principal Component Analysis. *Journal Of Humanities And Social Science (IOSR-JHSS)* Volume 23, PP 35-43.

Moshin Khan (2019). Poverty | a threat to human security Retrieved on 20/01/2020 from https://medium.com/@MohsinSad123/poverty-a-threat-to-human-security-1336bd7ade7b

Nlebem B. S. & Raji W. I. (2019), Impact of Agricultural Cooperative Society on Farmers Productivity and Rural Transformation in Etche Local Government Area of Rivers State GSJ 7(11) 353-367

Nzeh, E.C. & Ugwu, J.N. & Ogbodo, C.F., (2017). Analysis of viability of cassava products across selected value chain in Enugu State, Nigeria. Nigerian Agricultural Policy *Research Journal,* 11(2), 1-10.

Ogunyinka, A. I., Omoniyi, L. O., Abdullahi, A. (2019). Analysis of poverty status of cocoyam farmers in Edo State, Nigeria. *International Journal of Social Science and Humanities Research* ISSN 2348-3164 (online) Vol. 7, Issue 4, pp: (680-686)

Osayande, I and Julius I. O (2016). Effect of Yam-Based Production on Poverty Status of Farmers in Kabba/Bunu Local Government Area of Kogi State, Nigeria. *International Journal of Environmental* and *Agriculture Research* (IJOEAR) Vol-2, Issue-6.

Ravallion, M., Datt, G. (2019). "When Is Growth Pro-Poor? Evidence from the Diverse Experiences of India's States." Policy Research Working Paper 2263, World Bank, Washington, DC.

UN. (2015). Resolution adopted by the general assembly on 25 September 2015. United Nations General Assembly A/RES/70/1, Seventieth Session, Agenda items 15 and 116. Retrieved Yakubu, M., &Akanegbu, B. (2015). Neglecting agriculture and its consequences to the Nigerian economy: An analytical synthesis. European Journal of Research in Social Sciences Vol, 3(3): Pp 18-27.

SOCIOECONOMIC FACTORS INFLUENCING CONTRACT AND NON-CONTRACT RICE FARMING IN ABI LOCAL GOVERNMENT AREA, CROSS RIVER STATE NIGERIA

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ABSTRACT:
This study examined the socioeconomic factors influencing rice production in Abi Local Government Area. The study utilized cross-sectional data from field surveys using structured questionnaires. Data obtained were analyzed using multiple regression models, including linear, semi-log, double-log, and exponential specifications, the analysis revealed that age ($\beta = 0.462431$), educational attainment ($\beta = 0.2341532$), farm size ($\beta = 3.782122$), mechanization ($\beta = 0.023001$), household size ($\beta = 0.152310$), improved seed variety ($\beta = 5.234183$), and fertilizer application ($\beta = 0.435158$) exerted positive and significant effects on rice production. Conversely, market access challenges ($\beta = -177.3367$) hindered productivity, while contract farming exhibited a weaker positive influence ($\beta = 0.153451$). A comparative analysis between contract and non-contract farmers showed that contract farmers had higher returns on investment with a BCR ratio of 4.31 and 1.58, better profit margins of 76.8% and 36.7%, and lower operational costs of 0.23 and 0.62 for contract and non-contract farmers respectively. The Semi-log model emerged as the most robust specification, accounting for 96.1% of the variation in rice production. The findings underscored the critical role of socioeconomic factors and contract farming arrangements in shaping the productivity of rice farming in Abi. Policy interventions targeting education, mechanisation, and input accessibility were recommended to enhance rice production efficiency.

Keywords: rice production, socioeconomic determinants, contract farming, Abi.

INTRODUCTION

The Nigerian government began implementing policies and programs in the 1970s and 1980s to boost local rice production and achieve self-sufficiency. The Operation Feed the Nation program was launched in 1976 under General Olusegun Obasanjo's military government. The program aimed at making Nigeria self-sufficient in food production through intensive cultivation of land. In 1980, the National Accelerated Food Production Programme (NAFPP) was established to increase production of staple crops like rice. Other subsequent programmes included the Directorate of Food, Roads and Rural Infrastructure (DFRRI) in 1986 and the

National Agricultural Land Development Authority (NALDA) in 1992 (Okoruwa and Nkonya, 2011).

From 2008 through 2015, several initiatives were implemented by different administrations to revive the rice subsector. These included the Agricultural Transformation Agenda of the Goodluck Jonathan administration which targeted the rice value chain for growth. Commercial banks were encouraged to increase credit to rice farmers through the Anchor Borrowers Programme introduced in 2015 by the Central Bank of Nigeria (CBN). The programme made available subsidized agricultural loans to over 300,000 smallholder rice farmers in key producing states (Ehirim *et al.*,2019). However, local production still remained below consumption levels. In 2017/2018 marketing season, rice production was estimated at 5.8 million metric tonnes (MT) against consumption of 6.7 million metric tonnes (MT), leaving a deficit of almost 1 million MT. This necessitated further policy shifts by the Buhari administration. In 2015, a ban was placed on rice imports through the land borders to curb smuggling and promote local production. The government restricted foreign exchange for rice imports and raised import tariffs (Adeoti, 2019). This led to a significant decline in rice imports from over 1.1 million MT in 2015 to 21,000 MT in 2017.

Nigeria has long struggled with rice self-sufficiency and has relied heavily on rice imports. In 2006, rice imports were estimated at over 1.5 million metric tons annually, costing the country billions of dollars (Ugochukwu, 2016). To curb rising rice imports and boost local production, the federal government initiated various rice development programs over the past decade, including the Rice Transformation Agenda of 2013 and the Anchor Borrowers' Program launched in 2015 (Nwafor *et al.*,2022).

Furthermore, the Anchor Borrowers' Program provides cheap loans and farm inputs to rice farmers to enhance local production. It has been credited with significantly raising Nigeria's rice production in recent years. However, the country still imports some rice to meet demand (AgricNG, 2022).
Despite these efforts, local rice production could not meet the rising demand. In 2002, Nigeria's rice import bill was $1 billion annually. This high dependence on imports prompted the Obasanjo administration to launch the Nigerian Rice Transformation Agenda in 2002. The agenda aimed to reduce rice imports by 40% and achieve self-sufficiency in rice production by 2006/2007. It focused on increasing productivity, improving access to inputs and credit facilities and enhancing milling capacity among small-scale farmers (Kajisa, *et al.*,2015).

Recent studies indicate the policy measures are yielding positive results with local production expanding rapidly across major rice growing states like Kebbi, Kano, Jigawa, Ebonyi, Cross River State and Niger. Abi Local Government Area of Cross River State has long played a significant role in rice production in Nigeria. The LGA has ideal agricultural conditions for rice cultivation such as rainfall distribution and soil type. Commercial rice farming started in Abi in the 1980s under the River Basin Development Authorities established by the federal government. The Omambala Rice Dam was constructed to provide water for irrigation all year round, thereby boosting crop yields (Abi Local Government Area, 2013).

By the 1990s, Abi LGA emerged as one of the major rice producing zones in Cross River State. According to the United States Department of Agriculture (USDA) estimations, the LGA contributed over 30% of the state's total annual rice output in the late 90s-early 2000s, amounting to tens of thousands of metric tonnes. Rice varieties cultivated included FARO, ITA and NERICA, with yields reaching as high as 5MT/ha (USDA, 2005). This production surge was driven by private farmers leveraging irrigation schemes to cultivate large land areas.

Between 2008-2012, the Cross River State government prioritized the rice value chain under its Agricultural Transformation Agenda. Abi LGA was a focal point, receiving investments in irrigation infrastructure rehabilitation, provision of quality seeds, capacity building for cooperatives and credit support through the Agricultural Development Programme. This boosted the LGA's outputs, revenues and rural jobs. By 2012, total milled rice from Abi attained an estimate 70,000MT annually (Cross River ADP, 2012).

The area has since sustained its premier status in the state. Recent reports indicate continued expansion of production as more farmers are attracted to the subsector. For instance, in the 2018 wet season, over 700 hectares of land was cultivated across the LGA by rice out grower associations supported under the Central Bank of Nigeria's Anchor Borrower's Programme. This translated to estimated paddy yield of about 3,500MT (CBN Commodity Association Report, 2018).

Moreso, the rice production sub sector now accounts for about 5% of Nigeria's Agricultural GDP. However, challenges still exist around low productivity of smallholder farmers, poor access to high quality inputs and improved seeds, insufficient milling and storage capacity and infrastructural deficits that increase production costs. Concerted efforts are required across the value chain to achieve rice self-sufficiency and boost farmers' incomes.

Hence, the concept of contract farming, which is an agrarian practice that has been widely applied in developed and developing countries at different times for improved coordination and performance of the agricultural market and for addressing different types of market failures. Contract farming (often referred to as out-grower scheme) is an important component of many current public-private partnerships in developing countries (ActionAid, 2015; Yusuf, 2018). Such schemes appeal to farmers because the company often provides inputs and technical services and, as a result, open up new markets for produce, increased farming income and new technologies, thereby improving the farmers' livelihoods.

According to FAO (2016); Yusuf, (2018), contract farming is an agricultural production carried out according to an agreement between farmers and a buyer which places conditions on the production and marketing of the commodity. Such an agreement may be oral or written (Minot, 2007; Yusuf, 2018). The explanation of the motives for contract farming has witnessed diverse viewpoints. Allen (1972; Yusuf, 2018) considers it as a necessity if the consumer is to benefit fully from modern technologies especially in terms of promoting precise specifications and grades with regard to grains, fruits, vegetables and livestock products. Glover and Kunsterer (1990; Yusuf, 2018) place emphasis on the credit-facilitating aspect of contract farming as the farmers' principal motive for signing in.

Despite efforts since the 1990s to promote commercial rice production through irrigation schemes and out grower cooperatives in Abi Local Government Area, Cross River State, Nigeria, average yields and incomes of smallholder farmers have remained low (USDA, 2005; Abi Local Government Area, 2013). While contract farming models introduced in the late 2000s under programmes like the Abi Rice Out grower Cooperative Society helped restore farmlands and improve yields for some farmers to over 4MT/ha, a sizeable proportion continue engaging in independent non-contract production facing constraints (Cross River ADP, 2011). Report from Cross River ADP indicate about 60% of rice farmers in Abi achieve only 2-3m/ha due largely to lack of improved technologies and reliance on rainfall (Abi Local Government Area, 2013). With the emergence of the Central Bank of Nigeria anchored rice scheme from 2015, contract areas have grown but little is known about its spillover effects and comparative advantages over traditional non-contract models (CBN Commodities Report, 2018).

Empirical analysis is needed to better understand the socioeconomic factors influencing contract and non-contract rice farming in Abi Local Government Area, Cross River State.

METHODOLOGY

Description of study area

The study was conducted in Abi Local Government Area of Cross River State, Nigeria. Abi Local Government Area is in the Central Senatorial District of the state and is a riverside local government area with River, Cross River passing through the local government area. It lies between latitude 5°00' and 6°30' North of the Equator and longitude 8°00' and 8°10' East of the Greenwich Meridian (Akpoke, 2015). It shares borders with Obubra L.G.A to the North, in the East by Yakurr L.G.A, West by Ebonyi State and to the South by Biase L.G.A of Cross River State. Major communities in Abi LGA include Adadama, Afafanyi, Igonigoni, Igbo Ekureku, Igbo Imabana, Usumutong, Itigidi, Ebom, Ediba, Annong, Itigeve, Egboronyi, Emin Ekpon, Isongiyang. Abi however has a total land mass of 334,53162km2 (Abi Leeds, 2016). Going by the 2006 National Population Census results, Abi Local Government Area had a population of 144,802 persons (National Population Commission, 2006). Communities in Abi L.G.A are endowed with abundant swamps suitable for swamp rice cultivation. This accounted for why rice farming is a major livelihood in the area.

The people are engaged in farming, trading, fishing, hunting, post-harvesting processing, etc. Other crops grown include yams, cassava, vegetables, bush mango (Irvingia spp), etc. Livestock such as poultry, sheep, goats, etc. are kept in all the community which survive by scavenging around the homestead and nearby bush. Customary festival pertaining to farming activities are observed in most parts of the local government area annually to celebrate the rich harvest season (Ndifon and Bassey, 2008).

Sample Population and Technique

This comprises all rice contract and non-contract farmers in Abi LGA. A two-stage sampling technique was used to select the number of respondents for this study.

In the first stage, 10 communities where rice is mostly produced in commercial quantity were purposively selected from the 14 communities within the LGA.

In the second stage, 8 rice farmers from each community were surveyed through a snowballing technique due to the lack of a sampling frame.

Sample Size Determination

Since the population size is unknown, a sample size formula will be used to determine the sample size of rice farmers in the study area.

Cochran Formula (Cochran, 1977)

$n = p(1-p)z^2/e^2$

where:

n = sample size

p = the population proportion (p = 0.1)

e = acceptable sampling error (e = 0.05)

z = z value at reliability level or significance level.

Note:

Reliability level 95% or significance level 0.05; z = 1.96

Reliability level 99% or significance level 0.01; z = 2.58.

Now computing, we have:

$n = 0.1(1-0.1)1.96^2/0.05^2$

$n = 0.345744/0.0025$

$n = 138$

So, the sample size for the survey comprised of 138 respondents.

Sources of data and method of data collection

This study employed a quantitative approach using structured questionnaires as the primary data collection tool. The questionnaire was specifically designed to collect relevant data on the socio-economic factors influencing rice productivity for contract and non-contract farms in the study area.

The structured questionnaire was administered to 138 respondents, selected through a two-stage sampling technique, ensuring representation from contract and non-contract rice farmers in the study area.

Analytical Techniques

This study employed various analytical techniques to achieve its objectives.

Multiple Linear Regression Analysis

The general form of the linear regression model used is:

$Y = \beta0 + \beta1X1 + \beta2X2 + \ldots + \beta nXn + e$

Where:

Y = Rice productivity (tonnes/ha)

X1-X16 = Independent variables (as specified below)

$\beta0$ = Intercept

$\beta1$-$\beta16$ = Coefficients of independent variables

e = Error term

Independent Variables:

X1 = Age of farmers (Years)

X2 = Sex (male = 1, female = 0)

X3 = Educational level (Number of years)
X4 = Farm size (ha)
X5 = Household size (Number of members)
X6 = Mechanization level (1 = Mechanized, 0 = Non-Mechanized)
X7 = Farming experience (Number of years)
X8 = Fertilizer use (Kg/ha)
X9 = Improved seed varieties (1 = Used, 0 = Not Used)
X10 = Irrigation access (1 = Irrigated, 0 = Non-Irrigated)
X11 = Pesticide use (Litres/ha)
X12 = Storage facilities (1 = Adequate, 0 = Inadequate)
X13 = Credit access (1 = Received loan, 0 = Did not receive loan)
X14 = Market access (Distance to nearest market centre in km)
X15 = Farming system (1 = Mono-cropping, 0 = Intercropping)
X16 = Participation in contract farming (1 = Participates, 0 = Does not participate)
The data was fitted into four functional forms: linear, semi-log, double log and exponential. The best functional form was selected based on economic criteria (apriori expectation of signs of coefficients), Statistical criteria (R^2 and F-test statistics)

Gross Margin Analysis

Following Olajide and Omonona (2019), farm profit was measured in terms of Gross Margin (GM), calculated as:
GM = TR - TVC
Where:
GM = Gross Margin (Naira)
TR = Total Revenue (Naira)
TVC = Total Variable Cost (Naira)

Results and discussion

Table 1: Socioeconomic Characteristics and Farming Practices of Respondents

Characteristic	Frequency	Percent	Characteristic	Frequency	Percent	Characteristic	Frequency	Percent
Age (years)			Household Size (members)			Credit Facility		
20-29	2	2.0	1-5	57	58.8	Yes	1	1.0
30-39	32	31.4	6-10	40	41.2	No	96	99.0
40-49	34	33.3	Farming Experience			Education Level		
50 and above	27	26.5	1-5	20	14.7	No formal education	15	15.4
Sex			6-10	49	58.9	Primary	28	28.9
Male	92	94.8	11 and above	29	26.3	Secondary	40	41.2
Female	5	5.2	Farming System Adopted			Tertiary	14	14.4
Farm Size (hectares)			Mono-cropping	58	56.9	Local Irrigation usage	15 (Yes)	14.7

1-5	87	89.7	Inter-cropping	40	37.3		82 (No)	80.4
6-10	10	10.3	Storage Facility	6 (Yes)	6.2	Participation in contract farming	21(Yes)	24.5
			Yes	91 (No)	93.8		77(No)	74.5

Socioeconomic Characteristics and Farming Practices of Respondents

The findings of the study reveal key characteristics of farmers and their practices. Most respondents (33.3%) are between 40-49 years old, followed by 30-39 years old (31.4%). Respondents aged 50 and above comprise 26.5%, while those between 20-29 years old make up only 2.0%. This suggests that middle-aged individuals dominate rice farming activities in Abi Local Government Area.

Males predominate (94.8%), while females account for only 5.2%. This aligns with traditional roles and resource access patterns. Most respondents (89.7%) operate small-scale farms (1-5 hectares), with only 10.3% having larger farms (6-10 hectares). This indicates a preponderance of smallholder rice farming in the study area.

Most households have 1-5 members (58.8%), with 41.2% having 6-10 members. This suggests medium-sized families amongst rice farmers in the study area. Only 12.4% use machines, while 87.6% do not. Limited mechanization may likely reduce the productivity of the surveyed farms. Most respondents (58.9%) have 6-10 years of experience, while 26.3% have over 11 years of experience in rice farming. This indicates moderate to extensive experience of rice farming in the study area. Only 14.7% use local irrigation, while 80.4% do not. Resource constraints limit irrigation adoption. Mono-cropping is prevalent (56.9%), while intercropping accounts for 37.3%. Farmers prefer mono-cropping due to its simplicity and lower risk.

The study reveals that 74.5% of respondents do not participate in contract farming, indicating that independent or non-contract farming practices are prevalent in the sampled communities. In contrast, only 24.5% engage in contract farming, suggesting it is not the primary approach.This low participation rate may be attributed to challenges such as trust issues and small plot sizes with attendant risk of crop failure

These findings contradict previous studies, including Umeh and Asiabaka (2013), which reported that most rice farmers engaged in contract farming, specifically production contracts. In these contracts, farmers agreed to supply a predetermined quantity and quality of rice to agribusiness firms at a fixed price.

The discrepancy between this study and previous research highlights the need for further investigation into the factors influencing contract farming adoption and its suitability for different farming communities.

These findings imply a need for targeted support for smallholder rice farmers, investments in mechanization and irrigation, training programs for farmers, diversification of farming practices such as contract farming. This would enhance the productivity and sustainability of rice farms.

1 ha Cost and Returns of Rice Production in Abi (Contract vs. Non-Contract Farmers)

Variables	Unit	Contract Farmers	Non-Contract Farmers
Output of Rice	Kg	12.4	11.3
Revenue	N	581,644.9	195,314.85
Variable Costs			
Fertilizer	Kg	23.59 (26,246.4)	23.59 (25,510.23)
Seeds	Kg	28.4 (46,828.6)	28.4 (47,322.92)
Agrochemicals	Litres	1.7 (7,556.1)	1.7 (7,667.34)
Labour	Mandays	26.6 (49,535.2)	23.1 (38,589.9)
Total Variable Cost		133,184.3	122,035.42
Fixed Costs			
Depreciation		1,693.67	1,512.67
Total Cost		134,877.97	123,548.09
Net Profit		446,766.93	71,766.76
Gross Profit Margin		448,460.6	73,279.43
Productivity (Labour)		1.08	1.35
Farm Financial Ratio			
Benefit-Cost Ratio		4.31	1.58
Rate of Return/Naira Investment		3.31	0.58
Profitability Index		0.99	0.98
Profit Margin		0.77	0.37
Operating Expense Ratio		0.23	0.62

Source: Field survey, 2024.

Table 2 above provides a comprehensive analysis of the costs and returns of rice production in Abi, comparing contract and non-contract farmers. The data reveals significant differences in profitability between the two groups.

Contract farmers demonstrate exceptional profitability, with a benefit-cost ratio of 4.31, indicating that for every naira spent, they earn ₦4.31 in return. Their rate of return on investment is 3.31, and their profit margin is 76.8%. This suggests that contract farming is an economically viable option, with efficient use of inputs and labor.

In contrast, non-contract farmers have a lower benefit-cost ratio of 1.58, rate of return on investment of 0.58, and profit margin of 36.7%. While still profitable, non-contract farmers face challenges in managing costs, with a higher operating expense ratio of 0.62.
The comparison between contract and non-contract farmers highlights the advantages of contract farming. Contract farmers enjoy better returns on investment, improved profit margins, and more efficient cost management. This is likely due to the stability and support provided by contract farming arrangements, such as access to markets, inputs, and technical assistance.
The findings have important implications for policymakers and stakeholders. Promoting contract farming initiatives could enhance the economic viability of rice production in Abi. Additionally, non-contract farmers may benefit from training and support to improve their cost management and productivity.

The result supports previous research, such as Yusuf (2018), which found that contract farming is more profitable than non-contract farming. The study's conclusions are well-supported by the data, demonstrating the value of contract farming in improving the profitability and sustainability of rice production.

Socioeconomic Factors Influencing Rice Production in Abi

Table 3 presents the socioeconomic characteristics affecting rice production in Abi, using linear, semi-log, double-log, and exponential models. The lead equation, the Semi-log model, best explains the variation in rice production with the highest goodness-of-fit metrics and statistical significance.

Table 3: socio-economic characteristics affecting rice production in Abi

Variables	Linear	Semi-log	Double-log	Exponential
Age	0.223458 (1.100923)**	0.142123 (1.101026)***	0.241118 (0.175431)**	0.235431 (0.102236)***
Sex	0.462431 (0.032312)***	0.231417 (0.012360)*	0.231441 (0.342246)**	0.076231 (0.221120)
Educational level	0.2341532 (3.623547)***	0.122312 (1.234528)**	0.162434 (3.446341)**	0.153451 (2.600921)*
Farm size	0.162113 (-0.332503)	1.111232 (-0.120203)**	1.122393 (0.123403)*	1.345243 (-0.821103)***
Household	3.782122 (3.234185)*** 0.023001	1.232315 (-1.234002)**	1.112342 (1.342785)**	3.163377 (0.634212)

size Mech.	(2.002213)***	1.524311	2.124536	1.325222
level	211.3367	(2.002376)***	(2.432115)	(3.122315)*
Farming	(2.142331)	212.3367	-2. 55326	5.123367
experience	0.435158	(2.147431)*	(-2.213214)***	(4.121345)**
	(2.100235)**	0.215342	0.432318	0.125431
	0.223437	(1.101026)***	(0.100231)**	(0.102236)***
Fertilizer	(0.277620)	0.312417	0.463241	0.009937
im	0.152310	(0.012360)*	(0.211246)	(0.221120)
Improved	(3.621308)***	-0.124212	0.157234	0.124651
seed	1.122793	(2.234408)***	(3.692341)***	(2.600921)***
	(-0.231203)	1.221732	2.111293	1.345723
Irrigation	5.234183	(-0.121203)	(0.100203)**	(-0.821103)*
access	(3.148123)***	1.234125	1.112353	2.340083
	-177.3367	(-0.501372)**	(1.230125)**	(3.112485)*
Pesticide	(2.123411**	-132.3367	-7.442367	7.003367
use	0.232331	(-1.147431)**	(-2.223431)*	(5.021345)*
Storage	(0.102236)***	0.542001	1.232315	0.231441
facilities	0.023431	(2.002141)***	(-1.234002)**	(0.123246)**
	(0.22110)	122.3367	1.524311	0.162434
Credit	0.153451	(2.147431)	(2.002376)***	(3.446341)**
access	(2.632921)*	0.435158	132.3367	1.122393
		(2.100386)**	(2.147431)*	(0.122303)*
Market access				
Farming system				
Participatio n in contract				
R-squared	0.691228	0.961118	0.244762	1.098118
Adjusted R-s	0.234116	1.200126	0.723116	0.023416
S.E. of regres	2.212201	2.321723	2.325414	1.221743
Sum squared	126.2321	16.40921	2.092221	122.3001
Log likelihoo	23.01236	23.04476	2.124176	54.01226
F-statistic	2.233071	2.487071	0.214511	1.552471
Prob(F-statist	0.062332	0.032552	0.023116	0.120452

Source: Field survey, 2024

The result reveals several key factors influencing rice production in Abi. Age positively impacts production, with a coefficient of 0.462431, indicating that older farmers tend to be more experienced, leading to higher productivity. Education also improves farmers' ability to adopt new technologies, increasing output, with a coefficient of 0.2341532.

Farm size is another significant factor, with a coefficient of 3.782122, indicating that larger farms benefit from economies of scale, contributing to increased productivity. Mechanization

level also plays a crucial role, with a coefficient of 0.023001, highlighting the importance of access to machinery and improved farming tools in boosting production.

Fertilizer use contributes to better crop yields, with a coefficient of 0.435158, although its impact is slightly less significant compared to other factors. Household size positively impacts production, with a coefficient of 0.152310, as larger households provide more labour for farming activities.

The use of improved seeds significantly improves productivity, with a coefficient of 5.234183, highlighting the importance of seed quality. However, market access challenges, such as transportation costs or low prices, negatively impact production, with a coefficient of -177.3367.

Participation in contract farming has a positive but weaker influence on production, with a coefficient of 0.153451. This suggests that while contract farming provides some benefits, its impact is not as robust as other factors.

The Semi-log model's high R-squared value indicates that these socioeconomic factors collectively explain a large portion of the variability in rice production. Experience, education, farm size, mechanization, labor availability, and seed quality are crucial for improving productivity.

This study supports Oladeebo and Oladeebo (2008), highlighting the significance of access to improved seeds, fertilizers, and extension services in enhancing rice yields. Policymakers and stakeholders should focus on improving these factors to increase rice production in Abi.

The findings emphasize the importance of addressing socioeconomic factors to enhance agricultural productivity. By understanding these factors, policymakers can develop targeted interventions to support rice farmers and improve overall productivity in Abi Local Government Area.

Conclusion:

This study conducted a comparative economic analysis of contract and non-contract rice farming schemes in Abi Local Government Area, Cross River State, Nigeria. The results show that contract farming is more profitable than non-contract farming, with contract farmers having a higher benefit-cost ratio, rate of return on investment, and profit margin. Socioeconomic factors such as age, education, farm size, mechanization, labor availability, and seed quality significantly influence rice production.

The study recommends that policymakers and stakeholders promote contract farming initiatives and provide support to non-contract farmers to improve their productivity and profitability. Specifically, investments in mechanization, irrigation, and training programs for farmers, as well as access to improved seeds and fertilizers, are crucial for enhancing rice production in Abi.

REFERENCES

Abi Leeds. (2016). Brief geography of Abi LGA.
Abi Local Government Area. (2013). History of Abi local government area.
Abi Local Government Area. (2013). History of Abi local government area.

ActionAid. (2015). A critical analysis of contract farming in Liberia. ActionAid International Liberia.

ActionAid. (2015). A critical analysis of contract farming in Liberia. ActionAid International Liberia.

AgricNG. (2022, January 22). Nigeria still imports rice despite production increase. AgricNG.

Akpoke, G.C. (2015). An assessment of the physical development of Abi

Allen, C.R. (1972). The marketing performance of contract packers of vegetables for processing. (Ph.D. Thesis). Departments of Agricultural Economics and Business Management. Colorado State University. Colorado.

CBN Commodities Report. (2018). Performance of rice out grower associations in Abi LGA, Cross River State. Central Bank of Nigeria Commodity Association Implementation Support Report.

CBN Commodities Report. (2018). Performance of rice out grower associations in Abi LGA, Cross River State. Central Bank of Nigeria Commodity Association Implementation Support Report.

CBN Commodity Association Report. (2018). Performance of rice out grower associations in Abi LGA, Cross River State. Central Bank of Nigeria Commodity Association Implementation Support Report.

Cochran, W. G. (1977). Sampling techniques (3rd ed.). New York: John Wiley & Sons.

Cross River ADP. (2011). Performance review of rice out grower cooperatives in Cross River State 2005-2010. Internal Report.

Ehirim, N. C., Onuk, E. G., Diara, C. O., & Ajah, C. O. (2019). Impact of central bank of Nigeria (CBN) Anchor Borrowers' Programme (ABP) on rice farmers' income in Cross River State, Nigeria. Asian Journal of Agricultural Extension, Economics & Sociology, 33(3), 1-11.

FAO. (2016). Contract farming for inclusive market access. Food and Agriculture Organization of the United Nations (FAO). .

Glover, D. and Kusterer, K. (1990). Small Farmers, big business: contract farming and rural development.London: Macmillan.

Glover, D., & Kusterer, K. (1990). Small farmers, big business: Contract farming and rural development. Macmillan Education UK.

Kajisa, K., Place, F., & Mariano, M. J. (2015). Rice transformation in Nigeria and Senegal: Assessment of policies, impact and implications for future strategies. Environment and Production Technology Division Discussion Paper, 161. International Food Policy Research Institute (IFPRI).

Minot, N. (2007). Contract farming in developing countries: Patterns, impact and policy implications. ESA Working Paper No. 07-16. Agricultural and Development Economics Division, The Food and Agriculture Organization of the United Nations.

National Population Commission. (2006). Census population results. NPC Abuja.

Ndifon, C.J. & Bassey, N.E. (2008). Traditional festivals of Abi Local Government Area, Cross River State, Nigeria as vehicles for cultural promotion and rural tourism development. African Journal of Heritage Studies, Tourism and Hospitality, 1(1), 75-84.

Nwafor, C. A., Ugochukwu, S. C., & Ejiogu-Okereke, E. N. (2022). Impact of federal government intervention policies on rice production and productivity in Nigeria. African Journal of Agricultural Research, 17(6), 689-699.

Okoruwa, V. O., & Nkonya, E. (2011). Government agricultural programs and agricultural productivity in Nigeria. African Journal of Agricultural Research, 6(4), 933-940.

Oladeebo, J. O., & Oladeebo, O. E. (2008). Determinants of chemical input use and productivity among rural farmers in Ogbomoso agricultural zone of Oyo State, Nigeria. Journal of Social Sciences, 17(1), 13-18.

Olomola, A. S., & Omotilewa, O. J. (2010). Contract farming as a risk management strategy among rice farmers in Nigeria. African Journal of Agricultural Research, 5(13), 1611-1615.

Oyeyinka, R. A., & Bolarinwa, K. K. (2009). Determinants of yam production in Oyo State, Nigeria. Continental Journal of Agriculture Science, 3(1), 10-17.

Ugochukwu, S. C. (2016). Addressing postharvest losses and lack of storage facilities through agricultural mechanization: The case of rice in Nigeria. International Food and Agribusiness Management Review, 19(3).

Umanah, I. I., & Enete, A. A. (2014). Analysis of adaptation strategies to climate change among smallholder farmers in Abia State, Nigeria. Journal of Agricultural Economics, Environment and Social Sciences, 4(1), 11-14.

Umeh, J. C., & Asiabaka, C. C. (2013). Analysis of contract farming as a strategy for food crop production: A case study of rice farming in Nsukka Agricultural Zone, Enugu State. Agriculture and Biology Journal of North America, 4(1), 93-99.

USDA. (2005). Nigeria gains rice self-sufficiency. USDA Foreign Agricultural Service GAIN report. Cross River ADP. (2012). Abi LGA emerges top rice producing LGA in Cross River state. Cross River Agricultural Development Programme Internal Report.

Yusuf, S. A. (2018). Contract farming as a strategy for poverty reduction in Africa: The case of rice outgrower scheme in Nigeria. KCA Journal of Business Management, 3(1), 23-35.

EXTENT OF FOOD POVERTY AMONG URBAN FARMING HOUSEHOLDS IN ABEOKUTA, OGUN STATE, NIGERIA

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ABSTRACT

Urban agriculture is a vital strategy for addressing food poverty among growing urban populations. As urbanization surges, so does the demand for sustainable food systems. This study evaluated the extent of food poverty among urban farming households in Abeokuta, Ogun State, Nigeria. The primary goal was to measure food poverty levels, while specific objectives include identifying farming activities, profiling food poverty levels, assessing production efficiency, and pinpointing challenges and opportunities in urban agriculture. Data was collected from 80 urban farmers through structured questionnaires. Analytical tools such as the headcount index, Lorenz curve, Gini coefficient, and regression analysis were used. Results showed that 78.75% of urban farmers are not food poor, while 21.25% are food poor. The Gini coefficient of 0.2065 indicates a relatively equitable distribution of food expenditure while the regression analysis identified farm size, family labor, and hired labor as key factors in output variation among households. This findings implies that they were in stage II of the production function, suggesting increasing returns to scale. The study underscored the role of urban farming in reducing food poverty and highlights areas for enhancing productivity among urban farmers, which if explored and prioritized by policy makers, will contribute to a more resilient and equitable food system.

Keywords: Urbanization, food poverty, food insecurity urban farming, poverty alleviation

Introduction

The demographics of countries are continually evolving, showing an outlook of having more people living in cities and towns than in rural areas. By the year 2000, about 2.2 billion people resided in urban areas across Asia, Africa, and Latin America, half in cities with populations exceeding one million (Rabinovitch, 1997). Economic growth and migration from rural regions fuel urbanization (Okafor and Mgbenwelu, 2023), which has led to a significant shift in global demographics, particularly in developing countries, where more people live in cities than ever before. A growing proportion of the world's population now resides in urban areas, placing

immense pressure on food systems. In Nigeria, rapid urbanization and economic challenges have exacerbated food insecurity, particularly in urban areas. Food insecurity and poverty are still pervasive issues, with approximately 41% of the Nigerian population being food insecure (Olayeni, 1996a). The urbanization spread brings with it a slew of issues, including food insecurity, poverty and the exclusion of some socioeconomic groups from urban social services (Okafor and Mgbenwelu, 2023). As urbanization surges, so does the demand for sustainable food systems.

Food poverty refers to the inability of individuals or households to access an adequate and nutritious diet due to insufficient resources. This concept is closely tied to both poverty and food insecurity, as it highlights the economic and social barriers that prevent people from obtaining enough food to meet their dietary needs for a healthy and active life (Dowler & O'Connor, 2012).

However, urban agriculture may have a role to play in addressing urban food insecurity problems, which are bound to become increasingly important with the secular trend toward urbanization of poverty and of population in developing regions (Zezza and Tasciotti, 2010). Urban farming is crucial in addressing the challenges, especially as malnutrition, once primarily rural, now severely affects urban residents (Idachaba, 1991). Urban agriculture is the raising, processing, food distribution and other essentials through intensive planting and rearing of animals in and around urban areas (Okafor and Mgbenwelu, 2023). Urban farming has been recognized globally as a sustainable livelihood strategy among urban and peri-urban poor in developing countries, significantly and positively impacting food security and nutrition (Daramola *et al.*, 2021). It has been described as a viable option, to alleviate poverty among urban dwellers, especially the unemployed and low income earners that barely cope with the expensive lifestyle of urban centers (Adeyemo *et al.*, 2017).

Despite urban farming's rise in importance, little research exists on its effectiveness in reducing food poverty or on urban farmers' performance in the study area. Understanding urban agriculture's impact is essential for optimizing resources and addressing food security needs amidst limited resources. This study therefore focuses on Abeokuta, Nigeria, to analyse the effect of urban farming on food poverty alleviation.

Materials and Methods

Area of Study

This study focused on Abeokuta, comprising Abeokuta North and South Local Government Areas in Ogun State, Nigeria. Ogun State, known as the gateway to Nigeria, spans approximately 16,409.25 square kilometers with a population of around 2.3 million people (1994 Jures). It borders the Republic of Benin to the west, Lagos State and the Atlantic Ocean to the south, Ondo State to the east, and Oyo State to the north. The tropical climate in Abeokuta supports a range of agricultural activities, with residents engaged primarily in farming and trading.

Sampling procedure

One hundred urban farmers were purposively selected for the study from Abeokuta, the administrative headquarters of the State and therefore possessing many social amenities and other infrastructural facilities that is characteristic of most urban towns in the country.

Data Collection

Primary data were collected through a structured questionnaire designed to cover demographic information, farming practices, input use, output, and household expenditure. Secondary data was obtained from relevant government agencies, academic institutions, and published literature.

Data Analysis

Descriptive statistics were employed to analyze the socio-economic characteristics of the respondents. The food poverty line was determined based on the mean per capita household food expenditure, and the headcount ratio was calculated to measure the incidence of food poverty. A Lorenz curve was used to visualize the distribution of food expenditure, and the Gini coefficient was calculated to quantify inequality. To assess the efficiency of production, a multiple regression analysis was conducted using the Cobb-Douglas production model. The following variables were included in the model: farm size, family labor, hired labor, seed and planting materials, and fertilizer. The significance of the coefficients was tested using t-tests, and the overall model fit was assessed using the F-test.

Results and Discussion

Socioeconomic Characteristics

Among the urban farmers interviewed, only 3.75 % were 30 years below while 23.75 percent were between the ages 31 to 40, 31.25 % were between 41 to 50 years of age while 41.25 percent were above 50 years of age. This shows that older people engage in urban farming as the modal age is 50 years and above. This may not be unconnected with the fact that some of those older people spent the early part of their lives in village where farming was the main occupation and as such have imbibed it, the age distribution is seen in table 1.

Table 1: Age distribution of urban farmers in Abeokuta

AGE	FREQUENCY	PERCENTAGE
20-30	3	3.75
31-40	19	23.75
41-50	25	31.25
>50	33	41.25
Total	80	100.00

The majority of urban farmers in the study area were middle-aged (41-50 years) and married. A significant proportion had higher education levels, suggesting that urban farming may be a supplementary activity for professionals or retirees.

Table 2 shows that 89 % of the urban farmers interviewed were married, 6.25 % were widowed/divorced while only 5.0 % were single. Those without any formal education were about 2.5 %, some 28.75 % had primary school education while about 25 % hard post primary education and 43.75 % had higher education.

Table 2: Distribution of urban farmers according to marital status

Marital Status	FREQUENCY	PERCENTAGE
Married	71	88.75
Widowed/divorced	5	6.25
Single	4	5.0
Total	80	100.00

Table 3 shows the distribution of urban farmers by educational status in Abeokuta. Those without any formal education were about 2.5 percent, some 28.75 percent had primary school education while about 25 percent had post primary education and 43.75 percent had higher education. Thus it is clear that most urban farmers are educated and practice farming as a secondary occupation.

Table 3: Distribution of urban farmers by education status

LEVEL OF EDUCATION	FREQUENCY	PERCENTAGE
No formal education	2	2.50
Primary education	23	28.75
Post primary education	20	25.00
Higher education	35	43.75
Total	80	100.00

Table 4 shows that urban farmers were mostly male as they make up 83.75 percent of respondents while 16.23 percent were female. Majority of the people who practice urban farming in Abeokuta are male. However, there were cases where though the forms are owned by men the actual work on the farms done by women.

Table 4: Distribution of urban farmers by gender

GENDER	FREQUENCY	PERCENTAGE
Male	67	83.75
Female	13	16.25
Total	80	100.00

The results of household distribution size are presented in Table 5. The distribution of urban farmers by their household size (22.5) just above one further percent fell into the 1 to 4 persons household category while 70 percent were within the 5 to 9 persons category and 7.5 percent have a household size of 10 and above.

Table 5: Household Size Distribution

HOUSEHOLD SIZE	FREQUENCY	PERCENTAGE
1-4	18	22.5
5-9	56	70.0
≥10	6	7.5
Total	80	100.00

Table 6, revealed that mixed farming was most favoured by the urban farmers. There grew crops alongside animals such as sheep, goat and poultry. About 58 percnt adopted mixed

farming, while 33.75% practiced crop farming only and only 7.5 percent practiced animal farming alone.

Table 6: Types of farming system adopted by urban farmers in Abeokuta

FARMING SYSTEM	FREQUENCY	PERCENTAGE
Mixed farming(Animal & Crops)	47	58.75
Crops alone	27	33.75
Animals alone	06	25.00
Total	80	100.00

Based on the results (Table 7), urban farming households were grouped into different categories to determine the incidence of food poverty.

Households with a monthly per capital food expenditure of below ₦312.27 were said to be core food poor and as revealed in table 7, none of the urban farming households interviewed fell into this category. Those that had a monthly per capital food expenditure between N312.27 and N624.53 were said to be moderately food poor and those with a monthly per capital food expenditure above N624.53 were none food poor. The two categories; moderately food poor and non- food poor were 21.25 % and 78.78 percent respective. Mixed farming, combining crop and livestock production, was the most common farming system. However, crop cultivation was the predominant activity.

Table 7: Percentage distribution of urban farming households under different expenditure

FOOD EXPENDITURE (₦)	FREQUENCY	PERCENTAGE
	-	-
312.2624.53	17	21.25
Above 624.53	63	78.75
Total	**80**	**100.00**

Food poverty incidence by primary occupation can be seen in table 8.Among the urban farmers interviewed, 100 % those who are civil servants are found to be non-food poor and the same hold for those who are traders. For the artisans however, 69.23 percent were moderately food poor while 38.10 percent of the farmers were food poor line.

Table 8: Poverty distribution among different primary occupational groups of urban farmers

Primary occupation	**Moderately food poor**		**Nonfood poor**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Civil servants	-	-	35	100.00
Artisans	9	69.23	9	30.77
Traders	-	-	11	100.00
Farmers	8	38.10	13	61.90
	17	-	63	-

It was found that household size is a major determinant of poverty as can be seen in the table 9. The small households are non-food poor while the households in the 5 to 9 persons have a

poverty incidence of 25 percent and for those with household size of 10 and above, 50 percent are food poor.

Table 9: Food poverty distribution by household size among urban farming households in Abeokuta

Households size	Moderately food poor		Non-food poor	
	Frequency	Percentage	Frequency	Percentage
1-4	-	-	18	100.00
5-9	14	25.00	42	75.00
>10	3	50.00	3	50.00
	17	-	63	-

Food poverty distribution by gender is presented in table 10. The results showed that for the male respondents, poverty incidence was 22.39 percent while 15.38 percent of the female respondents were food poor.

Table 10: Poverty distribution by gender among urban farmers in Abeokuta

Gender	Moderately food poor		Non-food poor	
	Frequency	Percentage	Frequency	Percentage
Male	15	22.39	52	77.51
Female	2	15.38	11	84.62
	17	-	63	-

Poverty distribution by educational level is presented in table 11. Among the various categories of urban farmers by educational level it was found that all the people without formal education were food poor; 34.78 percent of those with primary education were food poor, while 30 percent of those with post primary education were food poor and 2.86 percent of those with higher education were food poor.

Table 11: Poverty distribution by educational level among urban farmers in Abeokuta

Educational level	Moderately food poor		Non-food poor	
	Frequency	Percentage	Frequency	Percentage
No formal education	2	100.00	-	-
Primary education	8	34.78	15	65.22
Post primary education	6	30.00	14	70.00
Higher education	1	2.86	35	97.14
	17	-	63	-

Poverty distribution of urban farmers by marital status is shown in Table 12. The analysis showed that 88.75 percent of urban farmers in the study area were married, among whom 21.13 percent were food poor, while 40 percent of those in the widowed/divorced category were food poor and none of those in the single category was food poor.

Table 12: Poverty distribution of urban farmers by marital status

Marital status	Moderately food poor		Non-food poor	
	Frequency	Percentage	Frequency	Percentage
Single	-	-	4	100.00
Widowed/divorced	2	40.00	3	60.00
Married	15	21.13	56	78.87

Distribution of monthly expenditure by urban households in Abeokuta (Table 13), showed that out of the total household expenditure of the urban farming household sampled, 63.09 percent went to food items while the remaining 36.91 percent was spent on non-food items. The distribution of household monthly expenditure on food and non-food items was gauged using the Lorenz curve of food expenditure. Also, the Gini coefficient which gives an indication of the level of inequality in the distribution was calculated as follows, using the formular;

$$\text{Gini coefficient} \quad 1 + \frac{1}{n} - \frac{2}{n^2 N} \sum y_i x_i$$

Where x_i = rank of expenditure such that the highest expenditure is ranked

y_i = Expenditure

n = number of households

if = mean of food expenditure

$$G = 1 + \frac{1}{80} - \left(\frac{2}{5995520} \times 2417674 \right)$$

$$= 0.2065$$

A Gini coefficient of 0.2065 further showed that the inequality in food expenditure distribution among urban farming households in Abeokuta is quite low. This can be attributed to the fact that urban farming households supplement their food expenditure with proceeds from urban farming either directly or indirectly.

A Cobb -Douglas production function was fitted to determine the efficiency of production among urban farmers who grow crops. The model was fitted for crops only because most of the respondents who raised animals did so on extensive system and could not really account for the inputs. However, there were few urban farmers who practiced intensive poultry production but their number was not sufficient for analysis. The estimated equation using linearized Cobb-Douglas production function is as follows:

$$\text{Log } y = 4.451 + 0.50x_1 + 0.35x_1 + 0.48x_3$$
$$(0.99) \quad (0.28) \quad (0.22) \quad (0.19)$$
$$- 0.03x4 + 0.007x5$$
$$(0.20) \quad (0.08)$$
$$R^2 = 0.787 \qquad \text{F ratio} = 63.631$$
$$\sum b_{is} = 1.34$$

The headcount index revealed that 21.25% of urban farming households were food poor. Factors such as household size, education, and occupation were significantly associated with food poverty. The Lorenz curve and Gini coefficient indicated a relatively equitable distribution of food expenditure among households. The t -test carried out on the regression coefficients showed that only those of farm size cultivated (x_1), family labour (x_2) and hired labour (x_3) were found to be statistically significant at one percent, ten percent and one percent respectively. The regression analysis indicated that farm size, family labor, and hired labor were significant determinants of output. However, the low R-squared value suggests that other factors not included in the model may also influence productivity.

Table 13: Distribution of monthly expenditure by urban farming household in Abeokuta

Items	Expenditure (₦)	Percentage
Food	425870	63.09
Non-Food	249175	36.91
Total	675045	100.00

The average and marginal products for all the inputs was calculated and the result obtained are presented in table 14.

Table 14: Summary of average and marginal product of inputs, mean values and coefficients

Input	Mean valuc of input	Coefficient	Average product	Marginal product
X_1 = Farm size	1.1561	0.50	30495.9556	15256
X_2 = Family labour	29.3378	0.35	1201.7176	420.6012
X_3 = Hired/labour	87.62	0.48	5.4088	2.5962
X_4 = Fertilizer/Manure	87.62	0.003	402.3641	1.2071
X_5 = Seeds/Planting materials	1544.73	0.007	22.8233	0.1598

The partial elasticity of production of each of the inputs is given by the coefficients of the cobb-Douglas function used. These are: $b_1 = 0.50$, $b_2 = 0.35$, $b_3 = 0.48$, $b_4 = 0.003$, $b_5 = 0.007$

Generally $EP = \frac{MP}{AP}$.

Wherever MP = AP = EP =1, this is the point of diminishing returns and this point gives the minimum amount of variable input that would be used and it occurs where the efficiency of the variable input is at a maximum (Doll and Orozem, 1978) from the results obtained, Elasticity of production for each of the input variable is less than one. This means production is at a stage where the average product is greater than the marginal product, and since all the marginal products are still positive the urban farmers' production is still in the efficient stage of production (Stage 11). This is in agreement with Koutsoyianis (1979) that the efficient part of the production function is on the range of output over which the marginal products of the factors are positive but diminishing or decreasing.

The study identified several factors that can contribute to the growth of urban agriculture in Abeokuta, including the availability of skilled labor and access to inputs. It affirms the reports of Idachaba (1991), Adeyemo *et al,* (2017).and Daramola et al, 2021that urban farm is veritable vehicle to alleviate poverty among urban dwellers. However, constraints such as land scarcity, inadequate infrastructure, and limited access to credit continue to hinder the development of urban farming. Obviously, by utilizing urban spaces such as rooftops, balconies, and vacant lots, urban farmers can produce fresh, nutritious food for local consumption.

Conclusion

This study revealed that a significant proportion of urban farming households in Abeokuta are food-secure. However, a substantial minority remains food-poor. The Lorenz curve and Gini coefficient indicate a relatively equitable distribution of food expenditure among farmers.

Indeed, urban farming has the potential to alleviate food poverty and enhance food security in Abeokuta. However, addressing the challenges faced by urban farmers requires a multi-faceted approach, including policy interventions to secure land tenure, provide access to finance, and promote sustainable agricultural practices.

Recommendation

Future research should explore the long-term impacts of urban farming on household livelihoods and community resilience.

References

Adeyemo, R., Ogunleye, A., Kehinde, A., and Olamide, A. (2017). Urban Agriculture UA) and Its Effects on Poverty Alleviation: A Case Study of Vegetable Farming in Ibadan Metropolis, *American Journal of Environmental Sciences and Engineering,* 1(3):68-73.

Daramola, R. B., Mohammed, B. T., Abdulquadri, A. F., Ashaye, W. O. and Oserei, M. K. (2021). The potentials of urban farming on household consumption in ilorin metropolis, kwara State, *Journal of Agricultural Mechanization,* 42-50.

Doll J.P., and Orazem (1978). Production economic Theory with applications. Grid Inc, 4666 Ohio Indianola Avenue, Columbus, Ohio, USA.

Dowler, E., & O'Connor, D. (2012). Rights-based approaches to addressing food poverty and food insecurity in Ireland and UK. *Social Science & Medicine, 74*(1), 44-51.

Idachaba, F. S. (1991). The nature of the Nigerian Food Problem. *Journal of Agriculture, Science and Technology*, 1:1-17.

Koutsoyannis, A. (1979). Modern Microeconomics. Second Edition, LTD The Macmillian Press Limited, London.

Olayemi, J.K., (1996), Food security in Nigeria. The report of a research study sponsored by Development Policy Center, Ibadan, Nigeria, 1996.

Rabinovitch, J. and Schmetzer, H. (1997), Urban Agriculture, Food, Employment and Sustainability for cities. Journal of Agriculture and Rural Development. 4(2): 48-49.

Zezza, A. and Tasciotti., (2010), Urban agriculture, poverty, food security: Empirical evidence from a sample of developing countries. *Food Policy*. 35(4): 265-273.

POST-HARVEST LOSSES: IMPLICATIONS FOR THE MARKETABILITY OF AGRICULTURAL PRODUCE IN NIGERIA

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ABSTRACT

This paper is a review on the prevalent issue of post-harvest losses (PHL) in Nigeria, particularly its effect on the marketability of agricultural goods. Specifically, the paper identified the factors contributing to post-harvest losses and explored the implications of post-harvest losses on the marketability of agricultural produce in Nigeria. Post-harvest losses reduce the quantity and quality of produce available for consumption, arising from inadequate handling, limited storage facilities, and inefficient transport systems. These losses have far-reaching effects on Nigeria's food security, market dynamics, and farmer incomes. The study reviews key drivers of PHL, including substandard handling practices, inadequate storage, and fluctuating market conditions. The study also highlights the implications of PHL to include supply shortages, price inflation, profit margins, and food insecurity. It also explores the potential of value-added processing as a mitigative approach to reduce waste and enhance agricultural profitability. The study recommends a comprehensive strategy involving improved infrastructure, farmer training, and enhanced storage solutions as measures to address the challenges from PHL.

Key words: Post-harvest losses, Marketability, Food security, Value addition

Introduction

Post-harvest losses (PHL) refer to the reduction in the quantity or quality of agricultural produce that occurs between harvest and consumption. These losses can arise due to a variety of factors, including improper handling, inadequate storage, transportation issues, pest infestations, and unfavourable weather conditions (Adewumi et al., 2021). Globally, approximately one-third of all food produced for human consumption is wasted, with post-harvest losses accounting for a significant portion of this waste (Food and Agriculture Organization [FAO], 2019). Post-harvest losses encompass both quantitative and qualitative losses. Quantitative losses refer to the physical quantity of food that is discarded or rendered unfit for consumption, while qualitative losses pertain to reductions in the quality of produce, which can diminish its market value (Nwafor et al., 2020). In Nigeria, it is estimated that about 40% of food produced is lost post-harvest, significantly affecting the food supply and the incomes of farmers (Ogunniyi, 2022).

In Nigeria, the impact of post-harvest losses is particularly pronounced due to various challenges, including poor infrastructure, inadequate storage facilities, and a lack of knowledge among farmers regarding best practices for handling produce. This review identified the factors

contributing to post-harvest losses and explores the implications of post-harvest losses on the marketability of agricultural produce in Nigeria, emphasizing the urgent need for effective management strategies to mitigate these losses.

Factors contributing to post-harvest losses

The review categorises post harvest losses into three main areas:

Handling Practices

Inefficient handling practices at various stages of the supply chain significantly contribute to post-harvest losses in Nigeria. Many Nigerian farmers lack training in proper harvesting techniques, leading to bruising and damage to produce. For instance, excessive force during harvesting can compromise the integrity of fruits and vegetables, making them more susceptible to decay (Ogundipe et al., 2023). Furthermore, inadequate transportation methods, such as using unregulated vehicles or containers, can exacerbate losses due to vibration, exposure to unfavourable weather, and contamination (Adebayo & Oyeleke, 2020). A survey by Nwosu et al. (2022) found that many farmers in Nigeria reported losses due to mishandling during transport, particularly for perishable items like tomatoes and yams.

Storage Conditions

Storage conditions play a critical role in determining the shelf life of agricultural produce. In Nigeria, many farmers lack access to adequate storage facilities, which results in spoilage due to pests, moisture, and temperature fluctuations (Ogunniyi, 2022). Traditional storage methods, such as open-air storage, further increase vulnerability to environmental factors and pest infestations, leading to substantial losses. A study by Adewumi et al. (2021) highlighted that a significant percentage of Nigerian farmers store their produce in inadequate facilities, which lack climate control and pest protection. Without proper storage facilities, farmers are forced to sell their produce quickly, often at lower prices, limiting their profit margins (Nwosu et al., 2022).

Market Dynamics

Market dynamics, including demand fluctuations and pricing, also affect post-harvest losses in Nigeria. Farmers may face pressure to sell their products quickly to avoid losses, leading to distress selling at lower prices. This situation is exacerbated in rural areas with poor market access, where farmers have limited bargaining power and face higher transportation costs (Adewumi et al., 2021). A report by the International Food Policy Research Institute (IFPRI, 2020) noted that market inefficiencies, such as lack of access to market information and high transaction costs, can lead to increased post-harvest losses, further impacting the overall marketability of agricultural goods.

Implications for Marketability

Post-harvest losses have profound implications for the marketability of agricultural produce, particularly in developing countries like Nigeria.

Reduced Supply and Increased Prices

Post-harvest losses directly reduce the overall supply of agricultural products in the market. When a significant portion of the harvest is lost, it leads to scarcity, which can drive up prices for consumers. Higher prices may reduce demand, creating a vicious cycle where farmers are unable to sell their produce at a profit, further exacerbating food insecurity (FAO, 2019). In Nigeria, the scarcity of staple foods like cassava and maize during the lean season is often attributed to high post-harvest losses, affecting food availability and affordability (Ogunniyi, 2022).

Lower Quality of Available Products

Quality is a critical factor in determining marketability. When agricultural produce suffers from post-harvest losses, the remaining products may be of lower quality, affecting consumer perceptions and willingness to pay. For instance, fruits and vegetables that have been bruised or infested with pests may be rejected by retailers, leading to further losses for farmers (Nwosu et al., 2022). As quality diminishes, so does the marketability of agricultural goods, limiting farmers' opportunities to access higher-value markets. A study by Ogundipe et al. (2023) found that Nigerian consumers are increasingly selective, opting for higher-quality products, which further disadvantages farmers who cannot meet these quality standards.

Impact on Profit Margins

Post-harvest losses significantly impact farmers' profit margins. When a portion of the harvest is lost due to spoilage or damage, farmers receive lower returns on their investments in inputs such as seeds, fertilizers, and labour. This financial strain can discourage farmers from investing in their operations, further perpetuating the cycle of low productivity and high losses (Ogundipe et al., 2023). Reduced profit margins can hinder farmers' ability to access better technologies and practices, limiting overall market competitiveness. In Nigeria, many smallholder farmers operate on tight margins, making them particularly vulnerable to the effects of post-harvest losses (IFPRI, 2020).

Food Insecurity at all levels

Post-harvest losses contribute to food insecurity at both the household and National levels. When food is wasted, it exacerbates hunger and malnutrition, particularly among vulnerable populations (Adewumi et al., 2021). In Nigeria, where food insecurity is already a pressing issue, post-harvest losses undermine efforts to achieve food security and stability. According to the World Food Programme (2023), approximately 18 million Nigerians are estimated to be food insecure, with post-harvest losses further complicating efforts to address this crisis. Additionally, food insecurity can lead to social unrest and increased pressure on government resources to address hunger-related challenges.

Opportunities for Value Addition

While post-harvest losses pose significant challenges, they also present opportunities for value addition. By investing in processing technologies, farmers can transform perishable goods into long-lasting products, such as jams, dried fruits, and sauces. This approach not only reduces waste but also enhances marketability by creating diverse product offerings (Ogundipe et al.,

2023). Furthermore, organizations like the Nigerian Export Promotion Council (NEPC) are actively promoting value-added processing initiatives to help farmers maximize their profits and reduce waste. Additionally, improving logistics and storage solutions can significantly reduce post-harvest losses and increase the profitability of agricultural enterprises.

Conclusion

Post-harvest losses present a significant challenge to the marketability of agricultural produce in Nigeria. The implications of these losses are far-reaching, affecting supply, quality, profit margins, food security, and overall market dynamics. Addressing post-harvest losses requires a multifaceted approach, including improving handling practices, enhancing storage conditions, and developing robust market systems. By investing in training, infrastructure, and technology, stakeholders can mitigate post-harvest losses, enhance marketability, and contribute to a more sustainable and equitable food system. Ultimately, reducing post-harvest losses is essential for improving the livelihoods of farmers and ensuring food security for vulnerable populations in Nigeria.

References

Adebayo, A., & Oyeleke, R. (2020). Cultural influences on food waste in Nigeria: Patterns and implications for food security. https://doi.org/10.1016/j.jenvman.2020.110671

Adewumi, O., Adetunji, M., & Fadeyibi, I. (2021). Post-harvest losses in Nigeria: An analysis of causes and solutions. African Journal of Agricultural Research, 16(5), 693-701. https://doi.org/10.5897/AJAR2021.15428

Food and Agriculture Organization. (2019). The state of food and agriculture 2019: Moving forward on food loss and waste reduction. FAO. http://www.fao.org/3/ca6030en/ca6030en.pdf

International Food Policy Research Institute. (2020). Food systems in Nigeria: Trends, challenges, and opportunities. IFPRI. https://doi.org/10.2499/9780896294051

Nwafor, C., Nwosu, L., & Ogunniyi, D. (2020). Assessing the food loss and waste protocol in Nigeria. Journal of Food Security, 8(3), 117-125. https://doi.org/10.12691/jfs-8-3-2

Nwosu, L., Obinna, E., & Nwaokorie, E. (2022). Understanding food waste behaviour among urban consumers in Nigeria

DETERMINANTS OF COCOA MARKETERS' PARTICIPATION IN MARKETING CONTRACTS IN CROSS RIVER STATE, NIGERIA

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ABSTRACT

The study focused on the determinants of cocoa marketers' participation in marketing contract in Cross River State, Nigeria. The study discussed the socio-economic characteristics of marketers and the determinants of participation in contracts. Structured questionnaires/interviews Were used and seventy-six (76) cocoa marketers. Data were analyzed using descriptive and inferential statistics. In terms of marketing contracts, 23.7%, 64.5% and 11.8% of the marketers had agreements with the producers for supply of cocoa. The results showed the gender distribution, 89% of the marketers were male while 10.5 % were females. Age distribution, 5.3 % were below the age bracket of 30years, while 13.2 % are within the age bracket of 31-40years, 43.4 % are between the age 41-50years and 38.2 % are 51years and above. In terms of level of education, majority had primary education 55.3 %, secondary was 35.55, few were in the category of the tertiary education and 6.6 % had no formal education. The factors that determined cocoa marketers' participation in marketing contracts includes household size, experience, membership of group and age. The study recommends that; the link between the various contract systems be strengthened to improve marketing contracts.

Keywords: cocoa, marketers' marketing, contract, multinomial logit

INTRODUCTION

Contracts are essential aspect of marketing most tree crops and vegetables used in agriculture. Cocoa farmers hold between 1 and 10 hectares, cultivate more than 90% of the total cocoa produced in the world (Poelmans & Swinnen, 2016). Contracts may take various forms of leases, contracts for deed, production contracts, or marketing contracts. Production contracts are mainly employed in livestock production with minimal use in the production of crops while marketing contracts usually covers livestock and crops. Growers who provide labor, land or facilities used in the farm, may benefit by increasing farm operations more rapidly, the amount of credit is less and the financial challenges are reduced (and rewards). Majority of agricultural commodities produced in United State America (U. S. A) are made possible through contract systems in marketing (Hayenga, Harl and Lawrence, 2000).

Contracting often assists in providing other government apparatus for the zone and increase productivity of business logistics management. Development can occur in the form of changing motivation for marketers, to significant partnership between the discrete phases of the series, and to enhance data for some groups as well as overseeing the output grade and proceeds. Excessive use of contract agreements can produce small spot market and reduced information on cost of the commodity which is the reason for contracting. The application of agreements in

vigorous markets where they are small customers can also raise concerns regarding the feasible abuses of market potential. Agreements constitute a problem for authority not only securing equity and a justice but also in terms of ensuring availability of reliable information (Vavra, 2009).

Understanding the marketing contracts system in the state by identifying the various contracts and the determinants of these contract arrangements will assist marketers do business better. Cocoa is an essential agricultural commodity, which provides the largest source of export earnings after oil in Nigeria. Cocoa marketing ensures the flow of products from processors to consumers in the form, time and place of need. Buyers need the product while the sellers in turn need to improve their socio-economic status through higher profits and enhanced income (Ejike and Chiebere-Mark, 2019). Pragmatic literature on cocoa performance and marketing contract system of cocoa in the Country are rather scanty in the state, hence the need for a study on marketing contracts. The objectives of this study are to; describe the socio-economic characteristics of cocoa marketers, to identify producers and marketers in contract and analyze factors that determine participation in marketing contracts.

Materials and methods

The study was carried out in Cross River State (CRS), Nigeria. The choice of Cross River State was informed by the number of cocoa farms across the State besides being one of the key players in the Nigerian Cocoa economy as evident in literature. Cross River State is a coastal State in South- Eastern Nigeria. It is one of the areas where Cocoa *(Theobroma cacao)* thrives.

The soils of Cross River State are *utisols* and *alfisol,* they are suitable for food and forest crops production for example, cocoa, oil palm, banana, plantain, rubber, groundnut, plantain, cassava, yam, maize and vegetables. Fisheries and livestock production are widely practiced, they include sheep, goats, piggery and poultry, In Cross River State most of its citizens are involved in small scale farming business.

Cross River is one of Nigeria's 36 states with 18 Local Government Area (LGAs), which are divided into three agricultural regions, which are Calabar (Southern), Ikom (Central) and Ogoja (Northern). Calabar is the state capital, and it includes other key towns, namely Obudu, Obanliku, Okundi, Ogoja, Ikom, Obubra, Yakurr, Odukpani, Akampa and Akpabuyo. Efik, Ejagham and Bekwarra are major languages spoken. For adequate coverage of respondents, the marketers were choosen based on purpose and multi-stage random sampling techniques were used.

Sampling procedure:

A sampling list of registered cocoa marketers was compiled from Cross River State Agricultural Development Project office, after which a multi-stage sampling procedure was adopted for the selection of respondence as follows.

Stage 1: Six Local Government Areas (LGAs), based on the areas where cocoa marketers are predominant were purposively selected. These are Akampa, Obubra Ikom, Boki, Etung, and Obudu LGAs (Fig. 1).

Stage 2: An exploratory survey from where twelve towns were choosen from the six Local Government areas based on the contract types (sharecropping, fixed rent and owner managed). In the second stage of sampling, all the seventy-six (76) cocoa marketers were used, since the entire number of cocoa marketers were very few in the six selected Local Government Areas. The marketers were categorized into those who buy cocoa from the different production contracts (sharecropping, fixed rent and owner managed).

Data collection

The study used primary data that were collected in the field survey using well prepared questionnaire/interview responses from cocoa marketers'

Data analysis

Data were analyzed using descriptive such as, frequencies, percentages, means, and inferential statistics such as, multinomial logistic regression.

TABLE 1

Number of cocoa marketers in the different marketing contract systems

LGA	Share cropping	Fixed rent	Owner manage
AKAMKPA	01	01	02
OBUBRA	01	01	02
IKOM	12	08	24
ETUNG	02	04	11
BOKI	03	04	09
OBUDU	-	-	01
TOTAL	09	1	49

Source: Cross River State Ministry of Agriculture, 2018 Cocoa farmer count

1. **Model specification**

Determinants of participation in marketing contracts was analyzed using multinomial logistic regression model. The model is as presented below:

$Y_i = \ln (P_i \backslash 1-P_i) = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + U_t$ ..... (1)

Where

β_0 = intercept

$\beta_1 - \beta_7$ = coefficients of independent variables

β_1X_1 = Household size (Number of persons in marketer's house)

β_2X_2 = Marketing Asset

β_3X_3 = Revenue

β_4X_4 =Experience (number of years spent in cocoa marketing)

β_5X_5= Access to credit

β_6X_6= Membership of group

β_7X_7=Age in years

The $Y_i$is response likelihood associated with participating in marketing contracts

i = 1, 2,.....n

Variables; k = 0,1....j participation category where j = 0 for sharecropping

j = 1 for fixed rent contract

j = 2 for owner managed

Owner managed contracts was used as the associating category and βj is the vector of the variable that relates α_i's to the likelihood of participating.

After appropriate normalizing, the general model that was used for the estimation was;

$$P_{ij} = \frac{e^{\beta j \alpha i}}{1 + \sum_{k=j} e^{\beta j \alpha i}} \quad \text{.....(2)}$$

4.Results and Discussion Socioeconomic characteristics

Results from table 3, showed that, about 89% of the marketers are male while 10.5 % are females. In terms of age distribution, the result revealed that 5.3 % of the marketers were below the age bracket of 30years, while 13.2 % are within the age bracket of 31-40years, 43.4 % are between the age bracket of 41-50years and 38.2 % are 51years and above. The result indicates that the model group are the age bracket of 41-50 years, these marketers are in their productive age. The mean age for the marketers was 48years, this shows that cocoa marketers are in their productive age. In terms of level of education of cocoa marketers, most of them had primary education which accounted for 55.3 %, secondary was 35.55, few were in the category of the tertiary education and 6.6 % did not have access to schooling. The analysis indicates that most marketers had formal education. A higher educational level is desirable to minimize cost of transacting in factor and product markets. Furthermore, the results, revealed that in terms of association, the result showed that 13.2 % are in cooperative society, 48.7 % are in cocoa marketers' association, 18.4 % were not in any association and 19.7 % are in both cooperative society and cocoa marketers association. Being in an association helps the marketers to pull resources, discuss the price of cocoa, provide information were needed and their problems as cocoa marketers in contract.

TABLE 2
Identification of producers and marketers' contract prevalent in CRS

Variable	frequency	Percentage
Production contract		
Fixed rent	56	18.0
Owner managed	139	44.7
Sharecropping	116	37.3
Total	311	100
Marketing contracts		
Fixed rent	18	23.7
Owner managed	49	64.5
Sharecropping	09	11.8
Total	76	100.0

Source: Field survey, 2018

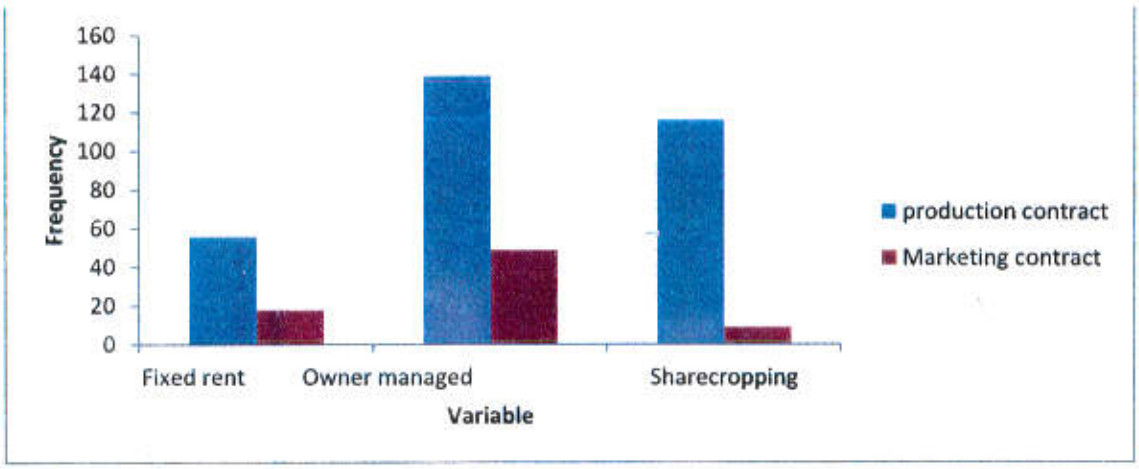

FIG 1: Identification of producers and marketers contract prevalent in CRS

TABLE 3

Socioeconomic Characteristics of cocoa marketers in management system

Variable	Frequency	Percentage
Gender		
Male	68	89.5
Female	8	10.5
Total	76	100.0
Age		
≤30	4	5.3
31-40	10	13.2
41-50	33	43.4
51≥	29	38.2
Total	76	100.0
Mean (SD)	48.29 (7.76)	
Marital Status		
Single	27	35.5
Married	44	57.9
Divorced	5	6.6
Total	76	100.0
Education		
None	5	6.6
Primary	42	55.3
Secondary	27	35.5
Tertiary	2	2.6
Total	76	100.0
Association		
Cooperative society	10	13.2
Cocoa marketers	37	48.7
None of the above	14	18.4
All of the above	15	19.7
Total	76	100.0
Agreement		
Fixed rent	18	23.7
Owner managed	49	64.5
Sharecrop	9	11.8
Total	76	100.0
Years of experience		
1-5	2	2.6
6-10	7	9.2
11-15	40	52.6
16-20	25	32.9
21>	2	2.6
Total	76	100.0
Mean (SD)	14.01 (3.49)	

Source: Field survey, 2018

The results on years of experience showed that 52.6 % of the marketers have spent between 11-15 years in business, 32.9 % have been in cocoa marketing between 16-20. The result also

showed that very few of the marketers have spent 21 years and above in the cocoa business. The mean years of experience is 14years for cocoa marketers. This showed that most of the marketers were very experienced and this will translate into an increase in revenue. The longer the time spent in a business helps the marketer perform better and the implication is that experience increases skill in any enterprise.

Factors that determine participation in marketing contracts

The coefficient for household size was positive and significant at 10% and 5% probability levels for fixed rent and sharecropping. It is also in line with *a priori* expectation in the fixed rent and sharecropping marketing contracts in contrast with owner managed. Analysis of household size showed that the probability of participation by respondents is highly dependent on the size of household in both fixed rent and sharecropping groups. This implies that an increase in household size will positively lead to an increase in contract agreement in fixed rent and sharecropping marketing contracts, this is due to the positive coefficient of household size.

Marketing assets were positively signed for both fixed rent and sharecropping categories estimation. For both categories, it is significant at 10% and 5% level of probability. This is in line with expectations based on theory implying that the probability of being in the fixed rent contract or sharecropping contracts group relative to participating in an owner managed contract increases as marketers' assets increase. Marketing assets serve as collateral in contracts negotiations and discussions. The finding agrees with Sriboonchitta and Wiboonpoongse (2008), who reported a direct relationship between assets and contract participation.

Revenue was positive and statistically significant at 5% in both fixed rent and sharecropping contract group. The reason is that profit is an important determinant of household decision making options. This is in conformity with *a priori* expectations implying that in choosing any marketing contract, the profit margin of the marketer is a major factor. There is a probability of marketers preferring a contract that will increase profit in others not to be squeezed by the downturn in the economy. The finding therefore revealed that the possibility of being in the fixed rent contract or sharecropping contracts group relative to participating in owner managed contract increases as marketer's profit increases. The finding conforms with Kinsella et al. (2000), who reported that financial resources such as cash, credit, profit from business and other economic assets are indispensable for pursuit of livelihood strategies.

The variable experience was negative and significantly signed at 1% and 5 % probability level for the fixed rent and sharecropping contract group. This means that the probability of belonging or participating in owner managed group increases against fixed rent and sharecropping as they gain more experience. This study is in conformity with *a priori* expectations but contrary with Birkann and Fernando (2008), who opined that the experience has a positive and significant relationship in contract agreement enforcement and delivery. Credit variable was significantly signed at both 1% and 10 % probability levels for fixed rent and sharecropping contracts respectively as compared to owner managed marketers. The implication is that marketers with financial assistants will prefer fixed rent and sharecropping contracts compared to owner managed and an increment in loan availability will increase the

probability of the marketers undertaking fixed rent or sharecropping contracts compared to owner managed contract.

Membership of social organization was negative but significant at 10% and 1% probability level at both fixed rent and sharecropping groups in contrast to owner managed. This is in contradiction to *a priori* expectations which implies that being in a social organization will positively determine the probability of a marketer participating in a fixed rent and sharecropping contract as compared with owner managed. According to Ntaganira, Shukla, Mbeche, and Mbabzize, (2017), membership of a social group was positively signed with contract agreement, social insurance acquired through bonds helps in the enforcement of contract agreement. The marketer's age was significant and positive on the choice of marketer engaging in sharecropping group agreement and fixed rent contract in contrast to owner managed (base category). This implies that that probability of participating in fixed rent and sharecropping contracts increases as age increases. The sign on age is positive and can be explained by a positive relationship that exist between age and marketing experience which is a veritable tool in marketing. According to D'Stiva., Hayool, Jegak, and Bahaman, (2009), the chances of participating in contract marketing increases as the age of marketer would have helped him to gained

TABLE: 4
Factors that determine participation in marketing contracts management system

Coef.		Std.	Err.	Wald	Marginal %
1 (fixed rent)	HHS	2.293 *	.17.497	0.017	1.3
	M. ASSETS	0.000 *	0.002	0.017	1.3
	REVENUE	0.000 **	0.000	0.007	5.2
	EXPERIENCE	-1.749 ***	30.007	0.003	1.3
	CREDIT	0.000 ***	0.000	0.000	3.9
	M.GROUP	-0.357 *	3.086	0.013	1.3
	AGE	0 .732*	3.484	0.044	3.9
	CONSTANT	-13.271***	396.409	0.001	15.6
2 (sharecropping)	HHS	0.500**	15.097	0.001	1.3
	M. ASSETS	0.000**	0.001	0.003	6.5
	REVENUE	0.000**	0.000	0.005	11.7
	EXPERIEN	-0.247***	24.101	0.000	16.9
	CREDIT	0.000*	0.000	0.085	6.5
	M.GROUP	-0.020***	2.986	0.000	3.9
	AGE	0.036***	3.593	0.000	1.3
	CONSTANT	-32.004**	395.884	0.007	1.3

Source: computation from field survey data; 2018.

The reference category is sharecropping
2Log likelihood = 457.595
Number of observation =76
Chi- square = 219.902
Cox and Snell = .942
Nagelkerte (Pseudo R^2) = .945
McFadden = .481
***, **, * significant at 1%, 5% and 10% level respectively using the Wald Criteria.

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it is evident that different contract systems exist in the state. Marketers do business with the farmers through contract either as sharecropping, fixed rent or owner managed. The study showed that factors that affect participation in marketing contracts systems include education, household size, farm assets, farm income, farm credit, age and membership group. Though there are advantages to these marketing contracts and challenges, farmers and marketers benefit immensely from this relationship especially during off-farm seasons. The study recommends that the linkage between marketers and farmers should be strengthened.

REFERENCES

Birkmann J. & Fernando N. (2008). Measuring revealed and emergent vulnerability of coastal communities to Tsunami in Srilanka. Disaster. 32(1), 82-105.

D'Stiva, J. L., Hayool, A. M. S., Jegak, U. & Bahaman, A. S. (2009). A Review of Contract Farming and Factors that Impinge Youths Acceptance of Contract Farming *European Journal of Social Sciences*, 11(2), 318-323

Ejike, R. D. and Chidiebere- Mark, N. M. (2019). Analysis of Cocoa Processing and Marketing in Abia State, Nigeria. Journal of Agriculture and Food Sciences 17(2):45-61

Kinsella J; Wilson S; Jang F & Renting H (2000). Pluriactivity as a livelihood strategies in Irish farm households and its role in rural development. *Sociology Ruralis*. 40(4), 481-496.

Ntaganira, E., Shukla, J., Mbeche, R. & Mbabize, M. (2017). Determinants of participation in contract farming among small holder dairy farmers in Rwanda. *International Journal of Thesis Projects and Dissertation*. 5(3), 11-19.

Poelmans, E & Swinnen, J. F. M (2016): A Brief Economic History of Chocolate LICOS Discussion Paper, No 412 Oxford University Press; Pp 11-42.

Sriboonchitta, S. & Wiboonpoongse, A. (2008). Overview of contract farming in Thailand Lesson Learned. *ADBI discussion paper No*. 112: 210-221.

Vavra, P. (2009). "Role, Usage and Motivation for contracting in Agriculture" In: OECD Food, Agriculture and Fisteries Working Paper; 16, 71-89

POST-HARVEST LOSSES AND INCOME INEQUALITY AMONG RICE VALUE CHAIN ACTORS IN NORTH-EAST NIGERIA

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ABSTRACT:

Post-harvest losses, particularly along the rice value chain, have been identified as a source of food insecurity and reduction in income among the value chain actors. It is therefore necessary to assess the pattern of post-harvest losses and to determine income inequality among the value chain actors in the study area so as to be able to provide a reliable policy stand that can help reduce these losses and to have an overview on the income inequality among the actors. Gombe, Taraba and Yobe state were purposively selected from North-Eastern state in Nigeria been the major producers of rice in the zone. Data were collected through the use of questionnaire from 107 farmers, 106 processors and 106 marketers. Descriptive statistics, Gini coefficient and Atkinson index were used to analyze the data. The result revealed that loss was highest for farmers at 189.22kg/ha of paddy rice (₦112,500.00 at ₦45,000.00/bag) (1 naira = $0.00066), processors (10.22 kg/bag at ₦1100/kg), marketers (3.22kg/bag at ₦1100/kg) of milled rice. The Atkinson index of the income distribution for farmer's increases from 0.46 to 0.74, while for processors it increases from 0.18 to 0.27 and from 0.32 to 0.52 for the marketers at ε =2. The Gini coefficient of farmers was 0.8799, processors 0.8407 and marketers 0.8753. It was thus recommended that government should intensify efforts and investment in rural infrastructural facilities such as good roads, stable electricity and storage facilities in addition to providing adequate training to the actors

Key words: Inequality, Post-harvest, farmers, processors, marketers

Introduction

It has been reported that roughly one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year (Ibrahim, *et al.*, 2018). These lead to a heavy loss of income and food supply to families, thereby threatening household food security and malnutrition can easily be the result. The FAO has documented that rice post-harvest losses are among the highest of the major crops grown in developing countries and has called attention to the potential to be gained by reducing postharvest losses of rice. Rice is subjected to more handling and processing steps as it moves from the rice paddy or field to the consumer than other grains produced in developing countries. Little mechanization exists in rice processing, and where it does, it is mostly inadequate or uses poorly designed equipment. The lack of adequate processing equipment contributes significantly to postharvest losses in rice, which have been estimated to be as high as 40% of total production (source). Food losses

and waste, which occur along the entire food value chain is unacceptable. Food losses not only have effects on a social and economic scale, but also represent a waste of resources used in production such as land, water, energy and other inputs.

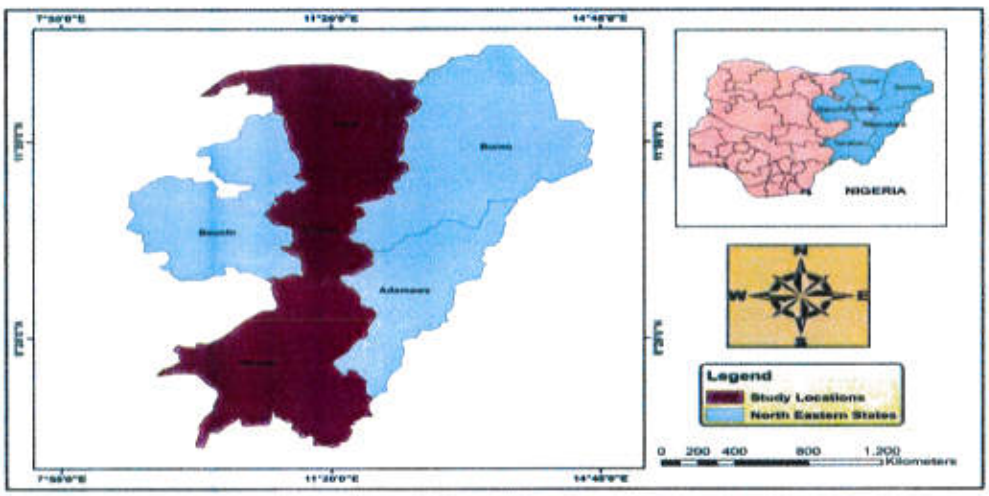
Food loss occurs at every stage of the value chain from the farm gate to the fork (that is, from production, reaping, processing, transportation, marketing to consumption) (Qu *et al.*, 2021).

Materials and Methods

The Study Area:

This study was conducted in northeast part of Nigeria. The area lies between the vast arid expanse of the Sahara and the dense tropical rain forest along the Guinea Coast. Sharing boundaries with the study area were Cameroon on the east, Niger and Chad republics on the north, North-Central Nigeria on the west, and South-Eastern Nigeria on the south. This geographical area constitutes the largest zone in Nigeria (Soltan *et., al.* 2017) and comprises of Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe State. The area is located between 6^0 26 - 13^0 45N and longitude 8^0 42 - 14^0 39 E. It covers an area of 262578 km^2 (Soltan *et., al.* 2017). The soil type in Northeast Nigeria was mainly ferruginous tropical soils, which are characterized by high iron content.

Map of Nigeria showing the study area.



Sampling Techniques:

The sample technique is a procedure involving a number of tasks and decisions in sampling. The main reason behind this process is to construct a subset of the research population which is appropriate and sufficient to represent the population being studied. A multistage sampling procedure was used for the study. In the first stage; Three States out of the six states in the zone has been purposively selected for the study, namely Gombe, Yobe and Taraba State which are the most highly rice producing states in the zone. In the second stage a purposive sampling procedure is used to select three local government areas (LGAs) from Gombe and Yobe respectively while four LGAs would be selected in Taraba state being the largest producer of rice in the zone. In the third stage, a raosoft sample size online calculator was used to determine the sample size of the study where by the calculator was set at an error margin of 8%, a confidence level of 90%, and a population of 98700, 24450 and 8414 for farmers, processors and marketers respectively and a response distribution of 50% that give a total sample size of 319 as shown in table 1 below (Mason *e.,t al.* 2018; Orifah *et., al.* 2020).

Table 1: Sampling frame for the respondents

Category	State	LGA	SLGA	Population	TSSS
Farmers	Gombe	11	Y/deba	11600	12
			Balanga	9700	11
			Kaltungo	5850	6
	Yobe	17	Nguru	12100	13
			Jakusko	8400	9
			Bade	6950	8
	Taraba	16	Kari lamido	14700	16
			Gassol	12250	13
			Ardo kola	9800	11
			Lau	7350	8
	Total	Total		98700	107
Processors	Gombe	11	Gombe	3280	14
			Y/deba	1400	6
			Balanga	920	4
			Kaltungo	430	2
	Yobe	17	Yusufari	4600	20
			Nguru	1300	6
			Jakusko	1750	8
			Bade	1200	5
	Taraba	16	Jalingo	5400	23
			Kari lamido	2060	9
			Gassol	1150	5
			Ardo kola	720	3
			Lau	240	1
		Total		24450	106
Marketer	Gombe	11	Gombe	1250	16
			Y/deba	470	6
			Balanga	365	5
			Kaltungo	350	4

	Yobe	17	Yusufari	1120	14
			Nguru	655	8
			Jakusko	480	6
			Bade	320	4
	Taraba	16	Jalingo	1340	17
			Kari lamido	676	8
			Gassol	520	7
			Ardo kola	454	6
			Lau	414	5
		Total		8414	106

Field survey (2023)
LGA- Local Government Area
SLGA- Selected Local Government Area
TSSS- Total Sample Size Selected

Methods of Data Collection
Primary and secondary data were used for the study. Secondary data which is the data that had already been collected in some other context other than this study were used. The reason is that it provides the needed background information, builds a level of credibility for the research report and clarifies the problem during the exploratory research process. For primary data, it was collected based on questionnaire and interview. The data were obtained from rice farmers, processors and marketers. The questionnaires were administered by the researcher and trained enumerators.

Method of Data Analysis:
In this study, descriptive and percentage and inferential were used.

A popular way to measure income distribution is the algebraic method that the Italian statistician Corado Gini (1884 – 1965) developed. Accordingly, the Gini coefficient is a number between 0 and 1, where 0 means the perfect equality and the Gini coefficient of 1 means complete inequality (Teimoori *et al.,* 2017), the model is expressed in its explicit form as;
$GC = 1 - \sum_{1=0}^{k-1}(Y_{i+1} + Y_i)(X_{i+1} - X_i)$.....(4)
Where;
GC = Gini Coefficient, X = cumulative proportions of actors' ith income group = $\frac{X_i}{CF}$
X_i = number of actors in ith income group, CF = cumulative frequency of value chain actors in ith income group, Y = cumulative proportions actors' income of ith income group = $\frac{Y_i}{\Sigma Ti}$, Y_i = actors' income of ith income group, T_i = total actors' income

The Atkinson index

The prominent welfare-based measure of inequality is played by the Atkinson's index of inequality and it is directly related to the class of additive social welfare function (FAO, 2006). The model is represented as:

$w = \frac{1}{N}\sum_{i=1}^{n} U(y_i)$ ..... (11)

The expression 1 says that the social welfare is represented by average utility. The form of the function U, according to Atkinson is the following:

$U(y_i) = \frac{1}{1-\varepsilon}\, y_i^{1-\varepsilon}$ ..... (12)

$\varepsilon \neq 1, U(y_i) = logy_i \quad \varepsilon = 1$ ..... (13)

Where,

U is the average utility of the respondents, ε is the parameter of inequality aversion

Results and discussions

Table 2: Socio-economics characteristics of respondents

Variable	Farmers frequency	Percentage	Processors Frequency	Percentage	Marketers Frequency	Percentage
Age						
21-35	35	32.71	66	62.26	52	49.05
36-45	39	36.45	27	25.47	38	35.84
46-55	22	20.56	12	11.32	15	14.15
56-65	9	8.41	1	0.94	1	0.91
66-75	2	1.87	-		-	-
Mean	41.7850		34.2547		36.7547	
Gender						
Male	105	98.1	96	90.6	61	57.5
Female	2	1.9	10	9.4	45	42.5
Marital status						
Married	74	69.2	48	45.3	55	51.9
Single	31	29.0	54	50.9	33	31.1
Divorced	-	-	3	2.8	5	4.7
Widowed	2	1.9	1	.9	13	12.3
Household Size						
1-5	52	48.59	84	79.25	67	63.21
6-10	30	28.03	17	16.04	30	28.30
11-15	20	18.69	5	4.71	8	7.54
16-20	2	1.87	-	-	1	0.94
21-25	3	2.80	-	-	-	-
Mean	6.9813		3.7170		5.0000	
Education						
Primary	8	7.5	6	5.7	10	9.4
Secondary	44	41.1	53	50.0	64	60.4
Tertiary	40	37.4	27	25.5	21	19.8
Islamic	14	13.1	19	17.9	11	10.4
Non-formal	1	.9	1	.9	-	-
Membership of coopt.						
Yes	19	17.8	33	31.1	19	17.9
No	88	82.2	73	68.9	87	82.1
Access to credit						
Yes	19	17.8	31	29.2	39	36.8
No	88	82.2	75	70.8	67	63.2
Experience						
1-10	69	64.49	85	80.19	83	78.30
11-20	21	19.62	21	19.81	21	19.81
21-30	10	9.35	-	-	2	1.88
31-40	6	5.61	-	-	-	
41-50	1	0.93	-	-	-	

Mean	12.0374	7.3302	7.8774

Source: Field survey (2023)

Table 1 shows socioeconomic distribution of the rice value chain actors in the study area. The results showed that 36.45% and 32.71% of rice farmers in the study area are within the active age of 21-35 and 36-45 years. While 62.26% processors and 49.05% marketers fall within the active age of 21-35 years. Meanwhile, farmers, processors and marketers had a mean age of 42, 34 and 37 respectively. Pendo-Edua (2011) opined that age structure can be used to facilitate an understanding about labour potential of a specific population. The table also presented distribution of respondents according to gender, it shows that 90.6% and 57.5"% of processors and marketers were male while 9.4% and 42.5% were female processors and marketers. Babatunde *et.,al* (2019) showed that rice processing such as parboiling, milling, drying, among others are predominantly done by women which might be due to the differences in culture and faith. However, 98.1% farmers were male while only 1.9% was female. This implies that male farmers participated in rice farming more than their female counterparts. This could be related to the dominant cultural and religion views of labour in some part of the study areas which didn't see farm work as a woman work. On the marital status of the respondents, it was shown that 69.2%, 45.3% and 51.9% of farmers, processors and marketers were married while 29%, 50.9% and 31.1% of farmers, processors and marketers were single and 1.9%, 0.9% and 12.3% were widowed and lastly 2.8% and 4.7% of processors and marketers were divorced. The marital status of a respondent is an indirect indicator of how responsible the respondent is and it is also a measure of the ability to shoulder socio-economic responsibility in the society. The distribution of respondents based on their household size revealed that 79.25%, 63.21% and 48.59% processors, marketers and farmers had between 1 – 5 household size while 28.30%, 28.03% and 16.04% marketers, farmers and processors had between 6 – 10 household sizes. 18.69%, 7.54% and 4.71% farmers, marketers and processors had between 11 – 20 household sizes. Moreover 1.87% farmers and 0.94% marketers had household size of between 16 – 20 persons while 2.80% farmers had household size of 21 – 25. However, farmers, processors and marketers had a mean household size of 7, 4 and 5. By implication, the value chain actors in the study area had relatively large household sizes and hence, the contribution of family labour will tend to be high leading to a decrease in demand for hired labour. However, high dependency ratio can affect both food expenditure and other expenditure and this could influence income inequality in their enterprises. The larger the household size the higher the need and expenses of the family. It also revealed that, educational levels of the value chain actors in the study area which showed that, about 41.1% farmers, 50% processors and 60.4% marketers had secondary education while 37.4%, 25.5% and 19.8% farmers, processors and marketers have tertiary education. The result further shows that 13.1%, 17.9% and 10.4% had Islamic education, 7.5% farmers had non-formal education while 5.7% of processors and 9.4% of marketers had the same non-formal education. It was observed that illiteracy militates against adoption of recommended packages of innovation and modern techniques. However, a good percentage of the value chain actors had basic knowledge that will help in the adoption of new innovation/technology to enhance activities. However, majority 82.2%, 82.1% and 68.9% of farmers, marketers and processors were not registered with any group or association while only 17.8%, 31.1% and 17.9% farmers, processors and marketers were registered members. This implied that majority of the value chain actors were not registered members and this may be due to unavailability of government and non-governmental interventions in the study area. Respondents who belong to cooperatives are better informed on resources use and planning which enables them to utilize resources more efficiently. Meanwhile, on whether the value chain actors have access to credit facility in the study area. The results revealed that majority 82.2%, 70.8% and 63.2% farmers, processors and marketers respectively didn't have access to

credit facilities while furthermore 17.8%, 29.2% and 36.8% farmers, processors and marketers have access to credit facilities. Therefore, this shows that there is poor access to credit facilities in the study area which if adequately tackle will help in boosting the activities of the value chain actors in the study area, furthermore it revealed that 80.19%, 78.30% and 64.49% farmers, processors and marketers fall within 1 – 10 years of experiences. Meanwhile 5.61% farmers have between 31 – 40 years of experience but only 0.93% of the farmers have 41 – 50 years of experience. Furthermore, the value chain actors (farmers, processors and marketers) have 12, 7 and 8 as mean experience. This implied that majority of the value chain actors` had adequate years of experience that will help them to manage risk and make sound decisions to enhance performance in their various activities.

Table 3:Average losses encountered by the value chain actors in the study area

	Farmers	Processors	Marketers
Loss	%	%	%
Harvesting	32.50	-	-
Threshing	30.18	-	-
Winnowing	16.43	-	-
Drying	12.19	-	-
Storage	5.14	-	30.68
Transport	3.55	12.52	25.37
Milling	-	17.70	-
Destoning	-	32.32	-
Parboiling	-	17.20	-
Upgrading	-	12.53	-
Measurement	-	-	43.95

Source: Field survey (2023)

The table above was used to present the pattern of post-harvest losses at various stages in the farm. The losses incurred at farm include the following; losses during harvesting, threshing, winnowing, storage, drying and transportation which were presented in table 3 above. The figure shows that farmers experiences higher losses of paddy during harvesting. Out of the total losses in the farm, about (32.50%) of paddy got lost during harvesting while (30.18%) of paddy got lost during threshing, meanwhile (16.43%) got lost during winnowing and (12.19%) during drying. However (5.14%) got lost during storage while only (3.55%) got lost during transportation. These losses were mostly attributed to the fact that most of the farmers in the study area use traditional techniques in farming operation except for transportation which were mostly conducted by modern transport system and the losses realized were minimal compared to that of traditional techniques. On the average, about 189.22kg/ha of paddy rice got lost during production which is equivalent to over 2.5 bags (at 75kg/bag or ₦112,500.00 at ₦45,000.00/bag). This is in line with the finding of Appiah *et., al.* (2011), where it was acknowledge that losses at harvesting stage is higher when compared with the losses at other

stages. But this results contradict the findings of Sani *et., al.* (2022), who found out that the farmers experienced higher losses of paddy during storage. This implies that postharvest losses of paddy rice contribute greatly to the reduction in the total quantity produced thereby affecting food security status and reduces the income of farmers in the study area.

Losses incurred by processors were also presented in table 3 above, and it shows that out of the total losses experienced by the processors', losses during destoning was the highest at (32.32%), followed by milling (17.70%) and parboiling (17.20%) while upgrading (12.53) and transporting (12.52%) were moderate and storage is the least at (7.72%). These findings differ from the 11%, 10%, 9% and 8% milling, parboiling, transportation and storage losses obtained by Coker (2016). The results revealed that destoning contained the highest loss during processing while storage is the least. On the average, about (10.22 kg/bag or ₦11,242 at ₦1100/kg) of milled rice got lost during processing. Therefore, it is recommended that credit facility should be provided to the processors so as to be able to acquired modern processing equipment which will go a long way in reducing losses at this stage of the value chain.

The results presented in table 3 above revealed that out of the total losses incurred by the marketers' measurement losses was (43.95%), storage losses (30.68%) and transportation losses (25.37%). The result shows that marketers experienced higher losses due to measurement/handling and follow by storage losses and lastly losses due to transportation. On the average (3.22kg/bag or ₦3,542.00 at ₦1100/kg) of milled rice got lost during marketing. This is mostly as a result of the use of poor measurement instrument and poor storage facilities. The use of good storage facilities and standard measurement instrument in addition to good transport facilities should be put in place so as to reduce the level of losses at this stage of the value chain.

The Atkinson Index

Table 2 present the Atkinson index. The index was used to calculate the proportion of social welfare that would be required if incomes were to be perfectly distributed. Some literatures mostly connects Atkinson index with social welfare function which is represented by average utility and a parameter of inequality aversion (ε) FAO (2007). However, in this study, Atkinson index was calculated based on $\varepsilon = 2$ and $\varepsilon = 3$ as done by Abdelateif and Omima (2015) as shown in table 2 below. The different level of inequality aversion (ε) give different values of equally distributed equivalent income. The value of the Atkinson index increases when the society attaches a higher weight to the lower income groups with rising ε. There is relatively difference in Atkinson index values between the three categories of the value chain actors in the study area. It shows that as ε increases from 2 to 3, the Atkinson index of the income distribution for farmer's increases from 0.46 to 0.74, while for processors it increases from 0.18 to 0.27 and from 0.32 to 0.52 for the marketers. This shows that at $\varepsilon = 2$, farmers', processors and marketers should be ready to give up 46%, 18% and 32% respectively of income to have equally distributed incomes. Meanwhile, at $\varepsilon = 3$, farmers' should be ready to sacrifice 74% of income to have equally distributed incomes while processors and marketers would have to sacrifice 27% and 52% of incomes so as to have equally distributed income respectively. This implies that processors are better off than the other value chain actors in the study area.

Table 4: Atkinson index and inequality distribution of income of the value chain actors

Category	Atkinson index (ε=2)	Atkinson index (ε=3)
Farmers	0.46	0.74
Processors	0.18	0.27

Marketers	0.32	0.52

Source: Field survey data computation (2023)

Distribution of Income Inequality among the value chain actors in the study area

Income distribution, despite many differences in socio-economic characteristics, seems to follow a particular universal pattern (Chakrabarti *et al.*, 2013). However, in order to specify income distribution among actors in the study area, the Gini coefficient was used; thus, the respondents were classified into ten groups called series and the results were presented in Table 5 below.

The result in table 5 revealed that the respondents (Farmers) had total incomes of ₦93,901,084.00; with the eight series constituting 16.82% (respondents) earned 24.61% of the total incomes, followed by ninth series 9.35% earning 15.48% while first series, 7.48% respondents earned 0.90% and in second series 8.41% earned 2.51% of the total incomes; this implies that, farmers' incomes varied in the study area which may be due to the level of production and the losses experienced by the actors in the study area. Also, the Gini-coefficient (0.8799) for rice farmers was close to unity (1), implying a very high inequality or wide variation in incomes among rice farmers; and technically, there was great variation in the revenue generated, considering income distribution of farmers across the series, where the major incomes was generated by the eighth and ninth series that controlled 40.09% of the total incomes. This result also agrees with Mbanasor *et al.* (2012), who in their finding reported a Gini coefficient (0.987) of farmers in Abia State Nigeria, which reflects high inequalities in income distribution, and thus, the gap between the rich and the poor is still wide. The results disagreed with Chikezie *et al.* (2011), who found the Gini-coefficient (0.320) of rice farmers in South-eastern States of Nigeria. However, table 3 further revealed that the respondents (Processors) had a total incomes of ₦307,092,000; with the third series constituting 23.58% (respondents) earned 22.95% of the total incomes, Meanwhile, in sixth series 1.89% respondents earned 2.91% and the eight series 0.94% respondents earned 1.95% of the total incomes; this shows that, processors' incomes varied in the study area which may be due to the size and nature of the processing plant. Moreover, the Gini-coefficient (0.8407) for the processors was also close to (1) but lower than that of the farmers (0.8799), implying a high inequality among rice processors; and this is as a result of great variation in revenue generated by the actors in the study area. The result is in line with Saleh *et. al.*, (2016), who reported Gini-coefficient of (0.8390) for groundnut value chain actors in Gombe State. Furthermore, table 3 revealed that the respondents (Marketers) had total incomes of ₦256,681,200.00; with the sixth series constituting 13.21% (respondents) earned 17.92% of the total incomes, followed by fifth series 15.09% earning 17.38% and third series 20.75% earning 15.22% while first series, 10.38% respondents earned 3.38% and in tenth series 0.94% (respondents) earned 2.19% of the total incomes; this shows that, marketers' incomes varied in the study area which may be due to the size of the business. Moreover, the Gini-coefficient (0.8753) for the marketers was also close to 1 but slightly lower than that of the farmers (0.8799) but higher than that of the processors (0.8407), implying a high inequality among rice marketers; and shows a variation in incomes of the respondents in the study area. More so, by considering the income distribution of marketers across the series, where fifth, sixth and third series took up the largest share of 50.52% of the total income generated.

However, the comparison of the share of total income by each group (series) and the value of Gini coefficient revealed an economic frightening of unequal distribution of income among the value chain actors in the study area, which calls for policy actions to scale up the production volume and check made the losses incurred by those at the lowest cadre of the distribution to stimulate economic growth.

Table 5: Total Income distribution for the value chain actors in the study area

Series	Income Range (₦'000)	F	CF	%	Total income (₦)	% of Income share	X	Y	XY
	Farmers								
1	36000 – 204399	8	8	7.4766	848,500.00	0.9036	0.0748	0.0090	0.0007
2	204,400 – 372,799	9	17	8.4112	2,356,900.00	2.5100	0.0841	0.0251	0.0021
3	372,800 – 541,199	10	27	9.3458	4,779,992.00	5.0905	0.0935	0.0509	0.0048
4	541,200 – 709,599	10	37	9.3458	6,254,000.00	6.6602	0.0935	0.0666	0.0062
5	709,600 – 877,999	17	54	15.8879	13,505,700.00	14.3829	0.1589	0.1438	0.0229
6	878,000 – 1,046,399	10	64	9.3458	9,809,000.00	10.4461	0.0935	0.1045	0.0098
7	1,046,400 – 1,214,799	12	76	11.2150	13,678,992.00	14.5674	0.1121	0.1457	0.0163
8	1,214,800 – 1,383,199	18	94	16.8224	23,105,500.00	24.6062	0.1682	0.2461	0.0414
9	1,383,200 – 1,551,599	10	104	9.3458	14,524,000.00	15.4673	0.0935	0.1547	0.0145
10	1,551,600 – 1,720,000	3	107	2.8037	5,038,500.00	5.3658	0.0280	0.0537	0.0015
	Total			**100**	**93,901,084.00**	**100.0000**	**1.0000**	**1.0000**	**0.1201**
	GC			**0.8799**					
	Processors								
1	1,440,000 – 2,016,999	24	24	22.6451	32952000	10.7303	0.2264	0.1073	0.0243
2	2,017,000 – 2,593,999	17	41	16.0377	37644000	12.2582	0.1604	0.1226	0.0197
3	2,594,000 – 3,170,999	25	66	23.5849	70476000	22.9495	0.2358	0.2295	0.0541
4	3,171,000 – 3,747,999	19	85	17.9245	66720000	21.7264	0.1792	0.2173	0.0389
5	3,748,000 – 4,324,999	12	97	11.3208	49140000	16.0017	0.1132	0.1600	0.0181
6	4,325,000 – 4,901,999	2	99	1.8868	8940000	2.9112	0.0189	0.0291	0.0005
7	4,902,000 – 5,478,999	4	103	3.7759	20820000	6.7797	0.0377	0.0678	0.0026
8	5,479,000 – 6,055,9999	1	104	0.9434	6000000	1.9538	0.0094	0.0195	0.0002
9	6,056,000 – 6,632,999	0	104	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	6,633,000 – 7,209,999	2	106	1.8868	14400000	4.6891	0.0189	0.0469	0.0009
	Total				**307,092,000.00**	**100**	**1**	**1**	**0.1593**
	GC			**0.8407**					
	Marketers								
1	540,000 – 1,048,899	11	11	10.3774	8,676,000.00	3.3801	0.1038	0.0338	0.0035
2	1,048,900 – 1,557,799	13	24	12.2642	16,864,800.00	6.5703	0.1226	0.0657	0.0081

3	1,557,800	–	22	46	20.7547	39,082,800.00	15.2262	0.2075	0.1523	0.0316
4	2,066,699		13	59	12.2642	29,928,000.00	11.6596	0.1226	0.1166	0.0143
5	2,066,700	–	16	75	15.0943	44,610,000.00	17.3795	0.1509	0.1738	0.0262
6	2,575,599		14	89	13.2075	46,000,800.00	17.9214	0.1321	0.1792	0.0237
7	2,575,600	–	10	99	9.4340	38,388,000.00	14.9555	0.0943	0.1496	0.0141
8	3,084,499		3	10	2.8302	12,700,800.00	4.9481	0.0283	0.0495	0.0014
9	3,084,500	–	3	2	2.8302	14,802,000.00	5.7667	0.0283	0.0577	0.0016
19	3,593,399		1	10	0.9434	5,628,000.00	2.1926	0.0094	0.0219	0.0002
	3,593,400	–		5	**100**	**256,681,200.0**	**100.0000**	**1.0000**	**1.0000**	**0.1247**
	4,102,299			10	**0.8753**	**0**				
	4,102,300	–		6						
	4,611,199									
	4,611,200	–								
	5,120,099									
	5,120,100	–								
	5,628,000									
	Total									
	GC									

Source: Field survey data (2023)

NB: Income distribution is in (₦'000); F = Frequency distribution; CF = Cumulative frequency; X = Proportion of

Frequency; Y = Proportion of total income and GC = Gini-coefficient.

Conclusion and Recommendation

Based on the findings of the study, it is evident that the postharvest losses in the study area is relatively high at an average of 189.22kg/ha of paddy for farmers, processors (10.22 kg/bag at ₦1100/kg), marketers (3.22kg/bag at ₦1100/kg) of milled rice. The actors` realize reasonable income even though based on the Atkinson index, processors are better off than the other value chain actors` in the study area. More so, the comparison of the share of total income by each group (series) and the value of Gini coefficient revealed an economic frightening of unequal distribution of income among the value chain actors.

Government should intensify efforts and investment in rural infrastructural facilities such as good roads, stable electricity and storage facilities. Training of value chain actors on post-harvest management and handling techniques as well as the provision of farm machineries and good storage facilities, that could help prevents losses especially at the farm level.

References

Abdelateif H. I and Omima A.M. (2015): Poverty status and inequality of income distribution among credit users in non-users in North KordofanState of Sudan. Journal of Agricultural science and Engineering Vol.1, No. 5, 2015, 213-224

Babatunde, R., Omoniwa, and Aliyu, A.J.(2019). Postharvest losses of rice in Kwara State, Nigeria: An assessment of magnitude and determinants. Cercetări Agronomice în MoldovaVol. LII , No. 2 (178) / 2019: 141-150.

Chakrabarti B, Chakraborti, A., Chakravarty, S. and Chatterjee, A. (2013): Econophysics of income and wealth distribution; Cambridge university press

Chikezie, C., Ibekwe, U.C., Ohajianya, D.O., Orebiyi, J.S., Oguoma, N.N.,Obasi, P.C., Henri-Ukoha,A., Emenyonu, C.A and Nwaiwu, I,U. (2011): Size distribution of income among rice-based farming households in south eastern States of Nigeria.

FAO (2006). Policy impacts on inequality: a welfare based measure of inequality. The Atkinson Index. *Director General's Report.*

Ibrahim, H.I, Saba, S.S and Ojoko, E.A.(2018). Postharvest loss in rice production: Evidence from a rural community in northern Nigeria. FUDMA Journal of Sciences (FJS) ISSN: 2616-1370, Vol. 2 No. 1, pp 17-22.

Mason T., Trochez C., Thomas R., Babar M., Hesso I., Kayyali R. (2018): Knowledge and awareness of the general public and perception of pharmacists about antibiotic resistance. BMC Public Health 18: 1 – 10. https://doi.org/10.1186/s12889-018-5614-3

Mbanasor, J.A., Nwachukwu, I.N., Agwu, N.M Njoku, M.E., and Onwumere, J. (2012): Analysis of income inequality and poverty dynamics among rural farm households in Abia state, Nigeria. International Journal of food and Agricultural economics (IJFAEC), Alanya Alaaddin keykubat University, Dept., of economics and finace, vol. 1(2), pages 1-6

Ogolo, E. O., Okogbue, E. C., & Emengini, E. A. (2016). Environmental assessment of North Eastern Nigeria: A review. American Journal of Environmental Science and Engineering, 1(4), 86-91.

Opara-Nadi, O. A., Ajaegwu, N. E., & Omonona, B. T. (2020). Soil morphological and physico-chemical properties of selected soil profiles in some ecological zones of Northeast Nigeria. Nigerian Journal of Soil and Environmental Research, 18(1), 1-9.

Orifah M. O., Sani M. H., Murtala N., Ibrahim A. A. (2020): Analysis of rice farmers' awareness of the effects of climate change in Kebbi State, Northwest Nigeria. FUDMA Journal of Agriculture and Agricultural Technology 6: 226 – 240.

Qu, X., Kojima, D., Wu, L. and Ando, M. (2021).The Losses in the Rice Harvest Process: A Review. *Sustainability,* 2021, 13, 9627. https://doi.org/10.3390/su13179627

Saleh A. Ochi J.E. and Sani M.H. (2016): "Efficiency measurement of modern Groundnut oil processing of RMP-12 and Ex-dakar varieties in Gombe metropolis Gombe State, Nigeria" Journal of behavioural economics, finance, entrepreneurship, accounting and transport, vol 4, no. 3: 71-80. Doi:10.12691/jbe-4-3-4

Sani A., Ibrahim U., Ibrahim S. (2022) analysis of post-harvest losses and technical efficiency of rice farmers in middle rima valley irrigation scheme (mrvis), sokoto state, Nigeria. FUDMA Journal of Agriculture and Agricultural Technology ISSN: 2504-9496 Vol. 8 No. 1, June 2022: Pp.142-150 https://doi.org/10.33003/jaat.2022.0801.033.

Teimoori M., Rajaee N.,and Hajian M., (2017): An investigation into income distribution in Zanjan province: A case Study of rural households in Abhar county. International journal of Agricultural management and development (IJAMAD)

ANALYSIS OF CONSUMERS' PREFERENCE FOR DIFFERENT CASSAVA PRODUCTS IN ABOH MBAISE LGA IMO STATE, NIGERIA.

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Abstract

This study analysed consumers' preferences for different cassava products in Aboh Mbaise LGA Imo State, Nigeria. The objectives of this study were to; identify the various and most important cassava product consumed, determine the factors affecting consumers preference for cassava product, and identify the constraints militating against the consumption of cassava products in the study area. A purpsive and simple random sampling techniques was used in selecting the sample size of 120 respondents. Descriptive and inferencial statistics were used to analyze the data. The result revealed that majority of cassava consumers were female 51.70%,with a mean age of 40.23 years and 38.3% were married. By educational status, majority with 55.80% attain tertiary education, the mean of the household size is 4 persons and their primary occupation is trading with a mean income of #278,000. Garri, akpu, tapioca and akara-akpu were the various types of cassava products consumed by the respondents in the study area and Garri emerged as the most important form consumed with of 90%. The multinomial logistic regression result shows that socioeconomic characteristics of consumers' affect the type of cassava products consumed. In fufu category, gender significantly influences the preference for fufu with a negative coefficient (B = -0.872) In terms of preference for Akara-akpu category, gender and age were significant at 5% level of significance. The major constraints faced by consumers were the taste, ranked first with a mean score of 3.55, price with a mean score of 3.26 and income with a mean score of 3.14. This research recommends that educational institutions, NGOs, and health agencies should launch public awareness campaigns to educate consumers on the nutritional benefits of cassava.

Key words: Consumers preference, Cassava.

Introduction

Agriculture provides the basic needs of food, clothes and shelter and supports over 75% of the rural populace in developing countries and less than 3% - 5% in developed countries, as well as generates income through different businesses (Iwena, 2017; Ndomi, 2018). In Nigeria, agriculture is a major sector of the economy, providing employment for about 70% of the population. The sector is being transformed by commercialization at the small, medium and large-scale enterprise level. In agriculture, crops are produced and consumed by individuals for sustenance. Amongst them is cassava. Cassava is the source of raw materials for a number of industrial products such as starch, flour and ethanol. It is seen as a dependable crop due to its ability to withstand harsh climatic conditions and the ability to grow in marginal environments (Alamu, 2021). Cassava is a staple food in Nigeria and many households largely depend on its food products for their daily caloric requirements (Apeh, Ugwuoti, and Apeh 2023). According

to Simonyan (2015), the production of cassava is relatively easy as it is tolerant to the biotic and edaphic encumbrances that hamper the production of other crops. Cassava farming in Africa produces common products like garri, eba, and fufu, with processing mainly done by women.

Consumers' preference is a term that refers to consumers' choices to maximize their satisfaction. Ge, Brigden and Häubl (2015) proposed that consumers often make choices in settings where some alternatives are known and additional alternatives can be unveiled through search. Consumers' preference therefore is a theory that explains the behavior of consumers. It states that consumers are influenced by their own preferences, the preferences of others, and the context in which they make decisions. It is influenced also by the prices of commodities, the consumer's taste, and income amongst other factors. Cassava when processed is often regarded as the most popular type of food consumed by indigenes in Aboh Mbaise Local Government Area. In Aboh Mbaise Local Government Area of Imo State, cassava is consumed by a huge number of its citizens. The processed product is reportedly available for consumption, as well as being a source of income for farmers and traders. The product is processed in various forms such as garri, akpu, tapioca akara-akpu, and indigenes consume them based on which form they desire. Income plays a huge role in the purchasing ability of an individual. This study is therefore carried to examine the analysis of consumer preference for different forms of cassava products in Aboh Mbaise L.G.A of Imo state, Nigeria. The specific objectives of the study is to: identify the various and most important forms of cassava products consumed in the study area. Determine the factors affecting consumers' preference for cassava products in the study area. Identify the constraints militating against the consumption of cassava products by respondents in the study area.

Materials and methods

Study area

The study was conducted in Aboh Mbaise LGA of Imo State, Nigeria. Aboh Mbaise LGA is one of the 27 LGAs in Imo State, Nigeria. It is in the South-East geopolitical zone of Nigeria. Aboh Mbaise has an area of 184 km² and a population estimated 194,779, with a population of males, 98,480 and females, 96,299 (Nigerian Population Commission, 2006). Aboh Mbaise lies between latitude 5°25'31"North of the Equator and longitude 7°15'06"East of the meridian. Aboh Mbaise is predominantly an agricultural community, with most of its inhabitants engaged in farming. The area is known for its fertile land and produces a wide range of crops, including cassava, yam, maize, vegetables and breadfruit. Livestock production is also practiced in Aboh Mbaise such as rearing of goats, sheep, and different classes of poultry.

Sampling techniques

A three-stage sampling technique was used in the selection of the samples size for the study. The first stage involves a purposive selection of two (2) communities in the study area and this is due to high production of cassava. Then the second stage involved a simple random selection of five (5) villages in the selected communities. The final stage, twelve (12) respondents were randomly selected from each village and a total sample of 120 respondents was used

Model specification

Multinomial Logit Regression

The model for this study was summarized as follows;

$Yi = \ln (Pi/1-Pi) = B_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + B_4 X_4 \ldots\ldots\ldots\ldots B_8 X_8 + U$

Y = (Cassava type preferred) where Y = 0 (Garri)

Y = 1 (Fufu), Y = 2 (Tapioca)

Y = 3 (Akara-akpu)
β_0 = Intercept
X_1 = Gender (1 = male, 0 = female)
X_2 = Marital status (1 = married, 0 =otherwise)
X_3 = Household size (number)
X_4 = Level of education (Years).
X_5 = Occupation (1 = Trader, 0 = otherwise)
X_6 = Religion (1 = Christian, 0 = otherwise)
X_7 = Income of household head (Naira)
X_8 = Age (Years)
μ = Error term
B_1 B_2 ..... B_8 are the coefficients of the above stated independent variables

Results and Discussions

Socioeconomic Characteristics of the Respondents

Table 1 reveals the socioeconomic characteristics of the respondents in the study area, The gender representation showed that female were (51.70%) and the males (48.30%), implying that the female respondents where the major consumers of cassava products. This study is in line with (Ojo, 2020) who found that 56.4% female household head consume more cassava products than male (43.6). Furthermore, the age distribution reveals that a large proportion of respondents are either below 30 years (37.5%) or over 45 years (38.3%), with a mean age of 40.23 years. This shows a diverse age range, suggesting that the study includes both younger and older adults, which can influence their preferences based on generational exposure to different forms of cassava products. Marital status shows that the majority of the respondents are married (38.3%) and single (34.2%). This indicates that the consumption of cassava products is greatly influenced by couples' decisions and by individual preference. Regarding educational status, more than half of the respondents (55.8%) have tertiary education, followed by 28.3% with secondary education. This relatively high educational attainment implies that the respondents are more likely to make a rational choice and decision on which cassava product to consume and also know their nutritional values. The household size with a mean of 4 members indicates that respondents are likely to purchase food in larger quantities because household size is associated with increased household consumption expenditure. The primary occupation of respondents reveals a significant portion engaged in trading (40.8%), followed by civil servants (27.5%) and students (16.7%). Traders, who typically have flexible income and work schedules, may opt for quick-cooking cassava products like cassava flour, while civil servants might prefer products that can be purchased in bulk and stored, given their fixed income structures. Students may gravitate towards affordable and convenient options like cassava snacks. Income levels show that nearly half of the respondents (47.5%) earn more than ₦200,000 monthly, with a mean income of ₦278,800. This relatively high income suggests that many respondents have the financial capacity to purchase more premium cassava products, such as those with added value through processing (cassava bread, cassava-based snacks). However, the 26.7% earning less than ₦100,000 may still rely on cheaper, more traditional forms of cassava like garri or fufu due to budget constraints

Table 1: Distribution of Respondents by their Socioeconomic Characteristics (n=120)

Socioeconomic characteristics	Frequency	Percentage
Gender		
Male	58	48.30
Female	62	51.70

Total	**120**	**100.0**
Age (years)		
≤ 30	45	37.50
31 – 35	14	11.70
36 – 40	10	8.30
41 – 45	5	4.20
> 45	46	38.30
Total	**120**	**100.0**
Mean ± (SD)	***40.23 ± 15.752***	
Marital Status		
Single	41	34.20
Married	46	38.30
Divorced	22	18.30
Widowed	7	5.80
Separated	4	3.40
Total	**120**	**100.0**
Educational status		
No formal education	3	2.50
Primary education	16	13.30
Secondary education	34	28.30
Tertiary education	67	55.80
Total	**120**	**100.0**
Household Size		
≤3	42	35.00
4 – 5	48	40.00
>5	30	25.00
Total	**120**	**100.0**
Mean ± (SD)	***4 ± 1.700***	
Religion		
Christianity	**93**	**77.50**
Islam	**13**	**10.80**
Traditional	**14**	**11.70**
Total	**120**	**100.0**
Primary Occupation		
Public servants	9	7.50
Civil Servants	33	27.50
Traders	49	40.80
Students	20	16.70
farming	9	7.50
Total	**120**	**100.0**

Income		
≤100,000	32	26.70
100,001 – 150,000	23	19.20
150,001 – 200,000	8	6.70
>200,000	57	47.50
Total	**120**	**100.0**
Mean ± (SD)	***278800.00 ± 227859.370***	

Source: Field Survey data (2024)

Identification of Different Cassava Products Consumed

Table 3 showed the different cassava products consumed by the respondents, majority of respondents (100.0%) confirmed consuming cassava products, indicating that cassava is a staple food in the study area. This widespread consumption underscores cassava's critical role in daily diets, likely due to its affordability, versatility, and cultural significance and many households largely depend on its food products for their daily calorie requirements (Apeh, Ugwuoti, and Apeh 2023). In terms of frequency of consumption, almost half of the respondents (47.5%) consume cassava products regularly or always. This suggests that cassava is a consistent part of their diet, likely consumed in different forms across meals. Another 40% consume cassava sometimes, indicating that while cassava is important, it may not be eaten daily but is still a regular component of their diet. A smaller group (12.5%) consumes cassava very sparingly, which may reflect either dietary preferences for other staples or perhaps economic factors affecting purchasing patterns.

Garri emerge as the most popular form of cassava, with a significant 91.7% of respondents consuming it. This aligns with Apeh, Apeh and Ugwuoti (2023) who found that garri is one of the most available cassava food products in Nigeria. Fufu, another common cassava product, is consumed by 64.2% of respondents, showing that it is also widely eaten, though not as popular as garri. Tapioca and Akara-Akpu are less popular forms of cassava, consumed by 38.3% and 37.5% of respondents respectively. These products might be considered more niche or regional, or they might be less readily available than garri and fufu. Their relatively lower consumption rates suggest that, while they are part of the cassava products, they are not staple foods for most respondents, possibly due to taste, preferences or the effort required in preparation.

Table 3: Distribution of Respondents by Different Cassava Product Consumed

Variables	Frequency	Percentage (%)
Consumption of Cassava Product	120	100.00
Yes	0	0.00
No	**120**	**100.0**
Total		
Frequency of Consumption of Cassava Product		
Regularly/Always	57	47.50
Sometimes	48	40.00
Very Sparingly	15	12.50
Total	**120**	**100.0**
What Form of Cassava do you consume?		
Garri		
Yes	110	91.70
No	10	8.30
Total	**120**	**100.0**

Fufu		
Yes	77	64.20
No	43	35.80
Total	**120**	**100.0**
Tapioca		
Yes	46	38.30
No	74	61.70
Total	**120**	**100.0**
Akara-Akpu		
Yes	45	37.50
No	75	62.50
Total	**120**	**100.0**

Computed from Field Survey data (2024)

Type of Cassava Products Mostly Consumed

Table 4 shows the types of cassava products mostly consumed, the result shows that Garri is the most commonly consumed cassava product, with 90% of respondents indicating it as their primary choice. This high percentage reinforces the earlier finding that garri is a staple in the diet of the majority. Its popularity can be attributed to its versatility, ease of preparation, and widespread availability, making it a go-to option for many households. This resonates with the findings of Ojo (2020); Apeh, Apeh and Ugwuoti (2023); Onyemauwa (2010) who's findings states that garri is the mostly consumed cassava product.

Fufu is the second most consumed product with 54.2% of respondents. This suggests that while fufu is a significant part of cassava product, it is less favoured compared to garri. Fufu's consumption may vary based on regional preferences, taste, and preparation methods, which could explain its lower prevalence relative to garri. This result corresponds with the findings of Apeh, Apeh, and Ugwuoti (2023); Salau, *et al*., (2019) that fufu (pounded cassava) is the second most consumed cassava product.

Tapioca and Akara-Akpu are the least favoured among the respondents, with only 13.3% and 5.8% respectively, choosing them as their primary cassava product. The low consumption rates for tapioca as cassava product consumed in the study area may be as a result of cultural influence (least regarded as a main meal but as dessert) Okoye *et al*., 2021). Tapioca and Akara-Akpu may be considered more niche or less versatile compared to garri and fufu. Their preparation might be more complex or less familiar to many respondents, contributing to their lower preference.

Table 3: Distribution of Respondents by Type of Cassava Product Mostly Consumed

Cassava Products	Yes (%)	No (%)
Garri	108 (90.00)	12 (10.00)
Fufu	65 (54.20)	55 (45.80)
Tapioca	16 (13.30)	104 (86.70)
Akara-Akpu	7 (5.80)	113 (94.20)

Computed from Field Survey data (2024)

Factors affecting consumers' preference for cassava products

The multinomial logistic regression analysis in Table 4 highlights several significant factors affecting consumers' preferences for cassava products. The significant results are marked by p-values below 5% or 1%. The estimation of the multinomial logistic model for this study was undertaken by normalizing one category which is referred to as the reference or the base category. The reference category is Garri and was chosen because of its wide acceptance by consumers, also from the earlier results in the study, majority of the consumers preferred it to others and this resonates with the findings of Ojo (2020); Apeh, Apeh and Ugwuoti (2023); Onyemauwa (2010) which states that garri is the mostly consumed cassava product.

In fufu category, gender significantly influences the preference for fufu with a negative coefficient (B = -0.872) and a p-value of 0.047 and significant at 5%. This implies that female respondents are likely to prefer garri to fufu compared to male respondents. It could reflect gender-based differences in dietary habits or food preparation responsibilities. In many cultural settings, women may be more involved in food preparation and are thus more likely to prefer garri because it is easier and more convenient to prepare. Religion is a significant factor in the preference for fufu, with a negative coefficient (B = -1.251) and a p-value of 0.003 and significant at 1%. This suggests that respondents who are Christianity are more likely to prefer garri to fufu. This could be due to religious dietary norms or beliefs that influences food choice where certain religious groups might favour garri over fufu.

In terms of Akara-akpu category, gender again plays a significant role in terms preference for akara-akpu, with a very large negative coefficient (B = -20.285) and a p-value of 0.014 and significant at 5%. This extreme value indicates a strong gender preference, with males more likely to favour garri over akara-akpu. This product might be more commonly associated with traditional food preparation methods or consumption patterns that align more with women than men. Age significantly affects the preference for akara-akpu, with a positive coefficient (B = 0.190) and a p-value of 0.020 and significant at 5%. This suggests that the older a respondent, the more likely he or she prefers akara-akpu. Akara-akpu is a traditional product, and older individuals may have stronger cultural ties to it, while younger people may be more exposed to modern alternatives or prefer more convenient food option.

With a likelihood ratio of 78.020, which is greater than the critical chi-square value of 15.507 at 0.05 with degree of freedom of 8, Ho_2 is rejected which hypothesizes that socio-economic factors of consumers do not affect their consumption preference for different forms of cassava products.

Table 4: Multinomial Logistic Regression Analysis on Factors Affecting Consumers' Preferences to Cassava Products

Logit Equation	Predictor Variable	B	Std. Error	Exp (B)	Sig.
Logit 1 (Fufu)	Constant	3.986	2.144	3.457	0.063
	Gender	-0.872	0.438	3.958	0.047**
	Marital status	0.308	0.310	0.986	0.321
	Household Size	0.132	0.134	0.970	0.325
	Educational Level	-0.422	0.307	1.887	0.170
	Occupation	-0.148	0.271	0.298	0.585
	Religion	-1.251	0.418	8.948	0.003*

	Income	0.000	0.000	1.589	0.207
	Age	-0.015	0.019	0.574	0.448
Logit 2 (Tapioca)	Constant	1.918	3.005	0.407	0.523
	Gender	0.484	0.638	0.574	0.449
	Marital status	-1.328	0.775	2.936	0.087
	Household Size	0.121	0.180	0.454	0.500
	Educational Level	-0.412	0.405	1.037	0.308
	Occupation	-0.367	0.425	0.747	0.388
	Religion	-0.578	0.867	0.444	0.505
	Income	0.000	0.000	1.111	0.292
	Age	0.021	0.036	0.341	0.559
Logit 3 (Akara-akpu)	Constant	5.907	6.557	.812	0.997
	Gender	-20.285	0.000	.	0.014**
	Marital status	-2.134	1.439	2.198	0.081
	Household Size	0.334	0.432	.597	0.431
	Educational Level	1.033	0.776	1.773	0.163
	Occupation	1.137	0.648	3.081	0.069
	Religion	-0.649	1.114	0.340	0.534
	Income	0.000	0.000	0.040	0.839
	Age	0.190	0.096	3.924	0.020**

Computed from Field Survey data (2024)
Reference category: Garri
Log likelihood = 78.020
Pseudo R^2 = 0.2382
Cox and Snell = 0.478
Number of observation = 120
*, ** = Significant at 1% and 5%

Constraints Militating Against the Consumption of Cassava Products by Respondents
The constraints impacting the consumption of cassava products in the study area are analyzed based on their weighted scores and mean scores. These scores provide an understanding into the relative significance of each constraint.
Taste emerged as the most significant constraint with the highest mean score of 3.55, indicating that taste is the primary factor deterring respondents from consuming cassava products. A substantial proportion of respondents (34.2%) rated taste as a very significant issue, and 26.7% considered it significant. This suggests that, despite the availability of cassava products, if they do not meet taste preferences, they are less likely to be consumed. Improving the flavor or enhancing the palatability of cassava products could address this major barrier.

Price ranked as the second most significant constraint with a mean score of 3.26. Although a smaller percentage of respondents viewed price as a very significant issue (19.2%), a considerable number (26.7%) still regarded it as significant. This indicates that the cost of cassava products can be a considerable barrier, especially in the context of fluctuating economic conditions. Addressing price concerns, perhaps through subsidies or reducing production costs, might increase consumption.

Income is the third-ranked constraint with a mean score of 3.14. Similar to price, income affects the affordability of cassava products. While a smaller proportion (21.7%) rated income as very significant, a significant portion (20.8%) found it significant. This suggests that individuals with lower incomes might struggle to purchase cassava products regularly. Enhancing economic opportunities or offering more affordable cassava product options could mitigate this issue.

Methods of Processing and Proximity to Market are ranked fourth and fifth, respectively. The mean scores of 2.22 and 2.07 indicate that these factors are less significant compared to taste, price, and income, but still relevant. Processing methods can influence the quality and appeal of cassava products, and the accessibility of markets affects purchasing convenience. Improving processing techniques and market access could help address these constraints.

Age, Norms and Culture are ranked sixth and seventh, with mean scores of 2.12 and 1.71. Age and cultural norms are less significant constraints, with respondents largely considering these factors as not very significant. While age might influence preferences, and cultural norms could impact consumption patterns, they are not as critical as taste, price, and income in this context

Table 5: Distribution of Respondents by Constraints Militating Against the Consumption of Cassava Products

Variables	VS	S	MS	NS	NP	Weighted Score	Mean Score	Rank
Price	23 (19.20)	32 (26.70)	29 (24.40)	25 (20.80)	11 (9.20)	391	3.26	2nd
Norms and Culture	1 (0.80)	2 (1.70)	8 (6.70)	59 (49.20)	50 (41.70)	205	1.71	7th
Taste	41 (34.20)	32 (26.70)	19 (15.80)	8 (6.70)	20 (16.70	426	3.55	1st
Income	26 (21.70)	25 (20.80)	29 (24.40)	20 (16.70)	20 (16.70)	377	3.14	3rd
Proximity to market	1 (0.80)	5 (4.20)	26 (21.70)	57 (47.50)	31 (25.80)	248	2.07	5th
Method of processing	4 (3.30)	6 (5.00)	32 (26.70)	48 (40.00)	30 (25.00)	266	2.22	4th
Age	8 (6.70)	18 (15.00)	12 (10.00)	24 (20.00)	58 (48.30)	254	2.12	6th

Computed from Field Survey data (2024)

Vs: Very serious, **S:** Serious, **MD:** Mildly severe, **NS:** Not severe, **NP:** Not a problem

Conclusion and Recommendation

It can be concluded that cassava remains a staple food in Aboh Mbaise LGA with most households consuming it in various forms. Garri is the most preferred cassava product. Also, the preferences for cassava products are influenced by several factors, including educational level, gender, religion, and age. Higher education levels appear to be associated with a preference for Garri, while gender and religious beliefs may influence the consumption of Fufu. Additionally, the primary constraints affecting cassava consumption are related to taste, price, and income.

Agricultural policymakers, in collaboration with cassava producers and marketers, should establish strategies that ensure the affordability of cassava products, particularly for lower-income households. This can be achieved by providing subsidies for cassava production or introducing price control measures that balance profitability for producers and affordability for consumers.

Cassava product manufacturers should consider producing specialized products targeted at specific demographics. For instance, premium cassava products could be developed for higher-income consumers, while more affordable, traditional variants could be promoted to rural and low-income households.

REFERENCES

Apeh, C., Apeh, A. & Ugwuoti, O. P. (2023). *Analysis of the consumption patterns of cassava food products amongst rural households in Imo State, Nigeria.* https:// DOI: 10.4314/gjas.v58i1.9

Ayuya, O. I, Kenneth, W. S& Eric, G. O (2012). Multinomial logit analysis for small-scalefarmers' choice of organic soil management practices in Bungoma county, Kenya. *Current Research Journal of social science, 4(4), 314-322.*

Ekezie, A. I. A. (2020). *Effects of environment on academic performance of students in agricultural science in secondary schools in Rivers State, Nigeria.* Tonad Publishers

Greene, W. H. (2003). *Econometrics Analysis.* 5th Edition, Prentice Hall Publisher, Upper Saddle River, New Jersey.

Greene, W. H. (1993). *Econometric Analysis.* 2nd Edition, Macmillan Publishing Company, New York.

Iwena, O. A. (Ed.) (2017). Essential agricultural science for senior secondary school. Peral Inc.

Kjeldsen-Kragh, Søren (2007). *The Role of Agriculture in Economic Development: The Lessons of History. Copenhagen Business School Press DK.* p. 73. ISBN 978-87-630-0194-6.

Ndomi, B. M. (2018). Imperatives for sustainable food security through agricultural education in Nigeria. *Journal of Agricultural Education Teachers' Association of Nigeria. 1(2), 23-33*

Ojo, M.A, Nmadu, J.N, Tanko, L. & Olaleye, R.S. (2013). Multinomial logit analysis of factors affecting the choice of enterprise among small holder yam and cassava farmers in Niger State, Nigeria. Journal of Agricultural Sciences, 4(1),7-12

Ojo, O. S. (2020). Analysis of consumer preference for cassava products in Akoko South West Local Government Area of Ondo State, Nigeria. *International Journal of Social Sciences Perspectives,* 7(1), 46-52

Okoye F. U. & Umeh S. I. (2021). *Consumption behaviour analyses of cassava products among rural household in Ebonyi state, Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension,* 20(2), 14 – 19

Onyemauwa, C. S. (2010). Analysis of household consumption of cassava products in Ohaozara, Ebonyi State, Southeast Nigeria. *Researcher*, 2(6), 1-6.

Rahji, M.A.Y. & Fakayode, S.B. (2009). A multinomial logit analysis of agricultural credit rationing by commercial bank in Nigeria. *International Research Journal of Finance and Economics Issues,* 24 (1): 90-100.

Salau, S. A., Nofiu, N. B., & Jimoh, T. A. (2019). Effect of cassava products consumption on food security of farming households in Kwara State, Nigeria. *Journal of Agriculture and Environmental Sciences*, *4*(2), 36-45.

Simonyan, K. J. (2015). Cassava post-harvest processing and storage in Nigeria: A review. *African Journal of Agricultural Research,* 9(53), 3853-3863

INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTs) UTILIZATION BY CASSAVA FARMERS IN IKOM AGRICULTURAL ZONE, CROSS RIVER STATE, NIGERIA.

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ABSTRACT

This study investigated Information and Communication Technologies (ICTs) utilization by cassava farmers in Ikom Agricultural Zone, Cross River State, Nigeria. The study described selected socio-economic characteristics of cassava farmers and identified the types of ICTs used by the farmers. A multi-stage sampling procedure was used to select 190 cassava farmers in the study area. Data obtained were analyzed using descriptive statistics. Results from the study revealed that more females (62.6%) were involved in cassava farming. A sizeable proportion (37.4%) of cassava farmers were between the age range of 31-40years. Most (90%) of the respondents had some form of formal education, 50.5% had between 1 and 10 years of cassava farming experience, and most (60%) of the respondents had contact with extension agents. The results also revealed that mobile/cell phone (93.2%), television (80.5%), radio (68.4%), social media (54.2%) and internet (53.2%) were the main types of ICTs frequently used by the farmers for cassava production. The study recommended that farmers be given opportunity through extension agents to learn skills needed on the use of ICT tools for better cassava production. Also, there is need for increase in extension visitation and contact with farmers to bridge knowledge gap on effective utilization of ICTs.

Keywords: Farmers, selected socio-economic factors, cassava production

INTRODUCTION

One of the major challenges facing developing countries of the world is poverty reduction and sustainable food production to feed an ever-increasing population, (Muhammad *et al*., 2019). These concerns have raised worries among development experts and academicians from all over the globe on how to provide sustainable food, Ehrlich & Harte, (2015). Access to information is one of the basic ingredients or tools for increasing farm productivity for agricultural development (Pandey, 2017). Aguilar-Gallegos *et al*., (2015) reported that better exchange of information among farmers can lead to improve adoption of technologies. This shows the importance of agricultural information among farmers and agricultural extension workers in the decision to take up innovations.

Information and communication technologies are seen as essential ingredients needed for effective transfer of technologies that are designed to boost agricultural production (Nwalieji *et al*., 2019). ICTs plays an important role in enhancing agricultural yields of food crops such as cassava which are in high demand (Olaniyi *et al*., 2013). Globally, Information and

Communication Technology tools are very essential in delivering agricultural information to cassava farmers. ICTs plays a critical role in decision making towards improving cassava productivity, processing and marketing of cassava products (Ommani & Chizari, 2008).

Cassava has increasingly gained prominence industrially, economically, and nutritionally, over the years because of the multi-uses of its starch-rich roots (Olaniyi *et al.*, 2013). Cassava has been transformed from being a staple food to a source of income with potentials of being valued as a major foreign exchange earner that can impact positively on the economic fortune of producing nations. Cassava production is well developed as an organized agricultural crop in Nigeria. The crop is produced in 24 of the 36 states in the country (Ettah & Kuye 2017). Cassava production dominates the southern parts of the country, both in terms of area covered and number of farmers growing the crop. Cassava displays an exceptional ability to adapt to climatic changes. It is tolerant to low soil fertility, it resists drought conditions, pests, diseases and it is suitable to store the roots for long periods underground even after maturity, hence, reasons why the crop is the most favorite among the farmers in Cross River State (Ettah & Kuye 2017).

Therefore, this study becomes imperative as it tends to focus on:

1. To describe selected socio-economic characteristics of cassava farmers
2. To identify the types of ICTs used by the farmers

METHODOLOGY

This study was carried out in Ikom agricultural zone, Cross River State. The zone comprises of six (6) agricultural blocks namely: Abi, Boki, Etung, Ikom, Obubra and Yakurr. Ikom agricultural zone shares boundary with the Republic of Cameroun to the East, Obanliku and Obudu to the North, Ebonyi State to the West and Biase and Akamkpa to the South, Cross River State Geological Agency (CRSGA 2010). A multi stage sampling procedure was used. Stage one entailed the use of purposive sampling to select major cassava producing agricultural blocks in the zone. These blocks are Obubra, Yakurr, Abi and Ikom, Stage two entailed the use of simple random sampling to select five cells out of the eight cells that make up each block, giving a total of 20 cells, with a total of 1900 registered farmers being the sample frame for this study. Finally, stage three involved the selection of 10% of the aforementioned registered cassava farming households from each of the selected cells using simple random sampling, giving a total of 190 cassava farmers as the sample size for this study of which a well-structured questionnaire were distributed and primary data collected for analysis.

RESULTS AND DISCUSSION

Socioeconomic characteristics of Farmers

Variables		Frequency (n = 190)	Percentage
Sex			
Male		71	37.4
Female		119	62.6
Age	**Mean Age**		
21-30	25.5	57	30.7
31-40	35.5	71	37.4
41-50	45.5	44	23.3
51-60	55.5	16	7.1

>60	66.5		2		1.5
Marital Status					
Single			15		7.9
Married	99			52.1	
Widow			55		28.9
Divorced/ Separated			21		11.1
Level of Education					
No formal education			19		10.0
Primary education			28		14.7
Secondary education			103		54.2
Tertiary education			40		21.1
Primary Occupation					
Farming			56		29.5
Business/ self-employed	46			24.2	
Civil servant			49		25.8
Unemployed			39		20.5
Farming Experience					
1-10 years			96		50.5
11-20 years			53		28
21-30 years			26		13.6
31-40 years			15		7.9
Farm Size					
1-5 hectares			54		28.4
6-10 hectares			126		66.4
11-15 hectares			9		4.7
>16 hectares			1		0.5
Household Size					
1-3			27		14.2
4-6			143		75.3
>7			20		10.5
Contact with Extension Agents					
Yes			114		60.0
No			76		40.0
Frequency of Extension Visit					
Quarterly			25		13.7
Biannually			68		35.8
Annually			20		10.5
Never at all			88		40.0

Source: Field survey data, 2023

Socio-economic Characteristics of Farmers

Gender distribution of the respondents: Results on gender of respondents shows that 62.6% were females while 37.4% were males (Table 2). This infers that more women are involved in cassava farming than men. This agrees with the findings by Nnenna, (2016) who reported that cassava production is dominated by female farmers. Similarly, Olayemi *et al.*, (2012) concluded that women are more directly involved in agricultural activities such as cassava production and processing than men in sub-Saharan African countries.

Age distribution of the cassava farmers: The results on age distribution of respondents indicate that 37.4% of cassava farmers were between 31 and 40years. Respondents with ages ranging from 21-30 years represented 30.7%, while those within 41 and 50 years represented 23.3%. Only 8.6% of the farmers were 51 years and above. This result agrees with that of Ezeh, (2013) who asserted that people within the age range of 30 to 50 constitute the major work force. The implication of this result is that more information on cassava production is likely to be exploited by younger cassava farmers. This is because younger farmers are more likely to operate ICT gadgets as well as apply the information gotten from them than the older farmers.

Marital status of the cassava farmers: Results on the marital status were presented on Table 2. They show that 52.1% of the respondents were married, 28.9% were widowed, and 11.1% were divorced. The fact that a sizeable proportion of the farmers were married infers that they are likely to have children to carter for, hence, they will engage in cassava production to meet their needs.

Level of education of the cassava farmers: Results on cassava farmers' educational level show that a majority (90%) of respondents have had some form of formal education. Up to 54.2% of them had completed secondary education, while 21.1% attended colleges or universities, and only 10.0% had no formal education (Table 2). This result implies that farmers in the agricultural zone are literate, hence they will likely operate and use information from ICT tools for cassava production. This result tallies with that of Oyekanmi & Okeleye, (2007) who asserted that high percentages of cassava farmers in the Southern agro-ecological zones were literate and were keen to get information from ICT tools and use it.

Primary Occupation of the cassava farmers: Results on farmers' primary occupation showed that 29.5% of the respondents were predominantly involve in farming, 25.8% were civil servants who also engaged in farming and 24.2% were involved in other business ventures (Table 2). These results show that the agricultural sector is the highest employer of labor in the study area. The result implies that quite a number of farmers were practicing farmers. The finding is similar to the conclusion drawn by Aboajah *et al.*, (2018), on socio-economic determinants of cassava production in Benue State, where they concluded that majority of cassava farmers in Benue State had farming as a major occupation.

Farming experience of the cassava farmers: Results on respondents' farming experience shows that 50.5% had between 1 and 10 years of farming experience, 28% had between 11 and 20 years, and 7.9% had between 31 and 40 years of farming experience. Farming experience plays a significant role in agricultural production. The higher the farmer's experience in farming, the better production capacity of the farmers (Adeyemi *et al.*, 2010). Audu *et al.*, (2013) also posited that productivity increases with years of experience in farming as farmers' master techniques of production and avoid previous mistakes.

Household size of the cassava farmers: Results on household size show that 14.2% households had between 1 and 3members, 75.3% had between 4-6 members, and 10.5% had 7 and above members (Table 2). Having a large family size has an implication on farm labor as members serve as additional labor force for cassava production activities and used as family labor to get work done. This view is upheld by Giroh, (2007) who observed that rubber tappers have large family size which could be used as labor for agricultural and other productive activities. Furthermore, when more people live in a household, it is likely that they will seek and share information on the production of valuable crops like cassava, such information may be gotten from ICT tools.

Farm size of the cassava farmers: Results on cassava farmers' farm size show that the majority (66.4%) of the farmers had farms ranging from 6 to 10 hectares of land, while 28.4% had between 1 and 5 hectares (Table 2). This infers that the size of cassava farms is relatively large in the study area. This is probably because cassava is fast becoming a major cash crop. As such, farmers will likely seek for information from various sources like ICT gadgets so as to improve in yields, hence income.

Contact with Extension Agents: Results on farmers' contact with extension agents show that the majority (60%) had been having contact with extension agents, up to 40% of the respondents had not had contact with extension agents. Having contact with extension agents infers that cassava farmers are aware of new innovations on cassava production which will subsequently lead to the adoption of these innovations. Furthermore, extension agents who are conversant with the use of ICT tools can teach the farmers who have them how to operate them.

Frequency of contact with Extension Agents: Result on frequency of contact with extension agent reveal that 35.8% of the respondents were contacted at least twice a year by an extension agent, 13.7% were contacted once every three months and 10.5% were contacted once a year by an extension agent (Table 2). The result infers a low rate of contact of farmers by extension workers. The implication is that farmers may not be aware of innovations on cassava production in the area. Therefore, farmers may rely on friends, neighbors and ICT tools for current information on cassava production.

Types of ICTs used by the Farmers

S/N	ICT Tools	Used	Percentage	Not used	Percentage
1.	Radio	130	68.4	60	31.6
2.	Television	153	80.5	37	19.5
3.	Internet	101	53.2	89	46.8
4.	Computer	33	17.4	157	82.6
5.	Mobile phone	177	93.2	13	6.8
6.	Email	53	27.9	137	72.1
7.	Social media	103	54.2	87	45.2
8.	Internet connected Com.	23	12.1	167	87.9
9.	Cassette recorder/player	23	12.1	167	87.9
10.	CD Rom	17	8.9	173	91.1
11.	Digital Camera	6	3.2	184	96.8
12.	Multimedia Projector	4	2.1	186	97.9

Source: Field survey data, 2023

Types of ICTs used by cassava farmers in the study area

Results on Table 3 show the types of ICT used by farmers. Results indicate that the majority (93.2%) of cassava farmers used mobile phones, 80.5% used television, 68.4% used radio, 54.2% used social media, and 53.2% used internet to access information and knowledge for cassava production. This infers that cassava farmers in the agricultural zone have ICT tools and are using them to get information on cassava production. This finding agrees with that of Abdoulaye *et al.*, (2014), who asserted that the most commonly used ICTs are television, radio and mobile phones. Also, Butt *et al.*, (2017), observed that majority of farmers used cell/telephone to seek information for agricultural marketing, micro-credit disbursement and crop management practices. Omotayo, (2015), reported further that rural farming communities in Nigeria have access to mobile phones.

Conversely, internet connected computer (12.1%), computer (17.4%), cassette recorder/player (12.1%), email (27.9%), CD Rom (8.9%), digital camera (3.2%) and multimedia projector (2.1%), were ICT tools not frequently used to get information and knowledge on cassava production by the respondents. This could be as a result of the relatively high cost of computer, internet, digital camera, projector, cassette recorder/player, as well as, the technicalities associated with their operation thereby limiting their access to use. This view was upheld by Muto and Yamano, (2009), who noted that people were reluctant to use advanced technologies such as internet, computer, projector, digital camera because they lack the required knowledge and skill.

CONCLUSION

Results from the study revealed that more females (62.6%) were involved in cassava farming. A sizeable proportion (37.4%) of cassava farmers were between the age range of 31-40years. Most (90%) of the respondents had some form of formal education, 50.5% had between 1 and 10 years of cassava farming experience, and most (60%) of the respondents had contact with extension agents. The study also revealed that 93.2% of the farmers used mobile/cell phone, 80.5% used television, 68.4% used radio, 54.2% used social media and 53.2% used internet to get information and knowledge on cassava production. Similarly, 12.1% of the farmers used internet connected computer. 17.4% used computer and 3.2% used digital camera.

REFERENCES

Aboajah, F., Onjewu, S., Chai, J., & Okeme, S. (2018). Socio-economic Determinants of Cassava Production in Benue State, Nigeria. International Journal of Environment, Agriculture and Biotechnologies. 3(2), pp. 7-17

Abdoulaye, T., Abass, T., Maziya-Dixon, B., Tarawali, G., Okechukwu, R., Rusike, J., Alene, A., Manyong, V. &Ayedun, B. (2014). Awareness and adoption of improved cassava Varieties and processing technologies in Nigeria. Journal of Development and Agricultural Economics. 6(2), pp. 67-75

Adeyemi, R., Oke, J. T. O. &Akinola, A. A. (2010). Economic efficiency of small scale farmers in Ogun State, Nigeria. Tropicultural Journal, 28(2), pp. 84-88

Audu, S. I., Otitolaiye, J. O., &Ibitoye, S. J. (2013). A stochastic frontier approach of measurement of cost efficiency in small scale cassava production in Kogi State, Nigeria. European Scientific Journal, 9(9), pp. 114-122

Butt, T., Qijie, G., Hassan, M., Luqman, M., Khan, M., Tian, X., & Mehmood, K. (2017). An Exploration of information communication technologies in agricultural development: the experiences of rural Punjab-Pakinstan. Transylvanian Review, 16(25). Pp. 4087-4096

Aguilar-Gallegos, N., Munoz-Rodriguez, M., Santoyo-Cortes, H., Aguilar-Avila, J. & Klerkx, L. (2015). Information networks that generate economic value: A study on clusters of adopters of new or Improved technologies and practices among oil palm growers in Mexico. Agricultural systems, 135(12), pp 122-132

Cross River State Geological Agency (2010). Report: Calabar Government press, pp. 65

Ettah, O. I., &Kuye, O. O. (2017). Analysis and determinants of profit efficiency of cassava Farmers in Cross River State, Nigeria. International Journal of Environment, Agriculture and Biotechnologies (IJEAB), 2(1), pp. 37-49

Ehrlich, P. R. & Harte, J. (2015). Food security requires a new revolution. International Journal of Environment Studies, 2(3), pp. 15-30

Eze, A. N. (2013). Access and application of ICTs among farming household of South-East Nigeria. Agricultural and Biological, Journal of North America, 4(6), pp. 605-616

Giroh, D. Y. (2007). Profitability analysis of natural rubber tapping in Southern Nigeria.

Muhammad, L., Muhammad, Y., Saleem, A., Muhammad, U., &Mujahid, K. (2019). Factors Influencing Use of Information and Communication Technologies among Farmers in Rural Punjab, Pakistan. Journal of Agricultural Extension, 23(2), pp. 20-45

Muto, M., & Yamano, T. (2009). The impact of mobile phone coverage expansion on market Participation. Uganda: panel data evidence World Bank. 37(1), pp. 87-96

Nnena, M. G. (2016). Assessment of Information and Communication Technologies Among Cassava Farmers in Anambra State, Nigeria. British Journal of Research, 3(2), pp.34-40

Nwalieji, H. U., Ezeakunne, C. C., Enwelu, I. A., Okeke, M. G., Udemezue, J. C., & Uzuegbunam, C. (2019). Mass Media Utilization by Poultry Farmers in Anambra State, Nigeria. Journal of Agricultural Extension, 23(2), pp.91-99

Olaniyi, O. A., Adetumbi, S. I., & Adereti, M. A. (2013) Accessibility and Relevance of Journal Information and Communication Technologies (ICTs) Among Cassava Farmers in Nigeria. African Journal of Agricultural Research, 8(35), pp.4514-4522

Olaniyi, O. A., Adetumbi, S. I., & Adereti, M.A. (2013). Accessibility and Relevance of Information and Communication Technologies (ICTS) Among Cassava Farmers in Nigeria. African Journal of Agricultural Research, 8(35), pp 4514 – 4522

Olayemi, F. F., Adegbola, J. A., Banishaiye, E. I., &Awagu, E. F. (2012). Assessment of Post-Harvest Losses of Selected Crops in Eight Local Government Areas of Rivers State, Nigeria. Asian Journal of Rural Development, 2(1), pp.13-23

Omotayo, O. M. (2015). ICT and Agricultural Extension. Emerging Issues in Transferring Agricultural Technologies in Developing Countries. In: Adedoyin, F.S. (ed), Agricultural Extension in Nigeria, pp. 145-148

Ommani, A. & Chizari, M. (2008). Information Dissemination System (IDS) Based E-Learning in Agricultural of Iran (Perception of Iranian Extension Agents). International Journal of Human and Social Sciences, 3(7), pp. 54-60

Oyekanmi, A. A., & Okeleye, K. A (2007). Cassava production systems across some Agro-Ecological Zones of South-West and North-West axis of Nigeria. Asian Journal of plant Science. 6(1), pp.158-162

Pandey, N. (2017). Role of Information Communication Technologies in Agriculture Development: A Study of Nabarangpur district, Scholedge International Journal of Business Policy and Governance, 4(4), pp. 171-190

ASSESSMENT OF EXTENSION STRATEGIES AND UTILIZATION AMONG CROP FARMERS IN CALABAR SOUTH LOCAL GOVERNMENT AREA, CROSSS RIVER STATE, NIGERIA.

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Abstract
This study assesses extension strategies and their utilization among crop farmers in Calabar South Local Government Area. Specifically, it identified the socioeconomic characteristics of crop farmers , the prevalent extension strategies in the study area, and farmers' usage of available extension strategies. A two-stage sampling technique was employed to select 110 crop farmers from the population of crop farmers in the study area. Data was collected using a structured questionnaire. Descriptive statistics were used for data analysis. Results indicate that the majority of respondents (54.5%) were female, with a significant portion (42.7%) aged between 31 and 40 years. Additionally, 54.5% were married, 53.6% had attained secondary education, and 49.1% belonged to households with 1-5 members. Furthermore, 34.5% had 1-5 years of farming experience, and 49.1% reported a monthly income exceeding 20,000 Naira. The study found that digital extension strategies, including mobile phones, internet, and social media platforms, were the most prevalent in the area ($\bar{x}$= 3.03). Similarly, farmers demonstrated a high level of usage of these recommended extension strategies, particularly in digital ($\bar{x}$= 2.97) and face-to-face methods such as farm visits and group meetings ($\bar{x}$= 2.88). These findings highlight the importance of digital extension methods in enhancing agricultural practices among farmers in Calabar South.As face-to-face extension strategies were found to have high usage rates, it is recommended that local agricultural agencies enhance their training for extension agents to ensure effective delivery of these services.

Introduction
In Nigeria, agriculture continues to serve as the backbone of the rural economy, exerting a significant influence on the national economy and providing numerous entrepreneurial opportunities, primarily at a subsistence level. In 2005, the agricultural sector contributed 41.67% to the gross domestic product (CBN, 2006), a stark contrast to its earlier status as the sole pillar of the economy during the pre-independence period. The food production landscape relies heavily on rural farmers who focus on staple food production, which is essential for their socioeconomic development. However, there is a noticeable trend of educated youth gravitating towards higher-status courses like engineering and accounting, while those without formal education resort to temporary jobs in sectors like construction and motorcycle transportation (Okada). This shift can be attributed to the overarching economic reliance on oil revenues.

Despite numerous agricultural development programs initiated post-independence, the government has struggled with logistics and a genuine commitment to diversifying agriculture away from oil. Key initiatives such as the National Accelerated Food Production Program (1973), Operation Feed the Nation (1976), and the Green Revolution (1981) aimed to bolster agricultural production but often fell short due to inadequate support and resources. The Agricultural Development Program (ADP) has been notable for its role in disseminating agricultural information and facilitating innovations among farmers. Various public extension methods, including Training and Visit and Farmers Field Schools, have evolved to promote innovation and encourage farmer engagement. Additionally, private extension systems have emerged to complement public efforts, enhancing outreach and support for farmers (Nkang and Effiong (2015); Ntui, *et al.*, (2022)).The establishment of the Federal Department of Agricultural Extension (FDAE) in 2013 aimed to harmonize public, private, and externally funded agricultural projects to promote integrated development. The ADP operates under a structured framework where the governor leads, supported by program managers, extension directors, and a network of extension agents. These agents receive continuous training, including Monthly Technical Review sessions and Fortnight Training meetings with farmers, to bolster their skills and knowledge, enhancing the effectiveness of extension services (Aboh and Effiong, (2019); Effiong, (2013)).Akinsorotan (2002) defines extension as an informal educational process designed to improve the efficiency and quality of life for rural farming families. However, the gap between food production and the growing population remains a critical issue, exacerbated by low agricultural budget allocations, logistical challenges, and limited access to agricultural inputs and information. The federal government's Agricultural Transformation Agenda lacks the sustained policy reforms and investments necessary to effectively address these challenges. As a result, food insecurity has escalated, with the proportion of food-insecure households increasing from 18% in 1996 to 40% in 2005 (Sanusi, Badejo, & Yusuf, 2006). Furthermore, the Economist Intelligence Unit's Global Food Security Index ranked Nigeria 80th among 105 countries regarding food affordability, availability, and quality (el-Kurebe, (2012), Effiong, (2012); Effiong and Aboh, (2024). Agricultural extension is widely recognized as a critical component for improving farmers' livelihoods, with investments in extension services seen as vital for enhancing agricultural productivity and income (Anderson & Feder, 2007). Nevertheless, sub-Saharan Africa has witnessed a decline in per capita agricultural production, contrasting with rising trends in regions like Latin America and East Asia (Haggblade& Hazell, 2010; Haggblade, Hazell, Kirsten, & Mkandawire, 2004); Effiong and Aboh, (2019); Effiong and Aboh, (2018). The poor performance of the agricultural sector in the region has contributed to heightened food insecurity, necessitating effective extension strategies to support farmers in improving their productivity and sustainability. Strategies such as face-to-face, mass media, digital, participatory, and agro-dealer extensions are essential in disseminating agricultural knowledge and technologies. Akpomedaye (2014) noted the positive impacts of agricultural extensions on food productivity and farmer welfare but also highlighted significant challenges like poor communication skills and financing issues, underscoring the need for improved education and training for both farmers and extension agents to enhance service delivery and ultimately boost food production. (Effiong, *et al.*, (2021); Effiong, *et al.*, (2016); Ijioma, *et al.*, (2024)).

1.2 Statement of Problem

Despite the lagging agricultural productivity recorded in sub-Saharan Africa in contrast to the rest of the world, the majority of impact evaluations conducted in the region have reported a positive impact of agricultural extension programs (Hailemichael, (2013): Effiong and Asikong, (2013), Etim, *et al.*, (2022); Etim and Effiong, (2022)). The International Food Policy

Research Institute (Dercon, Gilligan, Hoddinott, and Woldehanna, 2008) noted the positive impact of extension and roads on poverty and consumption growth in Ethiopia, based on an analysis of 15 villages. In the same vein, ECON Analysis (2005)studied the impact of agricultural extension in Mozambique, using a sample of 480 households, and concluded that agricultural extension services have positive effects on rural livelihoods in Mozambique, negating the earlier assertion of Walker et al. (2004) that agricultural extension had a negative and statistically insignificant impact on individual and household income in Mozambique. The contradictions in agricultural extension impact studies could be traced to the chain of delivery of extension programs in terms of complexity, predictability, acceptability and affordability of innovation packages, methods of dissemination, and impact of the innovation packages for adoption and sustained utilization by a targeted group or audience for a multiplier effect on the group's productivity.The slow growth of agriculture and food production is evident in the growing food importation, with eminent no sustainability, increased threat of food insecurity, and failing diversification of the economy from oil to agriculture, commerce, and trade.

1.3 Objectives of the study

Specifically, the study aims to:

v. Identify socioeconomic characteristics of crop farmers in the study area
vi. identify the extension strategies prevalent in the study area
vii. assess farmer's usage of available extension strategies..

RESEARCH METHODOLOGY

The study was carried out in Calabar South Local Government Area, in Cross River State. Calabar South is one of the eighteen (18) Local Government Areas of Cross River State. The area is located in the southern part of Nigeria and has a population of about 168,000 people. It has between latitude 4.9589^0N and longitude 8.3228^0E. It covers an area of about 120-678 sqkm. In the North, it is bounded by Calabar Municipality, in the South by Calabar River, in the East by Akpabuyo and in the West by Odukpani. The vegetation in the area is mainly mangrove swamps and rainforest.It has the following predominant crops: cassava, banana, plantain, rice, yam, maize, melon,pepper, pumpkin,water leaf etc. The population comprised of all crop farmers in the study area.Data was sourced from primary sources through the use of structured questionnaire.A two-stage sampling technique was used for the study. In the first stage, out of ten (10) cells in the study areas, five (5) cells was purposively selected based on the intensity oftheir agricultural production, while the second stage involved the random selection of twenty-two (22) crop farmers from each of the five (5) selected cells. This gave a sample size of 110 respondents.Data was analyzed using descriptive statistics

Results and Discussion

4.1 Socio-economic distribution of respondents

TABLE 1

Percentage distribution of the respondent's socio-economic characteristics

Variables	Frequency	Percentage (%)
Sex		
Male	50	45.5
Female	60	54.5
Total	110	100.0
Age		
Below 20	7	6.4

20-30	31	28.2
31-40	47	42.7
Above 40	25	22.7
Total	110	100.0
Marital Status		
Single	44	40.0
Married	60	54.5
Widowed	6	5.5
Total	110	100.0
Educational level		
No formal education	12	10.9
Primary education	32	29.1
Secondary education	59	53.6
Tertiary education	7	6.4
Total	110	100
Household size		
1-5	54	49.1
6-10	53	48.2
Above 10	3	2.7
Total	110	100.0
Farming experience		
1-5	38	34.5
6-10	35	31.8
11-15	13	11.8
Above 15	24	21.8
Total	110	100.0
Income (₦)		
Below 10000	22	20.0
10100-15000	11	10.0
15100-20000	23	20.9
Above 20000	54	49.1
Total	110	100

Source: Field survey, 2024

Table 1 presents the percentage distribution of the respondent's socio-economic characteristics. The results showed that majority (54.5%) of the respondents were female while 45.5% were males. Most (42.7%) of them were in the age category of 31-40years while others were 28.2%, 22.7%, 6.4% for the age categories of 20-30, above 40, and below 20 respectively. Most (54.5%) were married, most (40.0%) were single while only 5.5% were widowed. Majority (53.6) had secondary education, 29.1% had primary education, whereas 10.9% had no formal education and 6.4% had tertiary education. Majority (49.1%) had household size of 1-5 members, 48.2% had household size of 6-10 members while 2.7% had household size above 10 members. Majority (34.5%) had 1-5 years of farming experience, 31.8 had 6 to 10 years experience, 21.8% had above 15 years experience while 11.8% had 11-15 year experience. Majority (49.1%) had monthly income of above 20,000 while others (20.9%, 20.0%, 10.9%) had income of 15100-20000, below 10000 and 10100-15000 respectively. The result of this study suggests that there are more female farmers in the study area than male. According to Sunday and Undiandeye (2018) whose study had similar result, most crops require time and

attention which may likely be achieved by the female farmers while the males engage themselves in non-farming activities which provides additional income for the family. Also, most of the crop farmers were married youths with secondary education, small family size with few years of farming experience and monthly income above N20,000. People in their productive age are likely to be more conservative and take risk in crop production than older people who are above their productive age (Sunday and Undiandeye, 2018).

4.2 Prevalent extension strategies

Table 2: Mean rating of respondents based on prevalent extension strategies

Prevalent extension strategies	SA	A	DA	SD	Mean	Rank
Face-to-face extension strategies such farm visit, group meeting etc.	40	5	35	30	2.5	3
Mass media extension strategies such as use of tv, Radio, newspaper etc.	29	61	-	20	2.9	2
Digital extension strategies such as use mobile phone, internet, social media platforms etc.	51	30	10	19	3.03	1
Participatory extension strategies (i.e.) active involvement of farmers in extension processes	2	4	50	54	1.58	5
Agro-dealer extension strategies (i.e.) working with private sector in agro-dealer to deliver extension services, such as providing technical advice, training, marketing support etc.	1	2	81	26	1.80	4

Source: Field survey data 2024.

Table 2 present the result of the mean rating of respondents based on prevalent extension strategies. The results showed that the most prevalent extension strategies in the study area according to rank was digital extension strategies such as the mobile phone, internet, social media platforms etc. ($\bar{x}$= 3.03) ranked 1, followed by mass media extension strategies such as use of tv, Radio, newspaper etc. ($\bar{x}$= 2.9) which ranked 2 and face-to-face extension strategies such farm visit, group meeting etc. ($\bar{x}$ = 2.5) ranked 3. Others were, agro-dealer extension strategies (i.e.) working with private sector in agro-dealer to deliver extension services, such as providing technical advice, training, marketing support etc. ($\bar{x}$= 1.80) and participatory extension strategies (i.e.) active involvement of farmers in extension processes ($\bar{x}$ = 1.58). The result is in line with a study by Kumar et al., (2020) reveals that extension strategies have been found to be effective in improving farmers' access to information and knowledge, as well as their adoption of new technologies and practices. Also, Van der Veen et al., (2017) observed that face-to-face extension strategies have been found to be effective in improving farmers' knowledge, skills, and attitudes towards new technologies and practices.

4.3 Farmer's usage of available extension strategies

Table 3: Mean distribution of respondents based on farmer's usage of available extension strategies

Farmer's level of usage of available extension strategies	EH	H	L	EL	Mean
Face-to-face extension strategies, such as farm visits, group meetings, demonstrations etc.	60	12	3	35	2.88*
Mass media extension strategies, such as radio, television programs etc.	12	36	40	22	2.35
Digital extension strategies, such as mobile phones, internet-based platforms etc.	54	27	1	28	2.97*
Participatory extension strategies, such as farmer field schools and participatory research and development etc.	7	39	40	24	2.26
Gender-responsive extension strategies	-	42	36	32	2.09

Source: Field survey data 2024,

Table 3 present the result of the mean rating of respondents based on farmer's usage of recommended extension strategies. The mean score of 2.5 was used as a bench mark to indicate the farmer's usage. The results showed that high farmer's usage of recommended extension strategies was found in the area of digital extension strategies, such as mobile phones, internet-based platforms etc. ($\bar{x}$ = 2.97) and face-to-face extension strategies such farm visit, group meeting etc. ($\bar{x}$ = 2.88). Low farmer's usage of recommended extension strategies was in the use of mass media extension strategies, such as radio, television programs etc., ($\bar{x}$ = 2.35), participatory extension strategies, such as farmer field schools and participatory research and development etc. ($\bar{x}$=2.26) and gender-responsive extension strategies($\bar{x}$ =2.09). This study is in line with the study of Kumar et al. (2020) whose result reveals that the farmer's use of digital extension strategies, such as mobile phones and internet-based platforms, are becoming increasingly popular in rural areas, and have the potential to reach a large number of farmers, especially young farmers. Klerkx et al. (2012) study also revealed that the quality and effectiveness of face-to-face extension services can be variable, depending on the level of training and knowledge of the extension agents thereby improving the level of knowledge and use of recommended practices by farmers.

Conclusion

In conclusion, the assessment of extension strategies and utilization in Calabar South Local Government Area reveals critical insights into the socio-economic characteristics of the farming population and their interaction with various extension services. The majority of respondents were female, married, and in their productive years, which highlights the potential for female farmers to significantly influence agricultural practices. The study found that digital extension strategies, such as the use of mobile phones and internet platforms, were the most prevalent and effectively utilized, indicating a shift toward modern, technology-driven methods. Additionally, face-to-face extension strategies also demonstrated high usage, suggesting that personal interactions remain essential for knowledge transfer and skill enhancement among farmers.However, the findings also indicated lower utilization of mass media and participatory extension strategies, underscoring the need for more targeted interventions to enhance their effectiveness.

Recommendations

Based on the findings, the following recommendations were made:

1. Given that the majority of respondents are female farmers within the productive age range, it is recommended that agricultural programs focus on supporting women's access to resources, training, and credit facilities. Additionally, initiatives aimed at enhancing educational opportunities for young farmers should be prioritized to further improve their farming practices and productivity, ultimately contributing to the socioeconomic development of the community.
2. Given the findings that digital extension strategies are the most prevalent, efforts should be made to improve access to digital technologies for all farmers, including providing training on how to effectively use mobile phones and internet resources for agricultural purposes, thereby maximizing the potential of these strategies.
3. As face-to-face extension strategies were found to have high level of usage, it is recommended that local agricultural agencies enhance their training for extension agents to ensure effective delivery of these services, while also promoting the integration of mass media and participatory extension strategies to increase farmer engagement and adoption of innovative practices.

REFERENCES

Aboh, C. L., & Effiong, J. B. (2019). Adoption of different weed management techniques among cocoa farmers in Akamkpa Local Government Area, Cross River State, Nigeria. *Global Journal of Pure and Applied Science*, *25*(1), 7-12.

Akinsorotan, A. O. (2002). Agricultural extension education in external studies programme, Ibadan Centre for External Studies. Ibadan, Nigeria: University of Ibadan.

Akpomedaye, J. F. O. (2014). Agricultural Extension as a Strategy to Boost Food Production in Nigeria. *International Journal of Innovative Agriculture & Biology Research*, *1*(3), 36-41.

Anderson, J. R., & Feder, G. (2007). Agricultural extension. In R. E. Evenson & P. Pingali (Eds.), *Handbook of agricultural economics* (Vol. 3, pp. 2343-2378). Amsterdam, The Netherlands: Elsevier.

Dercon, S., Gilligan, D. O., Hoddinott, J., &Woldehanna, T. (2008, December). The impact of agricultural extension and roads on poverty and consumption growth in fifteen Ethiopian villages (IFPRI Discussion Paper 00840). Washington, DC: International Food Policy Research Institute. Retrieved from http://www.ifpri.org/sites/default/files/publications/ifpridp00840.pdf

Effiong, J. B. (2012). Youth Participation in Community Development: Evidence from Yakurr Local Government Area, Cross River State. *International Journal of Social Science Iowmorro*, *1*(6).

Effiong, J. B. (2013). Challenges and prospects of rural women in agricultural production in Nigeria. *Lwati: A Journal of Contemporary Research*, *10*(2), 183-190.

Effiong, J. B., & Aboh, C. L. (2018). Rubber production technologies and the related socioeconomic environments in Akwa Ibom State, Nigeria. *Global Journal of Agricultural Science*, *17*(1), 15-22.

Effiong, J. B., & Aboh, C. L. (2019). Effect of agro-chemicals on the health of farmers in Akpabuyo Local Government Area, Cross River State. *European Journal of Scientific Research*, *154*(1), 142-147.

Effiong, J. B., & Aboh, C. L. (2024). Effectiveness of agricultural extension models in food crop production in Cross River State, Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, *24*(3), 25871-25881.

Effiong, J. B., Aboh, C. L., & Aya, C. F. (2021). Perception of farmers on the contribution of vegetables to livelihoods in Yakurr Local Government Area, Cross River State, Nigeria. *Global Journal of Pure and Applied Science*, *27*(2), 82-91.

Effiong, J. B., Asikong, A. B. (2013). Mid-term assessment of the activities of Fadama III Development Project in Cross River State. *Global Journal of Agricultural Science*, *12*(1), 31-35.

Effiong, J. B., Ijioma, J. C., & Effiong, M. O. (2016). Endogenous determinants of adoption of improved rubber production technologies among farmers in Akwa Ibom State, Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology*, *8*(4), 2-7.

el-Kurebe, A. (2012, September 26). Nigeria ranked 80th on food security. Retrieved from http://www.vanguardngr.com/2012/09/nigeria-ranked-80th-on-food-security/

Etim, O. U., Effiong, J. B., Okoi, K. O., &Ntui, O. E. (2022). Climate change impact on the use of plastic products among agro-marketers and horticultural enterprises in Calabar Agricultural Zone of Cross River State. *International Journal of Agriculture and Earth Science*, *8*(1), 64-76. D.O.I: 10.56201/ijgem.v8.no1.2022.pg64.76

Etim, O. U., & Effiong, J. B. (2022). An evaluation of the benefits of the use of flexible and non-flexible plastic materials among agro-enterprise owners in the Calabar Agricultural Zone of Cross River State, Nigeria. *International Journal of Agriculture and Earth Science*, *8*(5).

Haggblade, S., & Hazell, P. B. R. (2010, May). Successes in African agriculture: Lessons for the future (IFPRI Issue Brief No. 63). Washington, DC: International Food Policy Research Institute. Retrieved from http://www.ifpri.org/sites/default/files/publications/ib63.pdf

Haggblade, S., Hazell, P., Kirsten, I., & Mkandawire, R. (2004, April). Building on successes in African agriculture: African agriculture—Past performance, future imperatives (2020 Vision Focus 12 Brief 1). Washington, DC: International Food Policy Research Institute.

Hailemichael, T. (2013). Evaluating the impact of agricultural extension programs in sub-Saharan Africa: Challenges and prospects. *African Evaluation Journal*, *1*(1), 1-9. doi:10.4102/aej.v1i1.19

Ijioma, J. C., Effiong, Ogbonna, M. O., &Okolies, N. O. (2024). Small scale farmers' perception in cassava (Manihot esculenta) production in Osisioma Ngwa Local Government Area, Abia State, Nigeria. *LWATI: A Journal of Contemporary Research*, *9*(4), 56-65.

Klerkx, L., Aarts, N., &Leeuwis, C. (2012). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural Systems*, *103*(6), 390-400.

Kumar, A., Singh, R., & Singh, K. (2020). ICT-based agricultural extension services: A review of literature. *Agricultural Reviews*, *41*(2), 128-136.

Nkang, M. O., & Effiong, J. B. (2015). The influence of consumers' perception on pork and poultry meat consumption in Calabar South Local Government Area in Cross River State.

Ntui, O. E., Effiong, J. B., Etim, O. U., &Okoi, K. O. (2022). An assessment of the factors inhibiting the use of plastic materials among selected agro-enterprises and farmers in Calabar Agricultural Zone of Cross River State, Nigeria. *International Journal of Agriculture and Earth Science*, *8*(5).

Sanusi, R. A., Badejo, C. A., & Yusuf, B. O. (2006). Measuring household food insecurity in selected local government areas of Lagos and Ibadan, Nigeria. *Pakistan Journal of Nutrition*, *5*(1), 62-67.

Sunday, I. M., &Undiandeye, U. C. (2018). Factors influencing farmers' participation in the Cross River Basin Development Authority Irrigation Project in Abak, Akwa Ibom State, Nigeria. *Journal of Agricultural Extension and Rural Development*, *1*(1), 153-161.

Van der Veen, Y., van Koppen, K., & Klerkx, L. (2017). Farmer-to-farmer extension: An underappreciated pathway for enhancing the scalability and sustainability of agricultural innovations. *Sustainability*, *9*(9), 1630.

Walker, T., Tschirley, D., Low, J., Pequenino Tanque, M., Boughton, D., Payongayong, E., & Weber, M. (2004, May). Determinants of rural income, poverty, and perceived well-being in Mozambique in 2001–2002 (Research Report No. 57E). Retrieved from http://ageconsearch.umn.edu/bitstream/56061/2/wps57E.pdf

ASSESSING INFORMATION NEEDS OF CASSAVA FARMERS IN IKOM AGRICULTURAL ZONE, CROSS RIVER STATE, NIGERIA

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ABSTRACT

This study assessed information needs of cassava farmers in Ikom Agricultural zone, Cross River State. Specifically, it determined the information needs of cassava farmers, identified sources of information for cassava production and discussed the constraints to the use of ICT tools for cassava production. A multi-stage sampling technique was used to select 190 cassava farmers for the study. The data was collected with a well-structured questionnaire and analyzed using descriptive statistics. The results show that (97%) of the farmers need information about where to sell their products, (85.7%) need information about agricultural loans and credits, (85.1%) need information about weather condition and flood warning and (78%) need information about current and future market price forecast. With regards to sources of information, the study found out that the majority (90.5%) of the farmers get their information from mobile phones, personal experience accounted for (85.3%) and friends and family (81.1%). The findings also show that low adoption and utilization, access to credit sources, high cost of ICT tools and high level of poverty were the major constraints to the use of ICT tools for cassava production in the study area. The study recommends that key stakeholders should be encouraged to provide affordable credit facilities to farmers to reduce the financial burden of acquiring and maintaining certain ICT devices.

Keywords: ICT tools, cassava production, Constraints, Ikom agricultural zone

INTRODUCTION

Cross River State is one of the major producers of cassava in Nigeria (Ettah and Kuye, 2017). Cassava displays an exceptional ability to adapt to climatic changes. Cassava, a staple crop in Africa, has gained prominence due to its multi-uses and starch-rich roots. It is tolerant to low soil fertility, it resists drought conditions, pests, diseases and it is suitable to store the roots for long periods underground even after maturity, hence, reasons why the crop is the most favorite among farmers in Cross River State (Ettah and Kuye, 2017). Cassava is grown in fallow lands and throughout the year making it preferable to the seasonal crops like yam, beans, pea etc. though, the use of fertilizer is limited.

In the field of agriculture, the role of information in enhancing agricultural development cannot be underestimated; information is a veritable tool in the production, marketing and distribution of agricultural produce particularly in Nigeria where majority of the farmers are uneducated

and as such face paucity of information on how to develop their agricultural production. Cassava farmers need information to improve on their production. In order to get high yield and bumper harvest as well as become economically and socially viable, they need various types of information on different areas that will help them improve their farming skills, technique, inputs, process, marketing as well as distribution strategies. However, it is important to adequately educate Cassava farmers on how to get tractors to plough and till the land for large scale farming. Information on how to acquire variety of Cassava is equally important. Other information is on the suitability of soil for cassava farming or cultivation period suitable for cultivation of cassava, irrigation techniques as well as pest control mechanism that are all very crucial to the cassava farmers.

Agricultural information dissemination is crucial to the productivity of farmers and makes them learn about those things which they are not aware of (Banmeke and Olowu, 2005). However, different categories of household and individual have different information needs, and their current expressed need for and potential access to information sources may also be different. Different people have different levels of access to the individuals and institution which mediate these flows of information. If we can identify those to which people have most access or regard as the most reliable, external agencies can use them as channels for getting new agricultural information into the communities or to specific categories of people and obtaining feedback information needs. According to EC and CTA (1998), farmers need training in technical knowledge if their productivity is to be enhanced. The transformation of traditional or peasant agriculture of farmers must of necessity emphasize the training and education of rural farmers.

Information and Communication Technology tools are very essential in delivering agricultural information to cassava farmers. They play a critical role in decision making towards improving cassava productivity, processing and marketing of cassava products (Ommani and Chizari, 2008). Proper information delivery on cassava production through effective ICT tools to the farmer is imperative to the sustainability, productivity and marketability of agricultural produce. In addition, a well- informed society is more responsive to government policies, willing to adopt innovations, and eager to participate in the nation's rural development programmes. Information is the most important facilitator and core of the marketing system as it is a *sine qua non* for agricultural development (Farhad *et al.*, 2011). Hence, farmers need access to information to improve the quality and quantity of the agricultural products marketed.

The use of ICT tools in agriculture has been gaining momentum in Africa and Nigeria in particular. The world has witnessed an unprecedented growth in ICT applications in the last two decades (Babuga *et al.*, 2020). Conventional communication channels such as farm visits, personal letters, and contact with farmers have been counterproductive, calling for the adoption of ICTs by researchers and extension workers to transmit relevant agricultural information efficiently. It has become necessary for all stakeholders to join hands in developing the ICT world in Nigeria since it has the potential to transform agriculture through agricultural extension in the country. However, several factors have impeded the use of ICT tools for cassava production in the study area such as; low adoption and utilization of ICT tools, access to credit sources, high cost of ICT tools, epileptic power supply, high level of poverty among farmers, complexity of usage, poor access to and use of relevant agricultural information which has resulted in low productivity of cassava and has also contributed to the demand and supply imbalance in the domestic market, (Adetimehin, *et al.*, 2018 and Ajani and Agwu, 2012). To address this issue, availability, accessibility, and utilization of ICT tools have emerged among researchers as a viable solution to help cassava farmers to break traditional barriers to

development, by improving access to valuable information, expanding market base and enhancing productivity (Chikaire, *et al.,* 2017). Despite the importance ICT tools plays in agriculture, their application in Nigeria has remained minimal (Oke, *et al.,* 2019). It is against this backdrop that this study was designed to investigate information and communication technology tools needs by cassava farmers in Ikom agricultural zone, Cross River State, Nigeria. Consequently, the specific objectives were to:

identify the information needs of cassava farmers for cassava production;

determine the sources of information used by cassava farmers for cassava production; and

identify constraints to the effective use of Information and Communication Technology tools among cassava farmers.

METHODOLOGY

Study Area

This study was carried out in Ikom agricultural zone, Cross River State. The zone comprises of six (6) agricultural blocks namely: Abi, Boki, Etung, Ikom, Obubra and Yakurr. Ikom agricultural zone shares boundary with the Republic of Cameroun to the East, Obanliku and Obudu to the North, Ebonyi State to the West and Biase and Akamkpa to the South, Cross River State Geological Agency (CRSGA 2010). The zone has a tropical rainforest vegetation. It houses some largest world's virgin forests and remains the center of environmental conservation concern. The main economic activities in the zone are farming, fishing, hunting and trading. The soils in the zone are fertile for agricultural activities and production of crops like cassava, yam, maize, groundnut, vegetable, rice etc.

Sampling and Sampling Technique

The population of this study comprised all registered cassava farmers in Ikom Agricultural Zone. A multi-stage sampling procedure was employed in this study. The first stage involved the use of purposive sampling to select three major cassava producing blocks in the zone. These blocks are Abi, Yakurr and Obubra. The second stage was to randomly select three (3) cells each out of the eight (8) cells that makes up each of the selected blocks. In the third stage, 20% of registered cassava farmers were selected as a sample frame using a simple random sampling technique, and finally, 190 farmers were selected from the 9 cells using a proportionality factor of 20%. The data type that was used in the conduct of the study was primary data. It was obtained through the use of a structured questionnaire and personal interviews. The distribution of the questionnaires was based on the total number of cells, as illustrated below:

Table 1: Selection of farmers for the study

S/N	Blocks	Selected Cells	No of Registered Farmers	20%
1.	Abi	Usumutong	120	24
		Ediba	100	20
		Itigidi	90	18

2. Yakurr	Ugep	130	26
	Ekori	110	22
	Nko	80	16
3. Obubra	Ovonum	100	20
	Ofodua	80	16
	Apiapum	140	28
Total = 3	9	950	190

Source: Cross River Agricultural Development Programme and Field survey 2024.

RESULTS AND DISCUSSION

INFORMATION NEEDS OF CASSAVA FARMERS FOR CASSAVA PRODUCTION

Results in Table 2 as presented below shows the findings of the analysis of the farmers' area of information needs. The results indicated that the majority (97%) needs information on where to sell their farm produce, information about agricultural loans and credit facilities (85%), weather conditions and early flood warnings (85%), pest and disease management (83%), current and future market prices forecast (78%), sources of farm input (75%), improved weed control (70%) and improved cassava varieties (58%). The result infers that cassava farmers in Ikom Agricultural zone are most in need of information about where to sell their farm produce, information about agricultural loans and credit facilities, information about weather condition and flood warning, current and future market prices, sources of farm inputs, improved weed control, improved cassava varieties, as they all ranked 1, 2, 3, 4, 5, 6, and 7 respectively. Farmers achieve joy whenever their products are sold. They also need agricultural credit and loans to help them increase farming productivity thereby bettering their lives and livelihood. Access to information about pest and disease management will also make farming a pleasurable experience and increase productivity. This finding agrees with that of Ogbuabor and Nwosu (2017), who asserted that agricultural credit and loan increased farm output significantly. Cassava farmers' need loans in cassava production as it helps them invest more in farming activities. Access to information on farm input will help farmers to improve productivity. This finding agrees with Pandey (2017), who affirmed that access to information and production inputs are basic ingredients for increasing farm productivity. The result also corroborates with the findings of Moagi and Oladele, (2012) who reported that the majority of Nigerian farmers required information on pesticides and farm implements. Results of the study also showed that farmers need information about current weather conditions and early flood warnings. This may be associated with climate change and global warming which has resulted in unpredictable weather conditions which have made farmers uncertain as to the right time to plant and harvest their crops. This finding is agreement with Benard et al, (2014) who asserted that access to relevant weather conditions information and its timely communication to cassava farmers can to a large extent reduce the risk and uncertainty in agriculture. Similarly, the result of the study also revealed that most farmers lacked access to marketing information such as available market prices, current and predicted prices of commodities, and information on improved seed varieties in Ikom Agricultural zone. This agrees with the findings of Benard et al., (2014) who noted that access to information on market prices is very important to small and marginal farmers especially in developing countries like Nigeria. Results also showed that farmers need information on improved seed varieties. This could be due to a lack of awareness of the existence of such varieties or insufficient capital to acquire the improved seeds. This corroborates with the findings of Benard et al., (2014) who pointed out that most farmers in

their study lacked knowledge of improved seeds hence they stick to the economically inefficient preferred varieties.

Conversely, areas of low information needs of the farmers include; contact with extension agents (25%), improved cassava farming technologies (15%), current government policies (14%). Farmers' low need for information on contact with extension agents and government policies could be a reason for the strong presence of intervention programs such as Fadama III, the International Fund for Agricultural Development (IFAD), and Nigeria Covid19 Action Recovery Stimuli (NGCARES).

Table 2: Information needs of cassava farmers for cassava production

S/N	Information Needs	Frequency (n=190)	Percentage (%)	
	Rank			
1.	Where to sell farm produce	185	97	1st
2.	Information about loans and credit	163	85.7	2nd
3.	Weather condition and flood warning	162	85.1	2nd
4.	Pest and disease management	158	83	3rd
5.	Current and future market price forecast	149	78	4th
6.	Sources of farm input	143	75	5th
7.	Improved weed control	134	70	6th
8.	Improved cassava varieties	112	58	7th
9.	Appropriate fertilizer application	94	49	8th
10.	Contact with extension agents	48	25	9th
11.	Improved cassava farming technologies	30	15	10th
12.	Current government policies	28	14	11th

Source: Field Survey, 2024

SOURCES OF INFORMATION USED BY THE CASSAVA FARMERS FOR CASSAVA PRODUCTION

The result of the analysis of sources of agricultural information among cassava farmers in Ikom Agricultural zone as presented in Table 3 below, reveals that major sources of information were mobile phones (90.5%), personal experience (85.3%), friends and family (81.1%), fellow farmers (77.9%) input suppliers (54.7%) and radio (53.7%). This implies that majority of farmers relies basically on mobile phones, personal experience, family and friends, fellow farmers and radio as the major sources of agricultural information. This could probably be as a result of their steady availability, coupled with their frequent and regular interactions and perhaps because they are the cheapest means of acquiring information without much effort. This finding agrees with a study carried out by Omotayo, (2015), who asserted that farmers can easily have access to agricultural information provided through mobile phones, radio. This finding also agrees with the result of Benard *et al.*, (2014), Adetimehin *et al.*, (2018) who asserted that agricultural information comes from interpersonal sources such as friends, family members, and neighbors due to their credibility, reliability and because they are trusted, community members.

Conversely, results in Table 2 also shows that the least used sources of information for cassava production in the study area include social media (44.2%), extension agents (39.5%), television (37.9%), and research institutions (22.6%). This implies that social media, extension agents, television and research institutions were seen as some of the least sources of information for cassava production. This could probably be because of inadequate power supply, connectivity, unavailability of complimentary services, poor network signal, and lack of awareness of the role of research institutions in the provision of agricultural information to farmers. This finding disagrees with the result from the study conducted by Omotayo, (2015), who asserted that farmers can easily have access to agricultural information provided through television. The result also disagrees with the work done by Moagi and Oladele, (2012) who reported that television was the most common source of information utilized by farmers in their study area. Few (39.5%) cassava farmers sourced information from extension agents. This indicates that extension services within the study area is inactive.

Table 3: Sources of Information for Cassava Farming

S/N	Information **Sources**	**Frequency (n=190)**	**Percentage (%)**	**Rank**
1.	Mobile phones	172	90.5	1st
2.	Personal experience	162	85.3	2nd
3.	Friends and family	154	81.1	3rd
4.	Fellow farmers	148	77.9	4th
5.	Input suppliers	104	54.7	5th
6.	Radio	102	53.7	6th
7.	Social media	84	44.2	7th
8.	Extension agents	75	39.5	8th
9.	Television	72	37.9	9th
10.	Research institutions	43	22.6	10th

Source: Field survey, 2024

CONSTRAINTS TO THE USE OF ICTS FOR CASSAVA PRODUCTION

The results on the constraints to the use of ICTs for cassava production is presented on Table 4. The most serious constraints faced by cassava farmers in the use of ICTs were low adoption and utilization of ICTs ($\bar{x}$= 4.38), access to credit sources ($\bar{x}$= 4.37), high cost of ICT tools ($\bar{x}$ = 4.37), high level of poverty among farmers ($\bar{x}$ = 3.68), lack of awareness ($\bar{x}$ = 3.68), epileptic power supply ($\bar{x}$= 3.67), readability problem ($\bar{x}$ = 3.30), lack of effective training ($\bar{x}$ = 3.31), illiteracy level of farmers ($\bar{x}$ = 3.11) and lack of connectivity ($\bar{x}$= 3.10). The constraints listed above will affect the number of farmers using ICTs for cassava production. The implication is that these constraints serve as obstacles that prevent farmers from taking full advantage of ICT tools to access information that will improve their productivity. Cassava farmers will not be able to exploit the opportunities that ICT tools present for cassava production, consequently, farmers yield will remain low. The finding is in line with Akinnusi *et al.*, (2018) who reported high level of illiteracy as a major constraint to ICT utilization by farmers. Oyeyinka and Bello, (2013), also reported high cost of ICTs as a major barrier affecting its utilization by farmers. Ani *et al.*, (2015) also reported high cost of ICT tools and services,

high level of illiteracy and readability problem of farmers as constraints to the utilization of ICTs. This result further supports that of Ajani and Agwu, (2012), who found consistent power failure and poor internet connectivity as hindrances to the utilization of ICTs for cassava production.

On the other hand, complexity of ICT tools ($\bar{x}$ = 1.96), lack of extension agent's conviction ($\bar{x}$ = 1.62), inadequate infrastructural facilities ($\bar{x}$= 1.40), and low computer literacy among cassava farmers ($\bar{x}$= 1.17), were all seen as not serious constraints faced by respondents in the utilization of ICTs for cassava production. This implies that these were not serious constraints and they had a limited effect on the farmers' effective use of ICTs in the study area.

Table 4: Constraints to the use of ICTs for cassava farming

S/N	Constraints	SA	A	U	D	SD	Mean	Rank
1.	Low adoption and utilization	65	124	1	0	0	4.38**	1st
2.	Access to credit sources	64	123	1	0	0	4.37**	2nd
3.	High cost of ICT tools	60	127	1	0	0	4.37**	2nd
4.	High level of poverty	3	137	29	21	0	3.68*	3rd
5.	Lack of awareness	11	129	29	21	0	3.68**	3rd
6.	Epileptic power supply	128	12	29	20	1	3.67**	4th
7.	Readability problem	2	84	79	19	6	3.30**	5th
8.	Lack of effective training	3	83	79	20	5	3.31**	6th
9.	Illiteracy level of farmers	1	64	83	39	3	3.11**	7th
10.	Lack of connectivity	2	63	83	39	3	3.10**	8th
11.	Negative attitude of farmers	0	64	62	53	11	2.94	9th
12.	Less concentration of ICTs In rural areas	0	33	71	64	22	2.61	10th
13.	Lack of knowledge on how To use the tool	1	22	66	60	41	2.40	11th
14.	Inadequate support from Organization and government	0	50	23	27	90	2.17	12th
15.	High cost of maintenance	17	9	23	63	78	2.0	13th
16.	Traditional beliefs/practices	11	0	4	148	27	2.05	14th
17.	Complexity of using ICT	0	0	1	87	54	1.96	15th
18.	Lack of extension agents Conviction	0	0	7	104	79	1.62	16th
19.	Inadequate infrastructural Facilities available	0	0	0	72	118	1.40	17th
20.	Low computer literacy Among cassava farmers	0	0	0	33	157	1.17	18th
n =			190					

Source: Field survey data, 2024.

SA = Strongly Agreed, A = Agreed, U = Uncertain, D = Disagreed, SD = Strongly Disagreed

CONCLUSION

The findings presented in the results and discussions section above were evident for a logical conclusion. Therefore, the study concludes that mobile phones were the most prevalent and accessible among cassava farmers in the study area. This underscores the potential of mobile technology for disseminating agricultural information and services. Cassava farmers have various information needs and timely delivery of this relevant and appropriate agricultural

information will increase cassava farming productivity. To increase farmers' access to these ICT tools, measures must be taken to address the issues of low adoption and utilization, access to credit sources, high cost of ICT tools, high level of poverty, lack of awareness, epileptic power supply, illiteracy level of farmers among other challenges the farmers are faced with in accessing ICT tools. It is on this note the study recommends the following:

i. More awareness should be created on the use of ICT tools for information on cassava production.
ii. Government needs to proffer lasting solutions to epileptic power supply, particularly in rural areas where cassava production is done more.
iii. Financial institutions should be encouraged to provide affordable credit facilities to farmers to ease the burden of acquiring and maintaining ICT tools.

REFERENCES

Ani, A., Umunakwei, P., Ejiogu-Okereke, E., Nwakwasi, R. & Aja, A. (2015). Utilization of mass media among farmers in Ikwere Local Government Area of Rivers State, Nigeria. Journal of Agriculture and Veterinary Science. 8(7), pp.41-47

Ajani, E. &Agwu, A. (2012). ICT needs of small scale farmers in Anambra State, Nigeria. Journal of Agriculture and Food Information, 13(2), pp. 144-156

Akinnnusi, F., Sodiya, C., & Adamu, C. (2018). Determinants of farm hygiene practices towards preventing and Controlling poultry disease among poultry farmers in Lagos State, Nigeria. Journal of Agricultural Extension, 22(2), pp.107-111

Adetimehin, O.D., Okunlola, J.O. & Owolabi, K.E. (2018). Utilization of agricultural information and knowledge for improved production by rice farmers in Ondo State, Nigeria. Journal of Rural Social Sciences, 33(1), 76-100.

Babuga, U. S., Ali, A. M., and Garba, A. (2020). The Effect of Information and Communication Technology (ICT) utilization among Small Scale Farmers in Bauchi Local Government Area, Bauchi State, Nigeria. Direct Research Journal of Agriculture and Food Science. 8(9):332-339

Banmeke, T.O.A and T.A. Olowu (2005): Accessibility of women farmers to agricultural information in South Western Nigeria. South African Journal of Agricultural Extension 34 (2): 237 – 246.

Benard, R., Dulle, F., & Ngalapa, H. (2014). Assessment of information needs of rice farmers in Tanzania; A case study of Kilombero District, Morogoro, Tanzania. Library Philosophy and Practice (electronic-Journal).1071. Accessed 28/10/19.

Chikaire, J.U., Anyoha, N.O., Anaeto,F.C. & Orusha, J.O. (2017). Effects of Use of Information and Communication Technologies (ICTs) on Farmers' Agricultural Practices and Welfare in Orlu Agricultural Zone of Imo State, Nigeria. International Journal of Research in Agriculture and Forestry, 4(3), 6-15.

Cross River State Geological Agency (2010). Report: Calabar Government press, pp. 65

EC and CTA, (1998): The European communities' food security strategy and the AC countries. A seminar in food security held in Brussels, 1997 published by, FAB Agenede production, Belgium. PP26-27.

Ettah, O. I., &Kuye, O. O. (2017). Analysis and determinants of profit efficiency of cassava Farmers in Cross River State, Nigeria. International Journal of Environment, Agriculture and Biotechnologies (IJEAB), 2(1), pp. 37-49

Farhad, L., Mohammadi, R., & Najafabadi, M. (2011). Identifying appropriate information and communication technology (ICT) in improving marketing of agricultural products in Garmsar City, Iran. African Journal of Biotechnology, 10(55), pp. 37-40

Moagi, T.M. & Oladele, O.I. (2012). Analysis of information needs among land distribution for agricultural development beneficiaries in Waterberg District, Limpopo Province, South Africa. Journal of Human Ecology. 39(2), 95-101.

Nenna, M.G. (2016). Assessment of Information and Communication Technologies (ICTS) among cassava farmers in Anambra State, Nigeria. British Journal of Research. Available at http://www.imedpub.com/articles/assessment-of-information-and-communication-technologies-icts-among-cassava-farmers-in-anambra-state-nigeria.php?aid=10033#8

Ogbuabor, J. E., &Nwosu, C. A. (2017). The impact of deposit money bank's agricultural credit on agricultural productivity in Nigeria: Evidence from an error correction model. International Journal of Economics and Financial Issues, 7(2), pp. 513-517

Ommani, A. & Chizari, M. (2008). Information Dissemination System (IDS) Based E-Learning in Agricultural of Iran (Perception of Iranian Extension Agents). International Journal of Human and Social Sciences, 3(7), pp. 54-60

Omotayo, O. M. (2015). ICT and Agricultural Extension. Emerging Issues in Transferring Agricultural Technologies in Developing Countries. In: Adedoyin, F.S. (ed), Agricultural Extension in Nigeria, pp. 145-148

Oke, O.O., Adeoye, A.S., Jatto, K.A., Adelusi, F.T. & Ojo-Fakude F.F. (2019). Assessment of Information Communication Technology (ICT), usage by maize farmers in Afijio Local Government Area of Oyo State, Nigeria. Information impact: Journal of Information and Knowledge Management. 10(2): 109-123.

Oyeyinka, R. A., &Bello, R. O. (2013). Farmers use of ICTs for marketing information outlets in Oyo State Nigeria. Journal of Agricultural Science, 5(1), pp. 56-70

Pandey, N. (2017). Role of Information Communication Technologies in Agriculture Development: A Study of Nabarangpur district, Scholedge International Journal of Business Policy and Governance, 4(4), pp. 171-190

SUSTAINABLE INTEREST-BASED CONFLICT RESOLUTION STRATEGIES AMONG RURAL FARMING COMMUNITIES IN OBUBRA LOCAL GOVERNMENT AREA, CROSS RIVER STATE, NIGERIA.

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ABSTRACT
The study investigated the perception of interest-based conflict resolution strategy among farming communities in Obubra Local Government Areas of Cross River State, Nigeria. Four specific objectives were raised to guide the study as follows: to describe the socio-economic characteristics of rural farmers, ascertain the perceived sustainable strategies involved; access the roles played by community leaders; determine the perceived benefits and examine the challenges to sustainable interest-based conflict resolution in the study area. A sample size of 150 farm-family heads were selected through a multistage stage sampling technique. Data obtained through a structured and validated questionnaire were analyzed using frequency, percentages, tables, mean. The result shows that the perceived strategies involved in sustainable interest-based conflict resolution included; identifying, focusing on one issue, dialoguing with conflicting parties, negotiating to get facts from conflicting parties in-order to come to a compromise. The roles played by community leaders were; convening a meeting through effective communication, setting up of judicial committee of enquiry, sensitization of affected communities/ courtesy visits. The perceived benefits of sustainable interest-based conflict resolution were; encourages peaceful co-existence among farmers enhances agricultural production, addresses complaints help to build trust among conflicting parties, enhances strong relationship among farmers, thus promote agricultural development. The result also showed the challenges to the use of interest-based conflict resolution strategies included; the corruption of many local leaders, lack of subject trust and openness in local traditional leadership, lack of finance to execute resolutions processes in communities, lack of efficient machinery to enforce or carry out peace deals. Conclusively, using sustainable interest-based strategies in resolving conflict among farming communities enhance agricultural production thus, promote the economic opportunity of rural farming communities. It was therefore recommended that community leaders be trained on peacekeeping in-order to enlighten the farmers on the need to co-exist in peace for sustainable agricultural development.

Keywords: Sustainable Interest-based, Conflict Resolution, Farming Communities, perception.

INTRODUCTION
Interest-based strategy is a sustainable community-based approach to conflict resolution built on reconciliation between the parties to a dispute rather than just deciding who is right and who is wrong and punishing offenders (Kuponiyi, Ayoade, Hammed and Adewole, 2021). The interest-based strategy is integral to community development, gained force as a negotiation strategy using collaborative approach thus, provides opportunity for alternative positive decision to resolve differences (Oghenechuko & Godbless, 2018). The outcomes of sustainable

resolution with stakeholders and improved relationships are often found in interest-based strategy where the hopes, worries, concerns, and needs of every participant are given priority, thus enhancing a supportive solution (Nwaogwugwu & Dabelema, 2019).

Interest based conflict resolution is comprehensive, consensus-based and frequently involve participation from both parties as well as the entire community coordinated by community leaders, hence an interactive strategy developed and applied to resolving problems among rural farming communities (Olowu, 2018). The foundation for interaction and the standards by which individuals and societies live are provided by cultural values and attitudes. These encourage resource sharing and fair distribution thus, enhancing a peaceful environment Dike, Toby & Elekima, 2020). Particularly in Nigeria, with inspirations from conflict resolution practices in the developed countries, rural communities are now concerned with how these strategies can be applied as means for a sustainable resolution of conflicts within and outside the community (Chikaire, Onoh, Ugwoke and Ejiogu-Okereke, 2018).

Since the beginning of time, this strategy aims to strengthen rural communities by giving them direct control over the settlement of conflicts that arise within the community through procedures that prioritize farming and sustainability in agricultural productivity (Hurley, 2014). The strategy has the capacity to resolve conflict that benefits the stakeholders involved in the problem-solving process by considering their interests thus, an essential component of interest-based strategy (Asenjo 2019). Interest-based conflict resolution help conflicting parties resolve their disagreements without harming their relationships and improve the efficiency of rural communities in handling conflicts (Iqwubor,2020).

Nevertheless, there are some challenges to the use of interest-based strategy; the lack of respect given to established institutions has killed community members' desire in using the interest-based strategy. According to Ibraheem, (2015) the compensation component of the overall cleansing procedure during resolution is similarly ambiguous, the introduction of fresh, contemporary ideas has made the approach obsolete, the combination of two ethnic groups has made the procedure cumbersome in resolving conflict as culture creates societal divisions and also seen as a barrier to peaceful conflict resolution in multiethnic and multicultural settings. It is on this premise that the researchers sought to analyze the sustainable interest-based conflict resolution strategy among rural farming communities in Obubra Local Government Areas, Cross Rivers State, Nigeria. In specific terms, the study was designed to: describe the socio-economic characteristics of rural farmers; ascertain the perceived strategies involved in sustainable interest best conflict resolution, the roles played by community leaders in sustainable interest best conflict resolution, determine the perceived benefits of sustainable interest-based conflict resolution to farming communities; examine the challenges to effective interest- based conflict resolution among farming communities in the study areas.

Methodology

The study was carried out in obubra Local Government area, Cross River State, Nigeria. Obubra is one of the oldest local Government areas in Nigeria. It lies between latitude 4^0 45^1 and 6^0 15^1 North of Equator and longitude 8^0 12^1 East of Greenwich Meridian. It is bounded in the North by Yala and Ikom local government area, in the South by Yakurr Local Government area and in the West by Ebonyi State. The present day obubra as a geo-political entity covers an area of 1115km^2 with o population of 172543 people as at 2006 census (National population commission of Nigeria, 2006). It is situated in the central senatorial district of Cross River State, Nigeria and has its headquarters at Obubra. There are eleven (11) council wards in the local Government Area; Ababene, Ofat, Ofodua, Ovonum, Apiapum, Iyamoyong, Ochon, Obubra urban, Ofumbongha/Yala, Osopong1 and Osopong 11. The Mbembe speaking people who constitute the majority consist of the following traditional clans; Adun, Okum, Osopong and Ofumbongha. Obubra could be best described as having the characteristics of an ethnic plural society. The people of Obubra main economic activities include agriculture, distribution and sale of farm products.

A multi-stage sampling technique was used for the study. At stage one, six (6) cells were randomly selected from the eleven cell (communities) that constitute the local Government Area. The selected cells (communities) were; Ofat, Ofodua, Ovonum, Osopong1, Ochon and Ofumbongha/ Yala wards respectively. At stage two, two (2) villages were randomly selected from each of the selected communities making twelve (12) villages. At stage three, 10% simple random selection of one hundred and fifty (150) rural farmers were selected villages. Data was collected from the primary source.

Result and Discussions

Table 1: Socio-economic characteristic of rural farmers, which influence the resolution of conflict in the study areas.

Variables	Frequency	Percentages
Age		
< 25	11	7.3
25-36	24	16
37-48	42	28
49-59	54	36
>60	19	12.7
Sex		
Male	82	54.7
Female	68	45.3
Marital Status		
Single	20	13.3
Married	85	56.7
Divorced	8	5.3
Widowed	37	24.7
Highest Educational qualification		
Non- formal education	15	10
Primary education	36	24

Secondary education	70	46.7
Tertiary education	29	19.3
Religion		
Christianity	139	92.7%
Islamic	-	-
Traditional	11	7.3%
Family size		
1-2	15	10
3-4	51	34
5-6	80	53.3
9 and above	4	2.7
Farming experience		
Below 5	14	9.3
5-10	31	20.7
11-20	35	23.3
21-30	45	30
31 and above	25	16.7
Membership of Association		
Yes	110	73.3
No	40	26.7
Income level(₦ per annum)		
Below 350,000	11	7.3
350,000-500,000	20	13.3
500,100- 650,000	25	16.7
650,100- 800,000	38	25.3
Above 800,000	56	37.3

SOURCE: Field survey, 2024

Table 1 shows that a greater proportion (36%), (28%) and (16%) were between the ages of 49-59years, 37-48years and 25-36years respectively. The result further shows that majority (54.7%) were males while (45.3%) were females. In addition, majority (56.7%) were married, (24.7%) were widowed while (13.3%) were single. Greater proportion (46.7%) had secondary education, (24%) had primary education while (19.3%) had tertiary education Majority (92.7%) belongs to Christianity, (7.3%) were traditional worshippers. Majority (53.3%) had 5-6 family size, (34%) had 3-4 family size, (10%) had 1-2 family size while (2.7%) had 9 and above family size. A greater proportion (30%) had between 21-30years of experience, (23.3%) had between 11-20years of experience, (20.7%) had between 5-10 years of experience. However, majority (73.3%) are members of association while (26.7%) are not. Lastly, a greater proportion (37.3%) had income above ₦800,000, (25.3%) had income between ₦650,100- ₦800,000 while (16.7%) had income between ₦500,100- ₦650,000.

The primary characteristics of rural communities, according to Hurley (2014), include surplus land and its resources. Due to the abundance of land in rural areas and the absence of significant industrial activity, farming or closely related occupations is necessarily the main source of income for rural residents. A variety of reported conflicts are usually brought about by

competition over farmland, struggling for resources, interaction in various farming groups as supported by Zhirin, Dauda & Zailani (2022) findings.

. Land is used for farming and agriculture-related production and trade in agricultural services are the main drivers of the rural economy. This is only made possible where issues concerning land, farming activities etc. are resolve in such a way that the interest of the conflicting parties are uphold. The outcome is also consistent with Aya & Eremi, (2015) findings on effect of farming activities on Agricultural biodiversity management.

Table 2: Distribution of respondents based on the strategies involved in sustainable interest- based conflict resolution

S/N	STRATEGIES INVOLVED IN SUSTAINABLE INTEREST BASED CONFLICT RESOLUTION	Mean(x)	RANK	DECISION
1	Identifying the issues.	3.26	1st	Accepted
2	Focusing on one at a time	3.20	2nd	Accepted
3	Dialoguing with conflicting parties.	3.18	3rd	Accepted
4	Negotiating to get facts from conflicting parties in-order to come to a compromise	3.16	4th	Accepted
5	Understanding the emotions and facts of both parties	3.14	5th	Accepted
6	Clarifying the interests of both parties.	3.12	6th	Accepted
7	Brainstorming ideas for resolving the conflict without evaluating or criticizing them.	3.10	7th	Accepted
8	Choosing a solution that satisfies the needs of all parties	3.09	8th	Accepted
9	Considering the economic, social, and environmental impacts of each option	3.08	9th	Accepted
10	Testing the solution before implementing it	3.04	10th	Accepted
11	Establishment of partnership by traditional rites.	3.02	11th	Accepted

SOURCE: Field survey, 2024; Decision rule (< 3.0= insignificant, ≥ 3.0= significant)

Table 2 shows the result of the strategies involved in interest-based conflict resolution. The result indicated that; identifying the issues with mean value of ($\bar{x}$ =3.26) ranked 1st; focusing on one issue at a time with mean value of ($\bar{x}$ =3.20) ranked 2nd; dialoguing with conflicting parties with mean value of ($\bar{x}$ =3.18) ranked 3rd; negotiating to get facts from conflicting parties in-order to come to a compromise with mean value of ($\bar{x}$ =3.16) ranked 4th. Approaches to resolving conflict that are community-based or indigenous have typically relied on dialoguing, negotiation, mediation, and open communication. This support the finding of Mustapha, (2023). The implication of this finding is that sustainable interest best strategies only function when the disputing parties are willing to identify a concrete issue to be settled. Therefore, interest based as a method for analysis and problem solving considers the requirements of individuals and groups, such as identification and recognition, as well as institutional reforms necessary to meet these needs. This corroborate the findings of Chikaire, Onoh, Ugwoke and Ejiogu-Okereke, (2018).

Table 3: Distribution of respondents based on the roles played by community leaders in sustainable interest-based conflict resolution

S/N	ROLES PLAYED BY COMMUNITY LEADERS	Mean(x)	SD	RANK	DECISION
1	Incorporating customs, beliefs, values, and traditions that govern social interactions in the resolution procedure.	3.19	0.31	8th	Accepted
2	Emphasizes on mutual satisfaction of demands of both parties.	3.02	0.33	13th	Accepted
3	Sensitization of affected communities/ courtesy visits	3.37	0.39	3rd	Accepted
4	convening a meeting through effective communication	3.45	0.38	1st	Accepted
5	. Emphasizes on the coming together of conflicting parties to end problems and consider peace.	3.15	0.30	9th	Accepted
6	Compromise, and reunion of the parties to end conflict	3.14	0.30	10th	Accepted
7	Promoting consensus building	3.13	0.38	11	Accepted
8	Setting up of judicial committee of enquiry	3.41	0.38	2nd	Accepted
9	Enforcement of local sanctions	3.00	0.31	15th	Accepted
10	Peace education/ trainings to build capacity for effective collaboration	3.35	0.36	4th	Accepted
11	Addressing complaints between conflicting parties and fostering deeper communication	3.29	0.31	6th	Accepted
12	Mobilize resources for reconstruction of affected areas and rehabilitation of people	3.09	0.38	12th	Accepted
13	Formation of peace committee to summon conflicting parties for settlement	3.31	0.26	5th	Accepted
14	Tendering apology to the negatively affected party	3.21	0.31	7th	Accepted
15	Custodian of indigenous culture and tradition of the community	3.01	0.32	14th	Accepted

SOURCE: Field survey, 2024; Decision rule (m − ≥ 3.0 accepted; (m < 3.0) not accepted

Table 3 shows the result of the roles played by community leaders in sustainable interest-based conflict resolution among farming communities; convening a meeting through effective communication with mean value of ($\bar{x}$ =3. 45) ranked 1st; setting up of judicial committee of enquiry with mean value of ($\bar{x}$ =3. 41) ranked 2nd; sensitization of affected communities/ courtesy visits with mean value of ($\bar{x}$ =3. 37) ranked 3rd; However, custodian of indigenous culture and tradition of the community with mean value of ($\bar{x}$ =3. 01) ranked 14th and enforcement of local sanctions ($\bar{x}$ =3. 00) ranked 15th. Interest-based or peaceful approaches are traditionalist and cling to peoples' customs. This implies that these traditions are ingrained in the population and do not simply shift. This finding is in line with the finding of (Bello and Olutola, 2016).

Table 4: Distribution of respondents based on perceived benefits of sustainable interest-based conflict resolution

S/N	PERCEIVED BENEFITS OF SUSTAINABLE INTEREST BASED CONFLICT RESOLUTION STRATEGY	Mean	Rank	Remark
1	It promotes consensus-building, social bridge reconstructions, and the re-enactment of order in society	3.46	6TH	significant
2	Maintain peace and morale within farming communities and prevent disruptions in productivity	3.14	11TH	significant
3	It helps to reintegrate conflicting parties	3.0	13TH	significant
4	Using interest-based strategy helps to preserve community heritage	3.19	10TH	significant
5	The strategy brings members together and encourages participation in community activities	3.35	7TH	significant
6	The strategy facilitates difficult conversations	3.32	8TH	significant
7	Reduce the stress level of conflicting parties	3.21	9TH	significant
8	Fosters growth and development to the benefits of all rural dwellers and inhabitants	3.07	12TH	significant
9	Provide opportunity to conflicting parties to understand a different perspective, which gives a new insight.	2.99	15TH	significant
10	Facilitates better collaboration between farming communities	3.69	4TH	significant
11	Enhances free access to farm and marketing of agricultural produce	2.90	14TH	significant
12	Promotes fair sharing of communal resources for farmers to produce surplus food.	3.57	5TH	significant
13	Encourages peaceful co-existence among farmers which enhance agricultural production	4.13	1ST	significant
14	Addresses complaints help to build trust among conflicting parties	4.03	2ND	significant
15	Enhances strong relationship among farmers, thus promote agricultural development	3.99	3RD	significant

SOURCE: Field survey, 2024; Decision rule (< 3.0= insignificant, ≥ 3.0= significant)

A well resolved conflict cases stand to benefits rural farm families and inhabitants. Table 4 showed that using interest-based strategy to resolve conflict among farming communities encourages peaceful co-existence among farmers which enhance agricultural production with mean value of ($\bar{x}$ =4.13) ranked 1st; addresses complaints help to build trust among conflicting parties with mean value of ($\bar{x}$ = 4.03) ranked 2nd, enhances strong relationship among farmers, thus promote agricultural development of ($\bar{x}$=3.99) ranked 3rd; When the interest of conflicting parties is given priority it reduces stress on their part, builds trust and promotes unity for sustainable agricultural production. Reducing stress is important for physical and mental well-being. People with lower stress level are easier to concentrate and engage with their roles. This corroborate (Rukwe, Halima, Fatima and Abdulshakur, (2019).

Table 5: Distribution of respondents based on the challenges to the used of interest-based conflict resolution strategy

s/n	Challenges	Mean	Rank	Remark
1	Culture and language problems where different ethnic groups are involved	3.22	5TH	Significant
2	a lack of subject trust and openness in local or traditional leadership	3.29	2nd	Significant
3	lack of efficient machinery to enforce or carry out peace deals	3.24	4th	Significant
4	Lack of training of leaders to update knowledge on peaceful coexistence	3.20	6th	Significant
5	Incompatible interests of conflicting parties due to value differences	3.19	7th	Significant
6	Criticism of the ritualized rites associated with the strategy.	3.15	8th	Significant
7	Difficulty in determining the proportionality of compensation	3.10	12TH	Significant
8	. Contradictions between laws and traditional practices	3.13	10TH	Significant
9	Lack of finance to execute resolutions process in communities	3.28	3rd	Significant
10	Political interference on local authorities	2.74	13TH	In-significant
11	Poor funding of peace committees in communities.	3.14	9TH	Significant
12	corruption of many community leaders	3.32	1st	Significant
13	Difficulty in arbitrating government influenced communal conflicts	2.82	14TH	In-significant
14	Difficulty in finding neutral party to mediate peace between conflicting groups	3.12	11TH	Significant
15	Intervention of military in armed conflict diminishes the value of indigenous approaches	2.94	15TH	In-significant

SOURCE: Field survey, 2024: ≥ 3.00 significant; < 3.00 is insignificant

The challenges to the use of interest-based conflict resolution strategy in the study area are shown in Table 5. The study found that, among other things, some of the most frequent challenges to interest-based conflict resolution in the region included the corruption of many local leaders (ranked 1st), Lack of subject trust and openness in local traditional leadership (ranked 2nd), Lack of finance to execute resolutions processes in communities (ranked 3rd), lack of efficient machinery to enforce or carry out peace deals (ranked 4th), culture and language problems where different ethnic groups are involved (ranked 5th), lack of training of leaders to update knowledge on peaceful coexistence (ranked 6th), incompatible interests of conflicting parties due to value differences (ranked 7th) and criticism of the ritualized rites of the strategy (ranked 8th). This finding implies that interest-based conflict resolution poses a number of difficulties, and that if these difficulties are resolved, the methods will be more successful in reducing conflict in rural communities. Some communities lack of efficient machinery to enforce or carry out peace deals hence resort to corrupt means. Corruption is an obstacle to interest- based strategy and where there is bias in resolving issues, both parties' interest are no longer projected, this affect the processes. This support the finding of Ibraheem (2015), who discovered that some community leaders assigned to carry out post-conflict peace initiatives are not trained and lack adequate knowledge in peace building and often use techniques that escalate the situation rather than mitigating. The results corroborate that of Asenjo (2019), who

linked lack of trust, compromised of local elites as factors influencing the effective utilization of interest-based conflict resolution. However, intervention of military in armed conflict diminishes the value of indigenous approaches (ranked 15th), difficulty in arbitrating government influenced communal conflicts (ranked 14th) and political interference on local authorities (ranked 13th) were not seen as obstacles to the use of interest-based conflict resolution strategy in the region. The study concluded that military intervention and political interference are not compatible with community-based peace strategies because, in the end, it is the community members who will accept peace and try to find peaceful ways to coexist. Bello and Olutola (2016) affirmed that local intervention provides all stakeholders with a voice and responsibility for the result leading to mutual trust and reduces tensions. This demonstrates why Ibraheem, (2015) believed that for a peace process to be successful, it is imperative to investigate external conflict management tactics and combine them with community-based intervention.

CONCLUSION

Based on the findings, it was concluded that Interest-based conflict resolution strategy addresses the interest and preserves relationships, which is crucial for a sustainable peaceful coexistence. Therefore the implication is that if interest-based strategy is used in resolving conflict among farming communities, agricultural production within the study area would be enhanced thus, promotes the economic opportunity of rural farming communities.

Recommendations

Based on the findings of the study it was therefore recommended that, government and international bodies should train community leaders from time to time on peaceful coexistence so as to educate the rural farmers on the need to forgive and unite for sustainable agricultural development.

REFERENCES

Alliyu, A., Issa, N.,Okafor, L.& Adedoyin, C. (2020). Roles of traditional rulers in conflict resolution for sustainable democracy in Nigeria. *Nigeria Journal of Social Studies.* 23(1), 51-62.

Asenjo, C. (2019). Conflict resolution in community development: Are the benefits worth the costs? *Critical Social Policy. 39*(2), 268–288.

Aya, C. F. & Eremi, E.O. (2015). Effect of farming activities on Agricultural biodiversity management

Bello, P. & Olutola, A. (2016). Indigenous conflict Resolution Mechanisms in Africa: Lessons Drawn for Nigeria: *Bangladesh e-journal of Sociology.* 13 (2),70-88.

Chikaire, J.U., Onoh, P.A. Ugwoke, F.O. and Ejiogu-Okereke, E.N. (2018). Rural Farmers' Perception of Conflict Resolution as a Strategic Tool for Grassroots Development in Imo State, Nigeria; *Applied Tropical Agriculture; 23 (1), 20-26*

Dike, S., Toby, B. & Elekima, D. (2020). Transforming mediation and conciliation practices for effective dispute resolution in Nigeria. *Journal of property law and Contemporary Issues*. 12 (1), 230-246.

Hurley, (2014). Conflict Resolution in a Community; How to overcome conflicts and grow a community *https://medium.com/@dbhurley/conflict-resolution-in-a-community-ifclf 1150296.html:accessed 15/02/2019*

Ibraheem, J.S. (2015). The roles and the challenges of Traditional Leaders in land conflicts and management in Nigeria, A case study of Bauchi State. *A publication from the office of Bauchi State Boundary Commission* Bauchi State, Nigeria 8(2):17-21. https://www,oicrf.org/verklaring van .
in Cross River State, Nigeria. International Journal of Natural and Applied Sciences 10(1&2): 123-127

Iqwubor, J.I. (2020). Traditional Institution and Nation Building. The role of traditional Rulers in the maintenance of National Security for sustainable Development. *UJAH* 21(4), 201-214.

Kuponiyi, F.A., Ayoade, A.R., Hammed, O.R. and Adewole, W.A.(2021). Effectiveness of Conflict Resolution Strategies among Rural Farmers and Herdsmen in Ogbomoso and Oyo Agricultural Zones of Oyo State. *International Journal of Arts Humanities and Social Sciences Studies;* 6(2),23-35.

Mustapha, A. (2023). Traditional Administrative system and Community Development in Nigeria: Roles and Relevance of Traditional institutions in Local Community Development. *Organization and Human Capital Development (ORCADEV)* 2(1):42-52. https:// doi.org/ 10.31098/orcadev.v2i/.1182.

Nwaogwugwu, O. N. &, Dabelema, D. (2019). Strategies for Conflict Resolution among Farming Communities in Ogu/Bolo and Eleme Local Government Areas of Rivers State, Nigeria; Specialty *Journal of Psychology and Management*; 5 (3), 38-45.

Oghenechuko, O.J. & Godbless, E. E. (2018).Interest-Based Conflict Management Systems: Beyond Traditional and ADR Systems of Conflict Resolution; *European Journal of Business and Management*; 10 (17),80-91.

Olowu, D. (2018). Indigenous Approaches to conflict Resolution in Africa: A study of the Barolong people of the North –West province, South Africa. *Journal of Law and Judicial System* 1 (1), 10-16.

Rukwe, D. T.1., Halima, M.1., Fatima, Z. I. and Abdulshakur, M. M. (2019). Farmers Perception on Conflict Resolution as a Tool for Rural Development in Taraba State, Nigeria; *Global Academic journal of Agriculture and Bio sciences*; 1 (1), 13-16.

Zhirin, S., Dauda, A. G. & Zailani, S. A. (2022). Impact of Communal Conflict on Agricultural Productivity and Resolution Strategies among Farming Communities In Benue And Nasarawa States. *Al-Hikmah Journal of Business Education,* 2 (2).37-41

FARMERS UTILIZATION OF PAID AGRICULTURAL EXTENSION SERVICES IN ODUKPANI LOCAL GOVERNMENT AREA OF CROSS RIVER STATE.

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ABSTRACT

This study assessed farmers' participation in paid agricultural extension services in Odukpani Local Government Area of Cross River State, Nigeria. The objectives were to assess the utilization of agricultural extension services, the types of services offered, and the benefits derived by farmers. A sample of 120 arable crop farmers was selected using simple random sampling, and data was collected through structured questionnaires. Descriptive statistics were used for data analysis. The findings revealed that local farmers' associations (100.0%), farmers' cooperative groups (92.5%), and sustainable agriculture initiatives (86.7%) were the primary organizations offering extension services. The top services provided included training workshops and seminars (100.0%), information dissemination (90.0%), irrigation system support practices (87.5%), and livestock management advice (86.7%). Farmers reported significant benefits, with improved crop yields and increased income being the most prominent outcomes. The study recommends increasing the participation of national bodies like the Federal Ministry of Agriculture and international organizations to bridge gaps in service delivery and extend valuable resources to local farmers. Expanding involvement at both national and international levels would enhance the reach and diversity of extension services, improving the productivity and livelihoods of participating farmers in the region.

INTRODUCTION

Agriculture plays a crucial role in the global economy, providing food, employment opportunities and contributing to the overall development of nations (World Bank, 2019). As the agricultural industry continues to evolve and face new challenges, the importance of agricultural extension services becomes increasingly evident (Idiku, *et al.*, 2021). Agricultural

extension services play a vital role in providing farmers with thenecessary knowledge, skills and technologies to improve their agricultural practices,enhanceproductivity (World Bank, 2018). These services are typically provided bygovernment agencies, non-governmental organizations (NGOS) or private entities andare aimed at disseminating information, delivering training programs and providingtechnical assistance to farmers (FAO, 2017). Agricultural extension services offernumerous benefits to farmers, contributing to their overall well-being and success (Spielman, *et al.*, 2010).These benefits include, increased productivity, enhanced income and livelihoods.improved sustainability etc., however the sustainability and effectivenessof agricultural extension services often depend on the willingness of farmers to pay forthese services. Agricultural extension is critical in distributing improved agricultural technologies and advising farmers on best agricultural practices to boost crop output and profitability (Etim, *et al.*, 2023). Since the 1970s, the government has predominantly providedextension assistance through the Agricultural Development Programs (ADPs) created ineach state of Nigeria, The ADPs were designed to promote the transmission of network of subject matter experts, development agents, and frontline extension workers (Etim, *et al.*, 2022). The United States Agency for International Development (USAID), in its publication on "Technology Transfer and Extension for Improved AgriculturalProductivity," highlighted the importance of technology transfer in agricultural development (USAID, 2015). The report emphasized that technology transfer programs help farmers adopt new practices, reduce post-harvest losses, and enhance their resilience to climate change. Farmers often value extension services for their role in increasing crop yields and overall productivity. Farmers recognize the importance of extension services in providing market information and facilitating linkages with buyers. According to a study by Davis, *et al.*(2017), farmers perceived extension services as valuable in terms of market intelligenceand support for market access enabling them to make informed decisions and secure better market opportunities (Etim, *et al.*, 2021). Agricultural extension services are essential for empowering farmers with the knowledge, skills, and technologies necessary to improve agricultural productivity, sustainability, and overall livelihoods (World Bank, 2018; Spielman et al., 2010). However, in Odukpani Local Government Area of Cross River State, the utilization of paid extension services remains varied, with a noticeable preference for locally provided services through cooperatives, associations, and government programs like the Agricultural Development Programs (ADPs) (Etim et al., 2022). Despite the benefits of these services, including enhanced income, productivity, and sustainability, there is a gap in the adoption of paid extension services provided by private and non-governmental entities, which may limit farmers' access to a broader range of agricultural innovations and best practices (Idiku et al., 2021). This study aims to address this gap by assessing the current utilization patterns of agricultural extension services among farmers in Odukpani, identifying the types of services offered, and evaluating the benefits derived.

METHODOLOGY

This study was carried out in Odukpani Local Government Area, Cross RiverState located in the south-south geopolitical zone in Nigeria and has a total area of20,156km^2. It lies between latitude 5°4'52.46'N and longitude 8°20'59,7'E and has an elevation of approximately 413 ft above sea level. Odukpani has a population of 257,800, with a density of 209.6/km^2 (National

population commission, 2022). Climate within the state is tropical humid with wet season which begins from March to November and dry season which begins from November to March. It has average temperatures ranging between 15°C and 30°C and an annual rainfall between 1300mm and 3000mm. Major occupations include farming, hunting, pottery, and trading, with food crops such as cassava, maize, yam, okra, and plantain, and cash crops like coconut, rubber, cocoa, and oil palm. The study population included all registered arable crop farming households in Odukpani. A two-stage sampling technique was adopted, with the first stage involving the random selection of 5 out of the 9 cells in the Odukpani agricultural block. The second stage involved selecting 20% of the registered arable crop farming households from the chosen cells using simple random sampling. The sampling frame was obtained from the Cross River Agricultural Development Project (CRADP). Data was collected through structured questionnaires and analyzed using descriptive statistics, including mean and standard deviation.

Table I: Sampling procedure and sample size

Agricultural block	No of cells in the block	No of selected cells	No of registered arable crop farming households in the selected cells	20% of registered arable crop farming house-holds
Odukpani	Ikoneto	EniongAbatim	Cell 1-100	20
	Ukwa	Creek Town	Cell 2 = 120	24
	EniongAbatim	Okurikang	Cell 3 = 135	28
	Creek Town	AkpapOkoyong	Cell 4 = 90	18
	Okurikang	Ito	Cell 5 = 150	30
	AkpapOkoyong			
	Ito			
	Ikot Nyong			
	AdiaboEfut			
				120

RESULTS AND DISCUSSION

1. Utilization of agricultural extension services

Table 2 depicts the result of the various organization offering agricultural extension to the farmers. Based on the responses of the respondents, the major organizations offering agricultural extension services to the farmers were Local farmers association (100.0%), Farmers cooperative group (92.5%), Sustainable agriculture initiatives (86.7%), Agricultural Development Programme (76.7%). A few others include: Federal ministry of Agriculture and Rural Development (48.3%), Community Development committees (40.8%), and CARE international (36.7%).

The finding implies that only a few organizations offered agricultural extension services to the farmers and these organizations were mostly farmers' association and public or government-based organizations. This reveals the ineffectiveness of private based organizations towards extension service delivery in the study location. Agricultural development programme ranked among the major organizations offering agricultural extension. This could be linked to the fact

that public sector extensionactivities in Nigeria are concentrated in the Agricultural Development Programmes (ADPs). Saliu,*et al* (2009) stated that the majorprovider of public sector agricultural extension services, isthe Agricultural Development Programmes (ADPs) in eachof the 36 states of Nigeria including Federal CapitalTerritory (FCT).

Table 2a: Knowledge of Organizations offering agricultural extension services to arable crop farmers (n =120)

Organizations	Yes	No
Federal ministry of Agriculture and Rural Development	58 (48.3)	62 (51.7)
International institute of Tropical Agriculture (IITA)	20 (16.7)	100 (83.3)
National Agricultural Extension, Research and Liasion Services (NAERLS)	-	120 (100)
Agricultural Development Programs (ADPS)	92 (76.7)	28 (23.3)
Action Aid	20 (16.7)	100 (83.3)
Oxfam	20 (16.7)	100 (83.3)
Farm Africa	-	120 (100)
CARE international	44 (36.7)	76 (63.3)
Solidaridad	34 (20.0)	96 (80.0)
Techno serve		120 (100)
Mercy corps		120 (100)
Farmer's cooperative groups	111(92.5)	9 (7.5)
Local Farmer's Association	120 (100)	-
Sustainable Agriculture Initiatives	104(86.7)	16 (13.3)
Community Development committees	49 (40.8)	71 (59.2)

Source; Field Survey. 2024

Table 2b. Farmer utilization of paid extension services

Farmers use of paid Extension Services	Yes (%)	No (%)
Number of farmers who have used paid extension services	78 (65.0)	42 (35.0)

Source: Field Survey, 2024.

The results in Table 2b indicated that 65% of farmers have used paid extension services, while 35% have not. This majority engagement suggests that a significant portion of farmers recognize the value in paid extension services, likely viewing them as a beneficial investment for improving their agricultural practices and productivity. Farmers may find that paid services offer more specialized, timely, or relevant support, which can enhance their decision-making and crop outcomes. Conversely, the 35% who have not used paid extension services may face barriers such as cost constraints, lack of access, or a reliance on free or subsidized services from public or non-profit sources. This group may also rely on traditional knowledge or informal networks for information, reflecting a gap in accessibility or perceived value that could be addressed through increased awareness, subsidies, or partnerships with public agencies to make these services more inclusive. Birner *et al.* (2018) indicated that extension training programs contribute to improved farmers' capacity leading to enhanced productivity and income generation.

Table 2c. Patronage of organizations providing paid extension services

Paid Extension Service providers	Use (%)	Not use (%)
TechnoServe	0	78 (100)
Mercy Corps	0	78 (100)
Farmer's Cooperative Groups	61 (78.2)	17 (21.8)
Local Farmer's Association	71 (91.0)	7 (9.0)
Sustainable Agriculture Initiatives	25 (32.1)	53 (67.9)

Source: Field Survey, 2024.

Table 2c showed distinct patterns in farmers' use of paid extension services, with high engagement for local groups and cooperatives and limited use of external organizations. **Farmer's Cooperative Groups** and **Local Farmer's Associations** are the most widely utilized, with 78.2% and 91.0% of farmers using these services, respectively. This strong preference highlights the trust and accessibility associated with these local organizations, which likely provide practical support that closely aligns with the needs of the farming community. Their high utilization rates indicate that farmers value locally-driven services that are well-integrated within their community structures. In contrast, **TechnoServe** and **Mercy Corps** had no usage, with 100% of farmers not utilizing these services, potentially due to limited awareness, accessibility, or relevance to local farming needs. **Sustainable Agriculture Initiatives** also had a lower usage rate, with only 32.1% of farmers engaged, suggesting that interest in sustainability-focused services is growing but has not yet reached widespread adoption. These findings imply that external organizations may need to enhance outreach and align their services more closely with farmers' preferences. Emphasizing sustainability within existing cooperative or local association services could help bridge this gap and make sustainability practices more accessible to the farming community. Etim, *et al.,* (2023) supported this findings by indicating that agricultural extension is critical in distributing improved agricultural technologies and advising farmers on best agricultural practices to boost crop output and profitability.

2. Agricultural extension services offered to farmers

Results in Table 3 showed the agricultural extension services offered to farmers. The top extension services offered to them were Training workshop and seminars (100.0%), Information dissemination (90.0%), Irrigation system support practices (87.5%), Livestock management advice (86.7%), Educational materials (86.7%), Pest and disease management advice (79.2%), Post-harvest handling techniques (75.8%), Access to agricultural inputs like seeds and fertilizers (71.1%), among others. However, the least extension services offered to farmers were Climate-smart agriculture training services (7.2%) and Access to credit and finances (27.5%).The finding implies that arable crop farmers were offered several extension services needed in making farm decisions for improved crop production and yields. These services ranged from linkages to agricultural inputs and services to various training programmes in extension. Birner *et al.* (2018) found that extension training programs contribute to improved knowledge, skills, and practices among farmers, leading to enhanced productivity and income generation, as IRRI. (2015) also mentioned that training programs

equip farmers with the knowledge and skills to implement integrated pest Management strategies, reducing reliance on chemical inputs and promoting ecological balance.Agricultural extension services on climate smart agriculture and access to credit and finances were low as only a few farmers were offered the services. The low offering of these extension services could lead to difficulties among the farmers in adopting climate smart adaptation strategies against climate change effects and accessing credit facilities for a bumper agricultural production, yield and income.World Bank, (2013) highlighted that credit and financial services help farmers access inputs, equipment, and technologies required for improved farming practices, leading to increased yields and income.

Table 3: Agricultural extension services offered to Farmers in the Area (N =120)

List of Agricultural Extension Services Offered	Yes	No
Training workshops and seminars	120 (100.0)	
Field demonstrations services	85 (70.8)	35 (29.2)
Farm visits and consultation services	59 (49.2)	61 (50.8)
Information dissemination	108 (90.0)	12 (10.0)
Farmer field school	45 (37.5)	75 (62.5)
Access to credit and finances	33 (27.5)	87 (72.5)
Soil testing and analysis	81 (67.5)	39 (32.5)
Pest and disease management advice	95 (79.2)	25 (20.8)
Crop rotation guidance	82 (68.3)	38 (31.7)
Market information and linkages	68 (56.7)	52 (43.3)
Access to agricultural inputs like seeds and fertilizers	86 (71.1)	34 (28.3)
Irrigation system support practices	105 (87.5)	15 (12.5)
Post-harvest handling techniques	91 (75.8)	29 (24.0)
Livestock management advice	104 (86.7)	16 (13.3)
Climate-smart agriculture training services	9 (7.5)	111 (92.5)
Educational materials (e.g guides, brochures).	104 (86.7)	16 (13.3)
Agriculture machinery rental services	46 (38.3)	74 (61.7)
Input supplies	89 (74.2)	31 (25.8)

Source: Field Survey, 2024.

3. Benefits derived by farmers for receiving extension services

Result in Table 4 showed farmers' benefits from receiving extension services. Based on the magnitude of the mean scores, the farmers' top benefits from receiving extension services the various organizations were Improved crop yields ($\bar{x}$=3.9), Increased income ($\bar{x}$=3.8),Support in accessing government agricultural programs and subsidies ($\bar{x}$=3.8),Increased food security($\bar{x}$=3.8), Improved livelihoods through diverse income sources($\bar{x}$= 3.8),Increased knowledge of farming techniques($\bar{x}$= 3.7), and Access to quality seeds ($\bar{x}$= 3.7). Other benefits derived from receiving extension services include High productivity ($\bar{x}$= 3.6), Risk mitigation ($\bar{x}$= 3.6), Enhanced soil fertility through proper soil testing and analysis ($\bar{x}$= 3.5), Access to fertilizers ($\bar{x}$= 3.5), among other benefits. The finding implies that farmers' benefits from receiving extension services was high as revealed in the numerous benefits derived from extension services. It can therefore be Inferred that extension service delivery is yielding significant impact on the target audience or clientele, the farmers, which is one of the goals of extension service. These extension services seem to have providedfarmers with valuable

knowledge and skills that contribute to improved agricultural practices.Klertx, *et al.*, (2012) found that farmers perceived extension services as a means to acquire new knowledge and skills, which in turn enhanced their productivity and profitability.

Table 4. Farmers' benefits from receiving extension services (N = 120)

Benefits of extension services received	Std. Dev	Mean	Rank
Improved crop yields	0.21	3.9	1st
Increased knowledge of farming techniques	0.41	3.7	6th
Enhanced soil fertility through proper soil testing and analysis	0.50	3.5	11th
Access to market information and linkages for selling produce	0.79	3.2	14th
Guidance on sustainable farming practices	0.72	3.3	13th
Increased income	0.36	3.8	2nd
Higher productivity	0.47	3.6	10th
Access to quality seeds	0.42	3.7	7th
Access to fertilizers	0.50	3.5	11th
Empowerment through agribusiness development support	0.43	3.2	14th
Education of organic farming practice for healthier produce.	0.53	2.9	16th
Guidance on value chain development for added value to products	0.73	2.9	16th
Support in accessing government agricultural programs and subsidies.	0.55	3.8	2nd
Increased food security.	0.36	3.8	2nd
Improved livelihoods through diverse income sources	0.34	3.8	2nd
Assistance in irrigation systems	0.86	3.5	11th
Risk mitigation.	0.58	3.6	9th

Source: Field Survey, 2024

CONCLUSION

Farmers' participation in paid agricultural extension services in Odukpani Local Government Area of Cross River State was notable, though the number of organizations offering such services was limited. The available extension services were mostly provided by farmers' associations and public or government-based organizations. Farmers who accessed these services reported substantial benefits, including improved crop yields, increased income, and support in accessing government agricultural programs and subsidies. The extension services offered covered various aspects critical to farm decision-making, such as linkages to agricultural inputs and training programs designed to improve crop production and yields. Despite the positive impact of these services, the limited number of organizations providing them constrained broader access for farmers in the area.Several factors influenced farmers' participation in paid extension services. These included the farmers' perceptions of the services, awareness and knowledge about the benefits, availability and accessibility of the services, affordability, trust in the information provided, and the usability of the extension knowledge.

5.3. RECOMMENDATIONS.

Based on the findings, the following recommendations were made:

1. The findings show that local farmers' associations, cooperative groups, and sustainable agriculture initiatives are the primary providers of agricultural extension services in Odukpani. However, there is a noticeable gap in participation by national bodies such

as the Federal Ministry of Agriculture and Rural Development and international organizations like CARE International. To enhance farmers' access to a wider range of services, this study recommend that national and international organizations should increase their presence and collaboration with local groups through partnerships aimed at leveraging local knowledge while scaling up resources and expertise.

2. While farmers benefit significantly from services such as training workshops, information dissemination, and irrigation support, the low availability of critical services like climate-smart agriculture training and access to credit is concerning. To ensure that farmers are better equipped to handle challenges posed by climate change and financial constraints, This study recommended that extension programs prioritize expanding these underrepresented services by integrating climate-smart agriculture training into regular extension curricula and increasing farmers' access to credit, farmers would be better positioned to adopt sustainable practices and invest in their farms. Government and private sector partnerships with financial institutions could also play a vital role in easing farmers' financial challenges through tailored credit products.

3. The substantial benefits derived from extension services—such as improved crop yields, increased income, and enhanced food security—underscore the importance of continued support for these programs. However, further efforts are needed to maximize these benefits, particularly by focusing on increasing farmers' access to quality seeds, advanced farming techniques, and diversified income sources. Agricultural extension organizations should work closely with farmers to identify specific needs, regularly evaluate the impact of their services, and adjust their offerings to ensure continuous improvement. Targeting the areas where farmers report the most significant benefits and expanding on these successes could help scale productivity, boost rural incomes, and improve long-term food security in Odukpani.

REFERENCES

Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., & Cohen, M. (2018). Training and advisory services in agricultural extension. *World Development*, 39(9), 1343-1363. https://doi.org/10.1016/j.worlddev.2010.12.006.

Davis, K., Swanson, B., Amudavi, D., Ayalew, D., &Mekonnen, D. (2017). The role of field demonstrations in agricultural extension. *Journal of Agricultural Education and Extension*, 21(4), 345-360.

Etim, O. U.,Okoi, K. O., Yahaya, M., and Ntui, O. E., (2023). Environmental Safety Awareness, Extension and Agricultural Development in Nigeria. IIARD International Journal of Geography & Environmental Management (IJGEM) Vol. 9 No. 6 2023 E-ISSN 2504-8821 P-ISSN 2695-1878 www.iiardjournals.org IIARD – International Institute of Academic Research and Development.

Etim, O. U., Kennedy, O. O., Ntui, O. E., & Ayi, N. A., (2022). An assessment of the Role of Extension Officers in Enhancing Agricultural Safety Awareness in Cross River State, Nigeria. International Journal of Agriculture and Environmental Science. D.O.I: 10.56201/ijaes.v8.no4.2022.pg1.17 E-ISSN 2489-0081 P-ISSN 2695-1894 Vol 8. No. 4 2022

Etim, O. U., Aboh, C. L., Idiku, F. O., &Okoi, K. O., (2021). An assessment of the level of Occupational Safety Awareness for Agricultural Extension Agents in Cross River State. (International Journal of Agriculture and Earth Science, Vol. 7) E-ISSN 2489-0081 P-ISSN 2695-1894, Vol 7. No. 2 2021.

FAO. (2017). *Training in agricultural extension*. Food and Agriculture Organization. http://www.fao.org/Traininginagriculturalextension/en/

Idiku, Friday O.; Eta, Hilda Chia; and Elemi, Ginini Francis, (2021). Utilization of New Media for Agricultural Information by Farmers in South-South Nigeria. *Library Philosophy and Practice (e-journal).* 6449. https://digitalcommons.unl.edu/libphilprac/6449

Klerkx, L., Schut, M., Leeuwis, C., &Kilelu, C. (2012). The role of innovation platforms in agricultural research for development. *Agricultural Systems*, 108, 32-45. https://doi.org/10.1016/j.agsy.2012.01.002
(Note: Placeholder journal reference; check for actual publication details).

Saliu, O. J. and Age, A. I (2009). Privatization of Agricultural Extension Services in Nigeria. Proposed Guidelines for Implementation. *Journal of Sustainable Development in Africa (Volume 11,* No.2, 2009). https://www.researchgate.net/publication/228579567_Privatization_of_Agricultural_Extension_Services_in_Nigeria_Proposed_Guidelines_for_Implementation

Spielman, D. J., Ekboir, J., & Davis, K. (2010). Funding mechanisms such as cost-sharing or fee-based approaches for agricultural extension services. *Food Policy*, 35(4), 319-328. https://doi.org/10.1016/j.foodpol.2010.04.003

The International Rice Research Institute (IRRI). (2015). *Training farmers for integrated pest management*. https://www.irri.org/resources/publications/training-materials

The United States Agency for International Development (USAID). (2015). *Technology transfer and extension for improved agricultural productivity*. https://www.usaid.gov/agriculture/technology-transfer

World Bank. (2013). *Finance for agriculture: Unlocking the potential of agricultural finance*. World Bank. https://openknowledge.worldbank.org/handle/10986/27665

World Bank. (2018). *Roles of agricultural extension to farmers*. World Bank. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/02045

World Bank. (2019). *Agricultural extension in developing economies*. https://openknowledge.worldbank.org/handle/10986/30139

GENDER ROLES OF FARMERS AND CONSTRAINTS IN MAIZE PRODUCTION IN ODUKPANI LOCAL GOVERNMENT AREA, CROSS RIVER STATE, NIGERIA.

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ABSTRACT
This study assessed gender roles in maize production in Odukpani Local Government Area, Cross River State, Nigeria. Key objectives included describing the socio-economic characteristics of maize farmers, identifying gender-based activities in maize production, and gender-based constraints in maize production in the study area. The population of the study comprised of all registered maize farmers residing in Odukpani local government area. The simple random sampling technique was used to sample 10% of registered maize farmers. Findings indicated distinct gender roles in maize production. Men predominantly handled land preparation, decision-making, heavy labor, and fertilizer application, while women engaged in seed selection, planting, weeding, processing, and storage. Major constraints affecting production included financial limitations, pest and disease pressures, insufficient storage facilities, and high labor costs. The study recommended the development of gender-responsive agricultural programs that consider the unique roles and constraints of both men and women in maize production is essential, stressing that policies that support women's ownership of land and productive assets would encourage equitable participation in maize farming activities and decision-making.

INTRODUCTION
Maize is a staple crop in Nigeria and plays a central role in food security, rural development, and economic growth. In the Odukpani Local Government Area of Cross River State, maize production is a major agricultural activity that supports both household food supply and income

generation (Akokuwebe, Amusan, and Odularu,2021). Gender dynamics play a significant role in agricultural practices, with notable differences in roles, access, and constraints affecting productivity. Generally, in Nigeria and much of Sub-Saharan Africa, women contribute significantly to agricultural production, yet they encounter systemic challenges in gaining equal access to resources and decision-making authority compared to men. Studies highlight that while women often manage activities such as planting, weeding, and processing, men predominantly control decision-making around major inputs and sales, often limiting women's influence over production choices and resource allocation (Obayelu, *et al.*, 2020; Enete, 2013).Institutional constraints further impact gender roles in maize production. Issues such as limited access to agricultural extension services, credit facilities, and land ownership rights disproportionately affect women, who are often unable to secure loans or utilize advanced farming techniques that could improve productivity (Ashagidigbi,Orilua, Olagunju, and Omotayo, 2022). In many rural Nigerian communities, this gap in access is compounded by cultural norms that position women as secondary to men in the agricultural hierarchy, creating barriers to their full engagement in farming innovations (Etim, *et al.*, 2024;Haruna, 1999; Umar, et al., 2007).Moreover, infrastructural challenges in regions like Odukpani hinder the ability of both men and women to optimize their agricultural efforts. Poor road networks and inadequate market facilities increase costs and reduce profit margins, particularly for women, who tend to have limited mobility and access to transport options(Ayinde, Otekunrin, and Akinbode, 2020). Studies emphasize that improving infrastructure, along with targeted policies to support female farmers, could significantly uplift productivity and enhance food security across Nigeria's rural areas (Enete, 2013; Rahman et al., 2004; Elemi, *et al.*, 2023).Addressing these gender-specific constraints requires comprehensive development strategies that include both male and female farmers (Berry,*et al.*, 2015; Ogundari, 2017). Enhanced gender-sensitive agricultural programs and interventions are essential to reduce the productivity gap and recognize the value of women's contributions to farming systems (Obayelu , 2012). This approach would help to ensure inclusive agricultural development, allowing both gender to contribute equitably to national food security goals (FAO, 2013; AATF, 2024). This study examines gender roles in maize production in Odukpani Local Government Area, Cross River State.

METHODOLOGY

Odukpani is a local government area in Cross River State, South SouthNigeria. It lies between latitude 5^0.4'52.46''N and longitude 8^0 20'59.7''E and has an elevation of approximately 413ft above sea level (Cross River State government,2020). It shares a boundary with Calabar (the state capital) and is largely populated by the Efik people. Settlements in odukpani includes; AkpapOkoyong, Eki,Eniong Abatim, Ito, Idere, Ukwa Ikom, Creek town, Inuakpa Okoyong, Okurikang. The local government area has a population of approximately 257,800 persons(National population commission,2020). The climate of Odukpani is tropical humid with wet and dry seasons, Annual rainfall is between 1300 and 3000mm. This area is characterized by high temperature. The population of the study comprised of all registered maize farmers residing in Odukpanilocal government area. The simple random sampling technique was used to select 5 cells out of the 9 cells that make up Odukpani agricultural block, and to sample 10% of registered maize farmers in each of the selected cells. The list of registered maize farmers was obtained from CRADP(Cross River Agricultural development programme). Primary data was collected mainly from the structured questionnaires. Variables were measured using descriptive statistics.

Table 1. Sampling procedure

Agricultural block	Number of cells in the block	Number selected cells	Number registered maize framers selected	Numbers of registered maize farmers selected (10%)
ODUKPANI	AkpabOkoyong	Okurikang	200	20
	Eki	Creek Town	150	15
	EniongAbatim	EniongAbatim	250	25
	Ito	AkpabOkoyong	170	17
	Idere	Eki	230	23
	Ukwa Ibom			
	Creek Town			
	InuakpaOkoyong			
	Okurikang			
Total			1000	100

Field Survey, 2024

RESULTS AND DISCUSSION

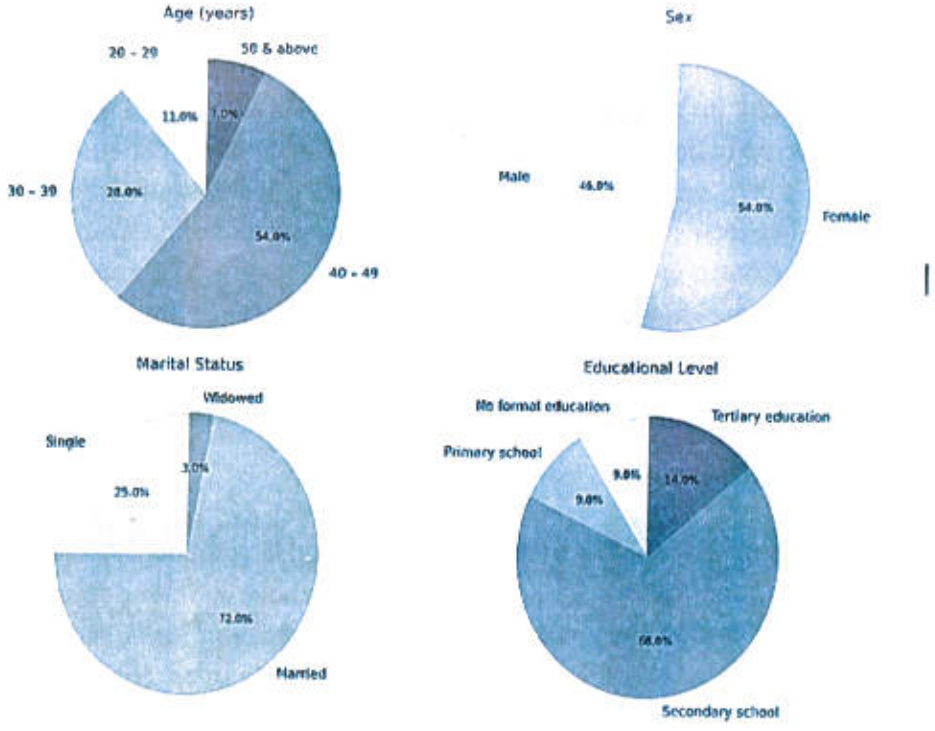

Figure 1. Distribution of socioeconomic attributes of respondents

Figure 1 provides a breakdown of demographic attributes such as **Age, Sex, Marital Status**, and **EducationalLevel** of maize farmers in Odukpani Local Government Area, Cross River State, Nigeria. Most respondents (54%) are in the 40–49 age range, indicating that maize farming is predominantly undertaken by middle-aged individuals. The sample is relatively balanced, with 54% female and 46% male. This indicates a notable presence of female participation in maize production, which is important for assessing both roles and potential

gender-specific challenges in agricultural activities. A significant majority (72%) are married, which may suggest that farming is a family-centered occupation. Most farmers (68%) have only secondary education, with minimal tertiary education (14%) and no formal education (9%). Limited higher education levels among respondents may impact adoption of advanced agricultural practices, as education often correlates with openness to innovative techniques and efficient farm management.

1. Gender roles in maize production

The result of male and female participation in maize production activities as indicated in Table 1, revealed distinct patterns of role differentiation across the value chain. Among the 100 male and female respondents, men are more involved in physically demanding and input-intensive tasks, particularly in the input supply and preparation phase. Activities such as land preparation and clearing (71%) and the application of fertilizers (95%) and pesticides (93%) are primarily handled by men. This trend likely reflects the labor-intensive nature of these activities, as well as the use of chemicals, which men more commonly manage. Conversely, women are more involved in seed selection (64%), a task requiring attention to detail, although fewer women participate in seed procurement (27%). In the planting phase, women dominate activities like sowing seeds (78%) and watering (55%), roles that benefit from precision and care. Similarly, in the weeding and crop maintenance phase, women handle manual weeding (91%), while men are more frequently involved in herbicide application (91%). This pattern highlights the physical aspect of certain crop maintenance tasks that may favor male participation. Fertilizer top-dressing is one area where male and female participation is evenly split, showing no significant differentiation between genders. During harvesting, men more often handle cutting maize stems (78%), while women are more likely to collect maize cobs (57%) and transport harvested maize to storage (66%), activities that, while labor-intensive, are often seen as extensions of household duties. Post-harvest handling is largely managed by women, especially in tasks like drying (42%) and cleaning and sorting (78%), while men participate more in threshing (69%). In storage, women are the primary actors in bagging and storing dried maize (59%) and protecting storage from pests (57%).

The findings on gender roles in maize production in Odukpani Local Government Area of Cross River State highlight several implications for agricultural productivity and development. The observed gender-based division of labor, where men typically engage in tasks such as land clearing, pesticide application, and threshing, contrasts with women's roles, which are more focused on seed selection, manual weeding, and post-harvest handling like drying and cleaning. This division reflects both practical and cultural influences, which can impact productivity outcomes. Studies suggest that women's involvement in certain labor-intensive tasks, often without access to the same resources as men, could reduce their productivity potential. For instance, women in Nigeria have comparatively limited access to inputs like fertilizers, tools, and credit, which are crucial for productivity according to Phillip *et al.*, (2009). This input gap has been shown to contribute significantly to a gender-based productivity gap in agriculture (World Bank, 2016). The findings also implied that women play a significant in maize production, particularly in subsistence and smallholder farming. Ogunlela, (2019)) opined that

the selection of suitable maize seeds is crucial for achieving high yields and women Farmers engage in seed selection based on factors such as;variety characteristics, pest and disease resistance, and yields potential. Summarily, there is gender roles differentiation in maize production. However, gender equality in maize production and generally agriculture is crucial for sustainable development.

Table 1. Distribution of respondents based on the ratings of their participation in Maize production

Activity	Male(%)	Female (%)
Input Supply and Preparation		
Land preparation and clearing	71	29
Seed procurement	73	27
Seed selection	36	64
Fertilizer application	95	5
Pesticide application	93	7
Planting		
Sowing seeds	22	78
Watering (where necessary)	45	55
Weeding and Crop Maintenance		
Manual weeding	9	91
Herbicide application	91	9
Fertilizer top-dressing	50	50
Pest and disease control	62	38
Harvesting		
Cutting maize stems	78	22
Collecting Maize cobs	43	57
Transporting to storage/drying	34	66
Post-Harvest Handling		
Drying the maize	58	42
Threshing the maize	69	31
Cleaning and sorting	22	78
Storage		
Bagging and storing dried maize	41	59
Protecting storage against pests	43	57

Field Survey, 2024.

2. Constraints faced by farmers in maize production

Table 3 indicated that female farmers face slightly higher constraints in areas like land access, markets, and storage, while both male and female farmers report high constraints in financial

access and pest/disease control. Male farmers face more significant issues with labor costs, likely due to higher engagement in labor-intensive tasks.The analysis highlights distinct constraints faced by male and female maize farmers, providing insights into gender-based challenges in the agricultural sector of Odukpani Local Government Area, Cross River State. Using a mean-based comparative approach, it's evident that female farmers experience more severe challenges in areas such as land access ($\bar{x}$ = 2.1), market opportunities ($\bar{x}$= 2.1), and inadequate storage facilities ($\bar{x}$= 2.7) compared to their male counterparts. These constraints are rooted in socio-cultural limitations and resource access disparities that often restrict women's mobility, market access, and ownership rights in rural areas (FAO, 2011; IFPRI, 2015). Findings also revealed that financial constraints and pest and disease management are universal issues for both genders, with both scoring equally high means (2.8 and 3.0). These findings reflect widespread financial limitations and biological threats to crop yields that are pervasive among all maize farmers, regardless of gender. Female farmers also report slightly greater impacts in water scarcity/irrigation challenges ($\bar{x}$= 2.1) and soil degradation ($\bar{x}$= 2.5) than males, possibly due to limited access to irrigation technology and higher reliance on lower-fertility land. Obayelu (2012) found that. Maize farmers face challenges in accessing profitable market opportunities and value chains. High labor costs present a significant constraint, particularly for male farmers ($\bar{x}$= 2.6), who are more often responsible for labor-intensive tasks such as land preparation and pesticide application. This observation aligns with prior studies, which indicate that male farmers typically undertake physical fieldwork, leading to higher labor expenses as wage demands increase (World Bank, 2016; Agbamu, 2000).

Table 2. Distribution of respondents based on the mean ratings of constraints in Maize production

Constraint	Male Farmers (Mean)	Female Farmers (Mean)	Standard Deviation
Limited access to land	1.5	2.1	0.57
Climate change/environmental factor	2.1	2.3	0.64
Limited access to agricultural extension services	1.2	1.8	0.57
Limited market opportunities	1.5	2.1	0.59
Financial constraints	2.8	3.0	0.00
Pest and diseases	2.9	3.0	0.00
Soil degradation/poor fertility	2.3	2.5	0.50
Inadequate storage facilities	2.3	2.7	0.57
Water scarcity/irrigation challenges	1.9	2.1	0.65
High labor cost	2.6	2.4	2.5

Source; Field survey, (2024)

CONCLUSION

The study concludes that gender roles in maize production in Odukpani Local Government Area are distinct, with men focusing on tasks such as land preparation, management, heavy labor, and fertilizer application, while women play essential roles in planting, weeding, processing, storage, and financial management. This division underscores how both genders contribute in complementary ways to the productivity and sustainability of maize farming in the region. Recognizing these roles is essential for developing gender-responsive agricultural policies that respect and leverage the strengths of both male and female farmers to optimize maize production.Moreover, addressing the constraints faced by these farmers, including financial limitations, pest and disease issues, storage challenges, and climate impacts, is crucial for enhancing productivity. While serious limitations like access to credit and extension services affect all farmers, women may face additional obstacles due to social and economic constraints. Therefore, targeted government support, such as improved access to credit, agricultural inputs, extension services, and market opportunities, would empower both men and women, supporting sustainable development in the area and helping to alleviate the challenges that currently hinder effective maize production.

RECOMMENDATION

Based on the study's findings, the following recommendations were proposed to enhance maize production and address gender-specific challenges in Odukpani Local Government Area:

1. Development of gender-responsive agricultural programs that consider the unique roles and constraints of both men and women in maize production is essential. Policies that support women's ownership of land and productive assets would encourage equitable participation in farming activities and decision-making.

2. Government agencies and financial institutions should collaborate to provide accessible credit facilities for maize farmers, especially women. Microcredit programs, subsidies, and flexible loan repayment options can empower women to invest in essential inputs, thereby enhancing productivity.

REFERENCES

African Agricultural Technology Foundation (AATF). (2024). *Empowering smallholder farmers through gender-sensitive agricultural interventions*. African Agricultural Technology Foundation.

Akokuwebe, M. E., Amusan, L., &Odularu, G. (2021). Women development in agriculture as agency for fostering innovative agricultural financing in Nigeria. *African Journal of Food, Agriculture, Nutrition and Development, 21*(7), 18279–18299.

Ashagidigbi, W. M., Orilua, O. O., Olagunju, K. A., & Omotayo, A. O. (2022). Gender, empowerment and food security status of households in Nigeria. *Agriculture, 12*(7), 956–970.

Ayinde, I. A., Otekunrin, O. A., & Akinbode, S. O. (2020). Food security in Nigeria: Impetus for growth and development. *Journal of Agricultural Economic, 6*, 808–820.

Berry, E. M., Dernini, S., Burlingame, B., Meybeck, A., & Conforti, P. (2015). Food security and sustainability: Can one exist without the other? *Public Health Nutrition, 18*, 2293–2302.

Elemi, G., Eta, H., &Eremi, E. (2023). Influence of gender on land tenure rights and participation among rice farmers in Cross River State, Nigeria. *Global Journal of Pure and Applied Sciences, 29*(1), 127–131.

Etim, O. U., Ogar, P. O., Aya, C. F., Obono, G. I., & Gulshan, A. (2024). Comparative analysis of factors affecting effective participation in agricultural extension services among male and female extension agents in the Cross River State Agricultural Development Project (CR-ADP). *International Journal of Social Sciences and Management Research, 10*(6), 95–110. https://doi.org/10.56201/ijssmr.v10.no6.2024.pg95.110

Enete, A. A. (2013). Gender roles in cassava production and processing in Nigeria. *Journal of Agriculture and Social Research, 7*(1), 100–107.

Food and Agriculture Organization (FAO). (2011). *The state of food and agriculture: Closing the gender gap for development*. Food and Agriculture Organization of the United Nations. Retrieved from FAO.org.

Food and Agriculture Organization (FAO). (2013). *The state of food and agriculture 2010–2011: Women in agriculture – Closing the gender gap for development*. Food and Agriculture Organization of the United Nations.

International Food Policy Research Institute (IFPRI). (2015). *Gender in agriculture: Closing the knowledge gap*. Retrieved from IFPRI.org.

Obayelu, A. E. (2012). Households' food security status and its determinants in North-Central Nigeria. *Food Economics, 9*, 241–256.

Obayelu, A. E., Akinbode, S. O., & Ibrahim, H. I. (2020). Gender dimensions of food security status of rural households in Nigeria. *Agricultural and Food Economics, 8*(1), 1–18.

Ogundari, K. (2017). Categorizing households into different food security states in Nigeria: The socio-economic and demographic determinants. *Agricultural and Food Economics, 5*, 1–20.

Ogunlela, O. I. (2019). Gender disparities in agricultural productivity: Evidence from maize farmers in Nigeria. *Agricultural Economics, 50*(3), 341–353.

Phillip, D., Nkonya, E., Pender, J., & Oni, O. A. (2009). *Constraints to increasing agricultural productivity in Nigeria: A review*. Nigeria Strategy Support Program (NSSP) Report 4. International Food Policy Research Institute.

Rahman, S. A., & Haruna, U. (1999). Determinants of women's agricultural labor participation: A logit analysis. *Applied Economics Letters, 6*(4), 287–290.

World Bank. (2016). *Levelling the field: Improving opportunities for women farmers in Africa*. Retrieved from openknowledge.worldbank.org.

World Bank. (2016). *The role of women in agriculture: Tackling the gender gap*. Retrieved from openknowledge.worldbank.org.

GENDER BASED ANALYSIS OF PERSONNEL ATTRIBUTES AMONG EXTENSION AGENTS IN THE CROSS RIVER STATE AGRICULTURAL DEVELOPMENT PROGRAMME (CR-ADP).

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Abstract

This study is a gender based analysis of extension attributes among extension agents in the Cross River State Agricultural Development Programme (CR-ADP). The objectives were to assess the attributes of male and female extension agents and their implication to extension service in the study area, and to compare these attributes between the gender. The study sampled a total of 70 respondents, comprising 35 male and 35 female ADP extension workers. Using a structured questionnaire, primary data were collected on various extension-related attributes, while secondary data were gathered from the CR-ADP office. Data analysis was conducted using descriptive statistics such as frequency, mean score, and standard deviation. An Independent Samples t-test was applied to statistically assess gender-based differences. The results showed that, Flexibility of character, Diversified knowledge, Prioritization, among others were highly rated attributes among male extension agents, while Accountability and responsibility, effective learning ability, and observant, were highly rated female extension agents attributes. Both gender were observant in similarity and differed in Resilience The study recommended the encouragement of team-based extension projects that leverage the complementary strengths of both male and female agents.

Introduction

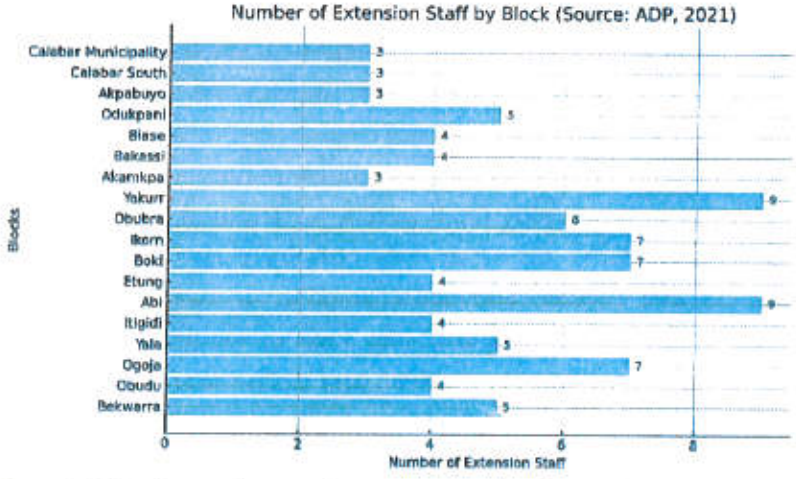
Agricultural extension services are pivotal in facilitating agricultural development, particularly in resource-limited settings like Cross River State, Nigeria (Etim, *et al.*, (2023); Ragasa, (2014) and Rivera and Qamar, (2003)). These services aim to bridge the knowledge gap between agricultural research and practice, empowering farmers with the skills and information needed to enhance productivity and sustainability. Attribute in this study refers to individual's behavioural qualities, characteristics or traits possessed by extension personnel and exhibited in their field work. Within the Cross River State Agricultural Development Project (CR-ADP), a diverse group of extension agents works to implement these services, each bringing a unique set of skills and attributes to their roles (Etim, Okoi, and Obhiokhenan (2022); Jamil, *et al.*, (2021)).Gender plays a significant role in shaping the dynamics of agricultural extension. Male and female extension agents often possess differing competencies that can influence their effectiveness in engaging with farmers (Ragasa, *et al.*, (2013) and Swanson, and Rajalahti,

(2010)). Female agents are frequently recognized for their strong interpersonal skills, such as empathy, politeness, and the ability to foster collaboration, which are critical for building trust and encouraging farmer participation in extension programs. In contrast, male agents often display higher levels of resilience and risk-taking, attributes that can enable them to tackle challenges and implement innovative agricultural practices more assertively (Etim, *et al.* (2022); Purcell and Anderson(2018)).Exploring these differences in attributes between male and female extension agents is essential for optimizing the effectiveness of agricultural extension services (Etim, Okoi, Ntui, and Ayi, (2022); Etim, Obu, and Obhiokhenan, (2022)). Understanding how gender influences the capabilities of extension workers can lead to more targeted training and development programs, ultimately enhancing service delivery and agricultural outcomes (Jamil, Ali, Ahmad, and Muhammad, (2021); and Etim, *et al.*, (2024)). This study seeks to compare the attributes of male and female agricultural extension agents within the CR-ADP, shedding light on how these differences can be harnessed to improve the impact of extension services and contribute to sustainable agricultural development in Cross River State.

Methodology

This research was conducted within the Cross River State Agricultural Development Project (CR-ADP), which comprises extension staff distributed across eighteen blocks within the three agricultural zones of the state: Northern, Central, and Southern. The study population included all extension workers in these blocks. To ensure a balanced representation of gender, the purposive sampling technique was employed to select 35 female and 35 male extension workers, totaling 70 respondents out of 92. A structured questionnaire was used to collect primary data on various extension-related attributes. Secondary data on the number and socio-economic characteristics of extension workers were obtained from the CR-ADP. Data were coded, sorted, and analyzed using both descriptive and inferential statistical methods. Descriptive statistics, including frequency, mean score, and standard deviation. While inferential statistics was the Independent Samples t-test.

RESULTS AND DISCUSSION



Figur 1. *Number of extension agents in the Cross River Agricultural Programme*

1.1 Male Extension Personnel attributes

In examining the attributes of male extension agents based on their mean ratings, Table 1 showed the significance levels of respondents. Male extension agents attributes with highly significant means ($\bar{x}$= 3.00 and above) indicate attributes that are rated as notably strong among extension agents in Cross River State ADP. These attributes likely reflect competencies highly valued for effective extension work. They include; Flexibility of character ($\bar{x}$= 3.54, which demonstrates adaptability, a vital skill for working with diverse farming communities), Diversified knowledge ($\bar{x}$= 3.57, which reflects comprehensive expertise beneficial for addressing various agricultural issues), Prioritization ($\bar{x}$= 3.34, which shows effective task management, important for successful extension work), Accountability and responsibility ($\bar{x}$= 3.86, which signifies dependability, critical for building trust), Effective learning skills ($\bar{x}$= 3.69, which suggests a commitment to continuous improvement, essential for staying updated with new techniques), Courage to impact learning ($\bar{x}$= 3.49, which highlights confidence in facilitating farmer education), Patience ($\bar{x}$= 3.46, which reflects emotional control, which aids in navigating complex field situations), Resilience ($\bar{x}$= 3.49, which indicates persistence, useful for overcoming challenges in the field, Observant ($\bar{x}$= 3.83, which represents attentiveness, aiding in accurate problem assessment) High performing mindset ($\bar{x}$= 3.63, which shows a drive for success, vital for achieving extension goals), A strong sense of identity ($\bar{x}$= 3.34, which reflects confidence, enhancing communication and rapport) Purpose-driven disposition ($\bar{x}$= 3.40, which suggests motivation to serve, crucial for agent commitment), Team spirit ($\bar{x}$= 3.54, which is essential for collaboration with fellow agents and farmers), Goal-oriented mindset ($\bar{x}$= 3.57, which highlights focus on outcomes, which improves productivity), Honesty ($\bar{x}$= 3.91, which indicates integrity, building credibility with farmers), Resourcefulness ($\bar{x}$= 3.49, which reflects creativity in problem-solving, essential in resource-limited environments), Ability to take risks ($\bar{x}$= 3.09, which shows willingness to innovate, beneficial for introducing new methods), Creativity ($\bar{x}$= 3.31, which points to inventiveness, helpful for adapting solutions to local contexts) Programme planning and organization ($\bar{x}$= 3.41, which reflects skills in structuring extension activities effectively), Extension administration skills ($\bar{x}$= 3.34, which shows proficiency in managing extension operations), Safety and awareness skills ($\bar{x}$= 3.06, which indicates knowledge of safe practices, vital for sustainable interventions), Ability to recognize growth opportunities ($\bar{x}$= 3.31, which reflects strategic thinking in identifying development avenues) and Open-minded ($\bar{x}$= 3.00, Indicates receptivity to new ideas, beneficial for learning and adaptation). Less Significant attributes included; Empathy ($\bar{x}$= 2.91), Ability to persuade farmers on innovation ($\bar{x}$= 2.91) and Politeness and respect ($\bar{x}$= 2.80). Important for building rapport but might need improvement for higher engagement with farmers. This implies that based on government inefficiency in developing the Nigerian Agricultural sector through public extension services, extension agents in the study area now have low confidence to persuade farmers, show politeness and respect, and show empathy in administration of extension programme in the study area. Insignificant attributes such as; Deliberate ($\bar{x}$= 2.60) and Being an extrovert ($\bar{x}$= 2.34) indicates a low level intentional decision-making to boost efficiency, and low sociability. This may be based in government inconsistencies in extension programms over time.

The highly significant attributes ($\bar{x} \geq 3.00$), such as accountability and responsibility ($\bar{x}$= 3.86) and honesty ($\bar{x}$= 3.91), reflect essential attributes that are critical for building trust in agricultural extension services. These findings are consistent with the work of Swanson and Rajalahti (2010), who emphasize the importance of integrity and reliability in extension agents, as these traits foster positive relationships with farmers and enhance communication and cooperation. Ratings in flexibility of character ($\bar{x}$= 3.54) and diversified knowledge ($\bar{x}$= 3.57) suggest that male agents are adaptable and possess a broad understanding of agricultural practices, which aligns with Rivera and Qamar (2003), who argue that diverse knowledge enables extension agents to address the varied challenges faced by farmers effectively .

Table 1. Distribution of respondents based on the mean ratings of extension personnel attributes among male extension agents

Attribute	Mean	Standard Deviation
Flexibility of character	3.54	0.84
Diversified knowledge	3.57	0.87
Prioritization	3.34	0.83
Accountability and responsibility	3.86	0.35
Effective learning skills	3.69	0.75
Courage to impact learning	3.49	0.94
Empathy	2.91	1.16
Patience	3.46	1.10
Resilience	3.49	0.81
Deliberate	2.60	1.05
Observant	3.83	0.38
High performing mindset	3.63	0.54
A strong sense of identity	3.34	0.83
Purpose-driven disposition	3.40	0.87
Team spirit	3.54	0.69
Goal-oriented mindset	3.57	0.49
Honesty	3.91	0.28
Resourcefulness	3.49	0.77
Ability to take risks	3.09	1.11
Being an extrovert	2.34	1.17
Creativity	3.31	0.85
Programme planning and organization	3.41	0.91
Extension administration skills	3.34	0.79
Safety and awareness skills	3.06	0.95
Ability to recognize growth opportunities	3.31	0.78

Attribute	Mean	Standard Deviation
Ability to persuade farmers on innovation	2.91	0.97
Politeness and respect	2.80	1.06
Open-minded	3.00	1.04

Field Survey, 2024. *Benchmark mean ≥ 2.5 implies significant*

1.2 IMPLICATION OF MALE AGRICULTURAL EXTENSION AGENTS ATTRIBUTE TO THE DEVELOPMENT OF AGRICULTURAL EXTENSION IN THE STUDY AREA.

The attributes of male agricultural extension agents in Cross River State have significant implications for agricultural extension development. High scores in accountability ($\bar{x}$= 3.86), honesty ($\bar{x}$= 3.91), and resourcefulness ($\bar{x}$= 3.49) reflect attributes essential for building trust with farmers and fostering a reliable support system. These traits suggest that agents can effectively establish credibility, crucial for encouraging farmer participation in extension programs. Moreover, attributes like a high-performing mindset ($\bar{x}$= 3.63) and resilience ($\bar{x}$= 3.49) are critical for overcoming field challenges, suggesting that agents possess the determination needed for successful program execution. However, the lower scores in empathy ($\bar{x}$= 2.91), persuasiveness ($\bar{x}$= 2.91), and politeness ($\bar{x}$= 2.80) indicate challenges in building rapport with farmers, potentially affecting engagement. Empathy and persuasiveness are particularly important for addressing farmer concerns and securing buy-in for new practices, which these scores suggest may currently be insufficient. The relatively low politeness score could reduce approachability, making farmers less receptive to guidance. These gaps suggest a need for targeted development in interpersonal skills to improve farmer-agent relationships. Lastly, attributes like intentionality ($\bar{x}$= 2.60) and openness to new ideas ($\bar{x}$= 3.00) scored low, signaling limited proactive decision-making and adaptability. Without these attributes, agents may struggle to identify and implement strategic improvements in extension programs. The inconsistency of government support for extension services may contribute to this lack of motivation. Strengthening these attributes through training and support can help agents become more dynamic, which is crucial for advancing agricultural development in Cross River State.

2.1 Female extension personnel attributes

The analysis of attributes among female extension agents in Cross River State ADP based on the ratings of their means in Table 2 revealed that they excel in various critical competencies, with a majority of attributes showing highly significant mean values. Attributes such as accountability and responsibility ($\bar{x}$= 3.86), effective learning ability ($\bar{x}$= 3.78), and observant ($\bar{x}$= 3.83) scored highest, indicating strong foundational skills in reliability, adaptability, and attentiveness. These attributes are crucial for effective extension work, where dependability and continuous learning enhance the agents' ability to support local farmers. Also, attributes like team spirit ($\bar{x}$= 3.57), high performing mindset ($\bar{x}$= 3.54), and politeness and respect ($\bar{x}$= 3.61) underscore the agents' emphasis on collaboration and professionalism. The notable scores for honesty ($\bar{x}$= 3.44), empathy ($\bar{x}$= 3.43), and resourcefulness ($\bar{x}$= 3.43) show that Female extension agents are perceived as trustworthy and adaptable, traits that foster productive relationships with farmers. This strength in interpersonal skills is essential for building rapport

and encouraging farmer participation in extension programs. Attributes in the less significant range ($\bar{x}$= 2.50–2.90), including flexibility of character ($\bar{x}$= 2.86), programme planning and organization ($\bar{x}$= 2.97), and open-mindedness ($\bar{x}$= 2.91), indicate moderate emphasis. Although these attributes are present, but may be undermned by administrative and policy factors in the Nigerian agricultural sector which has constrained it development among female extension agents. Insignificant attributes such as; Resilience ($\bar{x}$= 1.91) and ability to take risks ($\bar{x}$= 2.20) suggest these are less prominent among female agents. This might reflect a cautious approach within the ADP's context, where emphasis is on steady, proven methods over risk-taking. These attributes are critical in addressing farmers' diverse challenges, especially in resource-limited settings (Purcell & Anderson, 2018).

Table 1. Distribution of respondents based on the mean ratings of extension personnel attributes among male extension agents

Variable	Mean	Standard Deviation
Flexibility of character	2.86	1.15
Diversified knowledge	3.37	0.86
Prioritization	3.26	0.77
Accountability and responsibility	3.86	0.35
Effective learning ability	3.78	0.58
Courage to impact learning	3.23	1.07
Empathy	3.43	0.99
Patience	3.11	1.12
Resilience	1.91	0.87
Deliberate	3.14	1.07
Observant	3.83	0.38
High performing mindset	3.54	0.69
A strong sense of identity	3.40	0.83
Purpose driven disposition	3.23	0.93
Team spirit	3.57	0.49
Goal oriented mindset	3.29	0.70
Honesty	3.44	0.77
Resourcefulness	3.43	0.84
Ability to take risk	2.20	1.06
Being an extrovert	3.26	1.02
Creativity	3.31	0.95
Programme planning and organization	2.97	1.03
Extension administration skills	3.17	1.03
Safety and awareness skills	3.00	0.93
Ability to recognize growth opportunity	3.06	0.98

Variable	Mean	Standard Deviation
Ability to persuade farmers on an innovation	3.00	1.01
Politeness and Respect	3.61	0.55
Open minded	2.91	1.08

Field Survey, 2024.Benchmark mean ≥ 2.5 implies significant

2.2 IMPLICATION OF FEMALE EXTENSION ATTRIBUTES TO AGRICULTURAL DEVELOPMENT IN THE STUDY AREA

The results suggest important implications for agricultural extension, particularly when viewed through a gender studies lens. Female extension agents in Cross River State ADP demonstrate notable strengths in interpersonal skills, accountability, adaptability, and teamwork, with high mean scores in attributes like accountability and responsibility ($\bar{x}$= 3.86), empathy ($\bar{x}$= 3.43), and team spirit ($\bar{x}$= 3.57). This emphasis on relationship-building and collaboration aligns well with gender research indicating that women often excel in social skills and empathetic communication. Such skills are advantageous in agricultural extension, where building trust and understanding the needs of diverse farming communities are critical to successful engagement.The lower scores in resilience ($\bar{x}$= 1.91) and risk-taking ability ($\bar{x}$= 2.20) may imply a cautious approach among female extension agents, potentially influenced by structural and cultural factors that discourage risk-taking in professional settings. In gender studies, this tendency is often linked to limited access to resources, training, or decision-making authority that can reinforce conservative approaches. Addressing these areas through targeted training in innovation, resilience, and strategic risk-taking could empower female agents to feel more confident in trying new methods and tackling challenges, ultimately enhancing the extension service's adaptability and impact.From a gender perspective, this finding aligns with studies that advocate for equal access to resources and training for female professionals to ensure they can operate with autonomy and strategic influence in the agricultural sector. Ragasa (2014) highlighted that women in agricultural extension often excel in fostering inclusive and trustful relationships due to their strengths in empathy and accountability. However, she also argues for targeted training to empower women in technical and decision-making skills, supporting the notion that resilience and risk-taking should be fostered among female agents.

3.0 Comparison between Male and Female Extension Agents Attributes to Agricultural Development in the Study Area

Table 3. Distribution of respondents based on the mean ratings of similarity and differences in personnel attributes among male and female extension agents

Attributes	Mean Score (Male Agents)	Mean Score (Female Agents)	Interpretation
Flexibility of Character	3.54	2.86	Males show more adaptability, useful in diverse situations; females display moderate flexibility.
Diversified Knowledge	3.57	3.37	Males score slightly higher, aiding in addressing diverse agricultural issues; females also have broad knowledge.

Attributes	Mean Score (Male Agents)	Mean Score (Female Agents)	Interpretation
Prioritization	3.34	3.26	Both genders are competent in task management; males score slightly higher, which helps with structured extension work.
Accountability and Responsibility	3.86	3.86	High scores for both genders, reflecting strong reliability essential in building trust with farmers.
Effective Learning Ability	3.69	3.78	Females score higher, showing commitment to continuous learning, which is crucial for adapting to new methods.
Courage to Impact Learning	3.49	3.23	Males are slightly more confident in facilitating farmer education; females are also capable, with room for improvement.
Empathy	2.91	3.43	Females score higher, fostering rapport with farmers and enhancing understanding of their needs.
Patience	3.46	3.11	Males show slightly more patience, useful for navigating complex field situations; females also display patience.
Resilience	3.49	1.91	Males are significantly more resilient, beneficial for overcoming field challenges; females show lower resilience.
Deliberate	2.60	3.14	Females show more intentionality, aiding in thoughtful decision-making; males are less inclined toward deliberation.
Observant	3.83	3.83	Both are equally attentive, supporting accurate assessment of farmer needs.
High Performing Mindset	3.63	3.54	Males score slightly higher, reflecting a strong drive for success; females also have a high-performance orientation.
A Strong Sense of Identity	3.34	3.40	Both genders have a solid sense of self, enhancing communication and rapport with farmers.
Purpose-Driven Disposition	3.40	3.23	Males show a slightly higher purpose-driven approach; females are also motivated to serve, supporting agent commitment.
Team Spirit	3.54	3.57	Both score high in teamwork; females show a slight edge, essential for collaboration with other agents and farmers.
Goal-Oriented Mindset	3.57	3.29	Males are slightly more focused on outcomes, which supports productivity; females also show strong goal orientation.
Honesty	3.91	3.44	Males score higher in honesty, fostering credibility; females also demonstrate trustworthiness with farmers.
Resourcefulness	3.49	3.43	Both are resourceful, aiding in problem-solving under limited resources; males score slightly higher.

Attributes	Mean Score (Male Agents)	Mean Score (Female Agents)	Interpretation
Ability to Take Risks	3.09	2.20	Males are more open to risk-taking, promoting innovation; females are more cautious, preferring stability.
Being an Extrovert	2.34	3.26	Females are more sociable, which enhances relationship-building; males score lower, indicating less sociability.
Creativity	3.31	3.31	Both display moderate creativity, which supports adaptation in problem-solving and local contexts.
Programme Planning and Organization	3.41	2.97	Males score higher, which supports structured extension activity management; females show moderate skills in this area.
Extension Administration Skills	3.34	3.17	Males have a slight edge in administrative skills, useful for managing extension programs effectively.
Safety and Awareness Skills	3.06	3.00	Both score moderately, indicating awareness of safety practices important for sustainable interventions.
Ability to Recognize Growth Opportunities	3.31	3.06	Males score slightly higher in identifying development avenues; females show moderate strategic thinking.
Ability to Persuade Farmers on Innovation	2.91	3.00	Females score slightly higher, enhancing their ability to encourage farmers to adopt new methods.
Politeness and Respect	2.80	3.61	Females score significantly higher, supporting rapport-building and a welcoming environment for farmers.
Open-Mindedness	3.00	2.91	Males are slightly more open to new ideas; females show moderate openness, beneficial for learning and adaptation.

Field Survey, 2024.Benchmark mean $\geq$ 2.5 implies significant

Conclusion

This study highlights the distinct attributes of male and female agricultural extension agents in Cross River State, showing how each group contributes uniquely to the effectiveness of agricultural extension services. Male agents demonstrate higher resilience, risk-taking, and organizational skills, which enhance their capacity to manage challenging field situations and innovate in extension practices. Female agents excel in empathy, effective learning, and interpersonal skills, which foster stronger relationships with farmers, improve collaboration, and promote a supportive extension environment. These differences underscore the complementary strengths that male and female agents bring to extension work, suggesting that a balanced approach leveraging both sets of strengths could be highly effective.

Recommendations

The study recommended that Ministries of Agriculture, and other extension affiliated organizations should:

1. Provide targeted training on interpersonal skills, such as empathy and respect, to improve rapport-building with farmers, which can help male agents foster stronger, more trusting relationships.
2. Introduce resilience and confidence-building programs that encourage measured risk-taking, enabling female agents to be more adaptive and responsive in uncertain or challenging situations.
3. Encourage team-based extension projects that leverage the complementary strengths of both male and female agents. By pairing male agents' resilience and risk tolerance with female agents' empathy and communication skills, extension teams can address diverse farmer needs more holistically, enhancing the overall effectiveness of extension services in Cross River State.

References

Etim, O. U., Aboh, C. L., Idiku, F. O., &Okoi, K. O. (2021). An assessment of the level of occupational safety awareness for agricultural extension agents in Cross River State. *International Journal of Agriculture and Earth Science*, *7*(2). E-ISSN 2489-0081, P-ISSN 2695-1894.

Etim, O. U., Okoi, K. O., Yahaya, M., &Ntui, O. E. (2023). Environmental safety awareness, extension and agricultural development in Nigeria. *IIARD International Journal of Geography & Environmental Management (IJGEM)*, *9*(6). E-ISSN 2504-8821, P-ISSN 2695-1878.

Etim, O. U., Okoi, K. O., Ntui, O. E., &Ayi, N. A. (2022). An assessment of the role of extension officers in enhancing agricultural safety awareness in Cross River State, Nigeria. *International Journal of Agriculture and Environmental Science*, *8*(4). D.O.I: 10.56201/ijaes.v8.no4.2022.pg1.17. E-ISSN 2489-0081, P-ISSN 2695-1894.

Etim, O. U., Obu, K. O., &Obhiokhenan, M. I. (2022). Safety in agricultural extension and development in Cross River State. *International Journal of Agricultural Science, Research, and Technology in Extension and Education System (IJASRT IN EES)*, *12*(3), 139-149. DOR: 20.1001.1.22517588.2022.12.3.3.6. ISSN: 2251-7588.

Etim, O. U., Ogar, P. O., Aya, C. F., Obono, G. I., & Gulshan, A. (2024). Comparative analysis of factors affecting effective participation in agricultural extension services among male and female extension agents in the Cross River State Agricultural Development Project (CR-ADP). *International Journal of Social Sciences and Management Research, 10*(6), 95–110. https://doi.org/10.56201/ijssmr.v10.no6.2024.pg95.110

Jamil, F., Ali, T., Ahmad, M., & Muhammad, S. (2021). Enhancing agricultural extension services: The role of accountability and farmer engagement. *Journal of Rural Studies*, *83*, 155-162.

Purcell, T., & Anderson, J. R. (2018). Agricultural extension and development in low- and middle-income countries. *World Development*, *105*, 236-246.

Ragasa, C. (2014). Improving gender responsiveness of agricultural extension. In Gender in agriculture: Closing the knowledge gap (pp. 411-430). Springer.

Ragasa, C., Berhane, G., Tadesse, F., &Taffesse, A. S. (2013). Gender differences in access to extension services and agricultural productivity. *Journal of Agricultural Economics*, *64*(3), 733-755.

Rivera, W. M., & Qamar, M. K. (2003). Agricultural extension, rural development, and the food security challenge. *Food and Agriculture Organization (FAO)*.

Swanson, B. E., &Rajalahti, R. (2010). Strengthening agricultural extension and advisory systems: Procedures for assessing, transforming, and evaluating extension systems. *World Bank*.

FARMERS'EXTENT OF PARTICIPATION IN AGRICULTURAL EXTENSION SERVICES IN CALABAR AGRICULTURAL ZONE, CROSS RIVER STATE NIGERIA

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Abstract

The objective of this study was to analyze farmers' level of participation in extension services in Calabar agricultural zone. Specifically, the study identified extension activities in the study area; determined farmers' perception of effective extension activities; assessed the extent of farmers' participation. The study was conducted in the Calabar agricultural zone. A multi-stage sampling procedure was used to select 300 respondents for the study. Data obtained were analyzed using descriptive statistics such as mean, percentages and frequencies, The result revealed that extension agents carried activities such as organization of method demonstration trainings (79.0%), creation of environmental awareness (78.67%). The study revealed that farmers perceived all the identified extension activities to be effective and participated fully in all the listed extension activities. However, it was observed that farmers participated mostly in environmental awareness activities, acquisition of relevant up-to-date information, organization of result demonstration and organization of method demonstration. It was recommended that, Extension activities should be implemented in all locations of farmers to cover wide area and encourage the participation of those farmers who may be impeded by distance.

KEYWORDS: extension services, farmers, participation, perception,

Introduction

Agricultural growth is unquestionably a key factor in Nigeria's economic development. However, as seen by the percentages of uncultivated arable land area and wasting irrigable land mass, the situation of agriculture in the country has huge untapped potentials (World Bank, 2005). The average Nigerian farmer's resource-poor nature is evidenced by the low level of commercialization of agriculture, persistent reliance on family labor, and small and fragmented farm areas. Although agricultural extension is intended to help improve the situation, a lack of financing is a major barrier in the country's extension service provision (Ammani, et al 2010). As a result, the ratio of extension employees to farmers is abysmally low. Agricultural extension as a system tries to help farmers, extension workers, and researchers discover farming problems by exchanging information and transferring skills. This can be accomplished through informal adult training, communication with individual farmers, and community help in technical agriculture knowledge and procedures, all while taking into account the individual's and group's economic and social situations. In a nutshell, extension is an instructional process that employs a variety of approaches to assist farmers in raising their living standards. Similarly, extension approaches might be utilized to figure out how to best deal with farmers in order to suit their needs. Farmers must have timely and adequate access to relevant information, as well as proper

incentives, in order to embrace a new technology if it meets their socioeconomic and agro-ecological situations. One of the sources of knowledge is public extension, although it is not always the most effective (Anderson and Feder 2003). Although extension services are widely recognized as crucial components of farming, poor and marginalized farmers in distant communities remain out of reach of appropriate extension services. Farmers' participation in agricultural extension services is widely recognized as both a means to a goal and an end in and of itself among development practitioners. Farmers are major stakeholders in agricultural extension at the grassroots level.

Their involvement in all stages of the extension program development and delivery processes improves the efficiency and effectiveness of the planned change because it facilitates mutual learning among stakeholders, fosters ownership of the change program, and results in long-term and sustainable changes on the farm and in farmer behavior. As a result of this effect, the effectiveness of an extension program is heavily reliant on the participation of farmers. Hence, the objectives of the study were to identify the agricultural extension activities carried out in the study area, determine farmers' perception of effective extension activities and investigate the extent of farmers' participation in extension services

Materials and Methods

The research was carried out in Calabar Agricultural Zone, Cross River State. Cross River State is a Coastal State in Nigeria's South-South geopolitical zone. It is one of the 36 states that make up the country. It is located between 40281 and 60551 North latitude and 70501 and 90281 East longitude of the Greenwich meridian. It is bordered on the east by the Republic of Cameroun, the north by Benue state, the southwest by Ebonyi and Abia states, and the south by the Atlantic Ocean (Elemi, Angba, Ajah, Agube and Idiku, 2015; CR-SEEDS 2005-2007). As of the 2006 census, the population of Calabar agricultural zone was 371,022. (NPC, 2006). The Calabar are the three agricultural zones within the state. Akamkpa, Akpabuyo, Bakassi, Biase, Calabar Municipality, Calabar South, and Odukpani make up the Calabar agricultural zone, which also serves as the southern senatorial district. The soil is fertile, well-drained, and aerated, which favors plantain production. As a result, the vegetation and climate are very diverse, encouraging outdoor agricultural extension activities and crop growth. There are numerous natural resources and excellent tourism potentials that have drawn international interest.

Data obtained were analyzed using descriptive statistics such as frequency, percentage and mean, a multi-stage sampling technique was used to select 300 respondents as sample size.

1. **Stage 1:** Involves purposive selection of three blocks out of seven blocks that comprise Calabar agricultural zone, these are Akampkpa, Odukpani and Akpabuyo, this is because of their observed predominance in arable farming activities the study area.

2. **Stage 2:** This stage involved simple random selection of five (5) cells from each block due to its proximity.

3. **Stage 3:** A proportionality factor of 10% was applied, allowing for proportionate representation of respondents from each cell, resulting in a sample size of 300.

Result and Discussion

Table 1: Distribution of Respondents based on extension activities carried out

Distribution of Respondents based on extension activities carried out in the study area.

S/N	Activities carried out by Extension Agents	Yes		No		Remarks
		F	%	F	%	
1	Need assessment and problem identification	113	37.67	187	62.33	Majority disagree
2	Gathering farmers periodically	196	65.33	104	34.67	Majority agree
3	Helping to identify farm problems	191	63.67	109	36.33	Majority agree
4	Suggesting possible solution to solve farm problems	200	66.67	100	33.33	Majority agree
5	Organization of meetings	89	29.67	211	70.33	Majority disagree
6	Forming farmers into cooperative	222	74.00	78	26.00	Majority agree
7	Linkage with credit suppliers	226	75.33	74	24.67	Majority agree
8	Linkage with input suppliers	234	78.00	66	22.00	Majority agree
9	Dissemination of agricultural Information	224	74.67	76	25.33	Majority agree
10	Creating awareness of innovation	225	75.00	75	25.00	Majority agree
11	Organization of field days	64	21.33	236	78.67	Majority disagree
12	Helping you to understand the benefit of adopting innovation	82	27.33	218	72.67	Majority disagree
13	Organization of method demonstrations	237	79.00	63	21.00	Majority agree
14	Organization of result demonstrations	72	24.00	228	76.00	Majority disagree
15	Farmer training programmes	224	74.67	76	25.33	Majority agree
16	Getting relevant and up-to date information to me	75	25.00	225	75.00	Majority disagree
17	Environmental awareness generation	236	78.67	64	21.33	Majority agree
18	Workshop / seminar	73	24.33	227	75.67	Majority disagree

Source: Field survey, 2020 (Multiple responses)

Table 1 revealed that majority of the respondents (65.33% and 63.67%) attested that extension agents gathers farmers periodically and help them to identify farm problems, respectively. However, 34.67% and 36.33% of the farmers reported otherwise. Moreso, a large proportion (66.67%) of the farmers reported that extension agents helped in suggesting possible solution to solve their farm problems. Only 29.67% of them reported that extension agents helped in organizing meetings. It was also observed that from the result that 74.0% 75.33% and 78.0%

of the respondents revealed that extension agents helped in forming farmers into cooperative, linking them with credit suppliers and linking them with input suppliers, respectively. On dissemination of agricultural information and creating awareness of innovation, 74.67% and 75.0%, respectively, reported that extension agents carried out these activities. However, most of the respondent (78.67% and 72.67%) asserted that extension agents did not organize field days and that they (extension agents) did not help farmers to understand the benefits of adopting innovation, respectively. But 79.0% of farmers agreed that extension agents organized method demonstration; 74.67% reported that extension agents organized farmers training programs and 78.67% of them agreed that extension agents helped to generate environmental awareness. On the other hand, only 24.0% and 23.33% of farmers, respectively, reported that extension agents carried out result demonstration and organizing workshops/seminars. Furthermore, only one quarter of the respondents (25.0%) agreed that extension agents conveyed relevant and up-to-date information. The above result indicated that all of the listed extension activities were carried out in the study area. However, the reach of some of the activities was limited, which led to the negative response of some respondents

Table 2: Respondents mean rating of the effectiveness of agricultural extension activities.

S/N	Variables	Mean	SD	Decision
1	Needs assessment and problem identification	2.76	0.47	Very Effective
2	Gathering farmers periodically for lessons?	2.83	0.39	Very Effective
3	Identifying farm problems	2.80	0.44	Very Effective
4	Suggest possible solution to solve farm problems	2.84	0.39	Very Effective
5	Organization of meetings	2.85	0.38	Very Effective
6	Forming farmers into cooperative	2.89	0.33	Very Effective
7	Helping to link farmers with credit suppliers	2.90	0.35	Very Effective
8	Helping to link farmers with input suppliers	2.91	0.31	Very Effective
9	Dissemination of agricultural Information	2.85	0.43	Very Effective
10	Creation of awareness of innovation	2.86	0.44	Very Effective
11	Organization field days	2.87	0.41	Very Effective
12	Helping farmers to understanding the benefit of adopting innovations	2.88	0.39	Very Effective
13	Organization of method demonstrations	2.87	0.41	Very Effective
14	Organization result demonstrations	2.91	0.31	Very Effective
15	Carrying out farmers' training programs	2.90	0.33	Very Effective

16	Carrying out environmental awareness activities	2.92	0.30	Very Effective
17	Getting relevant and up-to date information of agriculture to famers	2.82	0.47	Very Effective

Source: Field survey, 2020 Mean $\geq$ 2.0 =effective, <2.0 = not effective

The result in Table 2 revealed that all the variables identified recorded mean scores above 2.5, which indicates that the respondents agreed that all the extension activities in the area were very effective. Specifically, it was found that farmers perceived the following activities to be very effective: identification of farm problems (M= 2.80); environmental awareness activities (M= 2.92); organizing method demonstrations (M= 2.87); creating awareness of innovation (M= 2.86); dissemination of agricultural Information (M= 2.85), among others. The implication of this result is that extension agents' activities were perceived to be highly effective by the farmers.

In terms of ranking, the result indicates that environmental awareness activities ranked first, organization of result demonstration and linkage with input suppliers, respectively, ranked 2nd, farmers' training programs and linkage with credit suppliers, respectively, ranked 3rd and forming farmers into cooperative ranked 4th. As a result, these were the most cited perceived effective extension activities in the study area. This finding is in line with Agbarevo and Benjamin (2013), who researched on Farmers' Perception of Effectiveness of Agricultural Extension Delivery in Cross-River State, and discovered that almost all the extension delivery activities were perceived to be effective. This result also aligns with the findings of Elias, Nohmi, Yasunobu and Ishida (2015), who found that about 55% of farmer were satisfied with extension activities in the study area.

Table 3: Respondents' mean ratings of the extent of farmers' participation in agriculture extension activities in the study area.

S/N	Variables	Mean	SD	Decision
1	Need assessment and problem identification	2.78	0.49	Fully participated
2	Participation in decision making	2.75	0.48	Fully participated
3	Workshops / seminar	2.82	0.43	Fully participated
4	Evaluating outcomes of extension programmes	2.83	0.41	Fully participated
5	Gathering farmers periodically	2.83	0.44	Fully participated
6	Helping to identify farm problems	2.81	0.45	Fully participated
7	suggesting possible solution to solve farm problems	2.81	0.45	Fully participated
8	Organization of meetings	2.81	0.48	Fully participated
9	Forming farmers into cooperative	2.82	0.47	Fully participated
10	Linkage with credit suppliers	2.83	0.47	Fully participated
11	Linkage with input suppliers	2.85	0.43	Fully participated

12	Dissemination of agricultural Information	2.87	0.37	Fully participated
13	Creating awareness of innovation	2.88	0.40	Fully participated
14	Organization of field days	2.89	0.39	Fully participated
15	Helping you to understand the benefit of adopting innovation	2.89	0.35	Fully participated
16	Organization of method demonstrations	2.90	0.35	Fully participated
17	Organization of result demonstrations	2.91	0.32	Fully participated
18	Farmer training programs	2.91	0.30	Fully participated
19	Getting relevant and up-to date information to me	2.91	0.32	Fully participated
20	Environmental awareness generation	2.91	0.31	Fully participated

Source: Field survey, 2020
Mean of 2.5 – 3.0 = fully participated; 2.0-2.49 = partially participated, <2.0 = no participation

The result shows the mean summary of the extent of farmers' participation in extension activities. Varieties and qualities of services determine the level of beneficiaries' preference and hence, participation in the extension services. The result also revealed that all the variables identified, recorded mean scores above the threshold of 2.0, which implies that the respondents agreed that farmers fully participated in all the extension activities. Specifically, it was found that farmers participated in extension activities such as need assessment and problem identification (M= 2.78); gathering farmers periodically (M=2.83); forming farmer into cooperatives (M= 2.82); linking farmers with credit suppliers (M= 2.83); creating environmental awareness (M= 2.91); dissemination of agricultural information (M= 2.87), among others.

Based on ranking, it was seen that farmers participated more in environmental awareness activities; getting relevant and up-to-date information and organization of result demonstration (ranked 1st). Ranked 2nd was organization of method demonstration. Ranked 3rd were helping farmers to understand the benefits of innovation and organization of field days. Following these (ranked 4th) was creating awareness of innovation and ranked 5th was dissemination of agricultural information. This result is similar to that of Ayansina, Oyeyinka and Ayinde (2015), who researched on "Farmers' Participation in the Services of Public and Private Extension Organizations in Southwestern Nigeria", and found that more than 50% of the respondents participated highly in extension activities (private). However, this is contrary to the findings of Wasihun, Kwarteng and Okorley (2014), who researched on "Farmers' perception of their level of participation in extension and found that the extent of participation was low (mean score below cut-off).

Conclusion and Recommendations

This study revealed that extension agents carried out several activities in the study area effectively and that farmers viewed their extent of participation in extension activities to be high, although full participation was hindered by some factors thus, addressing these factors will consequently increase farmers' participation in extension services. It was therefore recommended that agricultural extension activities should be implemented in all locations of

farmers to cover wider area and encourage the participation of those farmers who may be impeded by distance and agricultural extension agents should be equipped with adequate means of transportation, in order to increase their accessibility to rural farmers and thus, increase their participation in extension activities.

References

Agbarevo, M. & Benjamin, N. (2013). Farmers' perception of effectiveness of agricultural extension delivery in Cross-River State, Nigeria. *Journal of Agriculture and Veterinary Science,* vol 2, pp 01-07, e. ISSN :2319-2380.

Ammani. A, Jaafar, A., & Auta, S. (2010). Challenges to sustainability: applying the problem tree analysis methodology to the ADP system in Nigeria. An Article DOI:10.4314/jae. v14i2.64122

Ayansina, S. O., Oyeyinka, R.A. & Ayinde, A. F. (2015). Farmers' participation in the services of public and private extension organizations in southwestern Nigeria. *British Journal of Applied Science & Technology, 8(3): 238-245.*

Elemi, G., Angba, A, Ajah, E, Agube, E. & Idiku, O. (2015). Effect Of National Special Programme for Food Security on Cassava Output Among Rural Farmers in Cross River State, Nigeria. *International Journal of Agricultural Extension and Rural Development Studies,* 1 (2), 17-25.

Elias, M., Nohmi, K. Yasunobu, & Ishida, A. (2015). Farmers' Satisfaction with Agricultural Extension Service and Its Influencing factors: A Case Study in North West Ethiopia. *Journal Of Agricultural Science and Technology, 18: 39-53*

National Population Commission Census – NPC (2006). NPC report. Federal Republic of Nigeria Official Bulletin, Govt. Press, Abuja.

Wasihun, B. N., kwarteng, J. A. & Okorley, E. L. (2014). farmers' perception of their level of participation in extension in Ethiopia: policy implications. *journal of agricultural extension and rural development,* 6(2)" 80-86.

World Bank (2005). agricultural knowledge and information systems for rural development: strategic vision and guiding principles. FAO and world bank, Rome. food and agriculture organization of the United Nations.

EFFECTIVENESS OF SOCIAL PROTECTION PROGRAMME IN COCOA-PRODUCING COMMUNITIES IN IKOM AGRICULTURAL ZONE, CROSS RIVER STATE, NIGERIA

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Abstract
This study, conducted in the Ikom agricultural zone of Cross River State, Nigeria, aimed to assess the knowledge, effectiveness, and challenges of social protection programs among cocoa farmers. Using a three-stage sampling method, 144 respondents were surveyed. Data was collected using a structured questionnaire, distributed using the drop-and-collect method. The data was analyzed using means, percentages and standard deviation. Findings revealed widespread knowledge (80.6%) of social protection programs, with cash transfers being the most utilized, benefiting 91.4% of cocoa farmers. The common types of social protection programme were cash transfers (91.36%), food transfers (64.2%), public work (65.4%), and subsidies (60.5%). Existing social protection measures were effective in terms of adequacy (3.5), accessibility (3.0) and reliability (3.3). While these programs positively impacted cocoa production (3.4), household income (3.1), and food security (3.3), challenges such as irregularity of benefits (4.2) and corruption (3.9) were identified. Opportunities for improvement included increasing coverage (4.3), enhancing program adequacy (3.7), and removing intermediaries (3.9). it was recommended that awareness of social protection programs should be increased among cocoa farmers through targeted campaigns. Also, the adequacy and reliability of social protection should be enhanced by conducting regular assessments to determine the needs of cocoa farmers.

Keywords: Social protection, cocoa production, farmers, effectiveness

Introduction

Climate change presents a significant threat to agricultural livelihoods worldwide, with increasing temperatures, shifting precipitation patterns, and more extreme weather events impacting agriculture and agro-ecosystems (Keutgen, 2023). However, the sensitivity of agriculture to these changes varies regionally due to diverse weather patterns, crops, and management practices. This uncertainty exacerbates the threat to food security and livelihoods, particularly in regions already experiencing food insecurity (Wimmer, 2023). Smallholder farmers, in particular, face severe challenges such as droughts, high temperatures, and reduced soil moisture content (Keutgen, 2023). Despite employing various adaptation strategies, their effectiveness is hindered by inadequate adaptive capacity and structural challenges within the agricultural sector (Wimmer, 2023).

Among the sectors most vulnerable to climate change is cocoa production, which requires specific climatic conditions and faces numerous biophysical and socio-economic risks. Nigeria, the fourth largest cocoa producer globally, relies heavily on cocoa cultivation, with around

800,000 smallholder farmers operating in 14 states (FAO, 2015). However, these farmers encounter low productivity, poor quality, limited market access and finance, weak institutional support, and heightened exposure to climate hazards like droughts, floods, pests, and diseases.

Social protection measures, encompassing policies and programs aimed at reducing poverty, vulnerability, and inequality, have proven effective, particularly in upper-middle-income countries since 2005 (Rocha, 2023). These measures, essential for achieving universal health coverage, have demonstrated their value during crises such as the COVID-19 pandemic by mitigating economic hardship and protecting incomes and poverty levels (Oliveira et al., 2023). Access to social protection, including healthcare, is crucial for labor markets to generate productive and decent employment, thereby mitigating disruptions stemming from factors like climate change, population aging, and digitalization (Yue et al., 2023).

Moreover, social protection contributes to sustainable and inclusive food systems transformation by reducing poverty, enhancing food security and nutrition, and minimizing food loss and waste (Rana et al., 2022). In the context of cocoa farming communities, social protection can bolster resilience to climate change by addressing immediate needs and building adaptive capacity (Kosoe and Ahmed, 2022). However, effective implementation requires context-specific, participatory, and inclusive approaches to ensure coverage of vulnerable groups and address their specific needs (World Bank, 2023). Yet, social protection programs in Nigeria encounter numerous challenges, including low coverage, inadequate funding, weak institutional coordination, poor targeting and delivery mechanisms, and limited integration with climate change policies and strategies (Ladan, 2022; World Food Program (WFP), 2019). Overcoming these hurdles demands concerted efforts to enhance the design, implementation, and integration of social protection interventions into broader climate change adaptation strategies.

Cocoa production is a vital sector in Nigeria, contributing significantly to non-oil export earnings and offering employment to millions. However, climate change threatens the livelihoods of cocoa farmers and their communities, impacting yields, quality, and profitability. Social protection measures, including cash transfers and insurance schemes, can enhance resilience and adaptation to climate change by reducing poverty, inequality, and vulnerability. The case of cocoa-producing communities in Ikom agricultural LGA of Cross River State exemplifies the need for such measures due to multiple challenges exacerbated by climate change.

Therefore, in these communities, focusing on existing programs, their effectiveness in reducing vulnerability and promoting sustainable development, and the challenges and opportunities for improvement.

Objetives of the study

The broad objective of this study was to examine the social protection measures among cocoa farmers in Ikom Agricultural zone. The specific objectives were to:

i. assess farmer's knowledge of social protection programmes;
ii. identify the type of social protection program benefited by respondents;
iii. assess the effectiveness of existing social protection programme in reducing vulnerability, enhancing adaptive capacity, and promoting sustainable development among cocoa farmers;
iv. assess the impact of the social protection programs on cocoa production and household income;

v. identify the challenges faced by farmers in benefitting from social protection measures;
vi. identify suggested ways to improve the social protection measures

Methodology

This study was carried out in Ikom agricultural zone, Cross River State. The zone comprises of six (6) agricultural blocks namely: Abi, Boki, Etung, Ikom, Obubra and Yakurr. Ikom agricultural zone shares boundary with the Republic of Cameroun to the East, Obanliku and Obudu to the North, Ebonyi State to the West and Biase and Akamkpa to the South (Cross River State Geological Agency (CRSGA), 2010). It covers an approximate landmass of 16,280.02km^2 and lies at latitude 5^{0}32N and 4^{0}27N and between longitude 7^{0}50^{0}E and 9^{0}28^{0}E (CRSGA 2010), with an annual temperature range of 27^{0}C - 33^{0}C, while rainfall varies between 1500mm - 2000mm per annum (CRSGA 2010). The main economic activities in the zone are farming, fishing, hunting and trading. The major food crops produced here are cassava, yam, rice, potatoes, maize, bush mango, oil palm, vegetables, cocoyam etc.

Sampling procedure and sample size

A three-stage sampling method was adopted for this study. In the first stage, 3 blocks (Etung, Ikom and Obubra) were purposively selected based on their intensity of cocoa production. In the second stage, four (4) villages were randomly selected from each block to give a total of twelve (12) villages, used in the study. In the third stage, the Yamane (1967) formula was applied on the list of registered cocoa farmers in the selected villages, obtained from the agricultural development programme (ADP), to realize approximately 144 respondents for the study. Data was collected using structured questionnaires, employing the drop and collect method. Data generated from the study was analyzed using means, percentages and standard deviation.

Results And Discussion

Farmer's knowledge of social protection programmes

Table 1: Distribution of respondents based on their knowledge of social protection programmes

Variables		Freq.	%
Awareness of social protection programs	Yes	116	80.6
	No	28	19.4
	Total	**144**	**100.0**
Source of awareness	Radio/TV	39	33.6
	Internet/social media	53	45.7
	Friends/relatives/neighbours	19	16.4
	Extension gents/ NGOs	5	4.3
	Total	**116**	**10000**
Have you benefited from any social protection program	Yes	81	56.3
	No	35	43.7
	Total	**116**	**100.0**
How often did you benefit?	Once	61	75.3
	Twice	9	11.1
	Thrice	9	11.1

	More than three-time	2	2.5
	Total	**81**	**100.0**
Level of satisfaction with the social protection program	Very satisfied	8	9.9
	Satisfied	17	20.9
	Neutral	31	38.3
	Dissatisfied	9	11.1
	Very dissatisfied	16	19.8
	Total	**81**	**100.0**
Did you pay any fee or meet any conditions to benefit from the program	Yes	10	12.4
	No	71	87.7
	Total	**81**	**100.0**

Source: Field data, 2023

Table 1 reveals that the majority (80.6%) were aware of social protection programmes, which they learned about from sources such as internet/social media (45.7%), Radio/TV (33.6%), friends/relatives/neighbours (16.4%), among others. Results in Table 1 shows that out of the 116 farmers that were aware of social protection programmes, 56.3% of them had benefited from one social programme or the other. The majority (75.3%) of them benefited just once. Additionally, 9.9% of them were very satisfied with the programmes they benefited from, 20.9% were satisfied, 11.1% were dissatisfied and 19.8% were very dissatisfied with the programme they benefited from. The results also show that the majority (87.7%) of the beneficiaries did not pay any fee to benefit from any social protection programme.

The fact that the majority (87.7%) of beneficiaries did not have to pay any fees aligns with expectations, suggesting that the social protection programs are accessible without financial barriers. This is a positive aspect as it ensures that those in need can benefit without additional financial burden.

Type of social protection program benefited by respondents

Table 2: Distribution of respondents based on the types of social protection programmes they benefited from (n=81)

S/N	Social protection program,	Yes	%*
1.	Cash transfers (conditional or unconditional) by governments and NGOs	74	91.4
2.	Food transfers (food aid, school feeding, etc.)	52	64.2
3.	Subsidies (input subsidies, price subsidies, etc.)	49	60.5
4.	Insurance (crop insurance, health insurance, etc.)	42	51.9
5.	Public works (employment guarantee schemes, community infrastructure projects, etc.)	53	65.4
6.	Social pensions (old-age pensions, disability pensions, etc.)	45	55.6
7.	Subsidized health care and old-age pensions	34	41.9
8.	Livelihood recovery support (such as restocking of damaged cocoa farms)	37	45.7
9.	Livelihood diversification support	34	41.9
10.	labour guarantee scheme to offer free labour to cocoa farmers in times of climate disaster	24	29.6
11.	Free education for your children	25	30.9

12.	Promotion of minority rights	22	27.2
13.	Anti-discrimination campaigns	24	29.6
14.	Proactively challenging discriminatory behaviour	23	28.4
15.	Employment guarantee scheme	22	27.2
16.	Social Pensions to those whose farms were completely destroyed as a result of climate events	18	22.2
17.	Availability of free extension services to vulnerable farmers	26	32.1
18.	Price hedging to protect futures market uncertainties	24	29.6
19.	Weather–indexed insurance	10	12.4
20.	Emergency food aid	14	17.3

Source: Field data, 2023 *=multiple responses

Table 2 reveals that 91.4% of the cocoa farmers benefitted from cash transfers, 65.4% benefitted from public works, such as community infrastructure projects, 64.2% benefited from food transfers, such as food aids and school feeding, 60.5% benefitted from subsidies, such as input subsidies and price subsidies, 55.6% benefitted from social pensions, such as old age pension and disability pensions, 51.9% benefitted from insurance, such as crop insurance and health insurance.

From Table 2, only a few farmers benefitted from social protection measures such as weather-indexed insurance (12.4%), emergency food aid (17.3%), social Pensions to those whose farms were destroyed as a result of climate events (22.2%), promotion of minority rights (27.2%), employment guarantee scheme (27.2%), proactively challenging discriminatory behaviour (28.4%), anti-discrimination campaigns (29.6%), labour guarantee scheme to offer free labour to cocoa farmers in times of climate disaster (29.6%), among others.

Table 2 provides a comprehensive overview of the types of social protection programs embraced by cocoa farmers in the study area. Analyzing the participation rates in each category can guide policymakers and stakeholders in tailoring and optimizing social protection measures better to meet the diverse needs of the farming community.

Effectiveness of existing social protection programme in reducing vulnerability, enhancing adaptive capacity, and promoting sustainable development among cocoa farmers

Table 3: Distribution of respondents based on their perception of the effectiveness of social protection measures **(n=144)**

S/N	Variables	Mean	SD
1.	Adequacy (amount or quantity of benefit)	3.5*	1.33
2.	Accessibility (ease of reaching or obtaining benefits)	3.0*	1.02
3.	Affordability (cost of benefit relative to income)	2.9	1.20
4.	Reliability (regularity and timeliness of benefit)	3.3*	1.39
5.	Relevance (suitability of benefit to needs and preferences)	1.8	0.00

6.	Sustainability (continuity and durability of benefit)	1.6	0.00
7.	There was no social protection program at all	1.7	0.00

Source: Field data, 2023 Decision rule = 3.0

The results reveal that social protection programmes were rated to be most effective in terms of adequacy (amount or quantity of benefit), with the highest mean score of 3.5 and a rank of 1st. The social protection program was also effective in terms of reliability, with a mean score of 3.31. ranking 2nd. Following this order was accessibility, with a mean score of 3.00, ranking 3rd. affordability came 4th, with a mean score of 2.9. Table 3 reveals that the relevance and sustainability of social protection measures had mean scores that are below the cut-off score of 3.0, lending credence to the fact that social protection programmes in the study area were not effective in terms of relevance to their target audience and sustainability of the programmes.

Impact of the social protection programs on cocoa production and household income

Table 4: Distribution of respondents based on their perception of the impact of social protection programmes (n=144)

S/N	Outcome	Mean	SD
1.	Cocoa production (yield and quality)	3.4*	1.19
2.	Cocoa income (price and profit)	2.6	1.11
3.	Household income (diversification and stability)	3.1*	1.12
4.	Household expenditure (consumption and investment)	2.7	1.21
5.	Household food security and nutrition (Availability and access)	3.3*	1.28

Source: Field data, 2023 Decision rule = 3.0

Table 4 presents data on the impact of social protection programmes on cocoa production and household income, among farmers in the study area. The results reveal that the social protection programme impacted cocoa yield and quality. This could be because of the cash transfers that afforded farmers the means to purchase production resources and thus, result in quality produce. This parameter had a mean score of 3.4 and ranked 1st. Results in 7 also showed that social protection programmes positively impacted the availability of and access to nutritious food, leading to household food security. This could be because of the cash transfers that may afford farmers the ability to purchase nutritious food for their households. This parameter had a mean score of 3.3 and ranked 2nd.

Furthermore, the social protection programme helped farmers to diversify household income, leading to stability. This had a mean score of 3.1 and ranked 3rd. this implies that the social protection programme enabled farmers to have multiple income sources, resulting in financial stability. These findings are similar to the findings of Boone et al. (2013), that social protection

measures, such as cash transfers increase ownership of productive assets and help farmers to overcome constraints.

Challenges faced by farmers in benefitting from Social Protection Measures

Table 5: Weight of challenges faced by farmers in benefitting from social protection measures **(n=144)**

S/N	Challenges	Mean	Rank
1	Lack of awareness or information about available programs or policies	3.5*	1.57
2	Lack of eligibility or qualification for existing programs or policies	2.7	1.19
3	High cost of participating in programs or policies	2.8	1.25
4	Low quality or quantity of benefits from programs or policies	4.0*	1.38
5	Irregularity or delay of benefits from programs or policies	4.2*	1.32
6	Hijacking of program benefits by politicians and middle men	3.9*	1.35
7	Segregation based on tribe	4.2*	1.40
8	Corruption	3.9*	1.61

Source: Field data, 2023 Decision rule = 3.0

Table 5 highlights the challenges that hinder farmers from deriving maximum benefit from social protection programmes in the study area. From the result, irregularity or delay of benefits from programs or policies ranked 1st, implying that this is a critical bottleneck. Segregation based on tribe ranked 2nd, low quality or quantity of benefits from programs or policies ranked 3rd, corruption ranked 4th and hijacking of program benefits by politicians and middlemen ranked 5th.

Other challenges with lesser weights include lack of eligibility or qualification for existing programs or policies (rank = 8th), high cost of participating in programs or policies (rank =7th), and Lack of awareness or information about available programs or policies (rank = 6th). The lesser weights of these challenges imply that these challenges are not critical in the study area. This aligns with the findings of Mahendru and Tasker (2020) that social protection remains inadequate globally.

Suggested ways to improve the social protection measures

Table 6: Opportunities to increase social protection measures in the study area (n=144)

S/N	Opportunities	Mean	SD
1.	Increasing the coverage and outreach of existing programs	4.3*	1.13
2.	Enhancing the adequacy and affordability of existing programs	3.7*	1.17

3.	Improving the reliability and timeliness of existing programs	3.8*	1.31
4.	Introducing new or innovative programs that address the specific needs of farmers	3.9*	1.34
5.	Removing middlemen and agents and dealing directly with farmers	3.9*	1.41

Source: Field data, 2023 Decision rule = 3.0

Table 6 presents information on suggested opportunities to improve social protection measures in the study area. From the result, the following suggestions were proffered: increase in the coverage and outreach of existing programs (Mean = 4.3, rank = 1st), introduction of new or innovative programs that address specific needs of farmers (Mean = 3.9, rank = 2nd), removal of middlemen and agents and dealing directly with farmers (Mean = 3.9, rank =2nd), improving the reliability and timeliness of existing programs (Mean = 3.8, rank = 4th), and enhancing the adequacy and affordability of existing programs (Mean = 3.7, rank = 5th). This is similar to the report of Jackson (2020), who suggested that extending social protection to rural poor farmers reduces poverty and inequality.

Conclusion

The findings of this research highlight the crucial role of social protection measures in enhancing the resilience and adaptation of cocoa farmers to climate change impacts in the Ikom agricultural zone of Cross River State, Nigeria. Despite facing challenges such as irregularity of benefits and corruption, social protection programs have demonstrated their effectiveness in positively impacting cocoa production, household income, and food security. Cash transfers emerged as the most utilized program, benefiting a significant percentage of cocoa farmers surveyed. Opportunities for improvement, including increasing coverage, enhancing program adequacy, and removing intermediaries, were identified. Addressing these challenges and capitalizing on opportunities can optimize social protection measures, contributing to the sustainable development and resilience of cocoa-producing communities. Policymakers and stakeholders should prioritize implementing context-specific, participatory, and inclusive approaches to ensure the effective integration of social protection interventions into broader climate change adaptation strategies, ultimately benefiting vulnerable farmers and their communities.

Recommendations

1. Increase awareness of social protection programs among cocoa farmers through targeted awareness campaigns utilizing various channels such as radio, television, and community meetings. Ensure accessibility by simplifying application procedures and providing information in local languages to reach farmers in remote areas.

2. Enhance the adequacy and reliability of social protection benefits by conducting regular assessments to determine the needs of cocoa farmers. Implement measures to ensure timely and consistent delivery of benefits, minimizing delays and interruptions.

3. Establish effective coordination mechanisms among relevant government agencies, NGOs, and community stakeholders to streamline the implementation of social protection programs.

Enhance monitoring and evaluation frameworks to track program effectiveness and address any gaps or inefficiencies.

4. Implement measures to enhance transparency and accountability in the management of social protection funds and resources. Establish mechanisms for community participation and feedback to ensure that programs meet the needs of cocoa farmers and are free from corruption or misuse.

5. Explore innovative approaches, such as mobile-based payment systems and weather-indexed insurance, to enhance the effectiveness and resilience of social protection measures in the face of evolving climate change challenges. Continuously adapt programs based on feedback and lessons learned to ensure relevance and effectiveness in supporting cocoa farmers' livelihoods.

References

Boone, R., Covarrubias, K., Davis, B., Winters, P. (2013). Cash transfer programs and agricultural production: the case of Malawi. Agricultural Economics, 44(3), 365-378. doi: 10.1111/AGEC.12017. Cross River State Geological Agency (2010). Report Calabar: Government press, 65

FAO (2015). Nutrition and social protection. Rome, FAO. Availiable at http://www.fao.org/3/a-i4819e.pdf.

Jackson, R. H. (2020). Social protection and rural farmers: A microsimulation approach on poverty and inequality. Institute of Chartered Economics, Accra, Ghana. Available at: https://www.wider.unu.edu/sites/default/files/About/southmod-research-note-social-protection-rural-farmers.pdf. Retrieved 19/11/2023.

Keutgen, A.J. (2023). Climate change: challenges and limitations in agriculture. IOP conference series, 1183(1), 012069-012069. doi: 10.1088/1755-1315/1183/1/012069.

Kosoe E.A, and Ahamed A,(2022). Climate change adaptation strategies of cocoa farmers in the wessa east district: implications for climate services in Ghana.

Ladan M.T. (2022). A review of Nigeria's 2021 Climate Change Act: Potential for increased climate litigation. International Union for Conservation of Nature. https://www.iucn.org/news/commissionenvironmental-economic-and-social-policy/202203/a-review-nigerias-2021-climate-change-act-potential-increased-climate-litigation

Mahendru, R. & Tasker, M. (2020). Introduction: Child sensitive social protection: Programmes and Policy Options:. Global Social Policy, 20(1), 3-5. doi: 10.1177/1468018119895430.

Oliveira, R., Lastunen, J., Rattenhuber, P., Samarin, M., & Shahir, A. A. (2023). The role of social protection and tax policies in cushioning crisis impacts on income and poverty in low- and middle-income countries: A rapid scoping review. *WIDER Working Paper*. https://doi.org/10.35188/unu-wider/2023/314-7,

Rana, I. A., Khaled, S., Jamshed, A., & Nawaz, A. (2022). Social protection in disaster risk reduction and climate change adaptation: A bibliometric and thematic review. *Journal*

of Integrative Environmental Sciences, *19*(1), 65-83. https://doi.org/10.1080/1943815x.2022.2108458.

Rocha, M. F. (2023). Social protection, poverty, and inequality: global patterns and changes. 323-349. doi: 10.4337/9781800882300.00026.

WFP. (2019). Social protection and climate change. Rome: World Food Programme.

Wimmer, A. (2023). Climate Change and Consequences. 77-95. doi:10.1007/978-3-031-23108-7_4

World Bank. (2023). Nigeria: Social protection for inclusive growth project appraisal document. Washington DC: World Bank Group.

Yamane, T. (1967). Statistics: An Introductory analysis (2nd ed.). Harper & Row.

Yue, Q., Herrera, D. S., & Benammour, O. (2022). The contribution of social protection to reducing food loss and waste. *Food Loss and Waste Policy*, 63-77. https://doi.org/10.4324/9781003226932-7.

ENHANCING AWARENESS AND KNOWLEDGE OF BLACK SOLDIER FLY FARMING AMONG AGRICULTURE UNDERGRADUATES, UNIVERSITY OF PORT HARCOURT

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ABSTRACT

This research investigated the awareness and knowledge of black soldier fly (BSF) larva farming among undergraduate agricultural students at the University of Port Harcourt, Nigeria. This study sampled 100 respondents from 502 undergraduate students at the University of Port Harcourt, across years 1, 2, 3, and 5. A structured questionnaire collected demographic data and assessed awareness using means, frequency and percentages. Data was gathered in classrooms before an awareness seminar and analyzed descriptively to summarize student knowledge levels. The findings revealed that most students (68%) were familiar with the concept of BSF larva farming. However, their knowledge about specific applications, benefits, and challenges was lacking. Only 55% understood the life cycle, regulatory aspects, and efficiency factors. Knowledge of applications in waste management, environmental impact reduction, and circular economy principles was limited. Despite limited knowledge, a significant portion (72%) believed BSF larva farming could contribute to sustainable agriculture and address food security challenges. Recommendations for the study include the following: Implement programs to increase awareness of BSF larva farming benefits, applications, and technical aspects. The study generally highlights the need for increased education and awareness to unlock the potential of BSF larva farming as a sustainable agricultural practice in Nigeria.

Keywords: Black Soldier Fly (BSF), Awareness, Knowledge, Sustainable Agriculture, Undergraduate Students

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Introduction

Insect farming is the practice of raising and breeding insects as livestock, also referred to as mini livestock or microstock. Insects may be farmed for the commodities they produce (like silk, honey, lac, or insect tea), or for them themselves; to be used as food, as feed, as a dye, and otherwise. Insect farming is on the rise in the world of agriculture and food tech alike. Insects provide a sustainable source of protein and need minimum land and resources (Hasnan et al., 2023).

Nigeria is the most populous nation in Africa with the majority of its population within the working age group, by 2050, it is projected to have 433m people, more than the US, and behind

only India and China (Coleman, 2023). The country is endowed with a lot of natural resources, such as agriculture, having 70% of its land as arable land. Forest resources are abounding with enriching forest products yet to be tapped. Despite this, Nigeria is still a mono-product economy heavily dependent on crude oil for more than 90% of its foreign exchange earnings (Idowu, 2020). Consequently, the majority of its population is extremely poor, "with over 50% of its population depending on US$ 1 per day for livelihood; the poverty rate witnessed in recent years exceeded the first oil boom recorded in the 1970s, which was 35%" (Olowe, 2021). The unemployment rate in Nigeria is alarming (Makinde & Adegbami, 2019) and the government has done little to reduce the misery and frustration of its teaming youth. To address this problem of high unemployment rate and endemic poverty, there is a need for maximum utilization of natural resources to foster development through entrepreneurship. Tapping the country's resources requires the ability to identify potentially useful, economically viable and developmental enterprises in the country.

Insects being a candidate of the aforementioned listed properties are blessed with a lot of untapped resources. The insect is tipped worldwide as a recognized food (Tiencheu and Womeni, 2017; Van Huis, 2017; Dobermann et al, 2017), but here in Africa, insect-eating has been part of our menu for centuries (Ebenebe and Okpoko, 2015), also insect is used as feed formulation for domestic animals and pets (Karigidi, 2018). The sudden awareness generated by insects as food is due to their nutritional benefit (Khalaf and Elansary, 2018) and environmental qualities (Huis and Oonincx, 2017). There are increasing need for animal protein in Nigeria, according to (Ebenebe et al., 2020) the current protein consumption level is 7-10 g/person/day. This does not meet the standard set by the Food and Agriculture Organization of the United Nations of 34g of animal protein consumption per person per day.

Engaging in edible insect enterprise helps to meet the Sustainable Development Goal (SDG) two of the United Nations which is to achieve food security and improve nutrition (hunger reduction) (Dicke, 2018). Also, SDG thirteen talks about taking urgent actions against climate change and its impacts which insects fit perfectly to this profile as they are more environmentally friendly and more sustainable than their direct alternatives. Among them, the black soldier fly is gaining momentum, with its unique composting abilities and high protein content. Insects are increasingly gaining scientific and economic interest as agents for organic waste management. In terms of fertilizer production, converting organic waste into a stable soil amendment follows a similar principle as vermicomposting. In contrast to earthworms, however, industrially used insects are not primarily seen as producers of compost but rather as bioreactors capable of transforming low-value substrates into a source of value-added products that include protein, fat, chitin, and they also yield a by-product with fertilizing properties. Most of these products are directly derived from mechanically or chemically processing the raw insect biomass.

Due to the novelty of large-scale insect farming, legal restrictions, and immature research on the safety of insect-derived products limit the use of a broader variety of substrates that would otherwise also include animal manure or food wastes (Liu et al., 2022). Black Soldier Fly farming is presently the most widespread form of insect farming in the world. The Black Soldier Fly is ideally suited for food production due to its rapid production cycle and high concentration of protein. The high percentage of protein in the larvae makes them an ideal source of food for a wide variety of animals. Apart from its good taste, maggots are very nutritious and rich in proteins, a vital element in every animal feed. Proteins are important because they are a critical component in developing muscles in these animals which eventually become the meat that we humans eat.

Fly larvae developing in animal manure extract nutrients and by tunneling the substrate they improve its structure. The changes in manure during biodegradation, however, cannot be solely attributable to the maggot action but rather to the interaction of fly larvae with microflora (bacteria, yeast and fungi) already present in manure. The main contribution of fly larvae to biodegradation seems to be mechanical aeration which results in increased loss of water, ammonia and favouring the growth of aerobic microorganisms (Mertenat et al., 2019). During biodegradation by fly larvae, the temperature of the substrate rises, pH changes from neutral to alkaline, ammonia release increases, the activity of some enzymes within the medium shifts markedly, and moisture decreases (Mertenat et al., 2019). Humidity and odor emissions in biodegradable manure are markedly decreased (He et al., 2020). Insect farming is, in principle, much more efficient and sustainable than the farming of cattle, pigs, and poultry. Insects are 4 to 10 times more efficient in converting nutrients into body mass. In addition, insect larvae feed on a wider range of residual waste streams that are efficiently converted into protein-rich body mass.

Statement of the Problem

Fish farming and poultry farming are very common animal farming that most students of agriculture at the University of Port Harcourt are familiar with and the use of their bye product. This is because is there a low level of awareness, absence of resource material, and poor or no communication channel between black soldier fly farmers and the student body on the benefit of black soldier farming. Research has shown that the maggot meal of black soldier fly can be an excellent replacement for fish meal or soybean meal which are the main ingredient in animal feed (Diclaro, et. al, 2015; Belghit et al., 2019; Rawski et al., 2020; Lu et al., 2022) and also as a substrate in waste management. Again, insect farming requires much less space and water, and the emission of greenhouse gases also appears to be lower. An insect farming business offers a sustainable solution for the growing global demand for protein there is therefore need for future potential farmers and students of agriculture through this sensitization and awareness to know as regards the competitive advantage in starting up BSF farming owing to its economic significance.

Aim and Objectives of the Study

The study aims to enhance awareness and knowledge of black soldier fly farming among agriculture undergraduates at the University of Port Harcourt. The specific objectives of the study include:

i. To assess the current level of awareness and knowledge of black soldier fly farming among agriculture undergraduates;
ii. To explore the preferred learning methods and resources for learning about black soldier fly farming.

Research Methodology

Population and Sampling Procedure

This study focused on undergraduate students enrolled in years 1, 2, 3, and 5 of the Faculty of Agriculture at the University of Port Harcourt. The total population of students in these year levels was 502, with breakdowns of 250, 180, and 72 students in years 1, 2, and 3-5 respectively. To gain a representative understanding of student awareness, a sample size of 100 respondents was chosen. Random sampling was employed, ensuring each year level had an opportunity to participate. Twenty-five students were selected from each of years 1 and 5, while 50 students were chosen from year 4 due to its larger population. This approach balanced representation across year levels while accounting for population size differences.

Data Collection Instrument

A structured questionnaire served as the primary data collection tool. Divided into two sections, Section A gathered basic participant information like age, gender, and year level. Section B presented detailed questions about black soldier fly larva farming, utilizing a Likert-scale format. This format offered participants response options ranging from "Strongly Agree" to "Strongly Disagree," assigned numerical values for statistical analysis (4, 3, 2, and 1 respectively). A score of 2.5 was chosen as the central point for interpreting responses.

Data Collection Procedure and Analysis

Data collection involved direct contact with participants. Researchers personally dropped the questionnaire with students in their designated classrooms before an awareness seminar on black soldier fly larva farming. This approach maximized participation and ensured students understood the research context before completing the questionnaire. Descriptive statistical analysis was employed to interpret the questionnaire responses. This includes presenting data in clear tables and utilizing measures like means and percentages to summarize student awareness levels regarding black soldier fly larva farming.

Result and Discussions

Demographic Information of Respondents

Table 1: Gender and age distribution of respondents

Gender of Respondent	Frequency	Percentage (%)
Male	40	40.0
Female	60	60.0
Total	100	100.0
Age Bracket		
16-18	20	20.0
19 – 21	30	30.0
22 – 24	40	40.0
Total	**100**	**100.0**

Table 1 shows that 40.0 percent of respondents are male while 60.0 percent of them are female. This shows that more females participated in the study. Additionally, the results show that 20.0 percent of the respondents are within the age range of 16 – 18 years, 30.0 percent of them are in the age range of 19 – 21 years, while 40.0 percent fall within the age range of 22 – 24 years. Furthermore, 10.0 percent of the respondents are in the "25 years and above" age bracket. This indicates that respondents within the age bracket of 22 – 24 dominated the study.

The demographic data reveals a gender imbalance in the study, with a higher proportion of female respondents compared to male respondents. This finding suggests that women are more actively engaged in or interested in the topic of black soldier fly larva farming. The age distribution indicates that the majority of respondents are young adults aged 16-24 years, suggesting that the target population for educational initiatives and interventions should focus on this age group.

Current level of awareness and knowledge of black soldier fly farming

Table 2: Assessment of Current Awareness

S/N	Item	SA	A	D	SD	Mean	Remark
1	I am familiar with the concept of black soldier fly larva forming	15	20	35	30	2.20	Disagree

2	I can explain the potential benefits of black soldier fly larva forming in Agriculture.	20	15	30	35	2.20	Disagree
3	I understand the various applications of black soldier fly larva forming in waste management	10	30	20	40	2.10	Disagree
4	I am aware of the basic techniques involved in black soldier fly larva farming.	10	10	30	50	1.80	Disagree
5	I believe that black soldier fly larva farming can contribute to sustainable agriculture.	28	28	24	20	2.64	Agree
6	I have discussed black soldier fly larva farming in my course work or with peers	25	26	25	24	2.5	Agree
7	I am aware of the potential role of black soldier fly larvae in reducing the environmental impact of livestock farming.	20	15	30	35	2.20	Disagree
8	I know that black soldier fly larvae can be used in the production of sustainable eco-friendly animal feed.	18	20	35	30	1.72	Disagree
9	I understand the connection between black soldier fly larvae and circular economy principles	10	15	25	50	1.85	Disagree
10	I am familiar with the concept of up cycling organic waste through black soldier fly larvae farming.	15	15	30	40	2.05	Disagree
11	I know that black soldier fly larvae can be used as a sustainable protein source for poultry.	25	25	30	20	2.7	Agree
12	I am aware of any research or ongoing projects related to black soldier fly larva farming at our university.	33	25	27	15	2.8	Agree
13	I know the key factors that influence the growth and development of black soldier fly larvae.	20	20	40	20	1.99	Disagree
14	I understand how black soldier fly larvae can be incorporated into a sustainable agriculture system	9	21	30	40	1.99	Disagree
15	I am aware of any local or global initiatives promoting black soldier fly larva forming.	10	22	40	28	2.16	Disagree
16	I believe that black soldier fly larva farming has the potential to address food security challenges.	20	20	40	20	240	Disagree

Source: field survey (2023) Decision rule = 2.5

Results in Table 2 reveal that the majority of respondents (68%) are familiar with the concept of black soldier fly larva farming, indicating a reasonable level of awareness. While most respondents are aware of the potential benefits of agriculture (62%), there is a significant lack

of knowledge about specific applications in waste management (55%), reducing the environmental impact of livestock farming (55%), and circular economy principles (57%). Only 37% of respondents are aware of research or ongoing projects related to black soldier fly larva farming at their university, and only 34% are aware of local or global initiatives promoting it. Despite the limited knowledge, a significant portion of respondents (72%) believe that black soldier fly larva farming can contribute to sustainable agriculture and address food security challenges.

The result indicates that while respondents have a basic understanding of black soldier fly larva farming, there is a significant gap in knowledge regarding specific applications, benefits, and potential challenges. Addressing these knowledge gaps through education, research, and promotion can help drive the adoption of black soldier fly larva farming as a sustainable and innovative agricultural practice. The findings align with the studies of Raman et al. (2022), Bulinda et al. (2023), Dzepe et al. (2024), showing general awareness of black soldier fly farming but significant gaps in knowledge of specific applications, which limits its adoption in sustainable agriculture.

Knowledge of black soldier fly farming

Table 3: Knowledge of black soldier farming by respondents

S/N	Items	SA	A	D	SD	Mean	Remark
1	I have a clear understanding of the life cycle of black soldier flies	15	15	30	40	2.05	Disagree
2	I know the nutritional value of black soldier fly larvae for animal feed.	25	26	25	24	2.50	Agree
3	I am aware of the challenges and constraints associated with black fly soldier fly larvae farming.	10	30	20	40	2.10	Disagree
4	I understand the regulatory and environmental aspect of black soldier fly larva farming.	20	20	40	20	2.40	Disagree
5	I can differentiate between black soldier fly larva farming and other insect farming methods.	10	22	40	28	2.16	Disagree
6	I am familiar with the different stages of black soldier fly larvae development.	20	15	30	35	2.20	Disagree
7	I can explain how black soldier fly larvae can help in reducing food waste.	10	15	25	50	1.85	Disagree
8	I know the nutritional benefit of black soldier fly larvae food aquaculture.	20	26	25	24	2.5	Agree
9	I am aware of the potential challenges related a black soldier fly larvae as a protein source in human consumption.	20	25	20	10	2.5	Agree
10	I can describe the differences between the larvae of black soldier flies and other insect species used in farming.	18	22	35	30	1.72	Disagree
11	I understand the role of black soldier fly larvae in breaking down organic waste materials.	20	26	25	24	2.5	Agree
12	I am familiar with any legal regulations or guidelines related to black soldier fly larvae farming in our region.	20	15	30	35	2.20	Disagree

13	I can differentiate between the uses of black soldier fly larvae in agriculture and their potential applications in other industries.	15	20	25	25	1.95	Disagree
14	I know the specific environmental benefit associated with using black soldier fly larvae in waste management.	15	15	25	30	1.85	Disagree
15	I can identify key factors that can influence the efficiency of black soldier	10	22	40	28	2.16	Disagree

Source: field survey (2023) Decision rule = 2.5

Table 3 shows that about 55% of respondents have a clear understanding of the life cycle of black soldier flies, indicating a need for more detailed information. While most respondents (55%) are aware of challenges associated with black soldier fly larva farming, a significant portion (55%) lack knowledge about regulatory and environmental aspects. Respondents struggle to differentiate between black soldier fly larva farming and other insect farming methods (57%) and to identify key factors influencing efficiency (57%). There is a lack of knowledge about specific applications, such as using black soldier fly larvae in food aquaculture (55%) and reducing food waste (57%).

The analysis of the knowledge assessment reveals a significant knowledge gap among respondents regarding black soldier fly larva farming. While they are generally familiar with the concept, there is a lack of understanding of specific technical aspects, challenges, and potential benefits. This knowledge gap has implications for the successful implementation of black soldier fly larva farming initiatives. It is essential to provide comprehensive education and training programs to equip stakeholders with the necessary knowledge and skills. These findings are consistent with the studies of Van et al., 2022 and Ouko et al., 2023, who found that respondents exhibit basic knowledge of black soldier fly farming but lack an in-depth understanding of technical aspects and specific applications, which hampers broader adoption.

Preferred Learning Methods and Resources

Table 4: Preferred Learning Methods and Resources

S/N	Items	Yes	No
1	Workshop sessions on black soldier fly larva farming.	80	20
2	Online video tutorials	90	10
3	Interactive webinars	95	25
4	Printed educational materials (e.g brochures, pamphlets).	85	15
5	Practical hands-on demonstration	96	4
6	Participation in a black soldier fly larvae farming practical demonstration or field work.	98	2
7	Student club or organization focused on sustainable farming, including black soldier fly larvae farming	97	3
8	Online discussion forums or communities	99	1
9	Guest lectures or seminars featuring experts in black soldier fly larvae farming	95	5
10	Research projects related to black soldier fly larvae	92	8
11	Online courses or MOOCs (Massive Open Online Courses) on black soldier fly larvae farming.	90	10
12	Workshops and experiments related to black soldier fly larvae farming.	94	6

13	Newsletters or updates on the latest developments in black soldier fly larvae farming.	93	7
14	Involving black fly larvae farming in the university curriculum would be beneficial for students.	90	10
15	Sharing knowledge and experiences related to black soldier fly larvae farming with peers to promote awareness	98	2

Source: field survey (2023)

Results in Table 4 show that respondents are highly interested in practical hands-on demonstrations (96%), fieldwork (98%), and workshops and experiments (94%). This indicates a strong preference for experiential learning. Online resources, including video tutorials (90%), webinars (75%), online discussion forums (99%), and MOOCs (90%), are also highly preferred. This suggests a desire for flexible and accessible learning options. Respondents are keen to participate in student clubs or organizations focused on sustainable farming (97%) and to share their knowledge with peers (98%). This indicates a willingness to engage with the broader community and contribute to knowledge sharing.

The findings on preferred learning methods highlight a strong preference for hands-on learning experiences, online resources, and community engagement. This suggests that a diverse range of learning methods and resources are needed to effectively educate individuals about black soldier fly larva farming. A combination of hands-on experiences, online learning, and community engagement can provide a comprehensive and engaging learning experience. This finding is consistent with the research by Cheng & Chau (2016) and Fifolt et al. (2018), which indicates that respondents demonstrate a strong preference for experiential learning, online resources, and community engagement. This underscores the need for a diverse range of flexible educational methods in black soldier fly farming.

The results of this study have several implications for promoting the adoption of black soldier fly larva farming: Develop comprehensive educational programs that address the specific knowledge gaps identified in the study. Incorporate practical demonstrations, field trips, and workshops into training programs to enhance learning. Utilize online platforms to provide accessible and flexible learning opportunities, such as video tutorials, webinars, and online courses. Foster a sense of community and collaboration among stakeholders by organizing student clubs, discussion forums, and knowledge-sharing initiatives. Advocate for supportive policies and regulations that facilitate the implementation of black soldier fly larva farming initiatives.

Conclusion

This study provides valuable insights into the awareness, knowledge, and learning preferences of respondents regarding black soldier fly larva farming. The findings highlight the need for targeted education and training initiatives to address the identified knowledge gaps and promote the adoption of this sustainable and innovative agricultural practice. Based on the findings of this study, the following recommendations are made:

i. Develop comprehensive educational programs that cover the life cycle, benefits, challenges, and regulatory aspects of black soldier fly larva farming.
ii. Prioritize hands-on learning opportunities to enhance practical understanding and skills.
iii. Leverage online platforms to provide accessible and flexible learning resources.
iv. Foster community engagement through student clubs, discussion forums, and knowledge-sharing initiatives.

v. Advocate for supportive policies and regulations to facilitate the implementation of black soldier fly larva farming initiatives.
vi. Conduct further research to address remaining knowledge gaps and explore new applications of black soldier fly larva farming.

References

Belghit, I., Liland, N. S., Gjesdal, P., Biancarosa, I., Menchetti, E., Li, Y., Waagbø, R., Krogdahl, Å., & Lock, E. (2019). Black soldier fly larvae meal can replace fish meal in diets of sea-water phase Atlantic salmon (Salmo salar). *Aquaculture*, *503*, 609-619. https://doi.org/10.1016/j.aquaculture.2018.12.032

Bulinda, C. M., Gido, E. O., Kirscht, H., & Tanga, C. M. (2023). Gendered Awareness of Pig and Poultry Farmers on the Potential of Black Soldier Fly (Hermetia illucens) Farming in Kenya. *Sustainability*, *15*(4), 3613.

Cheng, G., & Chau, J. (2016). Exploring the relationships between learning styles, online participation, learning achievement and course satisfaction: An empirical study of a blended learning course. *British journal of educational technology*, *47*(2), 257-278.

Coleman, J. S. (2023). *Nigeria: Background to nationalism*. Univ of California Press.

Diclaro, I. I., Joseph W., and Kaufman, P. E. (2015). "Black Soldier Fly - HermetiaIllucens." University of Florida, July 2015. Web. 06 Dec. 2015.

Dzepe, D., Osae, M. Y., Asabre, J. O., Twumasi, A., Ofori, E. S., Atampugre, G., Abdoulaye, T., Asiedu, R., & Djouaka, R. (2024). Adoption potential of black soldier fly (Hermetia illucens (L.), Diptera: Stratiomyidae) larvae composting technology among smallholder farmers in Greater Ahafo-Ano, Ashanti region of Ghana. *Green Technologies and Sustainability*, *2*(3), 100112. https://doi.org/10.1016/j.grets.2024.100112

Ebenebe, C. I., Ibitoye, O. S., Amobi, I. M., & Okpoko, V. O. (2020). African edible insect consumption market. *African edible insects as alternative source of food, oil, protein and bioactive components*, 19-51.

Fifolt, M., Morgan, A. F., & Burgess, Z. R. (2018). Promoting school connectedness among minority youth through experience-based urban farming. *Journal of Experiential Education*, *41*(2), 187-203.

Hasnan, F. F. B., Feng, Y., Sun, T., Parraga, K., Schwarz, M., & Zarei, M. (2023). Insects as Valuable Sources of Protein and Peptides: Production, Functional Properties, and Challenges. Foods, 12(23), 4243.

He, P., Du, W., Xu, X., Zhang, H., Shao, L., & Lü, F. (2020). Effect of biochemical composition on odor emission potential of biowaste during aerobic biodegradation. *Science of the Total Environment*, *727*, 138285.

Idowu, S. S. (2020). Mono economy syndrome of Nigeria: Reposition of manufacturing sector for sustainable diversification and development. *Research Nepal Journal of Development Studies (RNJDS)*, *3*(1), 77-90.

Lu, S., Taethaisong, N., Meethip, W., Surakhunthod, J., Sinpru, B., Sroichak, T., Archa, P., Thongpea, S., Paengkoum, S., Purba, R. A., & Paengkoum, P. (2022). Nutritional Composition of Black Soldier Fly Larvae (Hermetia illucens L.) and Its Potential Uses as Alternative Protein Sources in Animal Diets: A Review. *Insects*, *13*(9), 831. https://doi.org/10.3390/insects13090831

Makinde, L. O., & Adegbami, A. (2019). Unemployment in Nigeria. *Ilorin Journal of Administration and Development*, *5*(2), 71-77.

Menino, R., & Murta, D. (2021). The insects as a workforce for organic fertilizers production–insect frass. *New Generation Organic Fertilizers*.

Mertenat, A., Diener, S., & Zurbrügg, C. (2019). Black Soldier Fly biowaste treatment–Assessment of global warming potential. *Waste management*, *84*, 173-181.

Olowe, V. (2021). Africa 2100: how to feed Nigeria in 2100 with 800 million inhabitants. *Organic Agriculture*, *11*(2), 199-208.

Ouko, K. O., Mboya, J. B., Obiero, K. O., Ogello, E. O., Mukhebi, A. W., Muthoka, M., & Munguti, J. M. (2023). Determinants of fish farmers' awareness of insect-based aquafeeds in Kenya; the case of black soldier fly larvae meal. *Cogent Food & Agriculture*, *9*(1), 2187185.

Raman, S. S., Stringer, L. C., Bruce, N. C., & Chong, C. S. (2022). Opportunities, challenges and solutions for black soldier fly larvae-based animal feed production. *Journal of Cleaner Production*, *373*, 133802.

Rawski, M., Mazurkiewicz, J., Kierończyk, B., & Józefiak, D. (2020). Black soldier fly full-fat larvae meal as an alternative to fish meal and fish oil in Siberian sturgeon nutrition: The effects on physical properties of the feed, animal growth performance, and feed acceptance and utilization. *Animals*, *10*(11), 2119.

Van, J. C. F., Tham, P. E., Lim, H. R., Khoo, K. S., Chang, J. S., & Show, P. L. (2022). Integration of Internet-of-Things as sustainable smart farming technology for the rearing of black soldier fly to mitigate food waste. *Journal of the Taiwan Institute of Chemical Engineers*, *137*, 104235.

ROLE OF DIGITAL PLATFORMS IN ACCESSING AGRICULTURAL INFORMATION BY RURAL FARMERS IN CROSS RIVER STATE NIGERIA

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Abstract
Digital platforms are transforming agriculture in Nigeria, especially for rural farmers. These technologies provide access to critical information such as weather forecasts, pest management, market prices, and innovative farming techniques. Despite these advancements, challenges such as infrastructure deficits, digital literacy gaps, and affordability hinder widespread adoption. This paper explores the role of digital platforms, their benefits, and the constraints faced by rural farmers in Cross River State Nigeria. Using a multistage sampling technique, 360 rural farmers with access to smart phones were selected and questionnaire administered to them to elicit information while data obtained was analyzed using descriptive statistics such as simple frequencies and percentages. The findings revealed that access to real-time information and financial inclusion, both receiving unanimous responses (100%) were the major benefits of digital platforms. Other notable benefits included improved market access (66.6%) and enhanced decision-making (58.3%). On the other hands, the most cited constraint was infrastructure deficiencies (50.0%), highlighting issues like inadequate internet access and unreliable electricity as well as affordability (28.0%) and digital literacy (17.0%) also emerged as significant barriers. Notably, cultural barriers (4.0%) and policy and regulation gaps (1.0%) were the least barriers. These findings emphasize the importance of addressing infrastructural and economic barriers to increase the adoption of digital platforms. Moreover, policymakers must prioritize regulatory frameworks that support innovation while ensuring inclusivity for smallholder farmers.

Keywords: Access, agriculture, digital, farmers, information, platform, rural

Sub Theme: Technological Advancements in Agriculture and Food Security

INTRODUCTION

Agriculture is the cornerstone of Nigeria's economy, employing over 70% of the rural population and contributing significantly to national GDP (Digital Agri Hub, 2023). Despite its critical role, the sector faces persistent challenges, including low productivity, inefficient farming practices, and limited access to local and international markets. In other words, limited access to timely agricultural information impedes productivity. A key factor exacerbating these issues is the lack of timely and accurate agricultural information, which hinders farmers' ability to make informed decisions about crop management, pest control, and market engagement (Phillip & Phillip, 2024). Thus, digital platforms offer solutions by providing instant, location-specific advice and connecting farmers to markets. These tools, including mobile apps, SMS

services, and web-based platforms, have become integral to agricultural extension systems (Digital Agri Hub, 2023). The adoption of digital platforms in Nigerian agriculture has been transformative, aligning with global trends in agricultural digitization. These platforms bridge critical information gaps, enabling farmers to access real-time data, market trends, and extension services (Agriculture Nigeria, 2024).

To address these challenges, digital platforms have emerged as transformative tools, leveraging technology to deliver critical agricultural information to rural farmers. These platforms, including mobile apps, SMS services, and online marketplaces, provide real-time updates on weather forecasts, market prices, and pest management. They also facilitate access to financial services and market linkages, empowering farmers to bypass intermediaries and connect directly with buyers (Digital Agri Hub, 2023). The rise of agri-tech startups in Nigeria, such as Agromall and Farmcrowdy, has further accelerated the integration of digital solutions into agriculture, creating new opportunities for innovation and productivity (Disciplines.ng.2024) Digital platforms, such as e-commerce marketplaces, enable farmers to bypass intermediaries, allowing them to connect directly with buyers. This not only secures better prices for their produce but also fosters transparency in transactions (Digital Agri Hub, 2023; Agriculture Nigeria, 2024). For instance, platforms like Farmcrowdy have significantly improved farmers' market linkages by creating digital ecosystems that connect producers with diverse markets (Phillip & Phillip, 2024). Farmers using digital tools can access real-time weather forecasts, crop management tips, and market analytics. This access enables them to make better decisions, reduce risks, and increase productivity. Agri-tech applications like Hello Tractor provide actionable insights that optimize farm operations and resource utilization (Agriculture Nigeria, 2024; Disciplines.ng, 2024). Mobile banking and digital payment systems have revolutionized financial access for farmers. Tools such as M-Pesa and local fintech platforms empower farmers to apply for loans, receive payments, and conduct secure transactions without relying on traditional banks. This shift has reduced transaction times and costs, increasing efficiency and inclusivity (Digital Agri Hub, 2023; Disciplines.ng, 2024). Agri-tech innovations, including smart irrigation systems and climate-smart agricultural practices, promote sustainable farming. These tools help farmers conserve resources, adapt to changing climate conditions, and enhance resilience against environmental challenges. For example, platforms offering drone-based monitoring and weather-specific advice have proven to increase resilience in farming practices (Phillip & Phillip, 2024; Agriculture Nigeria, 2024).

Digital tools, such as the Agricultural Market Information System (AMIS), provide updates on market prices and weather conditions, enabling farmers to make informed decisions (Digital Agri Hub, 2023). Social media platforms like WhatsApp and Facebook facilitate knowledge sharing among farmers and extension agents, reducing information asymmetry (IFLA, 2023). GPS-enabled devices help farmers map their land, improving crop planning and resource allocation. Platforms like TaroWorks bridge the gap for farmers in remote areas, leveraging offline functionality to collect data and provide tailored advice. Digital platforms offer multifaceted advantages for rural farmers: Platforms like e-commerce marketplaces allow farmers to bypass intermediaries, connect directly with buyers, and secure better prices for their produce. This model enhances income streams and fosters transparency in transaction. Mobile banking and digital payment systems empower farmers with tools for credit access, loan applications, and secure transactions, reducing dependence on traditional banking systems. Agri-tech innovations such as smart irrigation systems and climate-smart agricultural practices aid in resource conservation and adaptation to climate change, enhancing resilience against environmental challenges

However, the adoption of digital platforms by rural farmers in Nigeria remains limited. Structural barriers such as poor internet connectivity, high costs of digital devices, and inadequate digital literacy prevent many farmers from fully utilizing these tools. Additionally, cultural resistance to change and inconsistent policy frameworks further hinder the widespread adoption of digital technologies (Digital Agri Hub, 2023; Disciplines.ng, 2024). Addressing these challenges is critical to ensuring that digital platforms can effectively transform Nigeria's agricultural sector and improve the livelihoods of rural farmers. Poor internet connectivity in rural areas restricts the usability of digital platforms (Digital Agri Hub, 2023). Many farmers lack the skills to navigate digital tools, highlighting the need for training programs (IFLA, 2023). Smartphones and internet services remain expensive for smallholder farmers, limiting their adoption. Resistance to new technologies persists, often due to traditional practices or mistrust of modern systems.

This study delves into the role of digital platforms in enhancing access to agricultural information among rural farmers in Nigeria. It examines the benefits these platforms provide, identifies the challenges limiting their adoption, and offers recommendations to optimize their impact on agricultural productivity and sustainability. vice (World Bank, 2021). This study seeks to explore the role of digital platforms in addressing these agricultural information gaps, assess their benefits, and analyze the constraints hindering their widespread adoption.

MATERIALS AND METHODS

This study was conducted in Cross River State, one of the 36 states in Nigeria The state is situated between latitudes 4°33'N and 6°45'N, and longitudes 7°39'E and 9°30'E. It is bordered by Benue State to the north, Ebonyi and Abia States to the west, Cameroon to the east, and the Atlantic Ocean to the south. The state comprises 18 Local Governments Areas and experiences a tropical climate, characterized by two main seasons: the rainy season and the dry season. The rainy season typically lasts from March to October, with peak rainfall occurring between June and September. Annual rainfall ranges from 1,500 mm to 3,000 mm, supporting lush vegetation and diverse agricultural activities. The dry season, from November to February, is characterized by lower humidity and occasional harmattan winds from the Sahara Desert. The state is renowned for its rich biodiversity and diverse vegetation types. Cross River State is culturally diverse, with numerous ethnic groups including the Efik, Ibibio, Bekwarra, Ejagham, Boki and Yala among others. Each group has its unique cultural practices, languages, and traditional knowledge systems related to agriculture and natural resource management. Multistage sampling technique was used to select 360 rural farmers with access to smart phones as sample size. Questionnaire was used to elicit information from respondents and data obtained was analyzed using descriptive statistics such as simple frequencies and percentages to identify patterns and themes (Ibrahim & Yusuf, 2021).

RESULTS AND DISCUSSION

Table 1: Benefits of Digital Platforms (n=360)

S/N	Benefits of Digital Platforms	Frequency	Percentage
1	Access to real time information	360	100.0
2	Precision agriculture	120	33.3
3	Financial inclusion	360	100.0
4	Improved market access	240	66.6
5	Enhanced decision-making	210	58.3
6	Sustainability & climate adaptation	180	50.0

Source: Field survey, 2024 (Multiple responses)

The results from Table 1 highlight the multifaceted advantages of digital platforms for rural farmers. The most significant benefits reported were access to real-time information and financial inclusion, with both receiving unanimous responses (100%). These findings align with existing literature emphasizing the pivotal role of digital platforms in bridging critical information gaps and providing access to financial services that were previously unavailable to many rural farmers (Digital Agri Hub, 2023; Agriculture Nigeria, 2024).

Other notable benefits included improved market access (66.6%) and enhanced decision-making (58.3%). These results suggest that digital platforms are instrumental in empowering farmers to connect directly with buyers and make informed choices, which enhances productivity and income generation. However, the relatively lower adoption of precision agriculture (33.3%) and sustainability and climate adaptation (50.0%) indicates a potential gap in awareness or accessibility to advanced digital tools like smart sensors or climate-smart agriculture technologies.

The results underscore the transformative potential of digital platforms in enhancing agricultural productivity and resilience. However, the variation in the adoption rates of certain benefits suggests that efforts should focus on increasing farmers' awareness and capacity to use advanced features like precision agriculture. Policymakers and stakeholders should also prioritize scaling affordable, accessible digital solutions that address sustainability challenges in farming.

Table 2: Constraints to Adoption of Digital Platforms (n=360)

S/N	Constraints to Adoption	Frequency	Percentage
1	Infrastructure deficiencies	180	50.0
2	Digital literacy	60	17.0
3	Affordability	100	28.0
4	Cultural barriers	15	4.0
5	Policy and regulation gaps	5	1.0

Source: Field survey, 2024

Table 2 identifies key barriers to the adoption of digital platforms. The most cited constraint was infrastructure deficiencies (50.0%), highlighting issues like inadequate internet access and unreliable electricity, which are well-documented challenges in rural Nigeria (Digital Agri Hub, 2023; Phillip & Phillip, 2024).

Affordability (28.0%) and digital literacy (17.0%) also emerged as significant barriers. These results point to the economic and educational constraints that limit smallholder farmers' ability to leverage digital tools. Notably, cultural barriers (4.0%) and policy and regulation gaps (1.0%) had the lowest frequencies, suggesting that while cultural resistance exists, it is less significant compared to structural and economic challenges.

These findings emphasize the importance of addressing infrastructural and economic barriers to increase the adoption of digital platforms. Strategic investments in rural connectivity, subsidized digital devices, and digital literacy programs are essential to enhance farmers' access

and usability of these technologies. Moreover, policymakers must prioritize regulatory frameworks that support innovation while ensuring inclusivity for smallholder farmers.

CONCLUSION AND RECOMMENDATIONS

Digital platforms are pivotal for agricultural transformation in Nigeria, enabling rural farmers to overcome traditional barriers. However, achieving full integration requires addressing infrastructural, educational, and financial challenges. Policymakers and stakeholders must collaborate to create an enabling environment for digital agriculture to thrive

The following recommendations were made based on the findings

1. There is need for infrastructure development to expand rural internet connectivity and provide affordable devices for farmers.
2. Capacity building and training of farmers in digital literacy and establishing support centers in rural areas.
3. There is need for public-private partnerships and collaborate with tech companies to subsidize tools and ensure inclusivity.
4. Develop national frameworks to promote digital agriculture, with subsidies for rural farmers.

REFERENCES

Agriculture Nigeria (2024). *The Future of Agriculture in Nigeria: Trends and Innovations*. Retrieved from agriculturenigeria.com.

Cennamo, C. 2019. Competing in Digital Markets: A Platform-Based Perspective, Perspectives Vol.

Digital Agri Hub (2023). *Scaling Digital Extension and Advisory Services*. Retrieved from digitalagrihub.org

Digital Agriculture: Transforming the Landscape in Nigeria," Farming Farmers Farms, 2024. Link.

Disciplines.ng (2024). *How Nigeria is Bridging the Gap: Agri-Tech and Innovation*. Retrieved from disciplines.ng

FAO. (2019). Digital Agriculture Transformation: Pathways and Enablers. Food and Agriculture Organisation of the United Nations.

Ibrahim, A., & Yusuf, A. A. (2021). Adoption of pesticidal plants among farmers in Nigeria: A case study of selected communities in the Middle Belt region. *Journal of Agricultural Innovation and Sustainability*, 27(3), 345-358.

IFLA (2023). *Improving Rural Farmers' Access to Information Through ICT*. Retrieved from ifla.org

Phillip, D., & Phillip, B. (2024). *Understanding the Drivers and Distributional Effects of Digital Agricultural Platforms in Africa: A Case Study of Agromall*. PARI.

Saroniemi, R., Koskinen, K., & Tunainen, V.K. (2022). Vertical Integration of Digital Platforms in the Agricultural Industry. Hawaii International Conference on System Sciences. DOI:10.24251/HICSS.2022.816

World Bank (2021). *A Roadmap for Building the Digital Future of Food and Agriculture*. Retrieved from worldbank.org

World Bank. (2019). Growing Africa: Unlocking the Potential of Agribusiness. World Bank Group.

WILLINGNESS TO PAY FOR AGRICULTURAL EXTENSION SERVICES AMONG ARABLE CROP FARMERS IN ODUKPANI L.G.A OF CROSS RIVER STATE.

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Abstract

This study explored the willingness to pay for agricultural extension services by farmers in Odukpani Local Government Area, Cross River State. The study aimed to assess farmers' socioeconomic traits, factors affecting their willingness to pay, and the barriers they face in making payments. Using a two-stage sampling technique, 120 registered arable crop farming households were selected. Data were collected through structured questionnaires and analyzed using descriptive statistics and binary logistic regression. The findings revealed that 50% of the farmers were aged 30-39, with only 4.2% aged 20-29. Key factors influencing willingness to pay included; Price of extension services and Farmers' perception of the extension service providers' expertise and credibility. Barriers to payment included;Lack of awareness and understanding, Financial constraints or lack of funds, and Competing financial priorities for farmers, among others. The binary logistic regression analysis showed that marital status had a significant negative impact on farmers' willingness to pay. The study recommended strengthening financial support systems, such as microcredit schemes, to help resource-limited farmers access extension services.

Introduction

Agriculture is a key driver of the global economy, providing food, employment, and contributing significantly to national development (World Bank, 2019). As the agricultural sector evolves and faces increasing challenges, the role of agricultural extension services becomes even more critical. These services empower farmers with the necessary knowledge, skills, and technologies to improve their farming practices and boost productivity (World Bank, 2018). Typically delivered by government agencies, non-governmental organizations (NGOs), or private entities, agricultural extension services aim to disseminate information, provide training, and offer technical assistance (FAO, 2017). Farmers' willingness to pay for agricultural extension services is strongly influenced by the quality and relevance of the services provided. Research shows that farmers are more likely to invest in services that are tailored to their specific needs, reliable, and practical. Studies, such as those by Aboh (2010); Ofem, *et al.*

(2013) and Etim, *et al.*, (2023), found that farmers value extension services that deliver high-quality, accurate information and problem-solving support, making them more inclined to pay. Additionally, institutions like the World Bank, IFPRI, and FAO emphasize that services aligned with farmers' needs, preferences, and local conditions significantly boost willingness to pay. Meeting farmers' expectations through responsive and effective services is crucial for their continued investment in agricultural extension. Farmers face several barriers to paying for agricultural extension services, including lack of awareness, financial constraints, and trust issues. Many farmers are not fully aware of the benefits these services provide, such as improved productivity, better farming techniques, and access to new technologies, which reduces their willingness to invest (Gebremedhin *et al.*, 2010; Etim, *et al.*, 2021). When farmers lack understanding of how these services can enhance their operations, they hesitate to pay for them (FAO, 2016). Financial limitations are another significant barrier, especially for small-scale farmers who struggle to afford extension service fees, often prioritizing immediate needs like household expenses or inputs over long-term investments (FAO, 2016). The perceived lack of immediate returns on these services also contributes to their reluctance. Furthermore, trust issues regarding the quality and effectiveness of extension services can deter farmers from paying, as they may doubt the credibility and reliability of the service providers (Davis et al., 2015). To overcome these barriers, effective communication, cost-sharing arrangements, and efforts to build trust are essential (FAO, 2016; Etim, *et al.*, 2022). The research gap in this study centers on the need for a deeper understanding of the socioeconomic and situational factors that shape farmers' willingness to pay for agricultural extension services, along with the specific obstacles they encounter in making such payments in Odukpani Local Government Area, Cross River State. This study aims to assess the socioeconomic characteristics of farmers, identify the factors influencing their willingness to pay, and examine the barriers they face in accessing and financially supporting these services.

METHODOLOGY

This study was carried out in Odukpani Local Government Area, Cross River State located in the south-south geopolitical zone in Nigeria and has a total area of20,156km^2. It lies between latitude 5°4'52.46'N and longitude 8°20'59,7'E and has an elevation of approximately 413 ft above sea level. It shares a boundary with Calabar(the state capital) and is largely populated by the Efik people. According to the National population commission (2022), Odukpani has a population of 257,800, with a density of 209.6/km^2.Climate within the state is tropical humid with wet season which begins from March to November and dry season which begins from November to March. It has average temperatures ranging between 15°C and 30°C and an annual rainfall between 1300mm and 3000mm. The residents are involved in occupations like farming, hunting, pottery, and trading. Food crops cultivated in the area includes cassava, maize, yam, okra, pumpkin, plantain, banana, etc. While cash crops cultivated include; coconut, rubber, cocoa, oil palms among others. The population of this study consists of all registered arable crop farming households in Odukpani Local Government Area. The study adopted a 2-stage sampling procedure. In stage one: simple random sampling was used to select 5 out of 9 cells that make up the Odukpani agricultural block. In stage two: simple random sampling was used to select 20% of registered arable crop farming households in the selected cells. The list of registered arable crop farming households was obtained from CRADP. A set of structured questionnaires was used to collect the data.Variables were analyzed using descriptive statistics such as mean and standard deviation.The binary logistic regression model was used to test the relationship between socio-economic characteristics of the respondents and their willingness to pay for extension services,

Table I: Sampling procedure and sample size

Agricultural block	No of cells in the block	No of selected cells	No of registered arable crop farming households in the selected cells	20% of registered arable crop farming house-holds
Odukpani	Ikoneto	EniongAbatim	Cell 1-100	20
	Ukwa	Creek Town	Cell 2 = 120	24
	EniongAbatim	Okurikang	Cell 3 = 135	28
	Creek Town	AkpapOkoyong	Cell 4 = 90	18
	Okurikang	Ito	Cell 5 = 150	30
	AkpapOkoyong			
	Ito			
	Ikot Nyong			
	AdiaboEfut			
				120

RESULTS AND DISCUSSION

1. Socioeconomic characteristics of the respondents

The following socio-economic characteristics of respondents were highlighted in the study, as depicted in Table 2.

Age:

Half (50.0%) of the respondents were between the age range of 30 -39 years, while 44.4% were between the age range of 40- 49. Only 4.2% of the respondents were between the age range of 20 – 29 years. This implies that most of the farmers were in their mid and active age. According to Surry (1997), when one is young and agile, individual's efficiency tend to be high and activities are approached with vigor and seriousness.

Sex:

A high proportion (65.8%) ofthe rspondents were males, while 34.2% were females. This implies that arable crop farming is dominated by males in the study area.

Marital Status:

A greater proportion (65.8%) of the respondentst were married, while about (14.2%) were separated. This implies that most of the farmers were married with families to fend for. This could be related to the view of Nicholas, *et al.* (2013) that the high percentage of married farmers may be due to socio-cultural factors where land is handed over to individuals who are married only. Ifeanyi-obi *et al.*(2017)reported that most cocoyam farmers were married in Delta State, Nigeria.

Educational Level:

Slightly above half (50.8%) of the respondents had secondary school education, while 33.3 % and 10.0% of the respondents had primary and tertiary education respectively. The finding implies that most of the farmers were literate, having attended formal schooling. Education plays a significant role in technology transfer. Nwalieji and Ojike (2018) was of the view that education enhances technology adoption and ability of farmers to plan and take risks.

Household size:

A high percentage (81.7%) of the respondents had household size range of 5 - 10 members, while 12.5% had household size range of less than 5 members. The mean household size was 5

members. The result implies that the arable crop farmers had a relatively high household size. Ajani, *et al.* (2012) reported that large family size constitutes the family labour, which most farmers rely upon in carrying out farm operations.

Farm size:
A greater proportion (77.5%) of the respondents had farm size range of less than 1 hectares, while 14.2% had farm size range of 1-5 hectares. The finding implies that majority of the respondents are smallholder farmers and practicing subsistence farming which is typical of most farmers in Nigeria. The result agrees with the view of Ajayi and Solomon (2010) who reported that small farm holdings constitute more than 70.0% of all farming activities in Nigeria.

Main occupation:
The majority (86.7%) of the respondents' main occupation was farming, while only 13.3% combined farming with business. Combining farming with business is very crucial for farmers. This is because it improved their livelihoods; by generating higher more income, farmers can improve living standards and contribute to local economic growth.

Monthly income:
More than half (61.7%) of the respondents had a monthly income range of between ₦50,000.00 – 100,000.00, about 25.8% had a monthly income range of less than ₦50,000.00. The mean income range of the respondent was ₦66, 302.50. This implies that the respondents had a relatively low income. Low income of farmers may hinder adoption of innovations, as farmers may not have adequate fund to access and use such innovations.

Contact with extension:
Almost all (98.3%) the respondents never had contact with extension agent in the past one year. The finding implies almost all the arable crop farmers had not been visited by extension agents in the past one year. This reveals that there is a disproportionate extension agent to farm family ratio. Agbogidi & Ofuoku, (2009) noted that the disproportionate ratio of extension agent to farm family prevalent in developing countries has led to a situation in which many rural dwellers or farmers do not benefit from the available services.

Willingness to pay for agricultural extension services
A high proportion (99.2%) of the respondents agreed to pay for extension services, while 20.8% disagreed to pay for extension services. This is an indication that majority of arable crop farmers will be willing to pay for extension services if asked to pay for every service received.

Table 2: Distribution of the respondents based on socioeconomic characteristics

Variables	Frequency	Percentage
Age (years)		
20 – 29	5	4.2
30 – 39	60	50.0
40 – 49	53	44.2
50 – 59	2	1.7
Total	120	100.0
Sex		
Male	79	65.8
Female	41	34.2
Total	120	100.0

Marital status		
Married	78	65.8
Divorced	12	10.0
Widowed	12	10.0
Separated	17	14.2
Total	120	100.0
Educational level		
No formal education	7	5.9
Primary school	40	33.3
Secondary school	61	50.8
Tertiary education	12	10.0
Total	120	100.0
Household size		
Less than 5	15	12.5
5 -10	98	81.7
11 & above	7	5.8
Total	120	100.0
Farm Size (Ha)		
Less than 1	93	77.5
1 – 5	17	14.2
6 -10	10	8.3
Total	120	100.0
Occupation		
Farming	104	86.7
Farming & business	16	13.3
Total	120	100.0
Monthly Income (Naira #)		
Less than 50,000.00	31	25.8
50, 000.00 – 100, 000.00	74	61.7
101,000.00 – 150,000.00	13	10.8
151,000.00 & above	2	1.7
Total	120	100.0
Extension contact		
Yes	2	1.7
No	118	98.3
Total	**120**	**100.0**
Willingness to pay for extension service		
Yes	95	20.8
No	25	79.2
Total	120	100.0

Source: Field Survey, 2024

2. Factors influencing farmers' willingness to pay for agricultural extension services

Results in Table 3 showed the factors influencing farmers' willingness to pay for agricultural services. Based on the weight of the mean scores, Price of extension services ($\bar{x}$= 4.0) and Farmers' perception of the extension service providers' expertise and credibility ($\bar{x}$= 4.0) ranked 1st and 2nd respectively as factors influencing farmers' willing to pay for extension services. This was followed by Farmers' income and financial capacity ($\bar{x}$= 3.9), Perceived value of the

services offered ($\bar{x}$= 3.9), Qualify and relevance of information provided ($\bar{x}$= 3.7), Impact of the services on increasing income($\bar{x}$= 3.7),Impact of the services on increasing productivity ($\bar{x}$ = 3.6), Effectiveness of past extension services received ($\bar{x}$= 3.6), Farmers' education level and awareness about the benefits of extension services ($\bar{x}$= 3.6), Compatibility of the services with farmers' goals and practice($\bar{x}$= 3.5), Perceived risk associated with the services($\bar{x}$= 3.5), Farm and household size ($\bar{x}$ = 3.4), among other factors. However, the least ranked factor was Cultural and social norms surrounding payment for agricultural extension services ($\bar{x}$ = 2.6).

The implication of the finding is that myriads of factors influenced framer's willingness to pay for extension services, which ranges from perception, awareness, knowledge, availability, accessibility affordability, trustworthy and usability of the extension information to education, farm and household sizes of the farmers. Accordingly, FAO (2022). Stated that farmers are more likely to pay for extension services when they perceive them as valuable, trustworthy, and capable of addressing their specific challenges and needs effectively, as Mausch, *et al*. (2018) found that farmers are willing to pay higher prices for services that are relevant, tailored to their specific needs, and are perceived to have high quality in terms of accurate information, practical advice, and effective problem-solving support. The finding conforms with that of Asfaw (2018) who found that farmers who have limited access to information and knowledge are more willing to pay for extension services, as they see them as valuable sources for acquiring new information and improving their agricultural practices.

Table 4: Factors influencing farmers' willingness to pay for agricultural extension services (n =120)

Factors	Std. Dev	Mean	Rank
Perceived value of the services offered	0.27	3.9	4th
Qualify and relevance of information provided	0.46	3.7	5th
Trustworthiness of the service providers	50	3.4	12th
Affordability of the services	0.48	3.3	14th
Accessibility of services in terms of location and timing	0.48	3.3	14th
Farmers' education level and awareness about the benefits of extension services.	0,47	3.6	7th
Farmers' income and financial capacity	0.30	3.9	3rd
Impact of the services on increasing productivity	0.48	3.6	5th
Impact of the services on increasing income	0.45	3.7	5th
Availability of free or subsidized extension services.	0.96	3.0	18th
Cultural and social norms surrounding payment for agricultural extension services.	0.78	2.6	20th
Level of competition among extension service providers.	1.12	2.9	19th
Effectiveness of past extension services received.	0.49	3.6	7th
Perceived risk associated with the services	0.50	3.5	10th
Perceived benefit-cost ratio of paying for agricultural extension services	0.77	3.2	17th
Farmers' perception of the extension service providers' expertise and credibility.	0.00	4.0	1st
Compatibility of the services with farmers' goals and practice.	0.50	3.5	10th
Farm and household size	0.68	3.4	12th
Farming experience	0.81	3.3	14th
Price of extension services.	0.00	4.0	1st

Source: Field Survey, 2024

3. Barriers to payment for Agricultural extension Services

Results in Table 5 showed farmers' barriers to payment for agricultural extension services. Based on the weight of the mean scores, the barriers faced by the farmers towards payment for agricultural extension services were Lack of awareness and understanding($\bar{x}$= 4.0), Financial

constraints or lack of funds($\bar{x}$= 3.9), Competing financial priorities for farmers($\bar{x}$= 3.9), Language barriers that hinder effective communication and understanding of the services($\bar{x}$= 3.8) ,Limited access to payment options or credit facilities($\bar{x}$= 3.5), Fear of risk or failure associated with investing in the services($\bar{x}$= 3.5) , Lack of perceived return on investment in agricultural extension services($\bar{x}$= 3.5), Perception of low value for the cost of the services($\bar{x}$= 3.4) , High cost of services relative to income($\bar{x}$= 3.4), and Lack of trust and credibility ($\bar{x}$= 3.3), among other barriers. The least barriers to payment for agricultural extension services were Cultural beliefs or norms around payment for agricultural services ($\bar{x}$=3.1) and Inadequate feedback mechanisms for farmers to express their needs and concerns ($\bar{x}$=2.8). The implication of the finding is that crop farmers faced numerous barriers to payment of agricultural extension services which needs to be worked on. Almost all the farmers faced financial constraints, which is typical of small-scale farmers in Africa and other developing countries, that make it difficult for them to afford the cost of agricultural extension services. The fee charged for these services may be perceived as too high, especially when compared to their income levels or the perceived benefits. Limited financial resources can indeed be a significant barrier to payment for agricultural extension services. Rola-Rubzen et al. (2012) found that farmers with lower incomes and limited financial capacity were less likely to invest in these services. FAO, (2016)suggested that extension providers and policymakers should consider innovative approaches, such as cost- sharing arrangements or subsidies, to make these services more accessible and affordable for resource-constrained farmers.

Table 5: Barriersto payment for Agricultural Extension Services.

List of Barriers	Std.Dev	Mean	Rank
Lack of awareness and understanding	0.00	4.0	1st
Financial constraints or lack of funds	0.30	3.9	2nd
High cost of services relative to income	0.49	3.4	8th
Lack of trust and credibility	0.46	3.3	11th
Inadequate communication and outreach	0.43	3.2	12th
Lack of transparency in pricing and service delivery	0.49	3.4	8th
Limited access to payment options or credit facilities	0.50	3.5	5th
Language barriers that hinder effective communication and understanding of the services.	0.40	3.8	4th
Perception of low value for the cost of the services	0.50	3.4	8th
Limited government support or subsidies for extension services.	0.88	3.2	13th
Absence of tailored payment plans to suit farmers' financial capacities	0.92	3.0	14th
Fear of risk or failure associated with investing in the services.	0.50	3.5	5th
Lack of perceived return on investment in agricultural extension services.	0.50	3.5	5th
Competing financial priorities for farmers	0.74	3.9	2nd
Cultural beliefs or norms around payment for agricultural services.	1.14	3.1	5th
Inadequate feedback mechanisms for farmers to express their needs and concerns	1.19	2.8	16th

Source: Field Survey, 2024

4. Relationship of socioeconomic variables and willingness to pay for extension services

The result of the binary logistic regression model of the relationship between socio-economic characteristics of the respondents and their willingness to pay for extension services, as depicted in Table 6, showed that only marital status (B = -1.846, p= 0.002) had a negative significant relationship with farmers' willingness to pay for extension services at p< 0.05. This an indication that being married is associated with a decrease in the likelihood of paying for agricultural extension services by arable crop farmers. The result conforms with that of

Oluwatosin, (2024) who found that marital status had a significant relationship with farmers willingness to pay for extension services in Nigeria.

Table 6: Binary logistic regression of respondents' socioeconomic variables and willingness to pay for extension services

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Sex	0.705	0.722	.953	1	0.329	2.024
	Age	0.731	0.696	1.103	1	0.294	2.077
	Education	-0.152	0.484	.099	1	0.754	.859
	Marital status	-1.846	0.603	9.362	1	0.002**	.158
	Farmsize	-2.381	1.524	2.440	1	0.118	.092
	Household size	0.076	0.160	.228	1	0.633	1.079
	Monthlyincome	0.000	0.000	3.838	1	0.050	1.000
	Contactwithextension agents	2.825	2.090	1.826	1	0.1077	16.853
	Constant	-1.829	3.030	.364	1	0.546	.161

Source; Field Survey, (2024); significant p<0.05

CONCLUSION

The findings of this study indicate that arable crop farmers in Odukpani Local Government Area exhibit a high willingness to pay for agricultural extension services. Despite the availability of essential extension services that aid farmers in making informed decisions for improved crop production, various factors influenced their willingness to pay. These include their perception of the services, awareness, knowledge, accessibility, affordability, and trustworthiness of the extension information. Additionally, socioeconomic factors such as education, farm size, and household size also played a role. Barriers to payment, such as lack of awareness, financial constraints, and competing financial priorities, hindered many farmers from fully engaging with extension services. Addressing these barriers is crucial to ensure broader access and sustained investment in agricultural extension services for the farmers.

RECOMMENDATIONS.

Based on the findings, the following recommendations were made:

1. Government and agricultural organizations should focus on improving farmers' education and awareness through community-based training programs that enhance their decision-making capacity. Financial support systems, such as microcredit schemes or subsidies, should be strengthened to help farmers with limited resources invest in agricultural extension services.
2. The willingness of farmers paying for extensionservices should be experimented and implementedin a phased manner with utmost caution becausemany farmers in Nigeria operate on small scale andlack access to necessary resources that can enable them adoptthis system easily.
3. One of the major barriers to payment of extension services by farmer was financial constraints or lack of funds, it is therefore suggested that farmers' access to credits is a function of theirability to sustainably pay for extension hence,provision of credit by both private and public atlow interest rate to farmers is encouraged. As thiswill not only boost their agricultural productionwhen invested wisely in enterprise but can givethem the financial power to pay for extensionservices.

References

Aboh, C. L. (2010). Adult education and cassava farmers' productivity in rural communities in Akwa Ibom state, Nigeria. *Unpublished Ph.D. Thesis*, University of Calabar, Department of Agricultural Economics and Extension, 134.

Agbogidi, O.M. and Okonta, A.U. (2009) Biodiversity Conservation and Poverty Alleviation in the Niger Delat Are of Nigeria. Agriculturea Conspectus Scientificus, 71, 103-110.

Ajani, E. N., Onwubuya, E. A., &Nwalieji, H. U. (2012). Assessment of oil palm production and processing among rural women in Enugu North agricultural zone of Enugu State, Nigeria. *International Journal of Agricultural Sciences*, 2(12), 322-329.

Ajayi, M. T., & Solomon, O. (2010). Influence of extension contact and farmers' socio-economic characteristics on adoption of oil palm technologies in Aniocha North Local Government, Delta State, Nigeria. *Journal of Agriculture, Science and Technology*, 12(2), 35–46. https://ojs.jkuat.ac.ke/index.php/JAGST/article/view/174

Asfaw, A. (2018). Review on role and challenges of agricultural extension service on farm productivity in Ethiopia. *International Journal of Agricultural Education and Extension*, 4, 93-100.

Davis, K., Franzel, S., & Blum, M. (2015). The role of field demonstrations in agricultural extension. *Journal of Agricultural Extension and Education*, 21(3), 65-79.

Etim, O. U., Okoi, K. O., Yahaya, M., and Ntui, O. E., (2023). Environmental Safety Awareness, Extension and Agricultural Development in Nigeria. IIARD International Journal of Geography & Environmental Management (IJGEM) Vol. 9 No. 6 2023 E-ISSN 2504-8821 P-ISSN 2695-1878 www.iiardjournals.org IIARD – International Institute of Academic Research and Development.

Etim, O. U., Kennedy, O. O., Ntui, O. E., & Ayi, N. A., (2022). An assessment of the Role of Extension Officers in Enhancing Agricultural Safety Awareness in Cross River State, Nigeria. International Journal of Agriculture and Environmental Science. D.O.I: 10.56201/ijaes.v8.no4.2022.pg1.17 E-ISSN 2489-0081 P-ISSN 2695-1894 Vol 8. No. 4 2022

Etim, O. U., Aboh, C. L., Idiku, F. O., &Okoi, K. O., (2021). An assessment of the level of Occupational Safety Awareness for Agricultural Extension Agents in Cross River State. (International Journal of Agriculture and Earth Science, Vol. 7) E-ISSN 2489-0081 P-ISSN 2695-1894, Vol 7. No. 2 2021.

Food and Agriculture Organization (FAO). (2016). *Training in agricultural extension*. FAO.

Food and Agriculture Organization (FAO). (2022). *Technical assistance*. FAO. http://www.fao.org/technicalassistance/en/

Gebremedhin, B., Jaleta, M., & Hoekstra, D. (2010). Determinants of smallholder farmers' demand for extension services in Ethiopia. *Agricultural Systems*, 103(2), 82-89.

Mausch, K., D. Harris, E. Heather, E. Jones, J. Yim, and M. Hauser. (2018). Households' aspirations for rural development through agriculture. *Outlook Agriculture* 47 (2): 108–115.

Nicholas Ozor & Chris J. Garforth& Michael C. Madukwe, 2013. "Farmers' Willingness To Pay For Agricultural Extension Service: Evidence From Nigeria," Journal of International Development, John Wiley & Sons, Ltd., vol. 25(3), pages 382-392,

Nwalieji, H. U., &Ojike, H. U. (2018). Characteristics of small-scale palm oil production enterprise in Anambra State. *Journal of Agricultural Extension*, 22(1), 22–34. https://journal.aesonnigeria.org/index.php/jae/article/view/1167

Ofem, N. I., Elemi, G. F., &Agube, E. 1. (2013). The role of communication media in mitigating climate change effects on agricultural production in Cross River State, Nigeria. *Journal of Agricultural and Crop Research*, 1(3), 46-54.

Oluwatosin, F. (2024). Perception of agricultural extension personnel in the use of music in disseminating agricultural information in Ondo State, Nigeria. *Journal of Agricultural Extension*, 28(3). https://journal.aesonnigeria.org/index.php/jae

Rola-Rubzen, M. F., Paris, T., Hawkins, J., & Sapkota, B. (2020). Improving gender participation in agricultural technology adoption in Asia: From rhetoric to practical action. *Applied Economic Perspectives and Policy*, 42, 113-125. https://doi.org/10.1002/aepp.13011

Surry, D.W (1997). Diffusion theory and instructional technology. University of Southern Mississippi. [on-line] available: http :// w ww .gsu .e d u /-w wwitr /d o c s /d iffu s io n / [accessed 20/ I 0/02].

World Bank. (2018). *Roles of agricultural extension to farmers*.https://www.worldbank.org/en/research.

World Bank. (2019). *Roles of agriculture in the global economy*.https://www.worldbank.org/en/research.

COMPARATIVE QUALITY ASSESSMENT OF *GARRI* PRODUCED FROM THREE NEW CASSAVA VARIETIES

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ABSTRACT
"Garri" is major cassava product throughout the African Continent. This study aimed at evaluating the quality of garri processed from three improved varieties of cassava (TMF 368, TMS 3572 and TME 419) and multiplied by Crop Science Department, University of Calabar. The cassava varieties were harvested matured and processed into garri using standard procedures. The garri samples were labelled A, B and C from TMF 368, TMS 3572 and TME 419, respectively. The samples were analyzed for physic-chemical properties and sensory profile. The results shows that protein ranged between 3.81 and 4.19% with sample A having the lowest protein value and sample B had the highest protein value. Water absorption capacity and swelling index followed the same trend. Water absorption capacity and swelling index ranged from 4.43 to 5.63 g/ml and 3,34 to 4,03 g/ml, respectively with sample A having the highest values for both parameters and significantly different ($p<0.05$) from other samples. Sample A was found to have highest value in calcium (21.80 ppm), magnesium (8.68 ppm) and iron (2.87 ppm) showing that the sample is rich in minerals contents. Sample A is the most acceptable in term of colour, taste, aroma, texture and overall acceptability. Overall, sample A i.e garri from TMF 368 had the best quality for garri processing.

Keywords: Cassava, "garri, functional properties, pasting profile, particle sizes

INTRODUCTION
The increasing importance of cassava (*Manihot esculenta*) among crops grown in Nigeria is not only connected to its increasing demand as food but also as food security (FAO, 2000). Cassava products are dietary staple food in Nigeria and other countries in SSA. Nigeria is populated with about 200 million people, and seven in every ten Nigerians consume, at least, a product of cassava once in a day (Njoku and Banigo, 2006). These products include: cassava flakes (*garri*), cassava flour (pupuru and lafun), cassava paste (fufu) which are derived from cassava roots. It is a widely acceptable energy food source to over 600 million consumers of cassava across the globe (Hahn, 1989). Food insecurity is a major concern for Sub-Saharan Countries, where agricultural production is far much below the demand of the fast growing population. Nonetheless, the good news is that African traditional root crops, especially cassava have been proven, through scientific research, to have a considerable potential to boost food security (Adeniji *et al.*, 2005). In Africa, Nigeria is the leading cassava producer. Latest available statistics show that in 2018, it produced about 57 million metric tons (MT), while Kenya produced only 858,361 MT in the same period (Udoro, 2014).

Cassava is remarkably valuable and can substitute other crops in various uses depending on the preferences and customs of the local population. Cassava roots can be processed for human consumption and industrial purposes such as yeast, beer, and ethanol production. Its starch component is highly demanded by paper, plywood, pharmaceutical and textile industries (IITA, 2005). The success stories of cassava can be drawn from countries such as Brazil, Nigeria,

Thailand and Vietnam. For instance, in Brazil, cassava has been used successfully in the confectionery and baking industry (Sanginga and Mbabu, 2015).

The introduction of improved cassava varieties is believed to be vital for rural economies and household food security and should not be ignored. Stakeholders have been focusing on generalised approaches rather than dealing directly with the core issues that limit adoption of the new varieties. Most rural farmers and consumers do not have adequate idea about the quality of the different varieties of cassava in terms of the nutritional and the anti-nutritional qualities of the varieties. Low adoption of the new varieties is likely to compound the already uncertain future of food security situation in the county. Previous studies on improved cassava varieties have only assessed socioeconomic characteristics, institutional and policy factors determining adoption (Njine, 2010; Mulu-Mutuku *et al.*, 2013; Mwang'ombe *et al.*, 2013; Mutisya *et al.*, 2013; Danda *et al.*, 2014; Kamau *et al.*, 2016).

The major criticism of cassava breeders is the tendency to concentrate on improving yield while failing to integrate other desirable non-yield-related attributes into improved varieties. Non-yield-related attributes are important since cassava is grown mainly for subsistence in the rural society. Furthermore, genetic modification of crops tends to affect the constituent of food materials from such crops (Johnson, 2008). Thus, there is the tendency that, modification may have affected the nature and structure of the chemical composition of the new varieties. Therefore, there is need to evaluate the nutritional and functional properties of the new cassava varieties. Hence, this work was aimed at comparing the nutrients compositions and functional properties of *garri* produced from three improved varieties grown in Southern Nigeria.

MATERIALS AND METHODS

Materials

Three different varieties of cassava: TMF 368, TMS 3572 and TME 419 were harvested from Crop Science Teaching and research farm, University of Calabar (UNICAL), Calabar and transported to the Department of Food Science and Technology, UNICAL for processing into *garri*.

Sample Preparation

Freshly harvested cassava roots are sorted to remove the unwanted ones which are unfit for processing. The roots were peeled to remove the outer brown skin and inner thick cream layer and washed with clean water to remove stains and dirt. Fresh cassava root milling machine was used to grate the fresh cassava root in order into cassava mesh. Hydraulic press was used to dewater the bagged cassava mash, which was left on the hydrolic press for 3 days. Fermentation took place during dewatering period. At the end of the fermentation period, the mash will become a firm, wet cake. The wet cake was sieved into grits and then roasted with the use of roaster to form the final cripsy and dry product which Garri. The garri was spread on a cooling tray in the open air to cool. The garri samples produced hygienically from three different varieties of cassava were packaged separately after cooling in airtight containers prior further analysis.

Determination of Functional Properties of Garri

Functional properties of the garri samples were evaluated, these includes pH (Model HI 1270), water absorption capacity, bulk density by methods of Onwuka (2005), while wettability and pH by Methods of AOAC. (2020).

Determination of Pasting Profile of Garri

Pasting characteristics were determined with a Rapid Viscometer Analyzer (RVA) (Model RVA 3D+, Newport Scientific Australia). The rate of heating and cooling was at a constant rate of 11.250C per min. Pasting temperature (PT), peak viscosity (PV), minimum viscosity (MV), or trough viscosity (TV), final viscosity (FV), and peak time (PTime) was read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport Scientific, 1998). Breakdown viscosity (BV) was calculated as the difference between PV and MV, while total setback viscosity (TSV) Were determined as the FV minus MV. All determinations performed in triplicate by Nwaiwu and Onyeaka (2022).

Particle Size Analysis of Garri

Particle-size determination: The particle-size distribution of the garri samples were determined according to the method of Ngoddy and Nyekoroye (2000) with slight modifications. The shaker was operated for 20 min after which garri sample retained on each sieve will be weighed.

Proximate Analysis

The garri samples were analysed for moisture content, crude fat, crude protein, total ash content and crude fibre according to the method of analysis of the AOAC (2020), while Carbohydrate contents of the garri samples was determined by differences

Mineral ccontent ddetermination of *garri* samples

The mineral compositions of the samples were determined according to the method of AOAC (2020). The filtered solution was loaded to an atomic absorption spectrophotometer (Perking Elmer, model 402) for the determination of calcium, magnesium, phosphorous, potassium Were determined by flame photometry while iron was determined using the Vanodo-molybdate method.

Determination of Cyanogenic Glycosides

The samples (10g per sample) were loaded into glass bottles and acidified with 15mL of hot 20% HCl solution. The bottles were sealed with 3 picrate impregnated strips suspended above the acidified samples as the bottles were scaled. The system was left at room temperature (28 ± 20 C) for 24h. The red-coloured picrate paper strips were removed from the bottles and rinsed in 5mL of 50% ethanol solution for 30minutes and the absorbance of the solution measured at 510nm using a Spectrumlab 10 mgKCN/10g was 98.6% as 99.1% respectively (Ikediobi, *et al.*, 1980).

Sensory Evaluation of Garri

Sensory Quality Determination: The sensory profile was assessed using Hedonic scale. The sensory evaluation was carried out by 12 respondents which comprised of lecturers and students of the Department of Food Science and Technology, University of Calabar, Cross River State. Garri samples from the different cassava varieties were simultaneously presented to the panelist in plates. A glass of clean water was given to the respondents to rinse their mouth in between each determination to avoid discrepancies in taste. The samples of garri were analyzed for various attributes such as color, taste, and texture. The sensory test was performed in naturally illuminated room. Samples were evaluated for all sensory attributes on a 9 - point Hedonic scale which were quantified from one for like extremely to nine dislikes extremely by the method of Bolade, (2004)

RESULTS AND DISCUSSIONS

After carrying out the analysis on the garri samples, the results of the analysis carried out on the garri samples such as functional properties, pasting properties, particle size proximate composition, mineral contents, determination of hydrogen cyanide content and sensory analysis were collated.

Functional Properties of Garri Samples

The functional properties of a food material affect how it interacts with other food components and determines its application and end use. Functional properties of garri varieties are presented on table 1. Bulk density ranged from 0.56 to 0.60g/ml with sample A having the lowest bulk density (0.56g/ml) and Sample C having the highest bulk density (0.47g/ml). There was significant difference ($P<0.05$) between sample A and Sample C but they were no significant different between sample B and Sample C. Plaami (1997) reported that bulk density is influenced by the structure of starch polymers and loose structure of starch polymers result in low bulk density. The lower the bulk density, the higher the floatation of garri samples on top of water and as a result may not soak properly in water which may lead to rejection by consumers (Sanni *et al,*. 2008). This is evidence in the wettability results, where it took 302.33 seconds for Sample A to get soaked as against samples B and C which recorded 295.67 and 271.33 seconds, respectively. Wettability shows how proficient food products sample will be distributed. Therefore, the food product samples that will disperse fastest in water are the ones with the lowest wettability and higher values of wettability indicate lower reconstitution properties Ubbor, and Akobundu, 2009).

The results of water absorption capacity and swelling power followed the same trend. Water absorption capacity and swelling index ranged from 4.43 to 5.63 g/ml and 3,34 to 4,03 g/ml, respectively with sample A having the highest values for both parameters and significantly different ($p<0.05$) from other samples. Increase in water absorption capacity could be due to high water absorption capacity of garri. A good quality garri has been described as that which can swell to at least three times its original volume (Makanjuola *et al.*, 2012). Sanni *et al.* (2008) reported that the swelling index of granules reflect the extent of associative forces within the granules, therefore the higher the swelling index, the lower the associative forces.

Pasting Properties of Garri Samples

The pasting properties of garri are fundamental in predicting their behaviour during and after cooking, as these products may be reconstituted in hot water to *eba* before consumption (Adebowale *et al,* 2013). Table 2 depicts the results of the pasting properties of garri samples. The pasting temperature of garri samples ranged from 57.25 to 77.45 °C with sample A having the lowest pasting temperature and Sample C with the highest pasting temperature value. The pasting temperature is a measure of the minimum temperature required to cook a given food sample, which has implications for the stability of other components in a formulation and as well indicates energy costs (Adebowale *et al,* 2013). This result shows that sample C will take longer time to cook compared to others as the pasting temperature was the highest.

The peak velocity of garri samples ranges from 1395.00 to 2393RVU with sample A having the lowest peak viscosity and Sample C having the highest peak velocity. There's difference of peak viscosity between all the analysed samples. Ikegwu *et al* (2009) stated that the peak viscosity is the maximum viscosity developed during or soon after the heating process, and which contributes to the good texture of the cooked starchy food. The texture of cooked starchy foods may depend on the quantity of water used during reconstitution and the temperature and time spent for gelatinization Newport Scientific. The trough viscosity of garri samples ranges

from 1330.00 to 2095.00RVU with sample A having the lowest trough viscosity value and Sample C having the highest trough viscosity value. The trough viscosity, also known as holding strength, is the ability of granules to remain undisrupted when the starch is subjected to a period of constant high temperature and mechanical shear stress (Alsabagh,2014).

The final viscosity of garri samples ranges from 3014.00 to 3303.00RVU with sample B having the lowest final viscosity value and Sample C having the highest final viscosity value. There's difference between all analyzed samples. The final viscosity is the pasting parameter most commonly used to determine the quality of a starchy product as it indicates the ability of the material to form a gel after cooking (Sanni *et al.*, 2008) That is, the higher the final viscosity of garri, the better the quality, as the gelatinization process may be faster when reconstituted with boiled water to *eba*. The setback viscosity of garri samples ranges from 1877.00 to 1208.00RVU with sample A having the lowest setback viscosity value and Sample C having the highest setback viscosity value. There's no difference among between all the samples analyzed. The setback viscosity is a stage where retrogradation or re-ordering of starch molecules occurs; thus, low setback viscosity during the cooling of the paste indicates greater resistance to syneresis/weeping (Adebowale *et al.*, 2013).

Particle Size Profile of Garri Samples

The result of the particle size analysis of the garri samples showed that samples B and C had majorly coarse particle size (Table 3). Both samples did not have retain on 0.1mm sieves size and below which are flour particle size. Sample A however had a little portion of flour size particle and that may be an indication on the ratio of its amylose and amylopectin of their starch. The results also implies that, these sample B and C are good qualities and closely related in terms of uniformity in granules. Sample A stands out to be the best quality garri. The variation in particle size distribution might be due to the grating procedure, i.e., garrification process and the extent of fermentation of the mash (Oduro *et al.*, 2000).

Proximate and cyanide compositions of garri samples

The results of proximate composition of garri samples are as shown in Table 4. The moisture content of the garri samples ranged between 8.70 and 12.77%. There was significant difference ($P<0.05$) among the samples that were analyzed. Moisture content is an index of water activity of many foods. There was significant difference ($P<0.05$) among the samples that were analysed. The result showed that the garri samples would be able to store for long without mould infection as reported by Ash content of the garri samples ranged from 0.50 to 0.83% with sample B having the least ash content (0.50%) and Sample A and sample C had the highest ash content (0.83). Ash content of food is a determinant of mineral content of that food. This result is lower than the range; 1.35 to 1.62% of ash content reported by (Ogbonna *et al* (2017). Protein content of the *garri* samples ranges from 3.81 to 4.19% with sample A having the least protein content (3.81%) and Sample B having the highest protein content (4.19%). There was a significant difference ($P<0.05$) among the samples that were analyzed.

Fat content of *garri* samples ranges from 8.26 to 12.54% with sample C having the least fat content (8.26%) and sample A having the highest fat content (12.54%). Carbohydrate content of the *garri* ranged from 67.71 to 75.59 % which is expected for cassava-based products. The percentage of Cyanide ranges from 13.15%-29.24 mg/100g with sample C having the lowest value and Sample A having the highest value. There's significant difference ($p<0.05$) between all analyzed samples. These results showed that the *garri* samples are safe for consumption as cyanide contents are below 50 mg/100g require to cause harm to human. The low cyanide contents are probably due to the rigorous processing methods of *garri* processing steps such as

peeling, grating, fermenting, dewatering/pressing and roasting which invariably brings about the reduction in cyanogenic glucosides (Ogunsua 1980)

Mineral composition of Garri Samples

The results of the analysis as presented in Table 5 show that the mineral content (Calcium, sodium, potassium, magnesium, iron, and phosphorous). Phosphorous was the most abundant mineral with values ranging from 35.99 to 56.13 ppm. Potassium values ranged from 29.22 to 38.09ppm with sample A having the lowest value potassium while Sample B with the highest value of potassium. Sample A was found to have highest value in calcium (21.80 ppm), magnesium (8.68 ppm) and iron (2.87 ppm) showing that the sample is rich in minerals contents. All the analyzed samples are significantly different ($p < 0.05$). Significantly different ($p < 0.05$) existed in the mineral contents of the three samples.

Sensory parameters of garri samples

The result of sensory parameters is shown in table 6 showed that sample A is the most acceptable in term of colour, taste, aroma, texture and overall acceptability. Significant difference ($p < 0.05$) existed between sample B and C compared to sample A. To launch a product in the market, usually a sensory score of at least 7 (like moderately) is required (Hobbs *et al.,* 2014). Sample A and C had overall acceptability rating of 8.50 and 7.67, respectively meaning that these samples can be launched into the market successfully.

CONCLUSION

Garri sample prepared from TMS 3572 give the best proximate composition. TMF 368 was found to be richer in mineral content, with better functional properties and had the best consumer acceptability. Though the cyanide content of TMF 368 was the highest yet within permissible level. Improvement in the processing procedures involve in *garri* processing could reduce the cyanide further. Overall, *garri* from TMF 368 had the best quality from cassava *processing*.

REFERENCES

Adeniji A.A., Ega L.A., Akoroda M.O., Adeniyi A.A., Ugwu B.O., Balogun A. Department of Agriculture Federal Ministry of Agriculture and Natural Resources Nigeria. FAO; 2005. Cassava Development in Nigeria.

Akinwande, B. A., Ngoddy, P. O., Olajide, J. O., & Fakolujo, A. D. (2013). Production and storage of cassava chips for reconversion into gari. Innovative Systems Design and Engineering, 4 (9): 68, 72.

AOAC. 2006. Official Methods of Analysis. 15th edition, Gaithersbergs, Washington, DC, USA, pp 78-90.

Adebowale, A. A., Sanni, L. O., & Onitilo, M. O. (2008). Chemical composition and pasting properties of tapioca grits from different cassava varieties and roasting methods.

Awoyale, W., Oyedele, H., Adenitan, A. A., Alamu, E. O., & Maziya-Dixon, B. (2021). Comparing the functional and pasting properties of gari and the sensory attributes of the eba produced using backslopped and spontaneous fermentation methods. Cogent Food & Agriculture, 7(1), 1883827.

Alsabagh, A.M. M.I. Abdou, A.A. Khalil, H.E. Ahmed, A.A. Aboulrous, (2014). Investigation of some locally water-soluble natural polymers as circulation loss control agents during oil fields drilling, Egyptian Journal of Petroleum, Volume 23, Issue 1,

Bamidele, O. P., Ogundele, F. G., Ojubanire, B. A., Fasogbon, M. B., & Bello, O. W. (2014). Nutritional composition of "gari" analog produced from cassava (Manihot esculenta) and cocoyam (Colocasia esculenta) tuber. Food Science & Nutrition, 2(6), 706-711.

FAO. (2000). A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. Retrieved December 22, 2014, from http://www.fao.org/docrep/009/ a0154e/A0154E01.htm.

Hahn, S.K., 1989. An overview of African traditional cassava processing and utilization outlook in Agric, 18: 110-118.

Hobbs, D. A., Ashouri, A., George, T. W., Lovegrove, J. A., & Methven, L. (2014). The consumer acceptance of novel vegetable-enriched bread products as a potential vehicle to increase vegetable consumption. Food Research International, 58, 15-22.

Ikediobi, C. O., Onyia, G. O. C., & Eluwah, C. E. (1980). A rapid and inexpensive enzymatic assay for total cyanide in cassava (Manihot esculenta Crantz) and cassava products. Agricultural and Biological Chemistry, 44(12), 2803-2809.

Ikegwu, O. J., Nwobasi, V. N., Odoh, M. O., & Oledinma, N. U. (2009). Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria. African Journal of Biotechnology, 8(10).

Inyang, C. U., Tsav-Wua, J. A., & Akpapunam, M. A. (2006). Impact of traditional processing methods on some physico chemical and sensory qualities of cassava products, garri". African Journal of Biotechnology, 5(20).

Irtwange, S. V., & Achimba, O. (2009). Effect of the duration of fermentation on the quality of gari. Current Research Journal of Biological Sciences, 1(3), 150-154.

Lasekan, O., Hosnas, R., Ng, S., Lin, M., Azeez, S., Teoh, L. ... & Shittu, R. (2016). Identification of aromatic compounds and their sensory characteristics in cassava flakes and "garri" (Manihot esculenta Crantz). TA-Journal of Food, 14(1), 154-161.

Makanjuola, O. M., Ogunmodede, A. S., Makanjuola, J. O., & Awonorin, S. O. (2012). Comparative study on quality attributes of gari obtained from some processing centres in South West, Nigeria. Advance Journal of Food Science and Technology, 4(3), 135-140.

Njoku, B.A and E.O. Banigo, 2006. Physiochemical properties of processed Cassava (Manihot esculenta Crantz) flour prepared by adaptation of a traditional process.

Nwaiwu, O., & Onyeaka, H. (2022). New model high temperature pasting analysis of fermented granules. Fermentation, 8(2), 89.

Oduro, I., W.O. Ellis, N.T. Dziedzoave andK. Nimakoyeboah, 2000. Quality of gari from selected processing zones in Ghana. Food Cont., 11:297-303.

Ogunsua, A.O., 1980. Changes in some chemicalconstituents during the fermentation of cassava tubes. Food Chem., 5: 249-255.

Plaami, S.P., 1997. Content of dietary fibre in foods and its physiological effects. Food Rev. Interml., 13:27-76.

Sanni, L. O., Adebowale, A. A., Awoyale, W., & Fetuga, G. O. (2008). Quality of gari (roasted cassava mash) in Lagos State, Nigeria. Nigerian Food Journal, 26(2), 125-134.

Ubbor, S. C., & Akobundu, E. N. T. (2009). Quality characteristics of cookies from composite flours of watermelon seed, cassava and wheat. Pakistan Journal of Nutrition, 8(7), 1097-1102.

Udoro, E. O., Kehinde, A. T., Olasunkanmi, S. G., & Charles, T. A. (2014). Studies on the physicochemical, functional and sensory properties of gari processed from dried cassava chips. Journal of Food Processing and Technology, 5(1), 293.

Table 1. Functional Properties and pH of Varieties of Garri

SAMPLE	Bulk Density (g/cm^3)	Water Absorption (g/ml)	Swelling Index (g/ml)	Wettability (sec)	PH
A	0.56±0.02 [b]	5.63±0.57 [a]	4.03±0.25 [a]	302.33±1.52 [a]	3.90±0.00
B	0.59±0.02 [a]	4.95±0.20[ab]	3.68±0.33[ab]	295.67±0.58 [b]	3.90±0.00
C	0.60±0.00 [a]	4.43±0.10[b]	3.34±0.28[b]	271.33±1.52 [c]	4.10±0.00

*Values are means of triplicate determination (±SD). Means with same letters on same row are not significantly different (P≤0.05). **Keys**: **A-** TMF 368 **B-** TMS 3572 **C-** TME 419

Table 2: Pasting Profile properties of Garri samples

SAMPLE	Peak 1(RVU)	Trough 1(RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temperature (oc)
A	1395.00	1330.00	65.00	3207.00	1877.00	6.80	57.25
B	1880.00	1824.00	56.00	3014.00	1190.00	6.73	57.30
C	2393.00	2095.00	298.00	3303.00	1208.00	5.93	77.45

Keys: **A-** TMF 36 **B-** TMS 3572 **C-** TME 419

Table 3: Particle Size Properties of Garri Samples

SIEVE APERTURE (mm)	SAMPLE RETAINED (g)		WEIGHT	CUMULATIVE WEIGHT (g)		
	A	B	C	A	B	C
1.00	27.70	11.20	9.10	27.70	11.20	9.10
0.50	17.90	23.60	25.10	45.60	34.80	34.20

0.25	3.90	13.80	14.30	49.50	48.60	48.50
0.10	0.60	1.40	1.50	49.80	50.00	50.00
0.08	0.30	0.00	0.00	49.80	50.00	50.00
Base	0.00	0.00	0.00	49.80	50.00	50.00

Table 4. Proximate Composition and Cyanide content of Garri samples

SAMPLE	A	B	C
MOISTURE (%)	12.77±0.04[a]	9.48±0.07[b]	8.70±0.19[c]
ASH (%)	0.83±0.29[a]	0.50±0.00[a]	0.83±0.29[a]
CRUDE FAT (%)	12.54±0.21[a]	9.72±0.63[b]	8.26±0.60[c]
CRUDE FIBRE (%)	2.33±0.29[a]	1.67±0.29[b]	2.83±0.29[a]
PROTEIN (%)	3.81±0.12[b]	4.19±0.19[a]	3.85±0.10[b]
CARBOHYDRATE (%)	67.71±0.43[c]	74.43±0.85[b]	75.59±0.17[a]
CYANIDE	19.25±0.22[a]	16.47±0.25[b]	13.15±0.30[c]

*Values are means of triplicate determination (±SD). Means with same letters on same column are not significantly different (P≤0.05). **Keys: A-** TMF 368 **B-** TMS 3572 **C-** TME 419

Table 5: Mineral composition of varieties of Garri (ppm)

SAMPLE	Phosphorous	Calcium	Magnesium	Potassium	Iron (ppm)
A	42.17±0.20[b]	21.80±0.00[a]	8.68±0.00[a]	29.22±0.02[c]	2.87±0.00[a]
B	35.99±0.40[c]	18.50±.00[b]	7.10±0.00[c]	38.09±0.02[a]	0.84±.00[c]
C	56.13±0.60[a]	14.11±0.01[c]	7.81±0.00[b]	34.34±0.02[b]	1.40±0.00[b]

*Values are means of triplicate determination (±SD). Means with same letters on same roll are not significantly different (P≤0.05). **Keys: A-** TMF 368 **B-** TMS 3572 **C-** TME 419

Table 6: Results of Sensory Parameter of Garri Samples.

SAMLE	Colour	Taste	Aroma	Texture	Overall Acceptability
A	8.17±0.93[a]	8.33±0.98[b]	7.67±0.98[a]	8.33±0.89[a]	8.50±0.90[a]
B	4.00±1.54[b]	3.33±2.19[c]	2.92±2.15[b]	2.75±1.81[b]	3.00±1.91[b]
C	8.08±0.79[a]	7.00±1.13[a]	6.17±2.08[a]	8.00±0.85[a]	7.67±1.07[a]

*Values are means of triplicate determination (±SD). Means with same letters on same roll are not significantly different (P≤0.05). **Keys: A-** TMF 368 **B-** TMS 3572 **C-** TME 419

PERCEIVED EFFECTS OF CLIMATE CHANGE AND ADAPTATION STRATEGIES BY RICE FARMERS IN ABI LOCAL GOVERNMENT AREA, CROSS RIVER STATE

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Abstract

This study analyzed perceived effect of climate change and adaptation by farmers in Abi Local Government Area, Nigeria. The specific objectives of the study were to; describe the socioeconomic characteristics of rice farmers in the study area, ascertain farmers' awareness of climate change, ascertain perceived effects of climate change and identify the adaptation strategies adopted by farmers. The population of the study consisted of all registered rice farmers in the study area. Sample size was determined using multi-stage sampling. Data was obtained using questionnaires and analyzed using both descriptive and inferential statistics. Results showed that 58.7% of respondents were males, most of them were married. Most of them had between 4-6 hectares. About 80.9% had awareness of climate change and most of the respondents (x= 3.83) and ranked 1st identified the reduction in the yield of rice as the effect of climate change on rice production and 94.2% adopted the use of improved rice seedlings as their adaptation strategy. The study recommends that extension agents should train and encourage rice farmers to engage agricultural insurance and always get climate information from meteorological stations.

Introduction

There is a growing evidence to suggest that climate change is real and has potentially devastating effect on humanity Intergovernmental Panel on Climate Change (IPCC) (2014). Evidence from literature and past studies has revealed that the recent global warming has influenced agricultural productivity leading to declining food production, Kurukulasuriya and Mendelson 2016, Wbella et al., 2008). Climate change has already affected crops yield and their general wellbeing in many countries particularly the low income countries where climate is the primary determinant of agricultural production and their adaptative capacities being very low (Spore, 2008; Apata et al., 2009).

The intergovernmental panel on climate change (IPCC) (2022) posited that climate change will amplify existing stresses on agricultural systems especially in Africa where about 80% of Africa agriculture is rainfed and highly vulnerable to changes in climatic conditions such as drought, high temperature and reduced precipitation levels. These vulnerability, affects crops production including rice.

Rice (*Oryza sativa*) originated from the middle region of the pearl river in southern China more than 10,000 years ago and then gradually spread all over the world and sustaining over 7 billion world population (Huang, Kurata, Wei, Wang, Zhao and Wang, 2020). They added that rice is one of the most important crop on earth cultivated by more than 120 countries and feeding more than half of the world population. The rice sector in Nigeria as opined by Adeniyi, Ibitunde and Olaniyi (2020) is one of the most important sector over the decades, producing rice which is one of the most consumed stample food by over 174 million people across states and geopolitical zones. Despite the economic value of rice, it is affected by changes in climate and Yakubu, Akpoko Akinola and Abdusalami (2021) pointed out that rice plants need a significant amount of water estimated at about 500 + 600 mm, and an optimal temperature of between 22^0C and 31^0C with five to six hours of sunshine per day. However, vulnerability and changes in climate affects rice production resulting to reduction in yield and the general well-being of the crop.

Rice production is one of the major sources of income for farmers in Abi local government area, this study is therefore designed to ascertain farmers perceived effect of climate change on rice production with the following objectives;

i. describe the socioeconomic characteristics of rice farmers in the study area.
ii. ascertain farmers' awareness of climate change.
iii. ascertain the perceived effect of climate change as perceived by farmers in the study area.
iv. identify the adaptation strategies adopted by the farmer in response to climate change effect.

Hypothesis

There is no significant relationship between farmers' socioeconomic characteristics and their awareness of climate change.

Materials and methods

This study was conducted in Abi Local Government Area, Cross River State, Nigeria. Abi Local Government Area is one of the 18 local government area of the state, located at the central geopolitical zone of the state with headquarter in Itigidi. It is bounded to the west by Afikpo North local government area of Ebonyi state, bounded to the East and south by Yakurr and Biase Local Government Areas of Cross River State and to the North by Obubra Local Government Area. It has a population of approximately 126, 267 people (national population census and a land mass of 282km^2.

Abi local government area has economic activities which include agriculture, fishing, timber logging and small scale industries. Crops cultivated include yam, cassava, rice.

The population of this study consist of all registered rice farmers in the study area and a multi-staged sampling technique was adopted in the study to select respondents. Stage one involves the purposive selection of Abi Local Government Area, stage 2 involves the purposive selection of five wards out of the ten wards that make up the area. The selected wards include, Adadama,

Itigidi, Ebom, Ediba and Usumutong. Stage 3 involves the simple random selection wards to include; Etani, Imino, Ibegor, Ensuokwe, and Yenon respectively.
A sampling frame containing the registered rice farmers was used to select 30% of the registered rice farmers per community giving a total sample size of 121 respondents.

Table 1: Distribution of respondents based on socio-economic characteristics

	Frequency	Percent
Sex		
Male	71	58.7
Female	50	41.3
Total	121	100.0
Age		
Below20	11	9.1
20-29	19	15.7
30-39	32	26.4
40-49	28	23.1
above 49	34	28.1
Total	121	100.0
Marital status		
Married	48	39.7
Single	42	34.7
Divorced	20	16.5
Widowed	11	9.1
Total	121	100.0
Educational level		
no formal education	35	28.9
FSLC	39	32.2
WAEC/Neco	27	22.3
NCE/OND	10	8.3
B.Sc/HND	6	4.9
Postgraduate	4	3.3
Total	121	100.0
Farming experience		
<4years	39	32.2
4-6years	23	19.0
7-9years	37	30.6

Above 9 years	22	18.2
Total	121	100.0
Farm size		
less than 4ha	31	25.6
4-6ha	46	38.0
7-9ha	29	24.0
above 9ha	15	12.4
Total	121	100.0
Household size		
less than 4	27	22.3
4-6	14	11.6
7-9	30	24.8
above 9	50	41.3
Total	121	100.0
Membership of association		
Yes	99	81.8
No	22	18.2
Total	121	100.0
Access to credit		
Yes	59	48.8
No	62	51.2
Total	121	100.0
Access to extension		
Yes	110	90.9
No	11	9.1
Total	121	100.0

Source: Field survey data, 2024

The results on distribution of respondents based on socio-economic characteristics is shown in Table 2. It shows that the majority (58.8%) of the farmers were males while 41.3% were

females. This result shows that there were more male farmers than females in the study area. This result is similar to the findings of a study by Nwalieji and Uzuegbunam (2012) who discovered that in Anambra state, males dominated rice production (66%) than females (34.0%). Also (28.1%) of the respondents were above 49 years of age while only 9.1% below 20 years. Majority (39.7%) were married while 34.7% were single, others were either divorced or widowed. This result is also similar with the findings of Nwaueji and Uzuegbunam which showed that more married people were involved in rice production than unmarried people. The result further shows that majority (32.2%) of the respondents had first school leaving certificate and 28.9% had no formal education. Majority (30.3%) had household size above 8 persons while 17.6% had less than 3 persons. Mean household size was 5 persons. Majority (32.2%) had farming experience of <4years. Majority (38.0%) had farm size less of 4-6ha. Majority (41.3%) of the farmers had household size above 9 members. Majority (81.8%) were members of association, 51.2% had no access to credit while 90.9% had access to extension agents.

Table 2: Farmers' awareness of the concept of climate change

Awareness	Frequency	Percent
Yes	98	80.9
No	23	19.1
Total	121	100.0

Source: field survey data, 2024

Result on awareness of the concept of climate change is presented on Table 3. The result reveals that majority (80.9 %) were aware of the concept of climate change only 19.1% were not aware of the concept of climate change in the study area. This result is similar with the findings of Idoma and Mamman (2016) who discovered in their study that 92% of their respondents were aware of climate change. The result is also similar with the findings of Raghuvanshi, Ansari and Amardeep (2017) who also discovered that 100% of their respondents were aware climate change.

Table 3: Distribution of respondents according to perceived effect of climate change on rice production

Effect of climate change	Mean	Rank
Excess rainfall leading to flooding of farm.	3.40*	5
Reduction in the yield of rice.	3.83*	1
Drought causing water scarcity.	2.50*	10
Extreme heat affecting crops growth especially at early stage of development.	2.51*	9
Climate change leads to change in planting dates and harvesting date.	3.71*	2

Excess rain favouring growth of weeds	3.52*	3
Excess rain increasing incidences of pest and disease.	3.50*	4
Climate change reducing grains quality	0.89	14
High wind blowing away dry grains.	1.30	15
Flood causing soil erosion.	2.60*	7
Decrease in soil fertility due to flood	2.30*	11
Scarcity of rice due to crops failure.	1.50	13
Lost of quality harvested rice.	1.98	12
Extreme temperature damaging crops especially at flowing and grains formation stage.	2.98*	6
Extreme temperature causing death of young plants	2.59*	8

Table 3 show the respondents perceived effect of climate change on rice production. From the results, the serious effect of climate change on rice production in the study area include reduction in the yield of rice ($\bar{x}$ = 3.83) ranking 1st, climate change leads to changes in planting and harvesting dates ($\bar{x}$ = 3.71) ranking 2nd, excess rainfall favouring the growth of weeds and increasing incidences of pest and disease with mean values of ($\bar{x}$ = 3.52) and ($\bar{x}$=3.50) ranking 3rd and 4th respectively.

Effects that were not serious include; lost of quality of harvest rice ($\bar{x}$=1.98) ranking 12th, scarcity of rice due to crop failure ($\bar{x}$=1.50 ranking 13th, high wind blowing away dry grains ($\bar{x}$= 1.30) ranking 14th and climate change reducing grains quality ($\bar{x}$=0.80) ranking 15th. The implication of these results is that rice production in the study area. The results of this study are similar with those of Nwalieji and Uzuegbunam (2012) who discovered in their study that the effect of climate change on rice production in Anambra state were reduction in yield, reduction in grains quality, incidences of drought in the rice field, changes in the production calendar, etc.

Table 4: Percentage distribution of respondents based on adaptation strategies in rice production

	Adaptation strategies	Freq.	%
1.	Use of improved rice seedlings	114	94.2
2.	Regular weeding of rice farm	119	98.3
3.	Spraying with recommended pesticides and insecticides	96	79.3
4.	Application of fertilizer	77	63.6
5.	Application of manure	52	42.9
6.	Adjusting planting and harvesting dates	115	95.0
7.	Irrigation during drought	99	81.8
8.	Crops diversification (planting other crops in different farmers)	116	95.9

9.	Livelihood diversification (doing other businesses)	110	90.9
10.	Engagement with agricultural insurance	15	12.4
11.	Getting weather information	9	7.4

Source: Field survey data, 2023.

Results on climate change adaptation in rice production is presented on Table 4. The result show that majority (98.3%) of the respondents adopted the regular weeding of their farms, 95.9% adopted crops diversification in different farms. 95. 0% adjusted both their planting and harvesting time, 94.2% adopted the use of improved rice seedlings and 90.9% adopted livelihood diversification as an adaptation strategy to the effect of climate change on rice production. Other strategies utilized are, irrigation during drought (81.8%), spraying with recommended chemicals (79.3%), and application of fertilizer (63.6%).

The implication of this result is that rice farmers in Abi local government area adopted a variety of strategies in response to the effect of climate change. Result further show that only 12.4% and 7.4% of the respondents adopted insurance and getting weather information. This results are in line with the results of a study by Saud, Wang, Fahad et al. (2002) who discovered in their study that rice farmers adopted the use of improved rice seedlings, irrigation, integrated pest management, crops diversification and social conservation practices as adaptation strategies to rice production in China.

Conclusion

Rice farmers in Abi Local Government Area who were mostly males were very much aware of the concept of climate change and experienced various effect of climate change in the course of rice production. In order to cope with the challenges of climate change, they adopted various adaptation strategies like the use of improved rice seedlings, use of recommended pesticides and insecticides and the adoption of zero burning approach.

Recommendation

1. Rice cultivation was dominated by men in the study area, female farmers should be encouraged to go into rice production.
2. The farmers who are aware of climate change should educate other farmers on climate change.
3. Farmers should be encouraged to utilize climate information so as to plant rice at the right time.
4. Extension agents should train and encourage rice farmers to engage agricultural insurance and always get climate information from meteorological stations.

References

Adeniyi, K., Ibitunde, I. O., Olanyi, G. B. (2020). Effect of rainfall and temperature on rice production in Nigeria. *Nigerian Journal of Rural Sociology*, 20(2), 17-19.

Apata, T. G., Samuel, K. D. & Adeola, A. O. (2009). Analysis of climate change perception and adaptation among arable food farmers in south western Nigeria, presented at the International Agricultural Economist 2009 conference, Beijin, China August 16th – 22nd.

Food and Agricultural Organization (FAO) (2019). Nigeria at a glance. Retrieved from http://www.fao.org/nigeria./fao-in-Nigeria/Nigeria-at-a-glance.

Huang, X., Kurata, N., Wei, X., Wang, A., Zhao, Q. (2012). A main of rice genome variation reveals the origin of cultivated rice. Nature 490, 397-501.

Idoma, K. and Mamman, M. (2016). Access and utilization of climate change information and support services among vulnerable communities in Agatu local government area, Benue State. *International Journal of Science for Global Sustainability*. 3(1), -3.

Nwalieji, H. U. & Uzuegbunam, C. O. (2012). Effect of climate change on rice production in Anambra state, Nigeria. *Journal of Agricultural Extension*. 16(2), 88-89.

Raghuvanshi, A., Ansari, S. and Amardeep, B. (2017). A study on farmers awareness about climate change and adaptation practices in India. *International Journal of Applied Agricultural Science*. 3(6), 154-160.

Saud, S., Wang, D., Fahad, S., Alharby, H. F., Bamagooa, A. A. (2022). Comprehensive impacts of climate change on rice production and adaptive strategies in China. *Front Microbial Journal.*, 13(1), 17-19.

Yakubu, D., Akpoko, D. G., Akinola, M. O. & Abdusalami, Z. (2021). Assessment of perceived effect of climate change on rice production among farmers in North-West zone of Nigeria. *Ghana Journal of Agricultural Science* 56(1), 48-64.

CONSTRAINTS TO CLIMATE CHANGE ADAPTATION BY OIL PALM FARMERS IN AROCHUKWU LOCAL GOVERNMENT AREA, ABIA STATE, NIGERIA

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ABSTRACT
This study was conducted to ascertain the constraints to climate change adaptation by Oil Palm Farmers in Arochukwu Local Government Area, Abia State. The objectives of the study were to; describe the socio-economic characteristics of oil palm farmers in the study area, identify the adaptation strategies adopted by oil palm farmers and analyze the constraints to climate change adaptation in the study area. The population of the study consisted of all registered oil palm farmers in the study area. The sample size was selected using multi-staged and random simple random sampling procedure and data was obtained using a structured questionnaire. Same was analyzed using descriptive and inferential statistics. Results on socio-economic characteristic showed that majority (57.1%) of the farmers were males and the mean age of the farmers was 48 years. Also, 62.9% of the respondents were married only 19.1% of the respondents had no formal education. Mean farming experiences was 15 years, while mean household was 4 persons. On adaptation strategies, oil palm farmers identified regular pest and diseases management (87.6%), followed by regular clearing, weeding and clearing of palm plantation (79%) then the planting of new improved varieties of oil palm (70.5%). Lack of training and knowledge on climate change, poor access to information on climate change adaptation, were seen as major constraints. The study recommended oil palm farmers should be encouraged to form self-help groups so that through their contributions, they can raise money to buy materials for adaptation.

Key words: Constraints, Climate change, Adaptation perspective, Farmers.

Introduction
Empirical works have shown clearly that climate change is one of the most important challenges in the world in the 21st century. Climate change is occurring due to various factors such as human (anthropogenic) and natural factors (biogeographic) and those changes which constitute major challenges to humans' animals and the environment have been occurring for at least a century (Erda, Yinlong, Shaohong and Shiming 2007).

Menderlson (2008) opines that climate change is a pressing global issue that transcends boundaries, and affecting various sectors globally, agriculture being a very good example, Ojemade, Okorie and Enete (2019) maintained that the cultivation of oil palm in the face of a changing climate has far reaching consequences because as temperature rise, weather patterns become eratic and the ecosystem face an unprecedented shift. The United Nations Framework Convention (UNFCC, 2007) defines climate change as a change of climate which is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

Nigeria has been reported to be vulnerable to most impacts of climate change due to the fact that 70% of her farmers who are mostly small holder are engaged in rain -fed, agriculture (Ojemade *et al.*, 2019) oil palm is produced in many countries and crucial to the economy of many countries from which large quantities of its products are exported in the form of oil, and other derivatives yet climate change exert detrimental effects necessitating mitigation and adaptation measures (Murphy 2019).

Climate change, effects on oil palm production as opined by Oktar, Nurkhoiry and Prandiko (2020) are the reduction in yield, rotten bunch, abortion, increased incidences of weeds, pest and disease, delayed flowering, drought causing the death of young plants. Ahmed, Mohd and Abdullah (2021) added that due to the effect of climate change on oil palm production such as elongated inflorescence, tissue and cells dehydration, decreasing nutrients uptake amongst others, the need for adaptation becomes very necessary to enable farmers cope with such effect and Ahmed, Jibrin and Mohd (2021) stressed that farmers' adaptive capacity is very crucial to climate change especially in areas where fluctuations and variability are significant. However, while trying to adapt to the effect of climate change on oil palm production, farmers are constrained by certain factors and it is from the fore going that this study is designed with the following objectives;

1. describe the socio-economic characteristics of oil palm farmers on the study area
2. ascertain the adaptation strategies adopted by oil palm farmers in the study area.
3. analyze the constraints to adoption of climate change adaptation strategies.

Hypothesis

Ho. There is no significant relationship between farmers' socio-economic characteristics and their adaptation strategies to climate change.

Materials and methods

This study was conducted in Arochukwu Local Government Area, one of the Local Government Areas in Abia State. It is located in the South Eastern parts of the country. It is bounded in the north by Ohafia, south by Bende, West by Ikwuano Local Government Areas respectively and in the east by Ebonyi State. Its headquarters is in Arochukwu town and covers a land mass 524 km^2 with a population of approximately 234,008 people (National Population census 2006). Arochukwu has a rich cultural heritage and the food belt of Abia State where most staple food and palm oil is produced.

The population of the study consisted of all registered oil palm farmers in the study area and a multi-stage sampling procedure was utilized in selecting the respondents. The first stage involved the purposive selection of Arochukwu block because it is notable for the production of oil palm. The second stage involved the simple random selection of 5 wards out of the eleven wards that make up the block. The selected wards include, Isu, Arochukwu 1, Ututu, Arochukwu II and Arochukwu III. The third stage involves the simple random selection of 1 cell each from the selected wards as follows, Ujari from Arochukwu 1, Obinkita form Arochukwu II, Antai from Arochukwu III,Obiene form Ututu and Obieze from Isu respectively. From the sample frame of registered oil palm farmers, 30% of the registered oil palm farmers was sampled per cell giving a total sample size of 105. Data collected was analyzed using descriptive and inferential statistics (binomial logistic regression).

Table 1: Distribution of respondents based on socio-economic characteristics

	Frequency	Percent	Mean
Sex			
Male	60	57.1	
Female	45	42.9	
Total	105	100.0	
Age			
Less than 21	11	10.5	
21-30	22	21.0	
31-40	32	30.5	48
above 40	40	38.1	
Total	105	100.0	
Marital status			
Single	66	62.9	
Married	25	23.8	
Divorced	7	6.7	
Widowed	7	6.7	
Total	105	100.0	
Educational qualification			
no formal education	20	19.1	
FSLC	30	28.6	
Waec/Neco	25	23.8	
NCE/OND	15	14.3	
BSC/HND	9	8.6	
Postgraduate	6	5.7	
Total	105	100.0	
Farming experience			
<5years	19	18.1	
6-10years	14	13.3	15
11-15years	46	43.8	
16-20years	26	24.8	
Total	105	100.0	
Farm size			
less than 2	19	18.1	
2-4	31	29.5	4
5-7	25	23.8	
above 7	30	28.6	
Total	119	100.0	
Household size			
less than 4	17	16.2	
4-5	26	24.8	6
6-7	30	28.6	
above 7	32	30.5	
Total	105	100.0	
Membership of association			
Yes	90	85.7	
No	15	14.3	
Total	105	100.0	
Access to Credit			
Yes	42	40.0	
No	63	60.0	

Total	105	100.0
Access to Extension		
Yes	30	28.6
No	75	71.4
Total	105	100.0

Source: field survey data, 2024

The results on Table 1 show that the majority (57.1%) of the farmers were males while 42.9% were female. This result shows that there were more male oil palm farmers than females in the study area. Also (38.1%) of the respondents were above 40 years of age while only 10.5% were Less than 21 years with mean age being 48 years. Implying that the farmers were in their youthful age. Majority (62.9%) were married while 23.8% were single and 6.7% were divorced and widowed. Furthermore, the result shows that majority (28.6%) of the respondents had first school leaving certificate, 23.8% had Waec/Neco, 19.1% had no formal education and 14.3% had obtained NCE/OND. Also, 8.6% and 5.7% had BSC/HND and Postgraduate education respectively. The implication of this finding is that most of the oil palm farmers in the study area were educated. Majority (43.8%) had farming experience of between 11-15years while the least farming experience was 6-10years and accounted for 13.3%. Mean farming experience was 15years. Majority (29.5%) had farm size between 2-4ha, 28.6% had farm size of above 7, 23.8% had 5-7ha while 18.1% had less than 2ha. Mean farm size was 4ha. Majority (30.3%) had household size above 7 persons while 16.2% had less than 4 persons. Mean household size was 6 persons. Majority (85.7%) of the farmers belonged to association while 14.3% were not members of any association. Majority (60.0%) had no access to credit facilities whereas 40.0% had no access to credit facilities. Majority (71.4%) had no access to extension agents whereas 28.6% had no access to extension agents. Findings of the study by Bamidele (2015) shows that the male to female ratio was 4:1, males being (78.6%) and female (21.4%). Majority of the respondents were between 21-30 years of age. About two-third of the respondents were married and 93.2%. Majority (45.8%) had secondary education. Nmadu, et. al (2015) found that most (65.0%) of the oil palm farms were operated by males, with a mean age of 51.11 years. Majority (72.5%) had primary school education, with mean oil palm of 6.32 hectares.

Table 2: Mean distribution of respondents based on adaptation strategies adopted for climate change effect on oil palm production

	Adaptation strategies adopted for climate change effect on oil palm production	Freq.	%
1	Planting new improved and resilient varieties of oil palm seedlings	74	70.5
2	External water purchase for irrigation during drought	57	54.3
3	Planting oil palm with other crops (engaging in intercropping)	61	58.1
4	Making use of different planting dates from time to time	17	16.2
5	Mulching of the planted oil palm Seedlings	60	57.1
6	Planting other trees to provide shade (in young plantation)	66	62.9
7	Application of fertilizer	36	34.3
8	Regular weeding, cleaning and clearing of the oil palm farm	83	79.0
9	Application of manure	56	53.3
10	Prunning	49	46.7
11	Regular pest and disease management of the oil palm	92	87.6

Source: field survey data, 2024

Results on adaptation strategies adopted for climate change effect on oil palm production are presented on Table 2. From the table, majority (87.6%) of the respondents identified Regular

Pest and Disease management of the oil palm, this was followed by Regular weeding, Cleaning and Clearing of the oil palm farm (79.0%), Planting New Improved and Resilient Varieties of Oil Palm Seedlings (70.5%), Planting other trees to provide shade (62.9%), Planting Oil Palm with other crops (Engaging in Intercropping) (58.1%), Mulching of the planted oil palm Seedlings (57.1%), External Water Purchase for Irrigation during drought (54.3%) and Application of Manure (53.3%) as adaptation strategies adopted for climate change effect on oil palm production. In line with the findings of this study, Ojemade, *et. al.*, (2019) found that the adaptation strategies used by farmers were use of resilient varieties (23.39%), mulching (12.28%), purchase of water for irrigation (21.63%), crop diversification (12.28%), intercropping (9.94%), migration for income (13.45%), changing planting dates (10.52%) and planting trees (12.28%). Also, to optimize oil palm growth and mitigate climate change impacts, implement agronomic adaptation strategies such as fertilizer application, adjusting planting density, irrigation, pruning, pest and disease management. Invest in genetic adaptation by developing drought-tolerant, disease-resistant and pest-resistant oil palm varieties.

Table 3: Mean distribution of respondents based on constraints to climate change adaptation in oil palm production.

Constraints to adoption of Climate Change Adaptation strategies by Oil Palm farmers.	Mean	Std	Rank
Lack of training and knowledge on climate change	2.61*	0.501	1
Lack of capital to buy materials for adaptation	3.96*	1.009	6
Poor access to information on climate change adaptation	2.75*	1.026	5
Lack of improved oil palm production equipment and infrastructure	3.11*	0.370	2
Government lack of policy on climate change	1.73	0.497	9
Practicing adaptation is expensive and time consuming	2.53*	0.486	7
Lack of access to credit and insurance	2.94*	0.477	4
Climate change does not exist so I cannot practice adaptation	1.35	0.409	10
Lack of government support to carry out adaptation	2.02	0.101	8
Cultural and social barriers (culture, tradition, farming practices)	3.02*	0.33	3

*= Major constraints
Source: Field survey data, 2024

Table 3 presents the distribution of respondents' based on constraints to climate change adaptation in oil palm production. the results show that the major constraints to climate change adaptation in oil palm production in the study area were lack of enough money to buy materials for adaptation ($\bar{x}$ =3.96), lack of improved oil palm production equipment and infrastructure ($\bar{x}$ =3.11), cultural and Social barriers (culture, tradition, farming practices) ($\bar{x}$ =3.02), Lack of access to credit and insurance ($\bar{x}$ =2.94), poor access to information on climate change adaptation ($\bar{x}$ =2.75), lack of training and knowledge of climate change adaptation ($\bar{x}$ =2.61), Practicing adaptation is expensive and time consuming ($\bar{x}$ =2.53). Ojemade et. al (2019) found that high labour, land tenure, lack of training, poor access to information, lack of capital, limited availability of land and lack of improved oil palm production technologies were the constraints encountered by farmers in adopting climate change adaptation strategies.

Test of hypothesis

There is no significant relationship between socio-economic characteristics of farmers and their adaptation strategies to climate change. The result of the relationship between socio-economic characteristics of farmers and their adaptation strategies to climate change is presented in Table 4. The Mac Fadden R-square is 0.74 and implies that all the explanatory variables included in the model jointly accounts for about 74% variation awareness of climate change. The log-likelihood ratio (LR) test was 56.9 and significant at 5% implying that the model was adequate in explaining the relationship between explanatory variables and adaptation strategies to climate change. The study reveals that out of the 8 explanatory variables, 7 (age, marital status, education, farm size, membership in association, access to credit and Access to extension) had significant relationship with adaptation strategies of climate change at 5%. Out of the 7 significant variables 4 (marital status, education, membership in association and access to extension) showed positive relationship while 3 (age, farm size, Access to credit) were negatively related.

The positive coefficient of marital status, education, membership in association and access to extension implies that an increases in these variables increases farmers' adaptation strategies to climate change in the study area. Also, the negative coefficient of age, farm size, access to credit implies that a decrease in these variables decreases farmers' adaptation strategies of climate change in the study area. Based on these findings, the hypothesis that there is no significant relationship between farmers' socio-economic characteristics and their adaptation strategies of climate change was rejected and the study accepted that there is a significant relationship between farmers' socio-economic characteristics and farmers' adaptation strategies to climate change.

Table 4: Binary logistic regression analysis of the relationship between socio-economic characteristics of farmers and their adaptation strategies to climate change

Variables	Coefficient	Std.error	P-value
Constant	1.917	0.693	0.000
Age	-1.970	0.167	0.014*
Marital status	2.645	0.969	0.002*
Education	2.959	0.828	0.000*
Experience	8.169	2.967	0.234
Farm size	-0.579	1.607	0.000*
Association	0.000	0.263	0.003*
Access to credit	-0.314	0.941	0.001*
Access to extension	2.406	0.245	0.032*
Observations	105		
LRchi^2	54.8		
Prob> chi^2	0.000		
Psuedo R^2	0.74		
Log likelihood	56.88		

*P≤0.05

Source: Field survey data, 2024

Conclusion

Climate change is affecting the production of oil palm and farmers engage in various adaptation strategies such as the planning of improved varieties, application of manure and fertilizer as

well as regular pest and disease management. The main constraints faced by farmers is the lack of enough money to buy materials for climate change adaptation.

Recommendations

The following recommendations are made based on the results of the study.

i. Male dominated oil palm production in the study area, females should be encouraged to go into oil palm production and not just processing.
ii. Oil palm farmers should be encouraged to change their planting dates in periods of droughts.
iii. Oil palm farmers should be encouraged to form self help groups so that through their contributions, they can raise money to buy materials for adaptation.

References

Ahmed, A. Jibrin, G., & Mohd, Y. I. (2023). Chapter three - navigating climate challenges: unraveling the effect of climate change on oil palm cultivation and adaptation strategies. *Advances in Food Security and Sustainability Journal.* 8(5), 3-4.

Ahmed, A., Mohd, Y. B. I & Abdullah, A. M. (2021). Oil Palm in the face of Climate change: a review of recommendation. 10p Conference Series: Earth Environ. Science 646 012065.

Deressa, T. (2003). Analysis of Perception and Adaptation to Climate Change in the Nile Basin of Ethiopia. An unpublished Ph.D Thesis, Centre for Environmental Economics and Policy for Africa (CEEPA), University of Pretoria, South Africa.

Murphy, D. J. (2019). The future of oil palms as a major global crop – opportunities and challenges. *Journal of oil Palm Resources* 4 (7), 24 – 26.

National Population Census (NPC) (2006).

Ojemade, A. C. Okrji, E. C. & Enete, A. A. (2019). Difficulties in adaptation to climate change by oil palm farmers in Southern Nigeria. *African Journal of Agricultural Research* 14 (2), 46 – 53.

Oktarina, S. D, Nurkhoiry, R. & Pradiko, I. (2020). The effect of climate change to palm oil price dynamics: a supply and demand model. A paper presented at the International conference on Agriculture, Environment and Food Security at Indonesia, 2020.

United Nations Frame work Conservation on Climate change – UNFCCC (2007). Climate change: Impacts vulnerabilities and Adaptation in Developing countries. Bonne, UNFCCC secretariat 68.

SOCIO-ECONOMIC DETERMINANTS OF CLIMATE CHANGE ADAPTATION Practices BY ARABLE CROP FARMERS IN CROSS RIVER STATE, NIGERIA.

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Abstract

The purpose of this study was to examine the socio-economic determinants of climate change adaptation practices by arable crop farmers in Cross River State, Nigeria. The specific objectives were to describe the socioeconomic characteristics of farmers and identify farmers' adaptation practices in dealing with the effects of climate change. One hypothesis was formulated to guide the study. Multi-stage sampling procedure and a proportionality factor of 10% was used to select 215 arable crop farmers for the study. Descriptive statistics as well as spearman rank order correlation statistics were used to analyse data. The result revealed that majority of the respondents 34.4% have 10-19 years of farming experience, while 26.0% had less than ₦100,000.00 annual income. Majority of respondents (73.5%) had no access to extension services. Meanwhile, the practice of irrigation as an adaptation by respondents was low (69.8%) which is not common in the area. The spearman rank order correlation result showed that there is an inverse relationship between selected socioeconomic characteristics of farmers and adaptation measures. It was recommended that farmers should be sensitized about climate change, their effects, solutions and modern adaptation measures. This could be achieved by organizing seminars and workshops on climate change regularly.

Keyword; climate change, Adaptation, socio-economic determinant, Arable crop farmers.

Introduction

Impacts of Climate change on agriculture impinge complex social, economic, and political crisis globally. The connection of climate change, agriculture, and food security appear to be more intense and complicated with devastating impacts for developing countries, Omerkhil et al., (2020), and Ojo and Baiyegunhi (2019). Among all developing countries, Nigeria has been recognized as one of the most vulnerable developing countries towards climate change risks (IPCC, 2014). Climate change is a continuous process; without any counteracting responses, the magnitude and intensity will only increase in the future. Adaptation has been proposed as a critical policy option for combating the unavoidable consequences of climate change by several researchers (Huang and Sim, 2021; Khannal et al., 2021). Majority of the population in Nigeria live in rural areas and they depend on arable crop production as their major source of livelihood.

Arable farming entails the production of wide range of food crops or annual cops, in which the live cycle is within one year, from germination to seed production and maturity (Enete, Madu,

Onwubuya, Oyekuru, Mojekwu and Eze, 2012). The increase in food prices and food insecurity in various homes is not unconnected with the challenges facing arable crop production in the rural areas. Arable farming may be subjected to various challenges, ranging from scarcity of land and poor soil fertility, soil degradation, natural hazards etc. Adaptive capacity in every aspect according to Mortimore and Manvell (2011) is the ability of system to adjust to the change to reduce the potential damage, take advantage of opportunities or to cope with the consequences of the events. Therefore, the adaptive capacity of an individual or system in the environment describes the level of knowledge of the events, ability to reduce its behaviour in order to cope better with the changes in external conditions. Adaptation seeks to moderate or avoid harm or exploit beneficial opportunities in some natural systems, human intervention may facilitate adjustment to expected climate change and its effects (IPCC, 2014).

The nature of farmers' response to climate change effects also depends on the socioeconomic position of the household. is noted that some socioeconomic, policy and institutional factors may constraint the farmers' ability to adopt these strategies (Odjugo, 2010; Hansan and Nhemachena 2008). Given the huge amount of uncertainty surrounding specific climate change effects, choosing the most appropriate tools needs a very careful approach to avoid locking poor communities into unsuitable technologies (Hitz and Smith 2004). "Training and support for specific or technical interventions need to be focused on areas which enhance adaptive capacity and boost resilience for farmers to avoid maladaptive interventions" enabling producers to adopt or develop, sustainable agricultural techniques which is an essential means of improving resilience.

Previous studies have opined that farmers with high level of education are associated with access to information on improved technologies. Some studies indicated that larger families may enable the household to accomplish a variety of agricultural task given fewer household labour shortages (Nhemachena and Hassan, 2007). The studies of Knowler and Bradshaw (2007) show that household with higher income and greater assets will be more likely to adopt new farming technologies in order to adapt to effects of climate change, given greater access to information and financial resources.

Farming experiences and age also appear to be significant determinants of adaptation strategies in adopting new technologies. According to Adesina and Baidu-Forson (1995), in Blessing and Goodness (2014), older farmers are more risk adverse and less likely to be flexible than younger farmers and thus, have a lesser likelihood of adopting adaptation strategies.

Minot *et al.,* (2006) states that access to education increases the chance of accessing a number of activities, information and adoption of agricultural technologies to cope with climate change and adaptation practices on the farm.

The amount of farmer's land size was reported to positively affect farmers adaptation method to climatic change. This implies that farmers who have an adequate amount of farming land size are more likely to take any adaptation decisions because they have resources to implement new agricultural technology. This result is in agreement with the study by Kide (2014) in Marie, (2020) who reported that households with relatively large farm sizes were more likely to take up new adaptation strategies when compared to farmers with small farm sizes.

In most studies, rural farmers' level of awareness seems to be on the increase regarding their experiences in change and length of seasons, incidence of environmental hazards such as flood, droughts and crop failures, long term shift in wind speed, change in rainfall intensity and uncertainty of rain etc. (Morghadiya and Smarden, 2011). In addition to this, Webber (2010) in Hermann, Thittoa and Marc (2018) found that people's perception of climate change both in terms of its existence and extent are shaped by learning from personal experiences and by making use of statistical information.

It is therefore against this background that this study intended to fill this knowledge gap, by ascertaining arable crop farmers' socio-economic determinants of climate change adaptation practices Cross River State, Nigeria. The objectives of the study are;

i. Describe the socioeconomic characteristics of arable crop farmers
ii. identify adaptation practices used by farmers in dealing with the effects of climate change.

The following null hypothesis was tested:

H_{o1}: There is no significant relationship between selected socioeconomic characteristics of farmers and adaptation measures.

MATERIALS AND METHODS

The study will be conducted in Cross River State, Nigeria. Cross River State situated in the south-south geopolitical zone of Nigeria. It lies between latitude $4^0\,28^1$ and $6^0\,55^1$ North of the Equator and Longitude $7^0\,50^1$ and $9^0\,28^1$ East of the Greenwich meridian. The state is made of three agricultural zones namely: Calabar (comprising Biase, Calabar Municipal, Odukpani, Calabar South, Akamkpa, Bakassi, and Akpabuyo), Ogoja (Bekwarra, Yala, Ogoja, Obudu, and Obanliku blocks; and Ikom agricultural zone (covering Abi, Obubra, Yakurr, Ikom, Etung, and Boki blocks). It shares common boundaries with the republic of Cameroon in the East, Benue state in the north, Ebonyi and Abia state in the west, Akwa Ibom state in the southwest and the Atlantic Ocean in the south. The state has a landmass of 22,342.176 square kilometres (Adinya, 2009).

Population and sample size

The population of the study consisted of all arable crop farmers in Cross River State. A multi-stage sampling technique and purposive sampling was employed in the selection of arable crop farmers. The first stage involved purposive selection of one agricultural zone out of the three zones of the state. The selected zone is Ikom agricultural zone. The reason we utilized purposive sampling procedure was to select areas with high intensity of arable crop farmers and farming. The second stage involved simple random selection of three blocks out of six blocks that makes up the agricultural zone, the selected blocks were Abi, Yakurr and Obubra. The third stage was the selection of four cells from each of the selected blocks. At the fourth stage, a proportionality factor of 10% was applied to select arable crop farmers, who formed the respondents of the study. This percentage was chosen to give room for proportionate representation of respondents from each cell, while also taking cost into consideration. This summed up to a total of 215 respondents for the study.

Data collection method

Data collected through the use of structured questionnaire to obtain data on adaptation to effect of climate change by arable crop farmers in Cross River State. Primary data was obtained using

questionnaire distributed to respondents by the researcher with the help of trained enumerators in the study area.

Table 1: Distribution of sample by LGAs (blocks) in Ikom agricultural zone

Sampled Blocks	Cells	Total number of registered arable crop Farmers	10%
Abi	Itigidi	135	14
	Igbo Imabana	120	12
	Ediba	215	22
	Adadama	125	13
Yakurr	Idomi	160	16
	Ekori	130	13
	Bikobiko	220	22
	Ijom	190	19
Obubra	Ofombongha IV	290	29
	Apiapum	210	21
	Owakande	225	23
	Ababene	105	11
Total	12	2125	215

Source: CRADP, 2023

Data analysis

Data generated from the study was analysed using descriptive and inferential statistics. Objectives I, which is t _____ socioeconomic characteristics of and objective II to identify adaptation praci ırmers in dealing with the effects of climate change in the study area, were : sing descriptive statistics, specifically, frequencies, percentages, mean and cl thesis was tested using spearman rank order correlation analysis to determine the magnitude and direction of the relationship. This is mathematically defined as:

$$r_s = 1 - \frac{6\sum D^2}{n(n^2 - 1)}$$

Where:

r_s = spearman rank correlation coefficient

n = sample size

D = differences between the dependent and independent variable

$\sum$ = sigma (summation)

Result and Discussion

Table 2: Socioeconomic distribution of farmers

Variables	Frequency	Percentage
Age (years)		
21-30	21	9.8
31-40	39	18.1
41-50	58	27.0
51-60	62	28.8
61 and above	35	16.3
Total	215	100.0
Sex		
Male	107	49.8
Female	108	50.2
Total	215	100.0

Marital status		
Single	34	15.8
Married	134	62.3
Widowed	30	14.0
Divorced	17	7.9
Total	215	100.0
Household size		
<4	65	30.2
4-9	100	47.0
10-14	42	19.5
15 and above	8	3.8
Total	215	100.0
Annual income		
<100,000	56	26.0
100,000-200,000	52	24.2
200,001-300,000	53	24.7
300,001-400,000	37	17.2
400,001 and above	17	7.9
Total	215	100.0
Education		
No formal education	13	6.1
Primary	36	16.7
Secondary	110	51.2
Tertiary	56	26.0
Total	215	100.0
Land ownership		
Yes	124	57.7
No	91	42.3
Total	215	100.0
Access to extension service		
Yes	57	26.5
No	158	73.5
Total	215	100.0
Years of farming experience (year)		
<10	57	26.5
10-19	74	34.4
20-29	58	27.0
30-39	22	10.2
40 and above	4	1.9
Total	215	100.0
Farm size		
<1 ha	45	20.9
1-3 ha	73	30.0
4-6 ha	70	32.6
7ha and above	27	12.5
Total	215	100.0

Source: Field survey, 2023

Age is an important factor of the decision making about activity choice. The result showed that 28.8% (62 farmers) of the respondents were between the age bracket of 51-60 years, while 27.0% were between the age of 41-50 years and 18.1% were between the ages of 31-40 years, 16.3% represent age of 61 years and above, and 9.8% were between 21-30 years. This implies that people above the average age engage in farming activities and depend solely on it as their source of livelihood. The findings is at variance with that of Blessing and Goodness (2014) who states that older farmers are more risk adverse and less likely to be flexible than younger farmers and have lesser likelihood of adopting adaptation strategies.

On sex, 49.8% were males and 50.2% were females. This is an indication that more females engage in arable crop farming in the study area than males. However, the gap between the number of female respondents and that of male is very tint, this shows both males and females engage in arable crop farming depending on the context, it can be said that male or female headed households are more likely to adopt new technologies. This is in accordance with the findings of Asfaw and Admassive (2004).

Marital status of farmers revealed that 62.3% (134 farmers) of the respondents were married. 15.8% (32 farmers), 14.0% (30 farmers) and 7.9% (17 farmers) were single, widowed and divorced respectively.

Educational attainment of respondents also determines choices of adaptation. 6.1% of farmers had no formal education, 16.7% accounted for primary school education, 51.2% and 26.0% had secondary and tertiary education. This is an indication that the respondents have some level of education and would therefore be able to comprehend the complexities of farming and climate change effect better. Majority of the farmers representing 34.4% have been farming for the past 10-19 years, followed by 58 farmers (27.0%) who have spent 20-29 years, 26.5% have less than 10 years farming experience, 10.2% and 1.9% have 30-39 and 40 years and above experience respectively.

Respondents that have farm sizes of 1-3 hectares are 34.0% (73 farmers) while 32.6% (70 farmers) have 4-6 hectares, 20.9% (45) farmers have less than 1 hectare and 12.5% (27 farmers) have 7 hectares of farm sizes and above. This shows that farmers in the area are predominantly small-scale producers. Despite the smallness of the farms, majority (57.7%) own farm land which they cultivate as against 42.3% who rented theirs. Tenancy would motivate farmers to invest more in practices and technologies that would improve their farm output, including climate adaptation strategies.

Respondents with annual farm income of less than 100,000.00 represents 26.0% while 24.7% had income of between 200,001 – 300,000.00 followed by 24.2%, 17.2% and 7.9% who reported 100,000 – 200,000.00, 300,001 – 400,000.00 and 400,001 and above respectively. This prove that the respondents in the study area had low income from farming activities. It is expected that farmers with low income will find it difficult to adapt new farming technologies and adapt to change around them.

Household size ranges from less than 4(30.2%), 4-9(46.5%), 10-14(19.5%), 15 and above (3.8%). Higher family size is an indication that there are enough hands to carry out farming activity and is a proxy to labour availability which reduces constraints. If there are not engaged in other income generated activities, large household size may increase the probability to adopt new technologies, whereas low household size will affect farming activities in all stages of production adversely. It is reported that 26.5% of the farmers had access to extension services, whereas majority (73.5%) had no access. Lack of access to extension services will decrease the probability of uptake of proper adaptation measures to climate change.

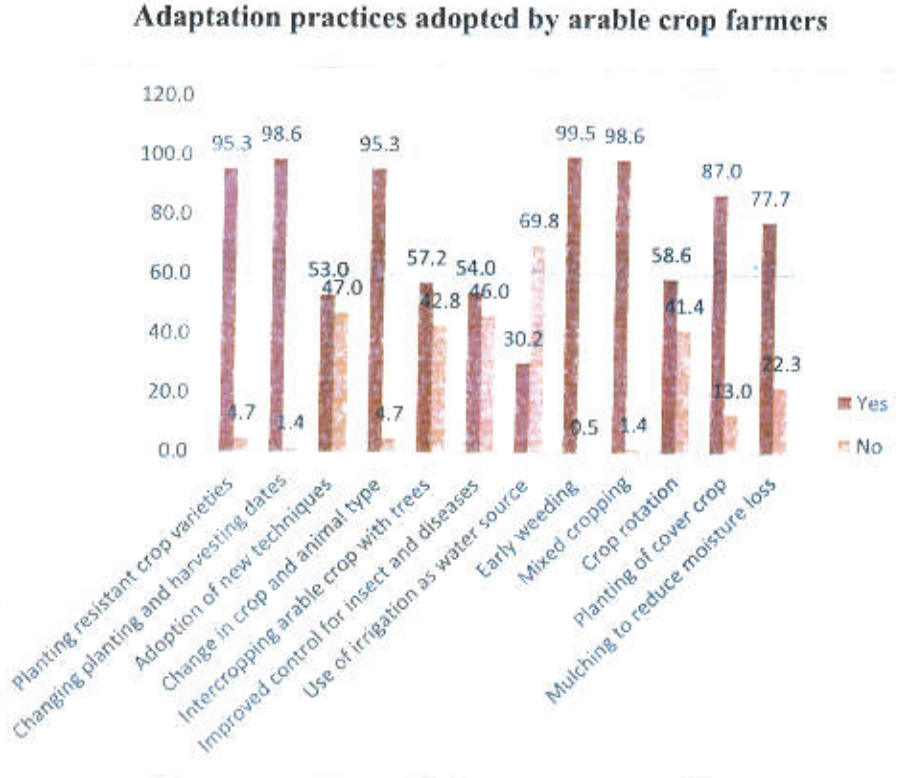

FIG. 1: Distribution of farmers according to their adaptation practices

Arable crop farmers have developed responses to degrading or changing conditions. As shown in figure 1, the main order of respondents according to adaptation practices being carried out include early weeding (99.5%), mixed cropping (98.6%), changing planting and harvesting dates (98.6%), planting resistant crop varieties (95.3%) change in crop and animal type (95.3%), planting cover crop (87.0%), mulching to reduce moisture loss (77.7%). This finding corroborates that of Apata, (2016) and Blessing and Goodness (2015) who noted that in coping with climate change, farmers carry out some measures like those mentioned above to adjust or cope with changes around them. Crop rotation (58.6%), the adoption of inter-cropping arable crops with trees (57.2%), adoption of new techniques (53.0%), improved control for pests and diseases (54.0%) were also carried out by farmers. Despite the importance of irrigation as an adaptation measures against unfavourable climatic conditions, it was revealed that majority of the respondents (69.8%) did not practice irrigation as it is not common in the area. This may be as a result of lack of irrigation facilities, or lack of knowledge about local irrigation systems that can be used by local farmers. Thus, farmers need to be convinced of the profitability and applicability of irrigation sufficient resources and proper knowledge to enable them to adopt new technology.

Test of hypotheses

Relationship between selected socio-economic characteristics of farmers and adaptation measures

Table 3: Spearman rank correlation result of the Relationship between selected socio-economic characteristics of farmers and adaptation measures.

Variable	N	Rho	p-value	Decision
Age	215	0.021	0.763	Accept H_o
Sex	215	-0.057	0.409	Accept H_o
Marital status	215	-0.053	0.442	Accept H_o
Education	215	0.012	0.855	Accept H_o
Years of farming experience	215	0.006	0.935	Accept H_o
Farm size	215	0.117	0.009**	Reject H_o
Access to extension service	215	0.050	0.464	Accept H_o
Household size	215	0.009	0.895	Accept H_o
Land tenancy	215	0.187	0.006**	Reject H_o

Source: Computed from field data, 2023

The result in table 3, shows that sex and marital status had negative correlation with adaptation practices, though the association was weak, and there is insignificant relationship between age, education, years of farming experience, access to extension agents, household size and adaptation measures. However, the result revealed a positive but weak associated between farm size (11.7%) and land tenancy (18.7%). This implies that there is a significant relationship only between farm size, land tenancy and adaptation measures so only these two socio-economic characteristics influenced, though weakly farmers' adaptation to climate change in the study area. This suggested majority of the -economicsocio-economic variable does not have decisive influence on strategies identified but perhaps by externality factors not inherent in a farmers' personal characteristics. This is at variance with the findings of Belay et al. (2017), who opine that access to education increases the chances of accessing a number of activities, information and adoption of agricultural technologies to cope with climate change effects and adaptation practices. The null hypothesis (Ho) was accepted except for farm size and land ownership which have a significant relationship on adaptation measures. The result is at variance with Maddison (2007), Nhemachena and Hassan (2007) who states that personal characteristics of farmers increases the probability of uptake of adaptation measures

CONCLUSION AND RECMMENDATIONS

The study concluded that, most farmers in Cross River State are aware of the climate change and its challenges because of the changes they observe in their environment and have developed resilience to the challenges posed by climate change. what they perceived does not influence their choice of adaptation as revealed in the study, this could be attributed to their inability to access adequate extension services, and other constraints which prevent the adoption of appropriate adaptation measures. It is therefore recommended that:

a. The government should assist farmers in implementing climate change policies to reduce the challenges they face and increase arable crop production in the area by strengthening the agricultural extension system and engaging trained extension personnel to assist in transmitting recent or modern appropriate climate change adaptation innovations to farmers.
b. The rate of adoption and utilization of irrigation as an adaptation strategy was seen to be low. Thus, farmers should be sensitized and supported to adopt irrigation as a strategy against drought.

REFERENCES

Chukwuji, C. N., Aliyu, G. T., Sayudi, S., Yusuf, Z., & Zakariya, J. (2019). "awareness, access and utilization of information on climate change by farmers in Zamfara State, Nigeria" Library Philosophy and practice (e-journal). http://difitalcommons.unl.edu/libphilprac/2016.

Cyprian, A., Egbe, Margaret A., Yaro, Asuquo, E., Okon & Francis E. Bisong (2014). Rural people's Reception to climate variability change ion Cross River State- Nigeria. *Journal of sustainable development*: 7(2) 2014 published by Canadian center of science and education.

Enete, A. A., Madu, I. I., Onwubuya, E. A., Onyekuru, A. N., Mojekwu, J. C., Mojekwu & Eze, F. (2012). Indigenous agricultural adaptation to climate change: study of SouthEast Nigeri. *African technology policy studies network.* Technology brief,N0.25 website: www.atpsnet.org Hermann, W., Thihoa, P. & Marc, V. (2018) farmers' perception and adaption to climate change in southeast Asia: The case study from Thailand and Vietnam.

Huang,K.& Sim, N.(2021). Adaptation may reduce climate damage in agriculture by two thirds J. Agric. Econ., 72 (1) (2021), pp. 47-71

Idoma, K. & Mamman, M. (2016). Access and Utilization of Climate Change Information and Support Services among Vulnerable Communities in Agatu L.G.A., Benue State, Nigeria. *Federal University Gusau International Journal of Science for Global Sustainability*, 2 (2), 46-63

IPCC, (2014). Climate change 2014: synthesis report. Contribution of Working Groups I." *II and III to the fifth assessment report of the Intergovernmental Panel on Climate* Change, 151 (2014)

Jha , C. K., & Gupta , V. (2021). Farmer's perception and factors determining the adaptation decisions to cope with climate change: An evidence from rural India

Marie, M., Yirga, F., Haile, M., & Tquabo, F. (2020). Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *journal homepage: www.cell.com/heliyon*

Ojo,T.O., & Baiyegunhi, L.J.S. (2019).Determinants of climate change adaptation strategies and its impact on the net farm income of rice farmers in south-west Nigeria. Land Use Pol. (2019), p. 103946 Google Scholar

Omerkhil,N., Kumar,P. M., Mallick, B. L., Meru,T. C. Rawat, P.S. & Pandey, R.(2020) "Micro-level adaptation strategies by smallholders to adapt climate change in the least developed countries (LDCs): insights from Afghanistan Ecol. Indicat., 118 (2020), p. 106781

ARABLE CROP FARMERS' ADAPTATION PRACTICES TO CLIMATE CHANGE IN CROSS RIVER STATE, NIGERIA

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ABSTRACT

The purpose of this study was to ascertain Arable crop farmers' adaptation practices to climate change in Cross River State, Nigeria. The specific objectives were to assess the effects of climate change, identify farmers' adaptation practices in dealing with the effects of climate change, and to examine relationship between effects of climate change and adaptation practices used. Multistage and simple random sampling techniques and a proportionality factor of 10% was used to select 215 arable crop farmers for the study. Descriptive statistics such as frequencies, percentages, and mean as well as spearman rank order correlation statistics were used to analyze data. The result revealed that factors perceived as effects of climate change in the study area as shown in the mean distribution of effects of climate change are; increase in cost of food crops ($\bar{x} = 4.79$), decrease in soil fertility ($\bar{x} = 4.72$), poverty ($\bar{x} = 4.67$), rising sea level ($\bar{x} = 4.54$). However, adaptation measures practice by farmers include early weeding (99.5%), mixed cropping (98.6%), change in planting and harvesting date (98.6%). The result of the Spearman rank order correlation analysis revealed that some climate change effect variables like Flooding ($r=0.112; P \geq 0.103$), Rising sea level ($r = 0.019; P \geq 0.783$), off season rain ($r=0.093; P \geq 0.172$), Poverty($r = 0.048; P \geq 0.485$), unpredictable farming calendar ($r=0.030; P \geq 0.662$), Social unrest ($r = -0.042; P \geq 0.564$) and unreliable availability of water ($r=0.098; P \geq 0.154$) do not have significant relationship on the adaptation measures fitted, It was recommended that farmers should be sensitized about climate change, their effects, solutions and modern adaptation measures. This could be achieved by organizing seminars on climate change regularly.

Key words: Climate change, effect, adaptation, farmers

Introduction

Majority of the world population consumes arable crops such as rice, yam, bean, maize, and cassava, among others (Food and Agricultural Organization (FAO) 2023). In Nigeria, every household consumes it. The large and densely populated nation is facing the worse climate crises across sectors, but particularly in agricultural sectors. The impact of a changing climate on arable crops is a catastrophe shared by many countries in Sub-Saharan Africa (SSA), Although reports have suggested that with the increase in global population and the adoption of technologies that affects the environment negatively, our world is

beginning to receive a reprisal attack from environmental components leading to the creation of environmental extremes in terms of rainfall and temperature which have been proofed to have increased excessively leading to a drastic change in the global climatic conditions (Jackson Weli, and Chukwu-Okeah 2021).These conditions have in turn affected agriculture to a very large extent as it has brought about a drop in the crop yield especially in developing nations who are technologically backward and lack the supportive capacity to turn things around by adopting agro based technology that enhances crop yield amidst the global climate change.

The arable crop sector in Nigeria must adapt to the changing environment for the livelihoods of the impoverished and increasing populations to be sustained. A variety of stakeholders, including legislators, extension agents, non-governmental organization (NGO), International non-governmental organization (INGO), researchers, communities, and farmers, will need to be included in the adaptation process. Evidence have shown that Nigeria is already experiencing diverse ecological problems which have been directly linked to ongoing climate change. The southern ecological zone of Nigeria largely known for high rainfall is currently faced with irregularity in rainfall pattern, while guinea savannah is gradually experiencing increasing temperature (Bello, Ganiyu, Wahab, Afolabi, Oluloye, Mahmud, Azeez and Adulmaliq, 2012). The northern zone faces threat of desert encroachment at a very fast rate per year occasioned by fast reduction in the amount of surface water, flora and fauna resources on land (Obioh 2008). Desertification and savanization are now becoming evident in some south-western states of Nigeria, which hitherto fell within rainforest (Kalejaiye-Matti, Nassar and Audu, 2010). In the Sahel zone of northern Nigeria, the most pronounced climate change related forms of land degradation are wind erosion and related sand dune formation, drought and desertification (Farauta, Egbule,Agwu, Idrisa and Onyekuru, 2012).

Previous empirical studies have proven that effect of climate change is seen and felt nationwide. Madaki, Muench, Kaechele, and Bavorová (2023), Mohammadi, Rydgren, Bakkestuen, Gillespie, (2023), and Akpata (2016) found that the general environmental effects of climate change include; reduction in crop yield, pest and diseases infestation, late maturity of crops and extinction of crops etc. were the visible effects of climate change in nigeria. Available evidences show that Nigeria is already experiencing diverse ecological problems which have been directly linked to ongoing climate change. The southern ecological zone of Nigeria largely known for high rainfall is currently faced with irregularity in rainfall pattern, while guinea savannah is gradually experiencing increasing temperature (Bello, Ganiyu, Wahab, Afolabi, Oluloye, Mahmud, Azeez and Adulmaliq, 2012). The northern zone faces threat of desert encroachment at a very fast rate per year occasioned by fast reduction in the amount of surface water, flora and fauna resources on land (Obioh 2008). Desertification and savanalization are now becoming evident in some south-western states of Nigeria, which hitherto fell within rainforest (Kalejaiye-Matti, Nassar and Audu, 2010). In the Sahel zone of northern Nigeria, the most pronounced climate change related forms of land degradation are wind erosion and related sand dune formation, drought and desertification (Farauta, Egbule,Agwu, Idrisa and Onyekuru, 2012).

Apata, (2016), Blessing and Goodness (2015) noted that in coping with climate change, farmers carry out some measures like; Crop rotation, the adoption of inter-cropping, arable crops with trees, adoption of new techniques, improved control for pest and diseases. Many studies have been carried out in addressing the effects of climate change on agriculture in Nigeria. However, not many of these have fully addressed the issues of adaptation measures. It is therefore against this background that this paper intends to fill this knowledge gap, by ascertaining arable crop farmers' adaptation to the effect of climate change in Cross River State, Nigeria. The objectives considered in the study include:

iii. assess the perceived effects of climate change on arable crop farmers in the study area;
iv. identify adaptation practices used by farmers in dealing with the effects of climate change.
v. ascertain the relationship between effects of climate change and adaptation practices used,

RESEARCH METHODOLOGY

Study area

The study will be conducted in Cross River State, Nigeria. Cross River State situated in the south-south geopolitical zone of Nigeria. It lies between latitude $4^0 28^1$ and $6^0 55^1$ North of the Equator and Longitude $7^0 50^1$ and $9^0 28^1$ East of the Greenwich meridian. The state is made of three agricultural zones namely: Calabar (comprising Biase, Calabar Municipal, Odukpani, Calabar South, Akamkpa, Bakassi, and Akpabuyo), Ogoja (Bekwarra, Yala, Ogoja, Obudu, and Obanliku blocks; and Ikom agricultural zone (covering Abi, Obubra, Yakurr, Ikom, Etung, and Boki blocks). It shares common boundaries with the republic of Cameroon in the East, Benue state in the north, Ebonyi and Abia state in the west, Akwa Ibom state in the southwest and the Atlantic Ocean in the south. The state has a landmass of 22,342.176 square kilometres (Adinya, 2009). Arising from its location, the state enjoys a tropical climate with the Obudu plateau at an altitude of 1,595.79m above sea level enjoying a temperate change. The state records heavy rainfall during the wet season (CRS, SEEDS, 2004).

Generally, the vegetation of the study area is a tropical rainforest region and the soil and hydrology of the study area permit the cultivation of most Nigeria's arable crops and still allows sufficient opportunities for grazing, fresh water, fishing and forest development. The zone is endowed with good soils that do not only accommodate the growth of cocoa, palms but also produces fine succulent plantain, banana, yam, cassava, maize and cocoyam in large quantities.

Population and sample size

The population of the study consisted of all arable crop farmers in Cross River State. A multi-stage sampling technique and purposive sampling was employed in the selection of arable crop farmers. The first stage involved purposive selection of one

agricultural zone out of the three zones of the state. The selected zone is Ikom agricultural zone due to the high intensity of arable crop farmers and farming. The second stage involved simple random selection (using hat and draw method) of three blocks out of six blocks that makes up the agricultural zone, the selected blocks were Abi, Yakurr and Obubra. The third stage was the selection of four cells from each of the selected blocks. At the fourth stage, a proportionality factor of 10% was applied to select arable crop farmers, who formed the respondents of the study. This percentage was chosen to give room for proportionate representation of respondents from each cell, while also taking cost into consideration. This summed up to a total of 215 respondents for the study.

Table 1: Distribution of sample by LGAs in Ikom agricultural zone

Sampled Blocks	**Cells**	**Total number of registered arable crop Farmers**	**10%**
Abi	Itigidi	135	14
	Igbo Imabana	120	12
	Ediba	215	22
	Adadama	125	13
Yakurr	Idomi	160	16
	Ekori	130	13
	Bikobiko	220	22
	Ijom	190	19
Obubra	Ofombongha IV	290	29
	Apiapum	210	21
	Owakande	225	23
	Ababene	105	11
Total	**12**	**2125**	**215**

Source: CRADP, 2022

Types of data and instrument for data collection

Primary data were obtained using questionnaire distributed to respondents by the researcher with the help of trained enumerators in the study area.

Analytical technique

Data were analyzed using descriptive and inferential statistics. Objective I, assess the perceived effects of climate change; objective II, ascertain the effective adaptation practices by farmers in dealing with the effects of climate change. Objective III, ascertain the relationship between effects of climate change and adaptation practices used, this was analyzed using spearman rank order correlation analysis. This is mathematically defined as:

$$r_s = 1 - \frac{6\sum D^2}{n(n^2 - 1)}$$

Where:

r_s = spearman rank correlation coefficient

n = sample size

D = differences between the dependent and independent variable

$\sum$ = sigma (summation)

On the other hand, the hypothesis was tested using binary logistic regression. The implicit model was expressed as:

$Y = f(X_1 + \ldots X_n + u)$

Where:

Y = dependent variable (adaptation strategies, 1=Yes, 0=No)

X_1 = rising temperature (SA=5, A =4, N = 3, D = 2, SD = 1)

X_2 = flood (SA =5, A =4, N = 3, D = 2, SD = 1)

X_3 = unreliable availability of water (SA =5, A =4, N = 3, D = 2, SD = 1)

X_4 = drought (SA =5, A =4, N = 3, D = 2, SD = 1)

X_5 = unpredictable production calendar (SA =5, A =4, N = 3, D = 2, SD = 1)

X_6 = off season rain (SA =5, A =4, N = 3, D = 2, SD = 1)

u = error term

Results And Discussion

Perceived effects of climate change

Table 2: Mean distribution of farmers based on Perceived effects of climate change

Perceived effects of climate change	SD	$\bar{x}$	Decision
Frequent occurrence of flooding during raining season	0.595	4.51	Critical
Rising sea level	0.601	4.54	Critical
Rising temperature	0.744	4.34	Critical
Occurrence of drought during raining season	0.790	4.48	Critical
Off-season rain	0.878	2.01	Not critical
Poverty	0.517	4.67	Critical
Health risk increases due to extreme conditions	0.860	4.13	Critical
Unpredictable farming calendar	1.268	3.34	Critical
Cost of food crops increases	0.411	4.79	Critical
Decrease in soil fertility	0.470	4.72	Critical

Social unrest	1.053	3.88	Critical
Climate change has led to rural-urban migration of youth	0.676	4.51	Critical
Unreliable availability of water	0.716	4.47	Critical
Crop infestation and diseases	0.856	4.30	Critical

Source: Field survey, 2023 $\bar{x}$ = Mean; mean score = 3.0

To adapt to climate change, farmers must first perceive that changes are taking place. The data in Table 2 above shows that a large share of respondents, with the mean score of $\bar{x} = 4.79$ perceived increase in cost of food crops over time and decrease in soil fertility, poverty with mean cores $\bar{x} = 4.72$ and $\bar{x} = 4.67$ respectively. These factors are as a result of climate change disaster in Nigeria. This agrees with Michael (2018). Other significant effects are rising sea level ($\bar{x} = 4.54$), frequent occurrence of flooding during rainy season ($\bar{x} = 4.51$) these corresponds to the studies of Madaki, Muench, Kaechele, and Bavorová (2023), Suleiman (2014) and Bellow *et al.*, (2012) who reported that many Nigerians living along the coastline of Niger Delta might be displaced by rising sea level and this will result to some farmers abandoning farming for non-farming activities. Furthermore, occurrence of drought, and Unreliable availability of water, crop infestation and diseases with mean scores $\bar{x} = 4.48$, $\bar{x} = 4.7$ and $\bar{x} = 4.30$ respectively, are also among the effects of climate change as perceived by respondents, this findings supports Mohammadi, Rydgren, Bakkestuen, Gillespie, (2023), who noted that persistent droughts and floods which have greatly affected growing seasons and ease spread of pest and diseases attack on crops are significant effects of climate change on crop production.

Long hotness of weather ($\bar{x} = 4.34$), change in temperature ($\bar{x} = 4.34$), increase in health risk ($\bar{x} = 4.13$) have all been observed also by respondents as effects of climate change. They observed many new ailments which have not been felt before but are present today and very severe. This finding corroborates Okhimamhe (2009) who reported that diseases like malaria, ulcer, hypertension and many others to be common in northern Nigeria and the disappearance of herbs which many relied on for treatment overtime due to climate change effects. Changes or fluctuations in temperature have resulted to decline in agricultural production. This agrees with Bello *et al.*, (2012). Most of the farmer accepted that there is increase in environmental refugees and social unrest ($\bar{x} = 3.88$) and due to this, rural people leave their homes or villages in search for relief or other sources for livelihood as noted by the respondent is as a result of communal conflicts (war) as indicated by respondents, this is in line with Gwaram *et al.*, (2004). Some of the farmers ($\bar{x} = 2.01$) disagreed that there is off-season rain in the study area. This is at variance with Hulme (2010), who mentioned off-season rains as one of the effects of climate change in study area. The difference may be because of differences in geographical location. By this result, farmers need daily weather forecasts on general weather conditions, such as, drought prediction, potential flood prediction, early warning messages, to guide their preparation.

Adaptation practices adopted by farmers

Arable crop farmers have, to some extent, been able to cope constantly with, and adapt to the challenging environmental conditions. They have developed innovative responses to degrading or changing conditions. As shown in figure 1, the main order of respondents according to adaptation practices being carried out include; early weeding (99.5%), mixed cropping (98.6%), changing planting and harvesting dates (98.6%), planting resistant crop varieties (95.3%) change in crop and animal type (95.3%), planting cover crop (87.0%), mulching to reduce moisture loss (77.7%). This finding is in accordance with that of Apata, (2016) and Blessing and Goodness (2015) who noted that in coping with climate change, farmers carry out some measures like those mentioned above to adjust or cope with changes around them. Crop rotation (58.6%), the adoption of inter-cropping arable crops with trees (57.2%), adoption of new techniques (53.0%), improved control for pest and diseases (54.0%) were carried out by farmers. Despite the importance of irrigation as an adaptation measure against unfavourable climatic conditions, it was revealed that majority of the respondents (69.8%) did not practice irrigation as it is not common in the area. This may be because of lack of irrigation facilities, or lack of knowledge about local irrigation systems that can be used by local farmers. Thus, farmers need to be convinced of the profitability and applicability of irrigation sufficient resources and proper knowledge to enable them adopt new technology.

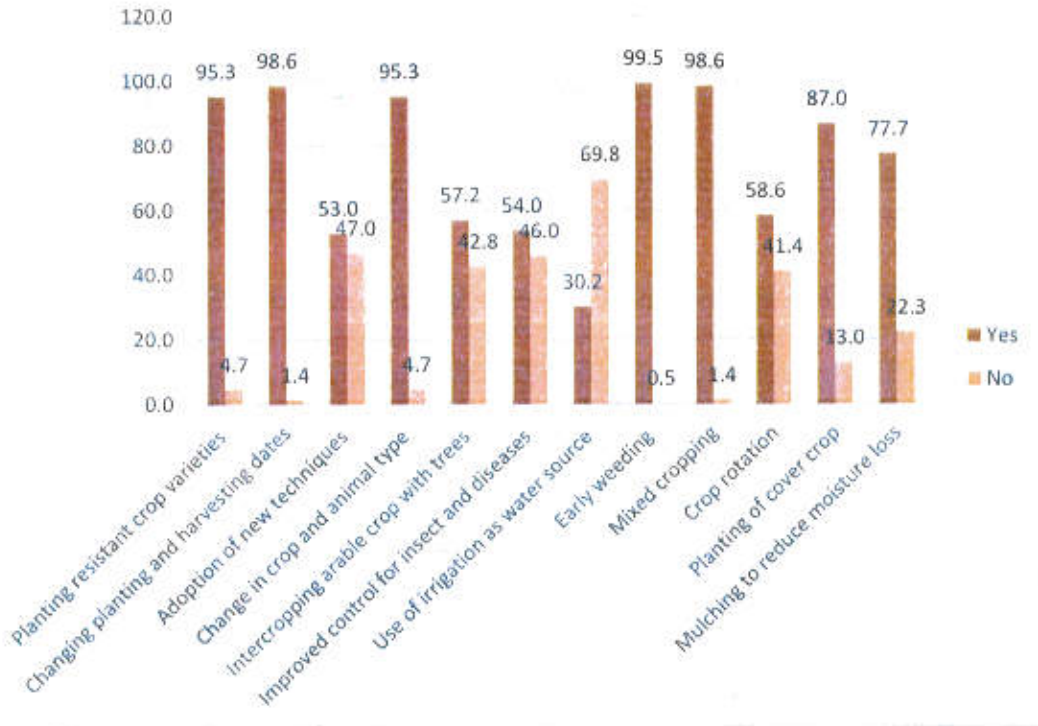

FIG. 1: Distribution of farmers according to their adaptation practices

Association between farmers' perception and adaptation measures

Table 3: Spearman rank correlation result of the association between farmers' perception and adaptation measures

Variable	N	Rho	p-value
Flooding	215	0.112	0.103^{ns}
Rising sea level	215	-0.019	0.783^{ns}
Rising temperature	215	-0.221	0.001*
Drought	215	-0.256	0.000*
Off-season rain	215	-0.093	0.172^{ns}
Poverty	215	0.048	0.485^{ns}
Increasing health risk	215	0.265	0.000*
Unpredictable farming calendar	215	0.030	0.662^{ns}
Decrease in soil fertility	215	0.33	0.000*
Livestock disease and pest	215	-227	0.001*
Social unrest	215	-0.042	0.536^{ns}
Rural urban migration of youth	215	-0.115	0.094***
Crop infestation and disease	215	0.143	0.036**
Unreliable availability of water	215	0.098	0.154^{ns}

Source: Computed from field data ***= 1%; **= 5%; *= 1

The result of the Spearman rank order correlation analysis in Table 3 reveals that some climate change variables do not have significant relationship on the adaptation measures fitted Flooding (r=0.112;$P \geq 0.103$), Rising sea level (r =0.019;P≥ 0.783), off season rain (r=0.093;P ≥ 0.172), Poverty(r =0.048; P ≥ 0.485), Unpredictable farming calendar (r=0.030;P≥ 0.662), Social unrest (r = -0.042; P ≥ 0.564) and unreliable availability of water (r=0.098; P≥ 0.154). None of the above mentioned variable was found to have significant association on farmers' choice of adaptation measures. Setbacks like; Lack of adequate knowledge about proper adaptation measures, lack of access to extension services, poverty, lack of adequate technology to mention a few can hamper farmers choice. This correlates with the findings of Neondo (2007) and Cooper (2002), who observed that farmers fail to exploit opportunities in wetter years and other unfavorable seasons and they tend to overestimate the adverse effects of variable climate. Meanwhile, The test result gave a significant association between effects of climate change variables and some adaptation measures like; Rural urban migration of youths (r = -0.115;P≤ 0.094), Crop infestation and diseases (r =0.143; P≤ 0.036), Livestock disease and pest (r = -227; P≤ 0,001), Decrease in soil fertility (r = 0.33; P≤ 0.000), Increasing health risk (0.265; P≤ 0,000), Drought (r =0.256; P≤ 0.000), Rising temperature (r = -0.221; P≤ 0.001), are strongly correlated, implying that the more farmers perceive about the effect of climate change, the more they adjust their farm practices to help them adapt to the climate change. The result is consistent with Mutabazi (2007) and Ghetibuo (2009) who found that the perception and attitude to risks shape the way farmers react to risk and course of action taken by an individual decision maker depends on what they perceived.

Conclusion

The study found out that the major factors considered to be effects of climate change as perceived by farmers are; cost of food crops increases, decrease in soil fertility, poverty, rising temperature, frequent occurrence of flooding during raining season, rising sea level, rural-urban migration of youths, health risk increases, unreliable availability of water, pest infestation and diseases, occurrence of drought during raining season. Farmers carried out some adaptation measures like early weeding, mix cropping, changing planting and harvesting dates, planting resistance varieties, change in crop and animal type perceived. Farmers are still acclimatized to their cultures or believes as changes in climate even as they perceived does not influence their choice of adaptation. It is therefore recommended that:

i. There is need for provision of and accessibility to timely agro meteorological information. to climate change adaptation among arable crop farmers. This can reduce the climate risk of farming communities.
ii. The adoption of new technologies is capital intensive and because poor communities lack empowerment to adapt, putting them in vulnerable situations. Hence, it is recommended that farmers should form cooperative societies to cope with the high cost of agricultural production.
iii. There should be further research on cultural factors that influence farmers' choice of adaptation measures to climate change, especially with regards to socioeconomic background.

References

Apata, O. (2016). *Adaptation Strategies to Effects of Climate Change on Arable Crops Production in Southwestern Nigeria. British Journal of Applied Science & Technology,* 12 (5). 1-7. ISSN 22310843

Blessing, E. & Goodness, C. A. (2015). Adaption to climate change by farmers in Makurdi Nigeria. *Journal of Agriculture and Ecology Research International*, 2(1): 46-57.

Cooper, E. (2007) farmers' misperception to climate change. A report presented on climate change in Africa, Eastern and southern international crop research institute.

Food and Agricultural Organization (FAO) (2023). Crop Prospects and Food Situation – Quarterly Global Report No. 1, March 2023. Rome; 2023.

Ghetibouo, G, A. (2009). Understanding farmers' perceptions and adaptations to climate change and variability the case of the Limpopo basin, south Africa IFRRI Discussion paper forth coming

Jackson S. O, Weli V. E, Chukwu-Okeah G. O, (2021). Climate Change and Adaptation Strategies of Arable Crop Farmers in Abia State, Nigeria. *Eart & Envi Scie Res & Rev,* 4 (2): 91-97.

Madaki, M. Y., Muench S, Kaechele H., & Bavorová M. (2023). Climate change knowledge and perception among farming households in Nigeria. Climate. 2023b;11(6):115. Available:https://doi.org/10.3390/cli110601 15

Michael, O. (2018). Climate change and its effects on presented Nigeria, Nigeria tribune.

Mohammadi S, Rydgren K, Bakkestuen V, & Gillespie MA. (2023). Impacts of recent climate change on crop yield can depend on local conditions in climatically diverse regions of Norway. Scientific Reports. 2023;13(1). Available:https://doi.org/10.1038/s41598- 023-30813-7

Mutabazi, K. D. (2007). Farmers perception and attitude to rainfall variability risks in dry lands areas at Tanzanis. Ph.D Thesis of sokoine university of agriculture Morogoro,Tanzania 194 pp

VEGETABLE FARMERS' ADAPTATION STRATEGIES TO THE EFFECTS OF CLIMATE CHANGE IN CALABAR METROPOLIS, CROSS RIVER STATE, NIGERIA.

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Abstract
This study assessed vegetable farmers' adaptation strategies to the effects of climate change in Calabar Metropolis, Cross River State, Nigeria. A multi-stage sampling technique was employed to select 100 respondents from 11 wards. The result revealed that respondents mostly perceived that there has been higher temperatures ($\bar{X}$=2.00) and increased incidence of drought ($\bar{X}$=2.00) and that changes in temperatures ($\bar{X}$=2.62) was the most perceived effects of climate change while the most practiced adaptation strategies was adjusting planting and harvesting practices ($\bar{X}$=2.69) and inadequate data on climate change ($\bar{X}$=4.84) was the most serious constraints to adaptation strategies to respondents in the study area. The study recommended that climate education should be fostered among vegetable farmers in the study area in order for farmers to have comprehensive information on climate change, its impacts, effects and adaptation strategies.

KEYWORDS: Adaptation, climate change, effect, farmers, strategies, vegetable

1.0 Introduction

Climate change is one of the global threats with serious implications on agriculture, natural ecosystem, water supply, health, soil and atmosphere, which are all elements that constitute the long term sustainability of life on earth (Emeka, 2008). Variability in climate and its associated risks have always been a part of agriculture, farmers have developed many ways of managing the menace. To farmers, climate change is not perceived in terms of the major disasters such as floods, drought or hurricanes, but rather as increased uncertainty, such as shifts in onset of rain at planting time or end of rain at harvest time; some years bring excessive rainfall while others are very dry, with a greater irregularity within and between annual rainy seasons (Ali & Erenstein, 2017). As global population increased, it became obvious that management of resources at the regional level is extremely important. Adewuyi (2020) inferred that the quality of air, water, climate, and other impacts on human activities has made us realize that there is a need to manage our human resources. Climate change poses a significant threat to agricultural practices worldwide, impacting crop yield, water availability, and overall food security. The Sustainable Development Goal 13 (Climate action) is the most urgent goal to attend to as it affects all other goals (Lykketoft, 2020).

According to the Intergovernmental Panel on Climate Change (2007), climate change is presently a threat to development as it poses potential adverse consequences to natural resources, including the management of water and land, ecosystem and human health and that greater than 95% of this cause is anthropogenic. McDowell and Hess (2012) maintained that "adaptation occurs in response to, and in preparation for, multiple stressors that reconfigure access to resources required for response." There are a number of factors established by numerous researchers that promote adaptation capacity: economic assets, technology, information and skills, infrastructure, the presence of effective institutions, equity, social capital, and collective action (Engle *et al.*, 2010). These factors are considered critical to the adaptation responsiveness of farming communities, particularly resource-poor populations living in core rural communities. Appropriate climate change information dissemination is thus, a critical factor in effective adaptation.

Possible impact of climate change may be visualized by change in productivity with reference to quality of crops; changes in agricultural practices like use of water, fertilizers, and pesticides; and environmental influences particularly in relation to the frequency and intensity of soil drainage which may lead to loss of nitrogen through leaching, soil erosion, and reduction of crop diversity. The AVRDC 2005 annual report suggests that vegetables are in general more sensitive to environmental extremes such as high temperatures and soil moisture stress. Carbondioxide (CO2), a major greenhouse gas, influences growth and development as well as incidence of insect pests and diseases of vegetable crops. Under changing climatic situations, crop failures, shortage of yields, reduction in quality, and increasing pest and disease problems are common, and they render the vegetable cultivation unprofitable. Oladipo (2021) posits that agricultural production needs to be adapted to the changing climate by mitigating its impact. Unless measures are undertaken to adapt to the effects of climate change on vegetable production, nutritional security in developing countries will be under threat.

The region's agriculture has been sustained in large part by the use of traditional farming techniques and local expertise. To maintain the resilience and sustainability of vegetable farming in Calabar, existing methods must be re-evaluated in light of the growing effects of climate change, and creative new approaches must be investigated. With current global climate change conditions, the urgency to provide agricultural knowledge on adaptation and mitigation measures has risen. This study intends to provide useful information to the larger conversation on agriculture's adaptation to climate change by concentrating on Calabar, Nigeria, and by providing useful suggestions for local stakeholders and policymakers alike. The study's backdrop lays the groundwork for an in-depth investigation of the complex interactions between climate change and the adaption techniques used by Calabar vegetable farmers.

It is on the strength on this that this research tends to fill in the gap by assessing the adaptation strategies to the effects of climate change to vegetable farmers in Calabar metropolis, Cross river state, Nigeria. The specific objectives of this study were to:

i. assess the perception of vegetable farmers about climate change in the study area.

ii. assess the perceived impacts of climate change impacts on vegetable farming in the study area.

iii. identify the adaptation strategies currently utilized by vegetable farmers to the effects of climate change in the study area.

iv. explore the constraints faced by vegetable farmers in implementing adaptation strategies in the study area.

2.0 Methodology

The study was conducted in Calabar Metropolis. Calabar Metropolis is comprised of Calabar Municipal Local Government Area and Calabar south Local Government Area and are both located in the Southern Senatorial District of Cross River State with headquarters at Marian and Anantigha respectively. It lies between Longitudes 8°18'00"E to 8°24'00"E and Latitudes 4°54'00"N to 5°04'00"N. It has an area of 406 square kilometers (157 sq mi) and, as of the 2006 census, a population of 371,022. It has 21 local government wards (10 in Calabar Municipal and 11 in Calabar south). It is bounded to north by Odukpani LGA, to the south by Akpabuyo LGA, to the east by Akamkpa LGA, and to the west by Calabar River. The climate of this area is tropical monsoon with a long, wet season lasting for 8 to 9 months and a brief dry season lasting for the final 3-4 months (Nku-Ekpang *et al.*, 2017). Calabar Metropolis falls within tropical equatorial climate of high temperature, high relative humidity and abundant annual rainfall. The annual rainfall is 2750 mm and mean annual average temperature is 26.1°C.

The major languages spoken are Efik and English. The major occupation of people in this area are farming, small scale business, and civil service. The study area has witnessed a tremendous increase in the population of 10,000 estimated at the pre-colonial, to 99,352 in 1993; 328,876, in 1991. The population growth of Calabar Metropolis has been followed by the expansion of its physical boundaries. This increase in the physical boundaries implies a corresponding loss of vegetation and land in the area thereby a direct impact on the micro-climate.

2.1 Sampling technique and sample size

A multi-stage sampling technique was employed to select the sample size. Since Calabar Metropolis comprises of two local government area with 21 wards, the first stage involved a simple random sampling technique to select ten out of twenty-one communities in the study area. In the second stage, purposive sampling was used to select the households where vegetable farming is done. In the third stage, purposive sampling was also used to select only vegetable farmers in the area to make up a total of 100 respondents. Primary data were collected using structured questionnaires and were analysed using frequency, mean, ranking and percentages with the aid of IBM SPSS version 23.

3.0 Results and discussion

3.1 Perception of climate change by vegetable farmers

Table 1 shows the distribution of respondents based on the perception of local farmers to climate change in the study using percentages, mean, and rank. The results shows that 100.0% of the respondents perceived climate change in the area as higher temperature and

increased incidence of drought, both ranking 1st. Additionally, 98% of farmers reported experiencing irregular rainfall patterns ranking it 2nd. The perception of late and early onset of rainfall is recognized by 95% of respondents positioning it 3rd. The incidence of flooding is acknowledged by 94% of farmers, ranking 4th. 86% of respondents believed there has been a lengthening of the growing season, which ranks 5th. This result implies that there is a high level of awareness among vegetable farmers regarding the impacts of climate change on their agricultural practices.

Table 1: Distribution of respondents based on perception of climate change (n=100)

	Yes	No	Mean	Rank
Statement	**%**	**%**		
There has been higher temperature	100.0	0.0	2.00	1st
There has been late and early onset of rainfall	95.0	5.0	1.95	3rd
There has been irregular rainfall patterns	98.0	2.0	1.98	2nd
There has been increased incidence of drought	100.0	0.0	2.00	1st
There has been increased incidence of flood	94.0	6.0	1.94	4th
There has been lengthen growing season	86.0	14.0	1.86	5th
$\bar{X}$ = 1.50				

Source: Field Survey, 2024. ***(Multiple responses)***

3.2 Perceived effects of climate change on vegetable farming

Table 2 shows the distribution of respondents based on perceived effects of climate change on vegetable farming using percentages, mean, and ranking. The results showed the prevalent perceived effects of climate change in the area were changes in temperature ($\bar{X}$=2.62), reduced agricultural produce ($\bar{X}$=2.48), and increased frequency of extreme weather events ($\bar{X}$=2.48) ranking 1st and 2nd respectively. Others included increased drought ($\bar{X}$=2.38), flooding ($\bar{X}$=2.26), shifts in planting season ($\bar{X}$=2.14), among other perceived effects. This implies that in the study area, climate change mostly brought about changes in temperature, reduced agricultural produce, increased drought among other perceived effects.

Table 2: Distribution of respondents based on perceived effects of climate change on vegetable farming (n=100)

	Very serious	Serious	Not serious	Mean	Rank
Statement	**%**	**%**	**%**		
Changes in temperature	80.0	2.0	18.0	2.62	1st

Altered precipitation patterns	54.0	0.0	46.0	2.08	6th
Increased frequency of extreme weather events	74.0	0.0	26.0	2.48	2nd
Shifts in pest and disease dynamics	38.0	4.0	58.0	1.80	9th
Water availability and Irrigation challenges	49.0	4.0	47.0	2.02	8th
Shifts in planting season	55.0	4.0	41.0	2.14	5th
Economic and livelihood impacts	47.0	9.0	44.0	2.03	7th
Flooding	61.0	4.0	35.0	2.26	4th
Increased drought	69.0	0.0	31.0	2.38	3rd
Reduced agricultural produce	74.0	0.0	26.0	2.48	2nd
$\bar{X} = 2.00$					

Source: Field Survey, 2024.

3.3 Adaptation strategies practiced by farmers

The table 3 shows the distribution of respondents based on adaptation strategies practiced in the study area using percentages, mean, and ranking. The result revealed that the most commonly practiced adaptation strategies used by the vegetable farmers in the study area were adjusting planting and harvesting practices and crop rotation ranked 1st and 2nd with mean score of 2.69 and 2.53 respectively. It also showed that enhancing soil management and use of cover crops ranked 10th and 11th with mean score of 1.83 and 1.79 were the least practiced adaptation strategies by respondents. Other strategies fell between these two extremes. This implies that while some adaptation strategies are recognized and practiced, some remain poorly practiced due to inability to use them or lack of knowledge concerning how to use them. This result is in line with Idrisa et., al (2012) who opined that farmers practice the use of irrigation, mulching/ cover cropping, planting ahead ahead of rain, soil conservation practices etc in order to adapt to climate change in the Sahel Savannah zone of Borno State, Nigeria.

Table 3: Distribution of respondents based on adaptation strategies practiced by farmers (n=100)

Statement	Not practiced	Practiced	Highly practiced	Mean	Rank

	%	%	%		
Adjusting planting and harvesting practices	79.0	11.0	10.0	2.69	1st
Diversifying crop varieties	52.0	4.0	44.0	2.08	7th
Improving water management	37.0	11.0	52.0	1.85	9th
Enhancing soil management	37.0	9.0	54.0	1.83	10th
Improving pest and disease management	69.0	4.0	27.0	2.42	3rd
Improving access to information and training	64.0	2.0	34.0	2.30	4th
Use of cover crops	32.0	15.0	53.0	1.79	11th
Minimum tillage	25.0	47.0	28.0	1.97	8th
Crop rotation	73.0	7.0	20.0	2.53	2nd
Planting of drought resistant crop varieties	50.0	17.0	33.0	2.17	6th
Improved irrigation efficiency	46.0	16.0	38.0	2.08	7th
Mixed cropping	59.0	1.0	40.0	2.19	5th
Soil conservation	53.0	2.0	45.0	2.08	7th
$\bar{X} = 2.00$					

Source: Field Survey, 2024.

3.4 Constraints to adaptation strategies

Table 4 shows the distribution of respondents based on constraints to adaptation in the study area. The result reveals that the most significant constraints to adaptation were inadequate data on climate change and inadequate funding, which ranked 1st and 2nd with mean score of 4.84 and 4.81 respectively. The result also revealed that the least significant constraints to adaptation strategies were market constraints and social and cultural factors, which ranked 10th and 11th with mean score of 3.83 and 3.10 respectively. All other constraints to adaptation fell between these two extremes. This result agrees with Stern (2006), in his work on barriers to adaptation, which suggested that the factors addressed in this result are of high relevance when dealing with adaptation to climate change.

Table 4: Distribution of respondents based on adaptation strategies practiced (n=100)

Statement	SA %	A %	U %	D %	SD %	Mean	Rank
Limited access to resources	60.0	38.0	0.0	2.0	0.0	4.56	5th
Knowledge and information gaps	65.0	33.0	0.0	2.0	0.0	4.61	4th
Institutional and policy barriers	51.0	22.0	6.0	17.0	4.0	3.99	9th
Market constraints	24.0	47.0	17.0	12.0	0.0	3.83	10th
Climate variability and uncertainty	35.0	40.0	23.0	2.0	0.0	4.08	8th
Social and cultural factors	15.0	30.0	17.0	26.0	12.0	3.10	11th
Poor extension services	64.0	30.0	0.0	6.0	0.0	4.52	6th
Inadequate funding	85.0	13.0	0.0	2.0	0.0	4.81	2nd
poor understanding of adaptation	74.0	22.0	0.0	4.0	0.0	4.66	3rd
Low level of awareness	58.0	27.0	0.0	15.0	0.0	4.28	7th
Inadequate data on climate change	84.0	16.0	0.0	0.0	0.0	4.84	1st
$\bar{X}$ = 3.00							

Source: Field Survey, 2024.

4.0 Conclusion

This study investigated vegetable farmers adaptation strategies to the effects of climate change in Calabar Metropolis Local Government Area, Cross River State, Nigeria. The result showed that 100.0% of the respondents perceived that there has been higher temperature and increased incidence of drought. The result also showed that changes in temperature ($\bar{X}$=2.62) and reduced agricultural practice ($\bar{X}$=2.48) were the most perceived effects of climate change in the study area. In addition, the result showed that the most practiced adaptation strategies by respondents in the area were adjusting planting and harvesting practices. Finally, the result revealed that inadequate data on climate change ($\bar{X}$=4.84) and inadequate funding ($\bar{X}$=4.81) were the most serious constraints to adaptation strategies to respondents in the study area.

5.0 Recommendation

Based on the results obtained, this study therefore recommends that;

(a) Climate education should be fostered among the respondents in the area in order for them to have comprehensive information on climate change, its impact, effects and adaptation strategies.

(b) Extension services should be readily available to respondents in the area as this would ease access to data on climate change, awareness and understanding on climate change, and new innovations in adapting to climate change.

(c) Conservation practices like minimum tillage, use of cover crops etc should be practiced in the study area as these practices were poorly undertaken in the area and are cost-effective adaptation strategies to climate change.

(d) Data collection and dissemination should be encouraged as this would provide farmers with timely information since inadequate data on climate change was the most significant constraints to adaptation strategies of climate change.

References

Adewuyi, S. A. (2020). Climate Change Adaptation Strategies in Nigerian Agriculture: A Review of Policy and Practice. *Sustainability*, 12(10), 4124.

Agboola, T. & Ojeleye, D. (2007). Climate change and food crop production in Ibadan, Nigeria. African Crop Science Conference Proceedings, Egypt. *African Crop Science Society*. 8, 1423-1433.

Ali, A. & Erenstein, O. (2017). Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. *Climate Risk Management*, 16, 183 – 194.

Bello, M., Salau, E.S., Galadima, O. E. & Ali, I. (2013). Knowledge, perception and adaptation strategies to climate change among farmers of Central State Nigeria. Sustain. *Agric. Res.* 2, 107–117.

Cooper, C. B. (2011). Media literacy as a key strategy toward improving public acceptance of climate change science. *BioScience*. 61, 231–237.

Doss, C. R., Meinzen-Dick, R., & Bomuhangi, A. (2014). Who's got the power? Gender, social capital, and agency in decision-making in rural Uganda. *World Development*, 61, 11-26.

Emeka, D.O. (2008). *Impact of climate change on livelihood sustainability in the lake chad region of Nigeria* Popoola (ed). Proceedings of the 32nd Annual Conference of Forestry Association of Nigeria

Emeka, D.O. (2008). "Climate change and Violet Conflict over Land Resources in North-eastern Nigeria". *J. Hum Ecol.* 23(4), 311-324

Engle, N. L. & Lemos, M. C. (2010). *Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. Glob. Environ. Chang.* 20, 4 –13.

Gowda, M. V. R., Fox, J. C., Magelky, R. D. (2017). Students' understanding of climate change: Insights for scientists and educators. *Bulletin of the American Meteorological Society*. 78(10), 2232-2240.

IPCC (2007). Climate change: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change New York: Cambridge University Press; 2001, 1032

IPCC (2007) Climate Change*: The physical science basis*- Summary for Policy Makers, Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Paris.

IPCC, 2001: Climate Change (2001). Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, J. J. McCarthy, O. F. Canziani, N A. Leary, D.J. Dokken& K.S. White, Eds., Cambridge University Press, 1032 pp.

IPCC, Climate Change (2014). *The physical science basis.* Contribution of Working Group I, II, III, and Synthesis report to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Paris.

Idrisa, K. T., Onwonga, R. N., Onyango, C., Mbuvi, J. P., Kironchi, G. (2012). Climate change and variability: Farmers' perception, experience and adaptation strategies in Makueni County, Kenya. *Asian J. Agric. Rural Dev.* 2, 411–421.

McDowell, J. Z., Hess, J. J. (2012). Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate. Glob. *Environ. Chang.* 22, 342–352.

Mittal, S. & Mehar, M. (2016). Socio-economic factors affecting adoption of modern information and communication technology by farmers in India: Analysis using multivariate probit model. *J. Agric. Educ. Ext.* 22, 199–212.

Mosser, S.C. (2007). *Communicating Climate Change and Facilitating Social Change*; Dilling, L., Ed.; University of Colorado, Boulder: Boulder, CO, USA, 2007.

Mtega, W. P., Ngoepe, M. & Dube, L. (2016). Factors influencing access to agricultural knowledge: The case of smallholder rice farmers in the Kilombero district of Tanzania. *S. Afr. J. Inf. Manag.* 18, 1–8.

Nku-Ekpang, K. K. & Ndaeyo, N. U. (2017). Climate change and coping strategies among peasant farmers in Cross River State, Nigeria. *Int. J. Basic Appl.* 2, 24–28.

Ogundare, D. A. (2019). Socio-Economic Characteristics and Vulnerability of Smallholder Farmers to Climate Change in Ibadan, Nigeria. *Journal of Environmental Management*, 246, 868-876.

Oladipo, F. O. (2021). Awareness, Perception, and Adaptation Strategies of Farmers to Climate Change: A Case Study of Oyo State, Nigeria. *Geo Journal*, 86(1), 1-18.

World Health Organization (2009). *Protecting Health from Climate change*. Global Research Priorities Geneva: WHO; 2009, 1-32.

AN ASSESSMENT OF THE USAGE PATTERN OF PLASTIC MATERIALS IN AGRO-ENTERPRISE DEVELOPMENT IN CROSS RIVER STATE, NIGERIA

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Abstract

This research assessed plastic agricultural development in Cross River State. It examined plastic materials and the level of usage by enterprise owners in the study area, highlighting the most utilized plastic materials among selected enterprises in the study area and development in Cross River State. Both primary and secondary data were used, structured questionnaire was used to collect data. Data were obtained from 150 respondents from five selected agro-enterprises which are; processing and packaging enterprises, Vegetable farms/Gardens, Poultry farm enterprise, Nursery/horticultural enterprises, and Agro-marketing enterprises by simple random and purposive sampling technique. Results revealed that Plastic products that are most inclusive in the agricultural activities of vegetable farmers included; Plastic Basin, Jerry Can, Poly-ethyneBags and Table.The use of Tapolyne Bags, Poly-ethyne Bags and Chair, Cup and Egg Crate, among agro-marketers, Egg Crates and Tapolyen Bags, Plastic Tanks, and Plastic Jerry Cans, among poultry enterprises. The study showed that Tapolyne Bags have the highest prospect as showed in the study with three 1st rankings in Agro-market, Poultry and Processing/packaging enterprises and one 2nd ranking for Nursery/Horticultural Enterprise (A^3B). The study recommended among others, that the government should provide tax relief, subsidies and educational support (through agricultural extension) to farmers in the implementation of sustainable plastic models, practices and technologies.

INTRODUCTION

In Africa, Nigeria is Africa's largest importers of plastics in primary forms (Fairtrade, 2019). With about 70% of raw materials imported (mainly from the Middle East, Europe and Asia) and only 30% produced locally, the Nigerian market has great prospect for export of plastics in primary forms. In the years 2008 to 2015, imports of plastic raw materials improved annually by 7.2% from 464 kt to 754 kt, +62.5% (Fairtrade, 2019). This makes Nigeria and Algeria, Africa's largest importers of plastics in primary forms. Several studies have undermined the efficacy of plastic in agricultural development (Muhammad (2014); Giuliano, Rosa, Ileana, Giacomo, and Evelia, (2015) while others uphold the beneficial impact of the utilization of plastic materials in agriculture (Hancock 1988; Desriac 1988 and Science Direct, 2015). Many types of plastic materials have been used in agriculture over the years in Cross River State, some of which finds application in the poultry farms as; Flexible plastics (Used for packaging feed, vaccines, and other products), Non-flexible plastics (used for equipment, infrastructure, and egg packaging), Plastic bags (used for packaging feed, disposing of waste, and covering floors), Plastic cups (used for vaccinations and medication administration) and Plastic

containers (used for storing feed, water, and other supplies). Plastic materials are also used for; Greenhouse covers (Plastic films or sheets are used to cover greenhouses, providing a controlled environment for plant growth), Mulch films (Plastic mulch films are used to retain moisture, suppress weeds, and regulate soil temperature), Irrigation pipes and fittings (Plastic pipes and fittings are used for irrigation systems), Pots and containers (Plastic pots and containers are used for seedlings, transplants, and plant sales), Packaging materials (Plastic bags, wraps, and boxes are used to package plants, flowers, and produce), Trellises and supports (Plastic trellises and supports are used for plant training and support), Ground covers (Plastic ground covers are used to control weeds and retain moisture), Hydroponic systems (Plastic materials are used in hydroponic systems for nutrient delivery and plant support), Labeling and tagging (Plastic labels and tags are used for plant identification), and Protective covers (Plastic covers are used to protect plants from frost, wind, and pests) in horticultural enterprises ((Agricultural Plastic Recycling and Producers Survey Final Report, (2012); Ntui, *et al.*, (2022a); Ntui, *et. al.*, (2022b); Nkang, and Effiong, (2015); Ijioma, *et al.*, (2024); Etim, and Effiong, (2022) and Etim, *et al.*, (2022)).

Most of the benefits of the utilization of plastic materials in agricultural development among agro-enterprises in include; Water conservation through efficient irrigation systems, Increased yields by protecting crops from pests, diseases, and harsh weather conditions, leading to increased yields, Reduced post-harvest losses by protecting produce during transportation and storage, Improved efficiency in agricultural production, processing, and marketing, Cost-effective than alternative materials, Soil temperature regulation since mulch films can warm the soil in cooler climates, promoting early seed germination and growth, Weed control which reduces competition for water and nutrients, Crop protection from frost, hail, and pests, reducing damage and increasing yields, Extended growing season, Improved crop quality, and Reduced soil erosion ((American Chemistry Council, (2017); Etim, (2018); Effiong, (2013), Effiong, (2012); Effiong, and Aboh, (2024); Effiong, and Aboh, (2019); Aboh, and Effiong, (2019)).

Some of the plastic materials used in agricultural activities include; Polyethylene (PE) (used for mulch films, greenhouse covers, and tunnel covers), Polypropylene (PP) (used for nursery pots, trays, and irrigation pipes), Polyvinyl Chloride (PVC) (used for pipes, fittings, and greenhouse covers), Bags and pouches (Plastic bags and pouches are used to package seeds, fertilizers, pesticides, and other agricultural inputs). Containers and tubs (Plastic containers and tubs are used to package and store agricultural products, such as grains, nuts, and dried fruits), Bottles and jugs (Plastic bottles and jugs are used to package and store liquids, such as pesticides, herbicides, and fertilizers), Wraps and films (Plastic wraps and films are used to cover and protect agricultural products, such as hay, silage, and cotton), Crates and boxes (Plastic crates and boxes are used to transport and store agricultural products, reducing damage and spoilage), and Pallets and trays (Plastic pallets and trays are used to transport and store agricultural products, improving efficiency and reducing costs) ((Bernard, (2015); Effiong, and Aboh, (2018); Effiong, *et al.*, (2021); Effiong, and Asikong, (2013) and Effiong, *et al.*, (2016)).The research gap lies in the limited understanding of the specific role and impact of plastic materials in enhancing agricultural productivity within the context of Cross River State's agro-economy. Although previous studies have presented conflicting perspectives on the benefits and drawbacks of plastics in agriculture, there is a lack of localized data on how different agro-enterprises in Cross River State utilize plastic, which materials are most commonly used, and the broader implications for sustainable agricultural development in the region. This study seeks to fill this gap by providing empirical insights into plastic usage

patterns among local agro-enterprises and exploring the feasibility of a plastic-centered approach to agricultural development specific to the area.

RESEARCH METHODOLOGY

The research was conducted in the Southern Agricultural Zone of Cross River State which lies between latitudes 5°32' and 4°27' North and longitudes 7°50' and 9°28' East of the Greenwich meridian. It has a tropical humid climate with wet and dry seasons and average temperature ranging between 15°C – 30°C and annual rainfall between 1300 – 3000mm. It has three major ethnic groups with their dominant languages as the Efiks, Bekwarra and Ejagham (www.Kekerete.tripod.com/CRSG). Cross River State is bounded in the North by Benue State, in the Southwest by Akwalbom State, in the west by Ebonyi and Abia States (CRS LEEDS 2 (2016)). The Southern Agricultural Zone has seven blocks which are; Calabar South, Akampka, Calabar Municipality, Biase, Akpabuyo, Bakassi, and Odukpani. The vegetation are; Mangrove, Swamp, and Rainforest. Major crops produced in the area includes; Cocoa, Rice, Cassava, Oil Palm, Rubber, Banana and Pineapple among others. Occupation is mostly farming, marketing and civil services. The population of study included owners of agricultural enterprises that uses plastic for their production, processing, packaging, marketing or storage

Table 1. Sampled Enterprises from the population of Agricultural Enterprises in the Southern Agricultural Zone as Registered by the State Ministry of Agriculture.

Enterprises	Calabar South	Calabar Municipality	Akamkpa	Akpabuyo	Odukpani	Total	Total Sample
Poultry	27	30	71	39	60	227	35
Nursery/Horticulture	21	26	27	40	30	144	25
Processing/Packaging	20	25	12	13	27	97	25
Vegetable/Garden	79	40	15	10	80	224	30
Agro-marketing	40	50	27	23	31	171	35
Total	187	171	152	125	228	863	150

Source: Field Survey, 2024

needs in the southern agricultural zone of Cross River State. Enterprise category measured in this study included; processing and packaging agricultural enterprises, Vegetable farms/gardens, Poultry enterprises, nursery/horticultural enterprises and agro-marketing enterprise.

Table 1 represent the sampling procedure and sample size for the study. A simple random sampling technique was used in the selection of five blocks in the zone which were;Akpabuyo, Calabar South, Calabar Municipality, Odukpani and Akamkpa. This is because they share similar developmental features in proximity, agriculture and presence of farm enterprises that make use of plastic. Also, a purposive sampling technique was used in the selection of five agricultural enterprises that makes use of plastic materials in their agricultural production in the five blocks. They are; processing and packaging enterprises, Vegetable farms/Gardens, Poultry farms, Nursery/horticultural enterprises, and Agro-marketing enterprises. This enterprises comprises of the cells in this study. Primary data was gotten through a through a researcher structured questionnaire. Descriptive statistics was adopted. The available plastic in agricultural production was measure by multiple response on variables such as; plastic bags, containers,

buckets, bottles, cans, and plastic crates using frequency, mean and percentages on charts and tables.

RESULTS AND DISCUSSIONS

1. MOST USED PLASTIC MATERIALS AMONG AGRO- ENTERPRISES

Fig. 1

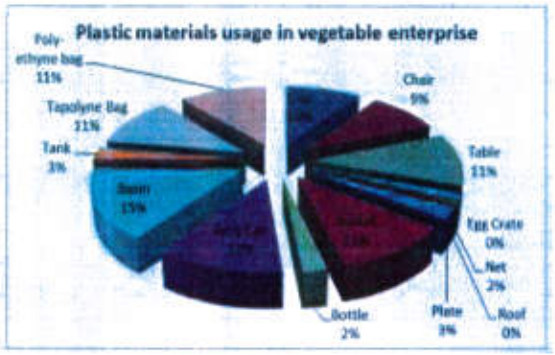


Fig. 2

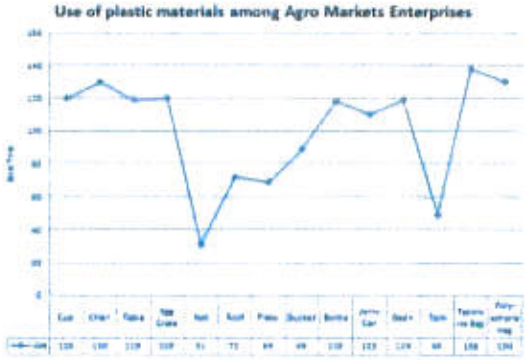


Fig. 3

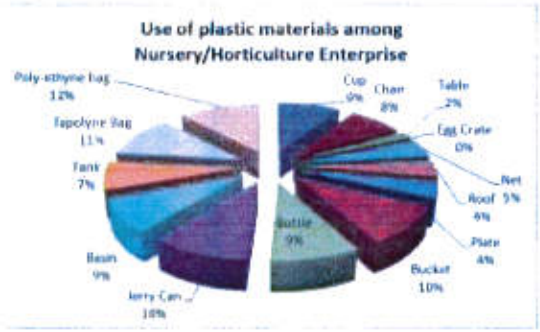
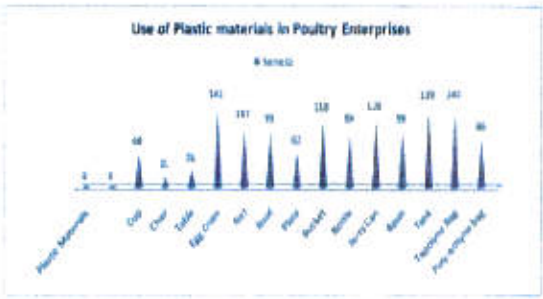
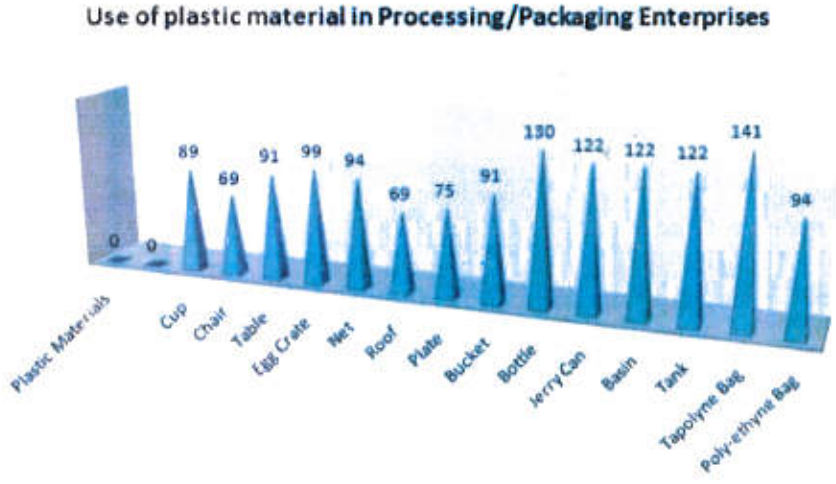


Fig. 4





Vegetable/Garden Enterprises

Figure 1 showed the distribution of respondents based on their ratings on plastic products used in vegetable/garden enterprises. Most frequently used plastics in the agricultural activities of vegetable farmers included; Plastic Basin (f= 139, $\bar{x}$ = 1.92), Jerry Can (f=109; $\bar{x}$ = 1.72), Poly-ethyne Bag and Table f=106; $\bar{x}$ = 1.70). This shows the relevance of these materials in haulage, and serving for placement of farm produce.

Agro-Marketing Enterprise

Figure 2 showed the distribution of respondents based on the ratings of plastic products used in agro-marketing enterprise. According to the findings, highly incorporated plastic materials/products among agro-marketers and their marketing enterprises includes; the use of Tapolyne Bags (f=138; $\bar{x}$=1.92), Poly-ethyne Bags and Chair (f=130; $\bar{x}$ =1.86), Cup and Egg Crate (f=120; $\bar{x}$ =1.80). Low ranked plastic products include; plastic plate (f=69; $\bar{x}$ =1.46), Plastic Tank (f= 49; $\bar{x}$ =1.32), Plastic Net (f = 31; $\bar{x}$ =1.20). This implies that respondents have need for plastic to spread their farm produces, wrap same, and use them for storage. The chair is mostly use for convenience at stationed market points.

Horticultural/Nursery Enterprise:

The utilization of plastic materials such as; Poly-ethyne Bag (f=141; $\bar{x}$ =1.94), Tapolyne Bag (f=130; $\bar{x}$ =1.86), Plastic Bucket and Jerry Can (f=118; $\bar{x}$ =1.78) showed a hug prospect in horticultural enterprises as indicated in Figure 3. The use of plastic bags or polyethene bags promote transplanting of seedlings while roots of nursery plants are intact. Buckets and Jerry Can serve for watering and conveyance of material inputs.

Poultry Enterprises:

Figure 4 showed that poultry enterprises mostly utilizes plastic materials such as; Egg Crates and Tapolyen Bags (f=141; $\bar{x}$ =1.94), Plastic Tanks (f= 139; $\bar{x}$ =1.92) and Plastic Jerry Cans (f= 120; $\bar{x}$ =1.80). This implies that most poultry farmers use Tapolyne for brooding purposes and Egg Crate for collection, storage and transportation of eggs.

Packaging and Processing Enterprises:

Figure 5 revealed that plastic materials mostly used by agricultural processers for their processing and packaging needs includes; Tapolyne Bags (f=141; $\bar{x}$ =1.94), Plastic Bottles (f=130; $\bar{x}$ =1.86), Jerry Cans, Plastic Basins, and Plastic Tanks (f= 122; $\bar{x}$ =1.81). Packaging and Processing Enterprises most often utilize polybags such as Tapolyne for packaging farm produces, milled produce, as well as bye produce for waste collection. Other plastic materials identified are mostly used for containment and storage purposes.

Several authors have indicated the relevance of plastic materials to agricultural activities in the study area. Etim and Effiong, (2022), evaluated the benefits of the use of flexible and non-flexible plastic materials among Agro-Enterprise Owners in the Calabar Agricultural Zone of Cross River State, Nigeria. Studies on Climate Change impact on the use of Plastic Products Among Agro-Marketers and Horticultural Enterprises in Calabar Agricultural Zone of Cross River State (Etim, Effiong, Okoi, and Ntui, 2022), Rubber Production Technologies and the related socioeconomic environments (Effiong, and Aboh, 2018) and the assessment of the factors inhibiting the use of plastic materials among selected Agro-Enterprises and farmers in Calabar Agricultural Zone of Cross River State, Nigeria (Ntui, Effiong, Etim, and Okoi, 2022), are studies that support the findings of this study and further stressed the benefits of a plastic agro-economy as a prospect for agricultural development in Cross River State, Nigeria.

2. Most Used Plastic Materials Among the Selected Enterprises

Table 8 – Distribution of plastic materials mostly ranked among the selected enterprises

	ENTERPRISES					
PLASTIC MATERIAL	**VEGETABLE**	**AGRO-MARKET**	**NURSERY/ HORTICULTURE**	**POULTRY**	**PROCESSING/ PACKAGING**	**CODE**
Plastic Basin	A	-	-	-	C	AC
Jerry Can	B	-	C	C	C	BC^3
Plastic Table	C	-	-	-	-	C
Poly-ethyne Bag	C	-	A	-	-	CA
Tapolyne Bag	-	A	B	A	A	A^3B
Plastic Bucket	-	-	C	-	-	C
Plastic Bottle	-	-	-	-	B	B
Plastic Tank	-	-	-	B	C	BC
Plastic Chair	-	B	-	-	-	B
Plastic Cup	-	C	-	-	-	C
Plastic Egg Crate	-	C	-	A	-	CA

Field Survey, 2024

KEY: 1^{st} - A
2^{nd} - B
3^{rd} - C

From the above representation and coding in Table 8, various plastic materials were evaluated based on their level of usage between enterprises for the most used plastic materials among the selected enterprises. Indications proved that Tapolyne Bags have the highest prospect of agricultural usage among all other plastic materials with three 1^{st} rankings in Agro-market, Poultry and Processing/packaging enterprises and one 2^{nd} ranking for Nursery/Horticultural Enterprise (A^3B). This is followed by Jerry Can which have one 2^{nd} ranking for Vegetable enterprise and three 3^{rd} rankings for Nursery/Horticultural, Poultry and Processing/packaging enterprises (BC^3). This shows that these two plastic materials (Tapolyne Bags and Jerry Can) have a very high prospect for agricultural development among these enterprises.

Tapolyne Bags are very useful in spreading, packaging, and barricading farm stead to conserve heat as commonly used in poultry during brooding. Jerry Can is a veritable material for the storage, collection and transportation of water, oil, or all liquid/fluid inputs. It is mostly used in any activity that has to do with the provision/supply of water to the farm and in the enterprise. This findings supports the assertion of the Agricultural Plastic Recycling and Producers Survey Report, (2012) that majority of farmers in Alberta use one or more types of agricultural plastic in their farm activities.

CONCLUSION

The study therefore concludes that plastic materials has improve the value of agro-enterprises in the study area by serving as a productive resources for their development, use and productivity of farmers while also enhancing their income and performance. The problem of plastic utilization in agriculture has been on pollution and sanitation concerns. The study has developed a framework for policy makers to harness the plastic opportunities in Agro-plastic waste initiatives, electricity generation, low input supply and the development of industries for the production of special, biodegradable and environmental friendly agri-plastics in Cross River State.

RECOMMENDATION

From the findings of the study, the following recommendations were made;

1. Most used plastic products identified in this study implies that the materials have a very high economic value and prospect in agricultural development among these enterprises. Such plastic products should be reform to have more unique characteristics and produced in various patterns that meet the unique needs of each agro-enterprise.

2. Better policies for improved environmental management as formulated by Etim, (2018) brought forward a framework that can support best environmental management and reduction of plastic waste and pollution while enhancing rural development through employment, industrialization and expansion. There are;
   a. There must be effective collaboration of all stakeholders such as the government, the plastic companies, plastic users across every sector, the enforcement agencies and NGOs.
   b. There should be a policy framework that stipulates that every plastic producing company must own a plastic recycling plant.
   c. Every plastic producing company must have a collection point for all it plastics at incentives to the users to motivate them to rid the environment of plastic waste. This will open more economic opportunity for plastic vendors.
   d. There should be an adequate enforcement of environmental laws by environmental bodies
   e. Environmental NGOs such as Safety Awareness and Environmental Support Initiative (SAESI) needs to be incorporated and inaugurated to support the government to ensure total cleanliness in the State, and Nigeria.
   f. Adequate awareness must be created to increase the consciousness of the people to their environment to improve environmental sanitation.
   g. There should be a participatory role of all stakeholders especially in the consumer sector. All restaurants, shops, super markets, beer parlour must have a collection bin or waste bin to collect all plastic materials at all times in their vicinity.
   h. Entrepreneurs should be encouraged to explore the opportunities of an emerging industry in plastic recycling.
   i. Development of environmental policies that attract investors through tourism and Leisure Park.
   j. The government of Cross River State should encourage the production and use of plastic materials in agriculture
   k. More agricultural plastic industries can be developed to further the expansion for a plastic driven agricultural economy.
   l. The production of customized plastic products for farm shed, doors, housing, roofs, walls, among others should be encouraged.

m. Investment into plastic technologies to boast agricultural productivity through large scale industrial farming should be encouraged and practiced within the state.

REFERENCE

Aboh, C. L., and Effiong, J. B. (2019). Adoption of different weed management techniques among cocoa farmers in Akamkpa Local Governement Area, Cross River State, Nigeria. Global Journal of Pure and applied Science 25(1), 7-12

Agricultural Plastic Recycling and Producers Survey Final Report,(2012). "Plastic users and non-users survey." Final Report October 2012 Alberta. Accessed 26th April, 2019.

Bernard, L. M. (2015). "Plastics in agriculture: a contribution to Intensive Ecological Agriculture (IEA)". CPA: French Committee for Plastics in Agriculture and APE Europe: European Association of Plastics Converters for Agriculture. Saltillo, Coahuila, México.

CRS LEEDS 2 (2016). "Cross River State government archives: Ikom"- LEEDS 2. Pp.2-18.

Desriac, P.,(1988). Choosing EVA for cladding plastic structures. Proceedings, Conference on 'Plastics in the Nineties'. 1988. British Agricultural and Horticultural Plastics Association.

Effiong, J. B (2013). Challenges and prospects of Rural Women in Agricultural Production in Nigeria. Lwati: A journal of contemporary Research 10(2), 183-190.

Effiong, J. B., (2012). Youth Participation in Community Development: evidence from Yakurr Local Government Area, Cross River State. International Journal of Social Siencelowmorrol(6)

Effiong, J. B., and Aboh, C. L. (2024). Effectiveness of agricultural extension models in food crop production in Cross River State, Nigeria. African Journal of Food, Agriculture, Nutrition and Development 24(3) 25871-25881

Effiong, J. B., and Aboh, C. L., (2019). Effect of Agro-chemicals on the Health of farmers in Akpabuyo Local Government Area, Cross River State. European Journal of Scientific Research, 154(1) 142-147

Effiong, J. B., and Aboh, C. L. (2018). Rubber Production Technologies and the related socioeconomic environments in Akwa Iom State, Nigeria. Global Journal of Agricultural Science 17(1)15- 22

Effiong, J. B., Aboh, C. L. and Aya, C. F., (2021). Perception of farmers on the contribution of Vegetable to livelihoods in Yakurr Local Governent Area, Cross River State, Nigeria. Global Journal of Pure and Applied cience 27(2), 82-91

Effiong, J. B. and Asikong, A. B. (2013). Mid-termj Assessment of the activities of Fadama III Development Project in Cross River State. Global Jurnalof Agricultural Science 12(1): 31-35

Effiong, J. B., Ijioma, J. C. Effiong, M. O., (2016). Endogenous determinants of adoption of improved rubber production technologies among farmers in Akwa Ibom State, Nigeria. Asian Journal of Agricultural Extension, Economics and Sociology 8(4), 2-7.

Etim, O. U. (2018). "Beat Plastic Pollution." Live Broadcast from Radio Nigeria - Canaan City FM (95.5Mhz) during the observance of the World Environment Day June 5, 2018 in Beat plastic pollution by Safety Awareness and Environmental Support Initiative – SAESI Nigeria, in collaboration with Miss Africa 2018, and the Cross River State Ministry of Environment, Calabar, Cross River State.

Etim, O. U., Effiong, J. B., Okoi, K. O., and Ntui, O. E., (2022). Climate Change Impact on the use of Plastic Products Among Agro-Marketers and Horticultural Enterprises in Calabar

Agricultural Zone of Cross River State. International Journal of Agriculture and Earth Science, Vol. 8 September Edition 2022 D.O.I: 10.56201/ijgem.v8.no1.2022.pg64.76 Vol. 8 No. 1 2022 E-ISSN 2504-8821 P-ISSN 2695-1878

Etim, O. U., and Effiong, J. B., (2022). An evaluation of the benefits of the use of flexible and non-flexible plastic materials among Agro-Enterprise Owners in the Calabar Agricultural Zone of Cross River State, Nigeria. E-ISSN 2489-0081 P-ISSN 2695-1894 Vol 8. No. 5 2022.

Fairtrade (2019). "Nigeria's 5th International Plastics, Printing and packaging trade show." Land mark Centre Victoria Island, Lagos-Nigeria. Available at: www.ppp-nigeria.com/nigeria -plastic-print-packaging.html.

Giuliano, V., Rosa, V. L., Ilcana, B., Giacomo, S. M., &Evelia, S. (2015). "Mapping of Agricultural plastic waste". Florence "Sustainability of Well-Being International Forum". 2015: Food for Sustainability and not just food, FlorenceSWIF2015. Amendola 165/A, 70126 Bari, Italy. Assessed on 25thJune, 2018.

Hancock, M. (1988). Mineral additives for thermal barrier plastic film. Proceedings, Conference on `Plastics in the Nineties'. 1988. British Agricultural and Horticultural Plastics Association.

Ijioma, J. C., Effiong, Ogbonna, M. O, Okolies, N. O., (2024). Small Scale Farmers Perception in Cassava (Manihot esculentta) production in Osisioma Ngwa Local Government Area, Abia State, Nigeria. LWATI A journal of contemporary Research 9(4)56-65.

Marine Policy, (2018). "challenges and emerging solutions to the land-based plastic wste issues in Africa". Volume 96, October 2018, pages 256 – 263

Michel, G., (2010). "Plastics in agriculture: a contribution to Intensive Ecological Agriculture (IEA)." Saltillo, Coahuila, México

Muhammad, K . R., (2014). "Using Plastic Bags and Its Damaging Impact on Environment and Agriculture: An Alternative Proposal." International Journal of Learning &*Development* ISSN 2164-4063 2013, Vol. 3, No. 4. Accessed on 23 February, 2020

Neumann, B., Vafeidis, A. T., Zimmermann, J & Nicholls, R. J., (2015). " Future costal population growth and exposure to sea-level rise and coastal flooding – a global assessment. PLoS One,10 (2015), p. 6, 10.1371/journal.pone.01371. Accessed on 23 February, 2020.

Nkang, M. O., and Effiong, J. B. (2015). The influence of consumer's perception on pork and poultry meat consumption in Calabar South Local Government Area in Cross River State.

Ntui, O. E., Etim, O. U., Obhiokhenan, M. I., and Ayi, N. A., (2022). An assessment of the interaction between climate change and plastic products among agro-market owners and horticultural farmers in the southern agricultural zone of cross river state, Nigeria. (International Journal of Agriculture and Earth Science). E-ISSN 2489-0081 P-ISSN 2695-1894 Vol 8. No. 5 2022

Ntui, O. E., Effiong, J. B., Etim, O. U., and Okoi, K. O., (2022). An assessment of the factors inhibiting the use of plastic materials among selected Agro-Enterprises and farmers in Calabar Agricultural Zone of Cross River State, Nigeria. International Journal of Agriculture and Earth Science (IJAES) E-ISSN 2489-0081 P-ISSN 2695-1894 Vol 8. No. 5 2022 www.iiardjournals.org

IMPACT OF CLIMATE CHANGE ON GARRI FOOD SYSTEMS IN OBUBRA LOCAL GOVERNMENT AREA, CROSS RIVER STATE, NIGERIA

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Abstract

This study assessed the impact of climate change on garri food systems in Obubra Local Government Area. The objectives were to assess the extent to which climatic change influences garri food system participants; and determine the various adaptation strategies employed by garri food system participants to adapt to climate change's effect on garri food systems. Multi-stage sampling procedure was used to draw 178 respondents for the study, from the three clans in the study area. Descriptive statistics such as means, frequency, tables and percentages, as well as inferential statistics such as Chi-square, were employed to analyze the research data. The results revealed that the calculated Chi-Square values for production (26.198), processing (28.514) and marketing (32.175) activities are significantly greater than the critical value of 15.51, respectively, indicating a highly significant relationship ($p < 0.05$) between climatic elements and the garri food system. Producers, processors, and marketers in the garri food system identified enhanced soil management, crop diversification, and collaboration as key adaptation strategies to effectively cope with climate change impacts. It was recommended that collaborative efforts and market stabilization initiatives should be put in place, as they are essential for ensuring the resilience and sustainability of the garri value chain.

Keywords: climate change, food system, garri

Introduction

Climate change is a global phenomenon that poses significant challenges to various sectors, including agriculture and food systems (Durán-Sandoval et al., 2023). In Nigeria, where agriculture is crucial to the economy and food security, climate change has substantial implications for staple food production, including the garri food system. Garri, a popular and widely consumed food made from cassava, serves as a vital source of sustenance and income for millions of Nigerians. The garri food system in Nigeria faces multiple climate-related challenges that affect its production, processing, and availability. Rising temperatures, changing rainfall patterns, increased frequency of extreme weather events, and prolonged droughts are some of the impacts attributed to climate change. These changes have far-reaching consequences on cassava cultivation, which is the primary raw material for garri production (Henri-Ukoha, 2019).

Climate change affects the garri food system at various stages. Shifts in rainfall patterns and prolonged droughts can lead to water scarcity and reduced soil moisture, negatively impacting cassava cultivation. Cassava is highly sensitive to water stress, and inadequate water availability can result in reduced yields and poor tuber quality. Conversely, increased rainfall intensity and flooding can also pose challenges, causing waterlogging, erosion, and nutrient leaching, which can affect the growth and productivity of cassava. Nigeria's climate has been

changing, evident in temperature increases; variable rainfall; rise in sea level and flooding; drought and desertification; land degradation; more frequent extreme weather events; dwindling freshwater resources and loss of biodiversity (Ebele and Emodi, 2016). The durations and intensities of rainfall have increased, producing large runoffs and flooding in many places in Nigeria (Umar & Gray, 2023). Rainfall variation is projected to continue to increase. Precipitation in southern areas is expected to rise and rising sea levels are expected to exacerbate flooding and submersion of coastal lands (Ebele and Emodi, 2016). Droughts have also become a constant in Nigeria, and are expected to continue, especially in northern Nigeria, arising from a decline in precipitation and a temperature rise (Amanchukwu et al., 2015). Temperature has risen significantly since the 1980s (Huang et al., 2023). Climate projections for the coming decades reveal a significant increase in temperature over all the ecological zones.

Furthermore, temperature variations and increased heat stress can influence the development and maturation of cassava tubers. Higher temperatures may accelerate the growth cycle, leading to shorter maturation periods, lower starch content, and reduced overall yield (Bonacina et al., 2023). Heat stress can also make cassava more susceptible to pests and diseases, exacerbating the challenges already faced by farmers. Climate change impacts on the garri food system extend beyond cultivation and affect processing and storage. Traditional cassava processing methods, such as sun drying, can be disrupted by unpredictable weather patterns, including heavy rains or prolonged cloudy days, making it difficult to achieve the desired moisture content. Additionally, increased humidity can contribute to post-processing losses through mold and fungal infestations (Baidhe et al., 2024).

The implications of climate change on the garri food system are significant for food security, livelihoods, and economic stability in Nigeria. The majority of garri production occurs within smallholder farming systems, where farmers have limited resources and access to technology or adaptive measures. Disruptions in garri system can lead to a burgeoning crisis in terms of increased food prices, reduced availability, and income losses for both farmers and consumers. An increase in garri production in Nigeria will lead to overall economic growth and development. Nevertheless, the tendency to achieve this is constrained by climate change on garri food system, which poses heavy losses in the production, processing, and distribution of garri (Mosunmola et al., 2024). Also, the vulnerability of cassava farmers in Nigeria to climate variation is mostly occasioned by their high dependency on rain-fed agriculture because of the impact of droughts, floods and storms, which exposes large numbers of people, such as consumers, to the risk of undernutrition and thereby hindering the garri food system (Oluwatimilehin & Ayanlade, 2023). These shortfalls in garri production would result in increased food price volatility and the stability of rural household incomes in areas already subject to high variability in yields.

With the constant emergence of various systems of adaptation to guide against the risk of climate change, producers as well as marketers are imposed with significant costs to bear amidst numerous adaptation options. However, effective adaptation to climate variation will only be possible if farmer's vulnerabilities are identified and understood. This can inform the minimization of costs associated with climate variation while aiding the adoption of technologies, policies and programmes that best suit local contexts. This study, therefore, intends to fill this gap in knowledge by assessing the impact of climate change on the garri food system in Obubra Local Government Area. The study assessed the following objectives:

ix. assess the extent to which climatic change impacts garri food system (production, processing and marketing) participants in the study area; and

x. identify the various adaptation strategies employed by garri food system participants to adapt to climate change's effect on garri food systems.

Methodology

Study area

This study was carried out in Obubra Local Government Area of Cross River State. Obubra is made up of eleven council wards from three mother clans of Adun, Osopong and Okum. Obubra has a population of 134, 255 (National Population Commission, 2006) people and occupies a land mass of 1086.275q.Km. Obubra is in the Ikom agricultural zone of Cross River State. It is bounded in the South by Yakurr Local Government Area, part of Yala and Ikom Local Government Area in the North, Akamkpa Local Government Area in the East, and Ebonyi State in the West. Obubra lies between longitude 7° 55'E and 8° 10' E of the Greenwich Meridian and latitude 5° 4' E and 6° 10' N of the equator. The climate of Obubra is characterized by distinct wet and dry seasons. The temperature is uniform with a mean monthly average of about 27°C. The topography is flat with a good drainage system. The soil is predominantly sandy-loam, the annual rainfall of Obubra Local Government Area is between 200mm - 250mm while the relative humidity varies from 60 - 70 percent in January and 70 - 80 percent in July.

Sampling Technique

A multi-stage sampling technique was adopted for the study. The first stage involved the purposive selection of three (3) clans (Adun, Okum and Osopong) in the study area. This is to enhance effective representation and spread. In the second stage, ten (10) villages were randomly selected from each clan, based on the frequency of garri production, processing and marketing activities. In the third stage, a proportionality factor of 10 percent was applied to select garri production, processing and marketing from the chosen villages, from a sample frame obtained from the ADP office in the LGA. This is illustrated in Table 1. This process was repeated to obtain a sample size of 187 respondents for the study. However, on retrieval of administered questionnaires from the field, only 179 were realized, and this discussion in chapter four is based on this.

Table 1: Selection of respondents in the study area

Clans	Villages	Sample frame	Sample size
Adun	Ofat	210	21
	Onyadama	230	23
	Ovonum	290	29
Okum	Ohana	210	21
	Iyamitet	160	16
	Apiapum	190	19
Osopong	Edondon	210	21
	Ogada	180	18
	Ogurude	190	19
Total	**9**	**1870**	**187**

Analytical Techniques

Descriptive statistics such as percentages, frequency distribution, means and tables were used to analyse the objective ii. on the other hand, objective i was achieved using Chi-square statistic. The chi-square analysis is stated thus:

$$X^2 = \frac{\sum(O_i - E_i)^2}{E_i}$$

Where:

X^2 = Chi distribution

O_i = Observed Frequency

E_i = Expected Frequency

k = Number of categories i.e. categories of small-scale cassava farmers.

The degree of freedom and level of significance were used to obtain the tabulated value. The degree of freedom= (No of Row-1) x (No of columns-1). 0.05 level of significance was used. This implies that 0.05 (5%) was the level of tolerable error.

Result and discussion

Impact of Climatic Change on Garri Food System

Production

Table 2: Chi-square test of climatic change on garri production

Climatic Elements	O	E	$(O-E)^2$	X^2
Amount of rainfall	72.5	59.66	164.866	2.76342
Temperature changes.	80.5	60.84	386.516	6.35298
Draught	70.5	59.66	117.506	1.96959
Flood	79	58.6	416.16	7.10171
Pests & diseases caused by climate change	71.5	59.66	140.186	2.34974
Storms/cyclones	72	60.06	142.564	2.37369
Prices of components affected by climate change	67.5	60.06	55.3536	0.92164
Health problems caused by climate change	69	59.66	87.2356	1.46221
Off-season rainfall	67	59.66	53.8756	0.90304
Chi-Square (calc.)				26.198
Critical value (df = 8)				15.51
P-value				0.05

Source: Field data, 2023

The chi-square analysis presented in Table 2 demonstrates a strong and statistically significant ($p < 0.05$) influence of climate change elements on garri production in the study area. The calculated X^2 value of 26.198 is substantially greater than the critical value (15.51) for a significance level of 0.05. This stark contrast indicates a highly significant relationship ($p < 0.05$) between the variables. This result implies that climatic elements enumerated in the study significantly influenced garri production in the study area.

This finding underscores the substantial impact of climatic factors on agricultural output, aligning with literature that highlights how climate variability affects crop yields and farming practices (Arora, 2019). Studies have shown that changes in temperature and precipitation patterns can lead to reduced productivity, particularly for staple crops like cassava, which is the primary source of garri (Abbas & Mayo, 2021; Kogo et al., 2021; Rusmayandi et al., 2023). The significant relationship observed in this study suggests that producers must adapt their practices to mitigate these impacts, as emphasized by Magesa et al. (2023), who advocate for the adoption of climate-resilient agricultural practices.

Processing

Table 3: Chi-square test of the impact of climatic change on garri processing

Climatic Elements	**O**	**E**	**$(O-E)^2$**	**X^2**
Amount of rainfall	47.5	60.06	157.754	2.6266
Temperature changes.	78	60.84	294.466	4.84
Draught	56	59.66	13.3956	0.22453
Flood	61.5	59.32	4.7524	0.08011
Pests and diseases caused by climate change	68	59.32	75.3424	1.2701
Storms/cyclones	73	60.06	167.444	2.78794
Prices of components affected by climate change	82	59.32	514.382	8.67131
Health problems caused by climate change	74	60.06	194.324	3.23549
Off-season rainfall	77	60.06	286.964	4.77795
Chi-Square (calc.)				28.514
Critical value (df = 8)				15.51
P-value				0.05

Source: Field data, 2023

The chi-square analysis reveals a strong and statistically significant influence of climate change elements on garri processing, with a calculated X^2 value of 28.514, exceeding the critical value of 15.51 at a 0.05 significance level. This finding indicates that climatic factors significantly affect processing operations within the garri value chain. This result is corroborated by existing literature, which highlights that climate change can disrupt processing activities by affecting the quality and availability of raw materials, as noted by TGomez-Zavaglia et al. (2020). Additionally, research has shown that climate variability can lead to increased uncertainty in

processing schedules and costs, necessitating adaptive strategies among processors to ensure efficiency and product quality (Ortiz-Bobea et al., 2021; Ayi, 2022). The significant relationship identified in this study emphasizes the need for processors to adopt flexible processing techniques and to invest in climate-resilient practices, reinforcing the broader call for adaptation strategies across agricultural value chains in the face of climate change challenges.

Marketing

Table 4: Chi-Square test of the impact of climatic change on garri marketing

Climatic Elements	O	E	$(O-E)^2$	X^2
Amount of rainfall	67	59.66	46.7856	0.7842
Temperature changes.	61	59.32	1.3924	0.02347
Draught	77	59.66	283.586	4.75336
Flood	80	59.66	413.716	6.93456
Pests and diseases caused by climate change	46	60.06	197.684	3.29144
Storms/cyclones	78	59.32	330.512	5.57169
Prices of components affected by climate change	75	60.06	208.514	3.47175
Health problems caused by climate change	69	59.66	87.2356	1.46221
Off-season rainfall	78	59.32	348.942	5.88237
Chi-Square (calc.)				32.175
Critical value (df = 8)				15.51
P-value				0.05

Source: Field data, 2023

The chi-square analysis results indicate a strong and statistically significant influence of climate change elements on garri marketing, with a calculated X^2 value of 32.175, surpassing the critical value of 15.51 at a 0.05 significance level. This result implies that climatic elements significantly influenced garri marketing in the study area.

This finding is consistent with existing literature that highlights how climate variability directly impacts agricultural supply chains, including marketing dynamics. For instance, studies have shown that climate change affects not only crop yields but also market access and pricing strategies due to altered production patterns (Wossen et al., 2018; Praveen & Sharma, 2019). Furthermore, the significant influence of climate change on marketing strategies aligns with research by Cameron (2019), which emphasizes that climate-related challenges necessitate adaptive marketing strategies among producers and marketers to maintain supply chain stability. The results from this study underscore the need for stakeholders within the garri value chain to develop collaborative approaches and flexible marketing tactics that can effectively respond to the ongoing and projected impacts of climate change.

Adaptation Strategies by Garri Food System Participants

Table 5: Adaptation Strategies employed by garri food system participants against climate change

Adaptation Strategies	SA	A	N	D	SD	Mean	Rank
Producers							
Climate-resilient crop varieties	76	64	10	24	5	3.07	2nd
Changing planting date	56	67	1	34	21	2.87	3rd
Water conservation practices	61	71	26	14	7	2.75	4th
Diversification	60	56	5	25	33	2.74	5th
Enhanced soil management	89	63	2	17	8	3.28	1st
Support from NGO/Government	16	15	76	24	48	1.15	6th
Processors							
Diversified varieties	77	54	4	25	19	3.01	1st
Improved water management	18	67	16	54	24	2.26	3rd
Energy Efficieint technology	25	45	5	65	39	2.26	3rd
Capacity building programs	54	29	43	26	27	2.13	5th
Adjusted timing of processing	86	44	36	13	0	2.80	2nd
Distributors/Marketers							
Diversified garri product offerings	56	43	6	43	31	2.63	2nd
New markets	55	44	8	41	31	2.60	2nd
climate resilient packaging	31	42	7	44	55	2.20	4th
Collaborations with producers	78	65	1	23	12	3.16	1st
Technology incorporation	17	24	32	72	34	1.78	5th

Source: Field data, 2023. SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly Disagree

The data in Table 5 reveals that the producers in the garri food system agreed that to adapt to the effects of climatic elements, they climate resilient crop varieties (mean = 3.07), they practiced enhanced soil management (mean = 3.28), they changed their planting date (mean = 2.87), they practiced water conservation practices (mean = 2.75) and diversified their crops planted (mean = 2.74). This result implies that the garri producers rated enhanced soil management as an adptive strategy, suggesting that they perceive this strategy as relatively more effective in adapting to the effects of climatic elements. Planting climate-resilient crop varieties and changing planting date had a positive perception of their effectiveness, although not as high as enhanced soil management. This indicates that, according to the surveyed producers, enhanced soil management is considered the most effective adaptation strategy among those listed. However, all adaptation strategies are perceived as having some level of effectiveness.

For the processors, they adapted to the effects of climate change elements by diversified their varieties to process (mean = 3.01) and adjusted the timing of processing garri (mean = 2.80). The garri processors, on average, highly rated the strategy of diversifying the varieties of cassava processed into garri as an effective adaptation measure. This suggests that they believe processing different varieties of cassava helps them cope with the impacts of climate change on their raw materials. Adjusting the timing of garri processing is also perceived as an effective strategy, although with a slightly lower mean value. This may indicate that, while still considered valuable, it is not rated as high as the diversification of varieties.

The marketers, they adapted to climate change effects by collaboration with garri producers (mean = 3.16), diversified their garri product offerings (mean = 2.63) and entered new markets (mean = 2.60). Marketers highly rated collaboration with garri producers as an effective strategy. This suggests that joint efforts between marketers and producers are seen as beneficial in mitigating the challenges posed by climate change. Diversifying garri product offerings is considered an effective strategy but with a slightly lower mean value. This could mean that expanding the range of garri products is perceived as less impactful compared to collaboration with producers. Entering new markets is also viewed as an effective adaptation strategy, though with a mean value of 2.60, indicating a moderate level of effectiveness. This strategy suggests that expanding market reach can be a way to mitigate the impacts of climate change on local markets. These adaptation strategies not only contribute to the resilience of individual actors but also highlight the importance of collaboration and flexibility in the entire garri value chain. This is in agreement with the report of Abbass (2022) who reported that farmers as well as consumers are willing to try new methods to mitigate climate variation on their production and/or consumption process in Nigeria.

Results in Table 5 indicate that producers in the garri food system prioritize enhanced soil management as the most effective adaptation strategy to climate change, with a mean rating of 3.28. This aligns with the findings of Davis et al. (2023), which emphasize the importance of soil health in agricultural resilience. Additionally, the adoption of climate-resilient crop varieties and altered planting dates reflects a broader trend observed in agricultural practices where diversification and timing adjustments are critical for coping with climate variability (Vernooy, 2022; Zsögön et al., 2022). For processors, diversifying cassava varieties for garri production is a strategic response consistent with the study of Olaosebikan et al. (2022), highlighting the benefits of variety diversification in enhancing resilience against climate impacts. Marketers' collaboration with producers further stresses the significance of integrated approaches within the value chain, as collaboration has been shown to enhance adaptive capacity and improve market stability amid climate challenges (Williams et al., 2019).

Conclusion

This study highlights the profound impact of climate change on the garri food system in Obubra Local Government Area, Nigeria. The findings reveal a significant relationship between various climatic elements—such as changes in temperature, rainfall patterns, droughts, and flooding—and the production, processing, and marketing of garri. The statistical analysis indicates that these climatic factors adversely affect both the yield and quality of cassava, the primary raw material for garri, thereby threatening food security and the livelihoods of smallholder farmers who rely heavily on this staple.

Furthermore, the study highlights the adaptive strategies employed by participants in the garri food system. Producers prioritize enhanced soil management and the use of climate-resilient crop varieties, while processors focus on diversifying the varieties they process. Marketers emphasize collaboration with producers as a key strategy to mitigate climate-related challenges. These findings suggest that while the garri food system faces significant threats from climate change, there are also proactive measures being undertaken by stakeholders to adapt to these challenges. Addressing the vulnerabilities of the garri food system to climate change is crucial for ensuring food security and economic stability in Nigeria. Policymakers must prioritize support for adaptation strategies, enhance access to resources, and promote collaborative efforts among producers, processors, and marketers. By doing so, it is possible to strengthen the resilience of the garri food system and safeguard the livelihoods of those who depend on it.

Recommendations

Based on the findings of this research, the following recommendations were made:

i. Collaborative efforts and market stabilization initiatives are essential for ensuring the resilience and sustainability of the garri value chain.
ii. Educational programs tailored to the specific needs of garri food system participants can enhance climate change awareness and adaptive capacities.
iii. Climate-smart policies should be formulated to ensure the long-term sustainability of the garri system activities in the study area.

References

Abbas, S., & Mayo, Z. A. (2021). Impact of temperature and rainfall on rice production in Punjab, Pakistan. Environment, Development and Sustainability, 23(2), 1706-1728.

Amanchukwu, R., ThankGod, O. and Nwachukwu P. (2015). Climate Change Education in Nigeria: The Role of Curriculum Review. *Journal of Education*. 71-79. 10.5923/j.edu.20150503.01.

Arora, N. K. (2019). Impact of climate change on agriculture production and its sustainable solutions. Environmental sustainability, 2(2), 95-96.

Ayi, N.A. (2022). Farmer Field School Extension approach: A knowledge booster in Calabar Agricultural Zone, Cross River State, Nigeria. *Journal of Agricultural Extension and Rural Development - JAERD*, *14*(2), 52-60. DOI: 10.5897/JAERD2021.1299.

Baidhe, E., Clementson, C. L., Senyah, J., & Hammed, A. (2024). Appraisal of Post-Harvest Drying and Storage Operations in Africa: Perspectives on Enhancing Grain Quality. AgriEngineering, 6(3), 3030-3057.

Bonacina, L., Fasano, F., Mezzanotte, V., & Fornaroli, R. (2023). Effects of water temperature on freshwater macroinvertebrates: A systematic review. Biological Reviews, 98(1), 191-221.

Cameron, E. (2019). Business Adaptation to Climate Change and Global Supply Chains. Background Paper for the Global Commission on Adaptation.

Davis, A. G., Huggins, D. R., & Reganold, J. P. (2023). Linking soil health and ecological resilience to achieve agricultural sustainability. *Frontiers in Ecology and the Environment*, *21*(3), 131-139.

Durán-Sandoval, D., Uleri, F., Durán-Romero, G., & López, A. M. (2023). Food, climate change, and the challenge of innovation. Encyclopedia, 3(3), 839-852.

Ebele, N., & Emodi, N. (2016). Climate Change and Its Impact in Nigerian Economy. *Journal of Scientific Research and Reports,* 10, 1-13.

Gomez-Zavaglia, A., Mejuto, J. C., & Simal-Gandara, J. (2020). Mitigation of emerging implications of climate change on food production systems. Food Research International, 134, 109256.

Henri-Ukoha, A. (2019). Assessment of the Viability of Climate Adaptation Strategies of Cassava-Based Farmers in Southern Nigeria. *Journal of Agriculture and Food Sciences.* 18(1); 105-117.

Huang, X., Dunn, R. J., Li, L. Z., McVicar, T. R., Azorin-Molina, C., & Zeng, Z. (2023). Increasing global terrestrial diurnal temperature range for 1980–2021. Geophysical Research Letters, 50(11), e2023GL103503.

Kogo, B. K., Kumar, L., & Koech, R. (2021). Climate change and variability in Kenya: a review of impacts on agriculture and food security. Environment, development and sustainability, 23(1), 23-43.

Magesa, B. A., Mohan, G., Matsuda, H., Melts, I., Kefi, M., & Fukushi, K. (2023). Understanding the farmers' choices and adoption of adaptation strategies, and plans to climate change impact in Africa: A systematic review. Climate Services, 30, 100362.

Mosunmola, O., Tope, A. I., Oladeji, F. O., Jacob, O. A., & Akpan, N. (2024). An Impact of Threshold Heat Level on Local Garri Producers in Osun State, Nigeria. Asian Journal of Food Research and Nutrition, 3(1), 24-32.

Olaosebikan, O., Bello, A., Utoblo, O., Okoye, B., Olutegbe, N., Garner, E., Teeken, B., Bryan, E., Forsythe, L., Cole, S., Kulakow, P., Egesi, C., Tufan, H., & Madu, T. (2022). Stressors and Resilience within the Cassava Value Chain in Nigeria: Preferred Cassava Variety Traits and Response Strategies of Men and Women to Inform Breeding. *Sustainability*, *15*(10), 7837. https://doi.org/10.3390/su15107837.

Oluwatimilehin, I. A., & Ayanlade, A. (2023). Climate change impacts on staple crops: Assessment of smallholder farmers' adaptation methods and barriers. Climate Risk Management, 41, 100542.

Ortiz-Bobea, A., Ault, T. R., Carrillo, C. M., Chambers, R. G., & Lobell, D. B. (2021). Anthropogenic climate change has slowed global agricultural productivity growth. Nature Climate Change, 11(4), 306-312.

Praveen, B., & Sharma, P. (2019). A review of literature on climate change and its impacts on agriculture productivity. Journal of Public Affairs, 19(4), e1960.

Rusmayandi, G., Hertini, E. S., Harahap, M. A. K., & Nugroho, R. J. (2023). Climate change, agricultural production, food security, and livelihoods of rural communities in rural districts: A qualitative approach. West Science Interdisciplinary Studies, 1(03), 102-110.

Umar, N., & Gray, A. (2023). Flooding in Nigeria: a review of its occurrence and impacts and approaches to modelling flood data. International Journal of Environmental Studies, 80(3), 540-561.

Vernooy, R. (2022). Does crop diversification lead to climate-related resilience? Improving the theory through insights on practice. *Agroecology and Sustainable Food Systems*, *46*(6), 877-901.

Williams, P. A., Crespo, O., & Abu, M. (2019). Adapting to changing climate through improving adaptive capacity at the local level–The case of smallholder horticultural producers in Ghana. Climate Risk Management, 23, 124-135.

Wossen, T., Berger, T., Haile, M. G., & Troost, C. (2018). Impacts of climate variability and food price volatility on household income and food security of farm households in East and West Africa. Agricultural systems, 163, 7-15.

Zsögön, A., Peres, L. E., Xiao, Y., Yan, J., & Fernie, A. R. (2022). Enhancing crop diversity for food security in the face of climate uncertainty. The plant journal, 109(2), 402-414.

INDIGENOUS CLIMATE ADAPTATION STRATEGIES USED BY WOMEN MAIZE-BASED FARMERS IN IKWERRE LOCAL GOVERNMENT AREA, RIVERS STATE, NIGERIA

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Abstract

This study investigates indigenous climate adaptation strategies used by women maize-based farmers in Ikwerre Local Government Area. The objectives of the study include to: identify the indigenous adaptation strategies practiced by the maize-based women farmers., determine the factors influencing the practice of indigenous adaptation practice employed by the maize-based women farmers in the study area amongst others. Data were collected using a structural questionnaire and interviews, and the results were analyzed using descriptive statistics and inferential methods, namely the Binary Logit regression model. The results show that 48.38 years is the average age of farmers, 58.75% chose farming as their primary occupation, 23.1 years is the average number of years of farming experience, and 0.56ha is the average farm size, with 51.25% employing indigenous climate adaptation strategies. Indigenous adaptation strategies used include mixed cropping (78.75%), crop rotation (37.5%), local insecticides and organic manure (35%). Binary Logit regression reveals that education (0.547) is significant at 1%, whereas farm experience (-0.012) and farm size (-0.247) were significant at 5%. The study recommends implementing programmes that provide women farmers with education and training; access to necessary resources; policies that promote farm-level adaptation; and the development of systems to provide timely and accurate weather information, all of which contribute to sustainable agricultural development in the face of climate change.

Keywords: Adaptation, Climate change, Indigenous strategies, Maize, Women farmers

Introduction

Climate change is one of the worldwide problems mostly in the twenty-first century and global warming are significant global change that has been encountered during the past 65 years (Abbass, Qasim, Song, Murshed, Mahmood and Younis, 2022). Climate change is a long-term alteration or change in the average weather pattern that defines the local, regional, and global conditions of the earth. It stands out as a prominent contemporary global threat. Its profound and well-documented impact on agricultural production over an extended period is evident (Ajayi, 2014). The agricultural sector of economies experiences various repercussions, including a direct influence on food production and sustainability. Climate change is a long-term alteration or change in the average weather pattern that defines the local, regional, and global conditions of the earth. It is the general challenge of an inter-governmental complex challenge globally with its influence over various components of ecological, environmental, socio-political, and socio-economic discipline (Feliciano, 2022). Hence, human activities, including fossil fuel combustion, land use changes, population growth, deforestation, industrialization, and incineration, release greenhouse gases such as carbon dioxide, methane,

nitrous oxide, sulfur dioxide, hydrofluorocarbons, hydrochlorofluorocarbons, and carbon monoxide, creating a greenhouse effect. This effect disrupts global temperatures and rainfall patterns, leading to global warming.

Maize is a photoperiod insensitive, it can be grown any time of the year, giving greater flexibility to fitting into different cropping patterns. It is one of the dominant cereal crops in the Guinea and Sudan savannas in northern Nigeria (Kamara, Kamai, Omoigui, Togola, Ekeleme and Onyibe, 2020). Maize is grown over a wide range of climatic conditions because of its many divergent types. The maize crop requires warmth throughout its active life. The greatest production potential lies in areas where isotherms in the warmest month range between 21 and 27 °C (Kamara *et al.*, 2020). Maize does not grow well in areas where the growing season temperature is less than 19 °C or where the average night temperature falls below 14°C distribution of rainfall are highly important factor in successful production. Maize requires a minimal range of 480–880 mm of well-distributed rainfall is adequate for maize, depending on the variety (Kamara *et al.*, 2020). Maize is one of the most cultivated crops in the world, it is a staple crop for most countries in Africa (Woomer, Roobroeck, and Mulei, 2023). While maize remains an important crop for many in Africa. Its yields are reducing due to climate change. Most importantly maize production depends on water availability and most places are experiencing a reduction in the amount of rainfall that makes maize not produce good yield. Suggest maize is sensitive to daytime high temperatures above 30°C and with climate, the projected 2°C in temperature for most of the country would affect maize production (Mulungu and Ng'ombe, 2019), which would further lower maize productivity level in Ikwerre LGA despite the increasing demand for maize for women maize-based farmers in Ikwerre LGA to become more resilient, attain food security, and advance sustainable agricultural practices in the face of climate change, it is essential to address these issues and follow the indigenous climate adaption tactics they have used.

Climate change significantly influences the food system, increasing prices of food commodities through altered growing seasons, shifting rainfall patterns, and extreme weather events. These changes pose a threat to maize-based farmers, adversely affecting crop production and contributing to food insecurity. The available evidence suggests an increasing frequency and severity of extreme weather events, such as droughts and floods, attributed to climate change. These events significantly affect faith-based farmers, particularly smallholder farmers in rural areas whose livelihoods depend on crop production. Despite their efforts to adapt to climate change, poverty, hunger, and malnutrition affect these farmers, with over 70% living below the poverty line (Uwadi, 2013). Additionally, research has investigated the sustainability of climate change adaptation strategies in various parts of the country. To address this challenge effectively they need to use some practices like cover crops which means planting certain crops to cover and protect the soil during periods when the main crop is not growing. This practice can enhance soil fertility, reduce erosion, and provide other ecological benefits, contributing to sustainable farming. Alternating the types of crops grown in a specific field over seasons. Crop rotation strategy helps prevent soil nutrient depletion, control pests and diseases, and improve overall soil health, contributing to better crop yields. Increasing ridge size by expanding the size of raised planting ridges. This adaptation may be employed to enhance water retention, improve drainage, and optimize soil conditions for maize cultivation, particularly in areas prone to climate-related challenges. They are employing natural materials such as compost or animal waste to fertilize the soil. This practice supports soil fertility, enriches nutrient content, and promotes sustainable agriculture while aligning with indigenous knowledge, planting maize crops at an earlier time in the growing season. This can be an adaptive measure to capitalize on favorable climatic conditions, potentially avoiding adverse weather events later in the season, and harvesting maize crops ahead of the typical schedule. This strategy could be a response to

changing climate patterns, aiming to secure a good yield before potential climate-related risks occur, such as extreme weather events. Adjusting the timing of planting based on observed changes in climate patterns. This adaptive strategy allows women maize farmers to consider planting with optimal weather conditions, enhancing the likelihood of a successful harvest. These Indigenous climate adaptation strategies collectively demonstrate the resourcefulness and knowledge of women maize-based farmers in adapting to climate change effects. It is essential to address these issues and follow the indigenous climate adaptation tactics. The specific objectives are as follows: identify the socio-economic characteristics of maize-based women farmers in the area; identify the indigenous adaptation strategies practiced by the maize-based women farmers., determine the factors influencing the practice of indigenous adaptation practice employed by the maize-based women farmers in the study area and identify the constraints faced by the maize-based women farmers while practicing indigenous climate adaptation practices in the study area.

Material and Methods

This research was carried out in Ikwerre Local Government Area (LGA) in Rivers State Nigeria. It is located in the Niger Delta region of Nigeria and is known for its cultural heritage, natural resources, and occupying the upland region in Rivers State. It shares boundaries with Imo State to the north, Emohua LGA to the west, Etche LGA to the east, and Obio-Akpor LGA to the south. It is made up of twelve major communities with their subs, and they are Isiokpo, Omagwa, Omudeme, Elele, Omuanwa, Apani, Ipo, Omerelu, Igwuruta, Ubima, Ozuahia, and Aluu. It is located between latitudes 4°58′10″N and 5°14′30″N, and longitudes 6°49′0″E and 7°0′0″E. It covers an area of about 655 km2 with a projected population of 265,400 by 2021 (National Bureau of Statistics NBS, 2022) with a 2.3% annual population change. This research targeted all the indigenous maize-based women farmers in the study area.

A multistage sampling procedure was used for the study. The first stage involved a purposive selection of two major communities, secondly, four (4) villages were selected using a simple random technique from each of the communities making eight (8) villages in the selected communities. Finally, using a sampling frame of maize farmers obtained from the farmers, a simple random technique was used in the selection of ten (10) women maize-based farmers in the selected villages to make it up the sample size of eighty (80). Primary data were collected using a structural questionnaire and interview schedule. Objectives i, ii, and iv were achieved using descriptive statistics while objective iii was achieved using the Binary Logit regression model.

Model specification

The logit model used in determining the factors influencing the practice of Indigenous adaptation practice employed by the maize-based women farmers is expressed as;

$$Ln\left[{}^{Y_1}/_{Y_2}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \varepsilon$$

Where;

Y_1 represent women maize-based farmers that use indigenous climate adaptation strategies

Y_2 represent women maize-based farmers that did not use indigenous climate adaptation strategies.

β_0 is the intercept

β_1 to β_6 are the regression coefficient to be estimated

X_1 to X_6 are the explanatory variables

ε = Error term

The explanatory variables are;

X_1 = Age of the farmer (years)

X_2 = Marital status (single, married and divorce)

X_3 = Education level (years)

X_4 = Farm experience (years)

X_5 = Household size (number)

X_6 = Farm size (hectare)

Results and Discussion

Socioeconomic characteristics of the women maize-based farmers in the study area.

Table 1: Socioeconomic characteristics of the women maize-based farmers in the study area

Variables	Frequency	percentage
Age (years)		
20-49	46	57.50
50-69	33	41.25
70 and above	1	1.25
Mean	48.38	
Primary occupation		
Farming	47	58.75
Others	33	41.25
Marital status		
Single	30	37.50
Married	50	62.50
Educational attainment		
No formal education	6	7.50
Primary education	42	52.50
Secondary education	25	31.25
Tertiary education	7	8.75
Mean	8.20	

Farming experience (years)		
1-10	19	23.75
11-20	22	27.50
21-30	13	16.25
31-40	24	30.00
41-50	2	2.50
Mean	23.10	
Household size		
1-5	23	28.75
6-10	44	55.00
11-15	13	16.25
Mean	7	
Farm size (ha)		
0.01-0.5	41	51.25
0.51-1.0	35	43.75
1.01 and above	4	5.00
Mean	0.56	
Income per month (₦)		
50,000 and below	29	36.25
50,001-100,000	48	60.00
100,001 and above	3	3.75
Mean	40,000	
Total	80	100.00

Source: Field survey, 2023

The result in Table 1 shows the socio-economic characteristics of women maize-based farmers that result majority (57.50%) of the women maize-based farmers fell within 20-49 years with a mean age of 48.38 years which shows that the women maize-based farmers in the study area were mostly young. Young people are very active and strong enough to make use of indigenous adaptation techniques for climate change. About 58.75% took farming as their primary occupation and source of their livelihood while 41.25% are farmers who have other businesses or work. The majority (62.50%) of women farmers were married. This shows that married women and married people dominant farmers in the study area have higher family responsibilities which makes them engage more in traditional farming strategies. About 55% of women maize-based farmers fell within the household size of 6-10 with a mean of 7 persons.

This implies that the farmers have an excessive population to feed, even though they provide sufficient labour to support women's maize-based farming practices in the study area.

Table 1 further shows that about 52.5% of the women maize-based farmers had primary education while 31.25% of the farmers had secondary education with a mean of 8.2 years to attain the level of education. This implies that most of the women have not acquired enough education that help them use climate adaptation techniques in that more education is needed for farmers to use climate adaptation techniques properly. This finding is consistent with Ruzzante, Labarta and Bilton (2021) who reported that many Indigenous women in farming communities have limited access to formal education, affecting their ability to adopt modern agricultural practices and access information. Farming experience shows that about 30% of farmers ranged fell between 31-40 years, and 27.5% ranged between 11-20 years with a mean of 23.1 years. This implies that most of the women maize-based farmers in the study area are experienced which encourages less climate effect. The result shows that about 51.25% of the women maize-based farmers have a farm size range within 0.01-0.05ha, 43.75% ranged within 0.51-1.0ha, and 5% a farm size above 1.01ha with a mean of 0.56ha. This implies that maize-based farmers in the study area a small-scale farmers and have limited farmland which is sometimes scattered and sparsely distributed making indigenous climate adaptation strategies a bit difficult. This finding agrees with Smith *et al* (2019) who reported that women tend to have smaller farmland compared to their male counterparts. The monthly income of the women maize-based farmers shows that the majority (60%) fell within ₦50,001-100,000, 36.25% were from ₦50,000 and below with a mean of ₦40,000. This implies that farming especially profitable is not enough to meet the current cost of living, this might be attributed to the size of the farmland used for maize production and the type of indigenous climate adaptation strategies adopted.

Indigenous adaptation strategies practiced

Table 2: The Indigenous adaptation strategies practiced by maize-based farmers in the study area

Indigenous adaptation strategies	*Frequency	Percentage
Crop rotation	30	37.50
Mixed cropping	63	78.75
Use of cover crop	12	15.00
Early planting	20	25.00
Regular weeding	26	32.50
Relocation of farmland	5	6.25
Use of organic manure	28	35.00
Increase in ridge sizes	29	36.25
Change in planting date	20	25.00
Mulching	27	33.75
Use of local pesticides	14	17.50
Early harvesting	21	26.25

Change in farming season	4	5.00

Note: * means multiple responses recorded

Source: Field survey, 2023

The result in Table 2 shows the Indigenous adaptation strategies used by the maize-based farmers in the study area. Table 2 shows that a higher number of the women maize-based farmers in the study area used mixed cropping (78.75%), about 37.5% used crop rotation, about 35% used local pesticides and organic manure, about 33.75% use mulching as indigenous climate adaptation strategies practice. While very few women maize-based farmers used the change in farming season (5%) and relocation of farmland (6.25%) as Indigenous climate adaptation strategies. Also, few women maize-based farmers used cover crops (15%) and local pesticides (17.5%) as indigenous adaptation strategies.

Use of Indigenous adaptation strategies

Table 3: Use of indigenous adaptation strategies by women maize-based farmers.

Use of Indigenous adaptation strategies	Frequency	Percentage
Yes	41	51.25
No	39	48.75
Total	80	100.00

Source: Field Survey, 2023

Women maize-based farmers' choice of using indigenous climate adaptation techniques is shown in Table 3. This shows that 51.25% were using the techniques while 48.25% were not using the indigenous climate adaptation strategies. This could be attributed to the poor indigenous climate adaptation strategies for agriculture production in the study area.

Factors influencing the Indigenous climate adaptation strategies practiced

Table 4: Results of the Logit regression of factors influencing the Indigenous climate adaptation strategies practice in the study area.

Variables	Coefficient	Standard error	P-value
Constant	-6.769***	2.223	0.002
Age	0.075	0.056	0.184
Marital status	0.274	0.694	0.693
Education	0.547***	0.136	0.000
Farm experience	-0.012**	0.056	0.027
Household size	0.056	0.121	0.644
Farm size	-0.247**	0.172	0.031
Log Likelihood Chi-Square	65.294		

Hosmer and Lemeshow test	14.962
Pseudo R^2	0.825

Note: ***, **, * means significant at 1%, 5%, and 10% respectively

Source: Field survey, 2023.

The result from Table 4, The Log Likelihood Chi-Square of 65.294 is significant indicating that the model is a good fit to the data. The Hosmer and Lemeshow of 14.96 shows the goodness of fit of the model, leading to the rejection of the null hypothesis. The Pseudo R^2 of 0.825 indicates that the model explains 82.5% of the variation in the dependent variable, suggesting a strong fit. Table 4 also shows that the level of education, farm experience, and farm size are significant, hence increasing the probability of using Indigenous climate adaptation strategies in maize production in the study area.

Education with a coefficient of 0.547 and a highly significant p-value ($p = 0.000$) at 1%, education has a strong positive effect on the use of Indigenous climate adaptation strategies in maize production by women. This means that higher levels of education are associated with a greater likelihood of the desired utilization of Indigenous climate adaptation strategies by women maize-based farmers in the study area. Hence, the level of education is significant implying that the more educated a farmer is, the higher the probability of using indigenous climate-smart agricultural practices in maize production in the study area.

Farm experience with the coefficient is -0.012, meaning that more experience may slightly reduce the odds of using Indigenous climate adaptation strategies in maize production by women. The p-value of 0.027 indicates that this effect is statistically significant at 5%. The farm experience is significant which shows that the higher the experience the probability of using indigenous climate adaptation strategies. This suggests that for each additional unit of farm experience a farmer possesses, they are more likely to Indigenous change adaptation strategies such as minimum tillage, altering planting dates, and employing mixed cropping, respectively (Henri-Ukoha and Umeh, 2018).

Farm size with the coefficient for farm size is -0.247, which is statistically significant ($p = 0.031$) at 5%. This indicates a negative relationship, meaning that larger farm sizes might be associated with lower odds of using Indigenous climate adaptation strategies in maize production by women. Farm size is significant which means the higher the farm size the probability of women maize-based farmers using Indigenous climate adaptation strategies in maize production in the study area. The likelihood of women maize-based farmers in the study area opting for indigenous climate change adaptation strategies such as minimum tillage, mixed cropping, and conservation techniques appears to increase with the size of their farms. This suggests that farmers with larger land holdings are more inclined to make these adaptation choices because they possess the necessary resources to effectively implement these strategies. Henri-Ukoha and Umeh (2018) observed that households with relatively larger farm sizes were more inclined to embrace new adaptation strategies compared to those with smaller farms.

Constraints farmers face while adapting to climate change

Table 5: The constraints farmers face while adapting to climate change in the study area.

Constraints	*Frequency	Percentage
Scarcity of inputs	42	51.25
Lack of support from the government	65	81.25
limited funds	66	82.50
Inadequate drought-tolerant varieties	50	62.50
Limited meteorological information	52	65.00
Transportation	23	28.75
Low soil fertility	13	16.25
High cost of farm inputs	56	70.00
Inadequate knowledge of adaptation strategies	58	72.50
Poor extension service	54	67.50
Inadequate credit facility	65	81.25
Distance of farm	48	60.00
Gender challenges	44	55.00

Note: * means multiple responses recorded
Source: Field survey, 2023

Table 5 shows the challenges faced by women maize-based farmers in using Indigenous climate adaptation strategies. Majority of the women maize-based farmers face the challenge of limited funds (82.5%). This was largely due to the stringent measures that are usually required for obtaining loans from financial institutions or to some extent ignorance of the farmers to existence of the credit that is available in Agricultural banks, Cooperatives, and other loan sources. Women maize-based farmers were also confronted with a lack of governmental support (81.25%) this serves as a constraint because of ineffectiveness of some scheme established to help farmers. Inadequate credit facilities (81.25%) as their main challenges. Inadequate knowledge of indigenous climate adaptation strategies (72.5%) and high cost of farm input (70%). Meanwhile very few women maize-based farmers face low soil fertility (16.25%) as their challenge while transportation (28.74%) is another constraint. Other constraints are as follows poor extension service (67.5%), limited meteorological information (65%), and inadequate drought tolerant varieties (62.5%), distance of farm (60%), gender challenges (55%), and scarcity of inputs (51.25%).

Conclusion and Recommendations

Indigenous climate adaptation techniques used by women farmers who grow maize in the Ikwerre Local Government Area demonstrate their adaptability and resourcefulness in coping with climatic fluctuation. The results highlight how, in spite of erratic weather patterns, these women depend on locally created techniques to maintain maize output. Crop rotation, mixed cropping, the use of cover crops, early planting, date changes, early harvesting, the use of organic manure, and routine weeding are a few of the important tactics. These tactics demonstrate how environmental care and local knowledge may be used to produce maize sustainably in spite of climate change. But further training and resource assistance could improve these women's ability to adapt, allowing them to better address the more severe effects of climate change. The following recommendations were made:

i. Implement programmes that provide education and training for women farmers to increase their awareness and understanding of Indigenous climate adaptation strategies.

Also organize community workshops where experienced farmers can share their indigenous knowledge and strategies with others; encourage peer-to-peer learning.

ii. Ensure that these farmers have access to the necessary resources, such as improved seeds, organic fertilizers, and tools, which can enhance the effectiveness of their adaptation strategies.

iii. Policies must aim at promoting farm-level adaptation through an emphasis on the early warning systems and disaster risk management and also, effective participation of rural farmers in adopting better agricultural and land use practices. Rural Farmers should be given more support from both Local, State and Federal Government as well as Nongovernmental Organizations in terms of training, information and knowledge sharing about climate changes and its adaptation.

iv. Develop systems to provide timely and accurate weather information to help farmers make informed decisions on when to plant, irrigate, or harvest. Establish a system to monitor the adoption and impact of these strategies, collecting and feedback from women farmers to continuously improve the support provided.

References

Abbass, K., Qasim, M.Z., Song, H., Murshed, M., Mahmood, H., & Younis, I. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. *Environ Sci Pollut Res 29*, 42539–42559. https://doi.org/10.1007/s11356-022-19718-6

Abid, M., Schneider, U.A., & Scheffran, J. (2016). Adaptation to climate change and its impacts on food productivity and crop income: perspectives of farmers in rural Pakistan. *Journal of Rural Studies 47*, 254–266.

Ajayi, J. O. (2014). Awareness of climate change and implications for attaining Millennium Development Goals (MDGs) in Niger Delta Region of Nigeria. Agro online papers in Economics and Informatics, 4001, 3-11. Use double line spacing between teo

Feliciano, D., Recha, J., Ambaw, G., MacSween, K., Solomon, D., & Wollenberg, E. (2022) Assessment of agricultural emissions, climate change mitigation and adaptation practices in Ethiopia. Clim Policy 1–18

Henry-Ukoha, A, & Umeh, J. A. (2018), Farmers' perception of climate change on maize production in Khana Local Government Area of Rivers State Nigeria, *Interactive Journal of Economics and Business Management, 4*(8).

Kamara, A.Y., Kamai, N., Omoigui, L.O., Togola, A., Ekeleme, F., & Onyibe, J.E. (2020). Guide to maize production in Northern Nigeria. Retrieved from: https://www.iita.org/wp-content/uploads/2020/07/Guide-to-Maize-Production-in-Northern-Nigeria.pdf

Mulungu, K. & Ng'ombe, J.N. (2019). Climate change impacts on sustainable maize production in Sub-Saharan Africa: A review DOI:http://dx.doi.org/10.5772/intechopen.90033

National Bureau of Statistics NBS. (2022). Database. Retrieved from: https://www.citypopulation.de/php/nigeria-admin.php?adm1id=NGA033

Ruzzante, S., Labarta, R., & Bilton, A. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. World Development, 146, 105599. https://doi.org/10.1016/j.worlddev.2021.105599

Smith, A., Asa, T., & Francis, O. (2019). Addressing gender gaps in agricultural productivity in Africa: Comparative case studies from Tanzania, Malawi and Uganda. *African Journal.*

Woomer, P.L., Roobroeck, D, & Mulei, W. (2023). Agricultural transformation in maize producing areas of Africa. In: New prospects of maize, Editor: Kaushik, P. Retrieved from:https://cgspace.cgiar.org/bitstreams/f86153dd-ddb3-4aa2-a3fb-4e31ae0345a9/download

EFFECT OF BIODIVERSITY CONSERVATION PRACTICES ON FOOD SECURITY IN AKAMPKPA LGA, CROSS RIVER STATE, NIGERIA

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Abstract

This study investigates the role of biodiversity conservation in achieving food security: strategies and challenges in Akamkpa LGA, Cross River State, Nigeria. The first objective assessed how existing conservation practices influenced food production sustainability, examining how biodiversity efforts contributed to resilience and productivity in local agricultural systems. While the second objective identified the main obstacles encountered in implementing these biodiversity strategies, such as policy limitations, resource constraints, and challenges in community engagement. The hypothesis posited that biodiversity conservation practices have a significant positive impact on food production sustainability in Akamkpa LGA. Employing a mixed-methods approach, the research utilized stratified random sampling to select 150 households across various communities, including Akamkpa Urban, Uyanga, Ikpi, Awi, ensuring a representative sample of local perspectives. Quantitative data were gathered through structured questionnaires, while qualitative perceptions were obtained from semi-structured interviews with community leaders, government officials, and local conservation groups. Findings revealed that specific conservation practices significantly influenced food production sustainability, with Conservation Practice rated highest by 20% of participants, indicating strong local support. Descriptive statistical analysis showed a mean score of 4.20 (SD = 0.85) for Conservation Practice A, compared to lower mean scores for other practices. Data analysis using ANOVA confirmed that the overall hypothesis was supported, highlighting significant differences in the impact of various conservation practices on agricultural productivity. Despite these positive outcomes, challenges such as habitat loss (42% of respondents), climate change impacts (35%), and economic limitations (28%) were identified as persistent barriers to effective conservation strategies. The study emphasizes the necessity for comprehensive policies that engage local communities and stakeholders in conservation efforts. To foster resilience in ecosystems and ensure food security, it is recommended that the local government implement educational programs to raise awareness about sustainable farming techniques and biodiversity conservation.

Key words: Biodiversity, Conservation, Food Security, Sustainability

Background to the study

Biodiversity is a remarkable gift, showcasing the dazzling variety of life on Earth, from vibrant coral reefs to lush rainforests and grasslands teeming with wildlife. This richness provides countless benefits that sustain and inspire us daily (Adams, Berger, Clayton, Crist, Crump,

Fleischner, & Whyte, 2024). Diverse ecosystems ensure clean air, fertile soils, fresh water, and pollination for the crops that feed us. Biodiversity also supports the discovery of new medicines and drives innovation, with nature offering endless solutions to challenges we face (Pilcher, 2023). Furthermore, the beauty and uniqueness of different species and habitats bring joy, wonder, and a sense of connection, enriching our cultures and strengthening our bond with the natural world. Through its vast array of species and ecosystems, biodiversity brings balance, resilience, and endless fascination to life on Earth.

Biodiversity conservation is the practice of protecting and managing the variety of life on Earth to ensure its persistence for future generations. It involves preserving habitats, restoring ecosystems, and protecting species from extinction through dedicated efforts like creating protected areas, supporting sustainable land and water use, and promoting eco-friendly practices (Hoffmann, 2022). Conservation ensures that ecosystems can continue to provide vital services, such as clean air and water, soil health, pollination, and climate stability, which all life depends on. It also helps maintain genetic diversity, which strengthens species' resilience to changes and challenges (Telo da Gama, 2023). By conserving biodiversity, we safeguard the beauty, resources, and balance of nature, preserving a rich legacy that sustains human cultures and inspires a sense of wonder and responsibility in people around the world.

Biodiversity conservation plays a crucial role in achieving food security globally by maintaining healthy ecosystems that provide the resources needed for agriculture, fisheries, and food production. Ecosystems rich in biodiversity contribute to resilient food systems by supporting soil fertility, pollinating crops, controlling pests, and ensuring clean water supplies all essential for sustainable food production (Muluneh, 2021). Globally, strategies to conserve biodiversity for food security include protecting natural habitats, promoting sustainable agriculture, and encouraging genetic diversity in crops and livestock. Organizations worldwide are also working to integrate biodiversity-friendly practices into food systems, such as agroecology and regenerative farming, which enhance productivity without compromising natural resources (Iyiola, Babafemi, Ogundahunsi, & Ojeleye, 2022). However, challenges such as land degradation, climate change, and habitat loss threaten both biodiversity and food security, requiring coordinated efforts across nations to create resilient food systems.

In Africa, biodiversity is especially vital for food security due to the continent's dependence on agriculture and its diverse ecosystems, which support many livelihoods. African nations employ strategies like preserving indigenous crop varieties, promoting sustainable fishing practices, and implementing land-use policies to prevent overexploitation of natural resources (Muluneh, 2021). Projects across the continent focus on agroforestry and sustainable land management, benefiting both biodiversity and food production. Yet, challenges like deforestation, population pressure, and economic constraints make it difficult to prioritize conservation, and climate change adds further strain, impacting the availability of water and arable land (Plieninger, Muñoz-Rojas, Buck, & Scherr, 2020). Stronger regional collaborations and investments in sustainable agriculture are key to overcoming these challenges and leveraging Africa's rich biodiversity to enhance food security.

Biodiversity conservation is essential for food security, as agriculture remains a primary source of income for many Nigerians. Conservation efforts include promoting sustainable agriculture,

conserving wetlands that support fisheries, and protecting forest areas that contribute to local food sources (Iyiola, Babafemi, Ogundahunsi, & Ojeleye, 2022). Strategies like encouraging the use of traditional crop varieties, enhancing soil management, and implementing sustainable water practices are being adopted to ensure food security. However, Nigeria faces unique challenges, including rapid population growth, deforestation, and unsustainable farming practices, which threaten both biodiversity and food production (Onuoha, Chinedu, & Ochekwu, 2022). Addressing these challenges requires the involvement of local communities, the implementation of supportive policies, and investment in education on sustainable practices, so that Nigeria's biodiversity can continue to support its food systems and rural communities.

Literature review

The impact of biodiversity conservation practices on food production sustainability

Biodiversity conservation is increasingly recognized as essential to sustainable food production, supporting resilience and adaptability in agricultural systems. Key concepts, such as ecosystem services, highlight the contributions of biodiversity to food production by improving soil health, pollination, and natural pest control, all crucial for crop yields and livestock health (Kremen, 2020). These services are foundational in agroecology and sustainable farming, where biodiversity is viewed as a core asset rather than a backdrop. Theoretical frameworks like ecosystem-based management provide insights into how conservation and food production can harmonize, emphasizing the importance of diversified cropping systems and natural habitats that help buffer against environmental stresses (Mishenin, Yarova, & Koblianska, 2021).

Empirical studies shed light on specific biodiversity practices, such as agroforestry, crop rotation, and organic farming, which are shown to enhance sustainability by reducing chemical inputs and increasing resilience to climate change (Rosati, Borek, & Canali, 2021). For instance, crop diversification helps control pests naturally while fostering richer soil microbiomes, thus maintaining productivity without compromising environmental health. Case studies across Africa, for example, reveal that integrating biodiversity into farming supports food security by stabilizing yields and reducing dependency on synthetic inputs (Renard, & Tilman, 2021). These empirical findings demonstrate that biodiversity conservation is not only feasible but also advantageous for sustainable food systems.

Despite its benefits, biodiversity conservation in food production faces several challenges, particularly in economically constrained regions. Limited resources, policy gaps, and social barriers can hinder the implementation of conservation practices that could otherwise improve food sustainability (Siebrecht, 2020). For instance, smallholder farmers in regions like Nigeria and East Africa often lack access to funding and training necessary to adopt biodiversity-friendly practices. Additionally, conflicting land-use priorities and short-term economic pressures can detract from long-term sustainability goals (Hue, Quan, & Lap, 2024). These challenges underscore the need for policies that support farmers and incentivize biodiversity conservation, ensuring that these practices can continue to benefit food security and environmental health well into the future.

Challenges to implementing biodiversity conservation strategies that enhance food security

Implementing biodiversity conservation strategies to enhance food security faces numerous challenges that stem from economic, social, political, and environmental complexities. Central challenges often involve economic and policy-related barriers, where lack of funding and weak regulatory frameworks restrict conservation efforts, especially in regions that depend on agriculture for income (Rizos, & Bryhn, 2022). Governments may prioritize short-term economic gains over long-term sustainability, leading to conflicting land-use policies and inadequate support for biodiversity initiatives. These policy gaps are particularly problematic in areas where conservation practices could improve food security by making agriculture more resilient to pests and climate variability (Muluneh, 2021). Without robust policies that incentivize conservation, the adoption of biodiversity-friendly practices remains limited, with farmers often lacking both the resources and motivation to transition to sustainable systems.

Economic and social factors further complicate biodiversity conservation efforts. Financial constraints, including limited access to credit and the high costs associated with implementing sustainable practices, deter many farmers from adopting biodiversity-enhancing methods (Clémençon, 2021). Moreover, social attitudes toward agriculture and traditional practices can influence acceptance of biodiversity conservation. In many communities, there is limited awareness of the environmental and food security benefits of conservation practices, resulting in a preference for conventional farming methods that prioritize immediate productivity (Patel, Sharma, & Singh, 2020). Education and awareness programs play a crucial role in bridging this knowledge gap, helping communities understand the value of biodiversity and encouraging a shift toward sustainable practices.

Environmental and resource-related challenges, including climate change, habitat degradation, and technological limitations, also hinder conservation efforts. Climate change exacerbates challenges for biodiversity conservation by altering habitats, increasing the frequency of extreme weather events, and disrupting ecosystems that support agriculture (Upadhyay, Kishore, Sharma, & Sundriyal, 2024). In addition, lack of access to modern conservation technology and sustainable farming infrastructure such as soil management tools and climate-adaptive crop varieties limits farmers' ability to implement biodiversity-friendly practices. This is particularly true in rural areas where resources are scarce, and technical support is minimal. Addressing these environmental and technological barriers requires a collaborative approach, combining scientific research, community support, and investment in technology that facilitates sustainable farming practices (Rossoni, de Vasconcellos, & de Castilho Rossoni, 2024).

Material and method

This study centered on Akamkpa Local Government Area (LGA) in Cross River State, Nigeria, a region spanning between latitudes 5°15'N and 5°45'N and longitudes 8°00'E and 9°00'E. With a population of approximately 300,000, Akamkpa is home to both indigenous residents and settlers attracted by its expanding agricultural and solid mineral sectors. The area's tropical climate and dense rainforests make it rich in biodiversity, positioning Akamkpa as a critical zone for both conservation and agriculture in Nigeria (Offiong, Eneyo, Ushie, Agbor, Ephraim,

Ajake, & Antai, 2022). Agriculture serves as the economic backbone here, with residents primarily engaged in farming crops like cassava, maize, and yams, as well as in logging and fishing. The ecological richness of Akamkpa's forests and rivers underscores the importance of balancing conservation efforts with food security (Afolabi, 2020). The local population, composed mainly of the Ejagham and Dusauga Iyong Iyong ethnic groups, reflects cultural diversity, with languages like Ejagham, Iyong Iyong, Efik, and English widely spoken. Predominantly Christian, the community's social values are tied to environmental respect, with traditional knowledge of farming and sustainable practices aligning with modern conservation goals. This blend of cultural heritage and contemporary agricultural needs makes Akamkpa a fitting setting to explore biodiversity conservation and food security challenges.

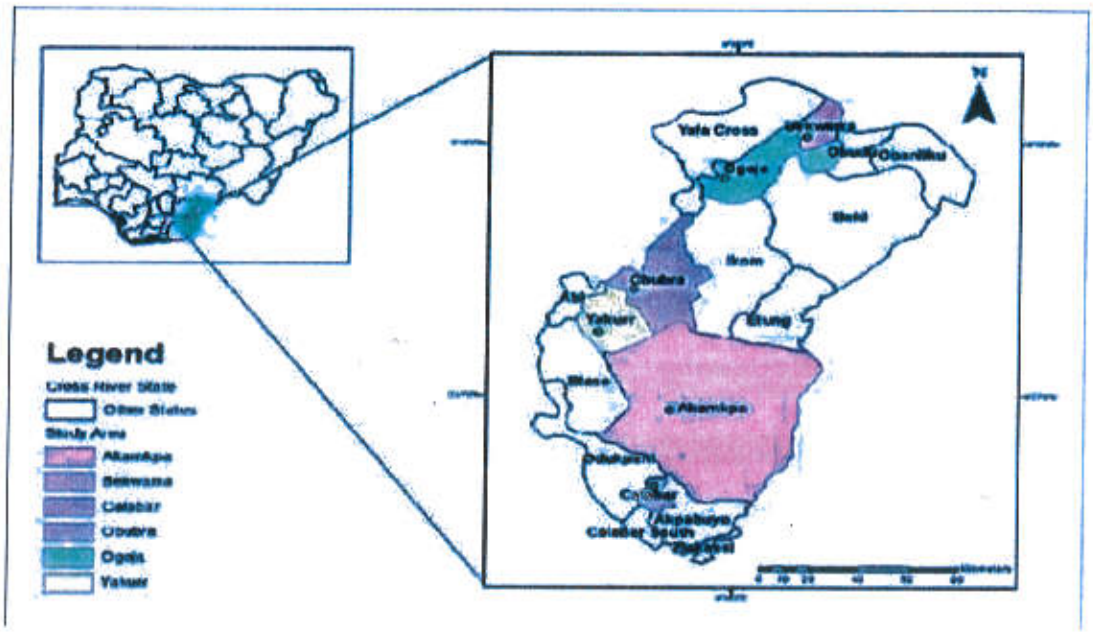

FIG. 1: Insert map of Nigeria, Cross River State showing Akamkpa LGA. Source: ResearchGate.

This study employed a mixed-methods approach, integrating quantitative surveys and qualitative interviews to assess the role of biodiversity conservation in achieving food security within Akamkpa LGA, Cross River State (Afolabi, 2022). Using stratified random sampling, 150 households were selected from key communities, including Akamkpa Urban, Uyanga, Ikpi, Awi, Mbarakom, Ojuk South, Ojuk North, and Oban, to capture a representative sample of local perspectives on conservation practices and food production. Structured questionnaires were distributed across these communities to gather quantitative data on conservation practices and challenges. Additionally, semi-structured interviews with community leaders, government officials, and local conservation organizations provided knowledge into policies, environmental changes, and cultural attitudes toward biodiversity conservation. Field observations documented land use patterns, habitat conditions, and active conservation practices, while secondary data from government reports and academic sources supported the contextual analysis. Quantitative data were statistically analyzed, and thematic analysis was applied to qualitative findings, offering a view of the challenges and strategies affecting biodiversity conservation and food security in Akamkpa.

Findings and result

Figure 1 examines the perceived impact of biodiversity conservation practices on food production sustainability within Akamkpa LGA. From the data, 28.7% of respondents view the impact as "significantly positive," suggesting a substantial number of community members recognize conservation as a meaningful contributor to sustainable food production. This high percentage reflects an understanding of how conservation practices help maintain soil quality, support water management, and reduce habitat degradation. A slightly lower percentage (26.0%) perceive the impact as "somewhat positive," indicating that while these respondents may appreciate the benefits of conservation, they might view its role in food production sustainability as limited or influenced by other external factors. The 22.0% who believe there is "little impact" may feel that current conservation efforts are insufficient to make a meaningful difference. Meanwhile, 23.3% selected "no impact," possibly reflecting a belief that economic or infrastructural challenges undermine conservation's role in enhancing food security in the area.

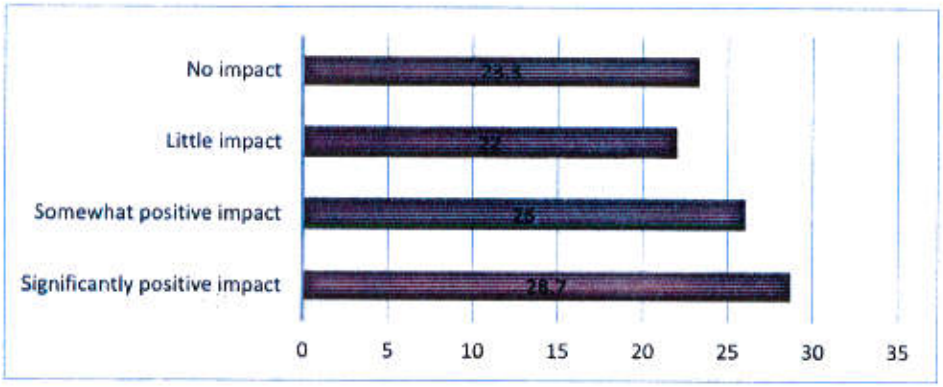

FIG. 1: Impact of biodiversity conservation practices on food production sustainability

Source: Author's Fieldwork, 2024.

In figure 2, respondents assess the effectiveness of biodiversity conservation practices in enhancing soil fertility, an essential component of sustainable food production. Here, 31.3% consider the practices "highly effective," emphasizing the direct benefits of biodiversity conservation, such as nutrient cycling and erosion control, which are vital for soil health. Another 23.3% find these practices "moderately effective," which may suggest a partial acknowledgment of conservation's impact on soil fertility, though possibly limited by factors like inconsistent implementation or knowledge gaps. Additionally, 24.7% view conservation practices as "slightly effective," and 20.7% as "not effective." These responses might imply that although the connection between biodiversity and soil fertility is recognized, many respondents experience barriers that limit the observable impact of conservation practices, such as accessibility to resources or support for implementing sustainable methods.

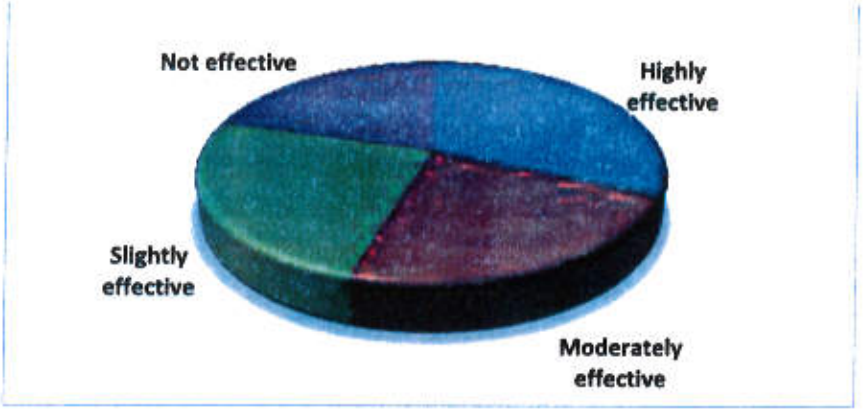

FIG. 2: Effectiveness of biodiversity conservation practices in enhancing soil fertility for sustainable food production

Source: Author's Fieldwork, 2024.

The third figure addresses the primary challenges that hinder biodiversity conservation strategies aimed at enhancing food security in Akamkpa. The most significant obstacle, selected by 27.3% of respondents, is "lack of funding." This highlights the need for financial support to initiate and sustain conservation efforts, purchase necessary resources, and facilitate community education programs. The second highest challenge, "limited technical expertise," chosen by 26.0% of respondents, points to a skill gap that may hinder the effectiveness of local conservation efforts. Furthermore, 24.7% of respondents cite "insufficient community awareness" as a primary barrier, indicating that many community members may not fully understand the importance of biodiversity conservation for food security. Finally, 22.0% identify "poor policy enforcement," suggesting that ineffective regulation and oversight may weaken conservation efforts and hinder progress towards food security.

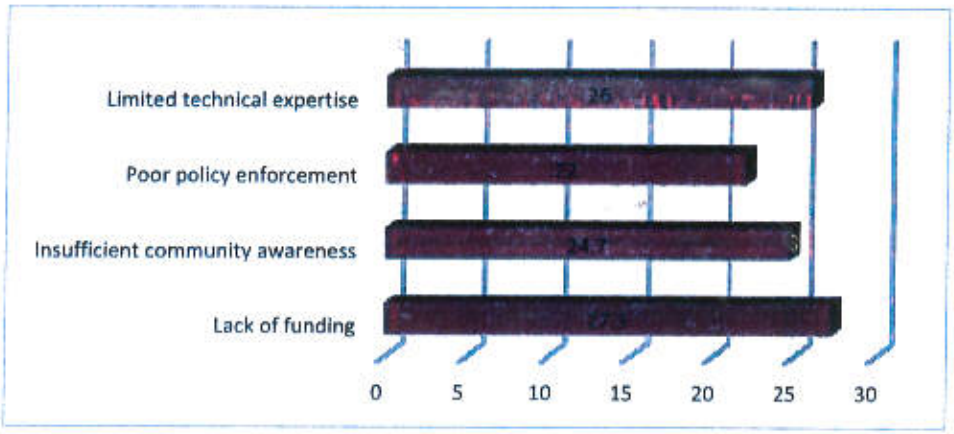

FIG. 3: Challenges affecting the implementation of biodiversity conservation strategies

Source: Author's Fieldwork, 2024.

In figure 4, the focus shifts to specific difficulties in maintaining biodiversity conservation in food production areas. A substantial 32.7% of respondents view "conflicting land-use priorities" as the most significant issue, reflecting the tension between conservation needs and

the demand for land to support agricultural expansion. This priority conflict can lead to unsustainable land use, reducing biodiversity and impacting long-term food security. Additionally, 24.7% consider "limited government support" a major barrier, implying that more governmental involvement is essential to sustain conservation efforts. "High costs of sustainable methods" (23.3%) further challenge the community's ability to implement conservation practices effectively. Lastly, 19.3% report a "lack of local engagement," highlighting the need for increased participation and ownership by local residents in conservation initiatives. Together, these tables illustrate the community's views on the importance, effectiveness, and challenges of biodiversity conservation for food production in Akamkpa, providing valuable insights for sustainable development strategies.

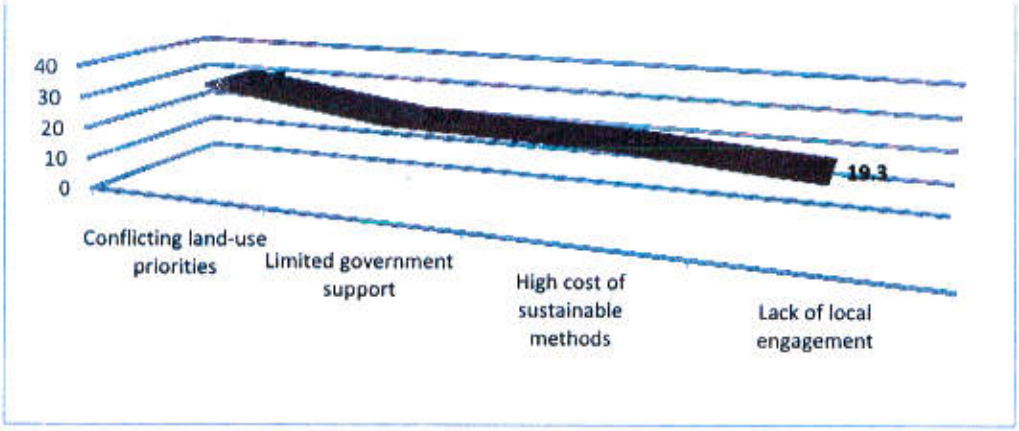

FIG. 4: Difficulty in maintaining biodiversity conservation practices

Source: Author's Fieldwork, 2024.

Hypothesis

H_0: Biodiversity conservation practices have no significant positive impact on food production sustainability in Akamkpa LGA.

H_1: Biodiversity conservation practices have a significant positive impact on food production sustainability in Akamkpa LGA.

To test the hypothesis "Biodiversity conservation practices had no significant positive impact on food production sustainability in Akamkpa LGA," an Analysis of Variance (ANOVA) was employed. ANOVA is a statistical method used to compare the means of three or more groups to determine if there were statistically significant differences among them. The formula for a one-way ANOVA was expressed as:

$$F = \frac{MSbetween}{MSwithin}$$

Where F represented the F-statistic, MSbetween is the mean square between the groups, and MSwithin is the mean square within the groups. The groups represented different levels or types of biodiversity conservation practices implemented in Akamkpa.

Hypothesis one testing

Table 1 summarizes the sample sizes, means, and standard deviations for each conservation practice group. Conservation Practice A showed the highest mean (4.20), indicating a strong perceived positive impact on food production sustainability, while Conservation Practice D had the lowest mean (2.80). This suggests variability in perceptions across different conservation practices.

The ANOVA table presents the analysis of variance between groups. The F-statistic of 9.30 and a p-value of 0.0002 indicate a statistically significant difference among the means of the different conservation practices at the 0.05 significance level. This result suggests that not all conservation practices have the same impact on food production sustainability, leading to a rejection of the null hypothesis.

The correlation table shows a moderate positive correlation ($r = 0.63$) between conservation practices and food sustainability, with a significant p-value of 0.001. This indicates that as the effectiveness of biodiversity conservation practices increases, the perceived food production sustainability also improves, further supporting the conclusion that conservation practices positively influence food production sustainability in Akamkpa LGA.

Descriptive Statistics table for Biodiversity Conservation Practices summarizes key statistical measures for four conservation practices in Akamkpa LGA, detailing their impact on food production sustainability. Each practice group shows varying levels of effectiveness, with Conservation Practice A receiving the highest mean score of 4.20, indicating strong positive perceptions, while Practice D scored the lowest at 2.80, suggesting less favorability. The standard deviations range from 0.78 to 1.00, reflecting varying agreement levels among respondents about each practice's effectiveness. The total mean score of 3.55 indicates a generally positive outlook on biodiversity conservation practices, highlighting the need for continued efforts to enhance food production sustainability in Akamkpa LGA.

Table 1: Statistical Summary

Group	N	Mean	Std. Deviation	Std. Error Mean
Conservation Practice A	30	4.20	0.85	0.16
Conservation Practice B	40	3.75	0.78	0.12
Conservation Practice C	50	3.10	0.90	0.13
Conservation Practice D	30	2.80	1.00	0.18
Total	150	3.55	0.95	0.08

Table 2: ANOVA Results

Source of Variation	Sum of Squares	df	Mean Square	F	p-value
Between Groups	25.45	3	8.48	9.30	0.0002
Within Groups	136.75	146	0.94		
Total	162.20	149			

Table 3: Correlation Analysis

Variables	r (Correlation Coefficient)	p-value
Conservation Practices vs. Food Sustainability	0.63	0.001

Table 4: Descriptive Statistics for Biodiversity Conservation Practices

Conservation Practice Group	N	Mean	Std. Deviation	Minimum	Maximum
Conservation Practice A	30	4.20	0.85	2.00	5.00
Conservation Practice B	40	3.75	0.78	2.50	5.00
Conservation Practice C	50	3.10	0.90	1.00	5.00
Conservation Practice D	30	2.80	1.00	1.00	4.00
Total	150	3.55	0.95	1.00	5.00

Conclusion

This study has highlighted the vital role that biodiversity conservation practices play in ensuring food security in Akamkpa LGA, Cross River State, Nigeria. The findings revealed that strategies blending sustainable farming techniques with traditional ecological knowledge significantly enhance food production sustainability, with Conservation Practice A receiving particularly high marks from respondents. This demonstrates that effective biodiversity management can boost agricultural productivity while preserving the region's rich ecological heritage. However, the study also identified challenges such as habitat loss, climate change impacts, and economic constraints that hinder the implementation of these crucial strategies. To overcome these hurdles, it is essential to develop comprehensive policies that engage local communities, government bodies, and conservation organizations in collaborative efforts. By prioritizing biodiversity conservation, Akamkpa can foster resilient ecosystems that support food production and sustain the livelihoods of its residents, ultimately contributing to broader sustainability goals on national and global levels.

Recommendations

To enhance the effectiveness of biodiversity conservation practices in achieving food security in Akamkpa LGA, it is recommended that local government and stakeholders prioritize the development of educational programs that raise awareness about the importance of sustainable farming techniques and biodiversity conservation. Secondly, establishing community-based conservation initiatives that empower local farmers to implement eco-friendly practices will foster a stronger connection between agriculture and biodiversity. Lastly, securing funding and resources for research on climate-resilient crops and sustainable land management will provide farmers with the tools needed to adapt to environmental changes while maintaining food production levels. By implementing these recommendations, Akamkpa can create a more sustainable future that balances agricultural needs with ecological preservation.

References

Adams, B., Berger, J., Clayton, S., Crist, E., Crump, M. L., Fleischner, T. L., ... & Whyte, K. (2024). The Heart of the Wild: Essays on Nature, Conservation, and the Human Future. Princeton University Press.

AFOLABI, A. (2022). Beyond Forest Conservation: Exploring the Impact of REDD+ on Livelihood and Detection of Forest Cover Change in Cross River State, Nigeria.

Afolabi, T. E. (2020). The role of international, national and sub-national policies in sustainable forest management and climate change in Nigeria: a case study of Cross River State (Doctoral dissertation, University of British Columbia).

Bodo, T., Gimah, B. G., & Seomoni, K. J. (2021). Deforestation and habitat loss: Human causes, consequences and possible solutions. Journal of Geographical Research, 4(2), 22-30.

Clémençon, R. (2021). Is sustainable development bad for global biodiversity conservation?. Global sustainability, 4, e16.

Hoffmann, S. (2022). Challenges and opportunities of area-based conservation in reaching biodiversity and sustainability goals. Biodiversity and Conservation, 31(2), 325-352.

Hue, H. T. T., Quan, P. Z., & Lap, K. Q. (2024). Review of biodiversity assessment and resource management orientation for sustainable rural development in Lang Son province, Vietnam. Environmental Research Communications, 6(9), 095019.

Iyiola, A. O., Babafemi, O. P., Ogundahunsi, O. E., & Ojeleye, A. E. (2022). Food security: a pathway towards improved nutrition and biodiversity conservation. In Biodiversity in Africa: Potentials, Threats and Conservation (pp. 79-107). Singapore: Springer Nature Singapore.

Iyiola, A. O., Babafemi, O. P., Ogundahunsi, O. E., & Ojeleye, A. E. (2022). Food security: a pathway towards improved nutrition and biodiversity conservation. In Biodiversity in Africa: Potentials, Threats and Conservation (pp. 79-107). Singapore: Springer Nature Singapore.

Khatri, P., Kumar, P., Shakya, K. S., Kirlas, M. C., & Tiwari, K. K. (2024). Understanding the intertwined nature of rising multiple risks in modern agriculture and food system. Environment, Development and Sustainability, 26(9), 24107-24150.

Khattak, W. A., Sun, J., Hameed, R., Zaman, F., Abbas, A., Khan, K. A., ... & Du, D. (2024). Unveiling the resistance of native weed communities: insights for managing invasive weed species in disturbed environments. Biological Reviews, 99(3), 753-777.

Kremen, C. (2020). Ecological intensification and diversification approaches to maintain biodiversity, ecosystem services and food production in a changing world. Emerging Topics in Life Sciences, 4(2), 229-240.

Mishenin, Y., Yarova, I., & Koblianska, I. (2021). Ecologically harmonized agricultural management for global food security. Ecological intensification of natural resources for sustainable agriculture, 29-76.

Muluneh, M. G. (2021). Impact of climate change on biodiversity and food security: a global perspective—a review article. Agriculture & Food Security, 10(1), 1-25.

Muluneh, M. G. (2021). Impact of climate change on biodiversity and food security: a global perspective—a review article. Agriculture & Food Security, 10(1), 1-25.

Muluneh, M. G. (2021). Impact of climate change on biodiversity and food security: a global perspective—a review article. Agriculture & Food Security, 10(1), 1-25.

Offiong, E. E., Eneyo, V. B., Ushie, M. A., Agbor, C. N., Ephraim, I. E., Ajake, A. O., & Antai, A. S. (2022). Survey and ethnobotanical investigations of key non-timber forest products in home gardens and sacred forests in Cross River State, Nigeria. Environment and Ecology Research, 10(5), 580-591.

Onuoha, C. A., Chinedu, N., & Ochekwu, E. (2022). Environmental Challenges Awareness in Nigeria: A Review. African Journal of Environment and Natural Science Research, 5(2), 1-14.

Patel, S. K., Sharma, A., & Singh, G. S. (2020). Traditional agricultural practices in India: an approach for environmental sustainability and food security. Energy, Ecology and Environment, 5(4), 253-271.

Pilcher, H. (2023). The Time Nature Keeps: A Visual Guide to the Cycles and Time Spans of the Natural World. The Experiment, LLC.

Plieninger, T., Muñoz-Rojas, J., Buck, L. E., & Scherr, S. J. (2020). Agroforestry for sustainable landscape management. Sustainability Science, 15(5), 1255-1266.

Renard, D., & Tilman, D. (2021). Cultivate biodiversity to harvest food security and sustainability. Current Biology, 31(19), R1154-R1158.

Rizos, V., & Bryhn, J. (2022). Implementation of circular economy approaches in the electrical and electronic equipment (EEE) sector: Barriers, enablers and policy insights. Journal of Cleaner Production, 338, 130617.

Rosati, A., Borek, R., & Canali, S. (2021). Agroforestry and organic agriculture. Agroforestry Systems, 95, 805-821.

Rossoni, A. L., de Vasconcellos, E. P. G., & de Castilho Rossoni, R. L. (2024). Barriers and facilitators of university-industry collaboration for research, development and innovation: a systematic review. Management Review Quarterly, 74(3), 1841-1877.

Siebrecht, N. (2020). Sustainable agriculture and its implementation gap—Overcoming obstacles to implementation. Sustainability, 12(9), 3853.

Telo da Gama, J. (2023). The role of soils in sustainability, climate change, and ecosystem services: Challenges and opportunities. Ecologies, 4(3), 552-567.

Upadhyay, R. K., Kishore, N., Sharma, M., & Sundriyal, S. (2024). Environmental Sustainability and Its Impact on Public Health. Sustainability and Health Informatics: A Systems Approach to Address the Climate Action Induced Global Challenge, 47-72.

COMPARATIVE INSECTICIDAL EFFICACY OF *POLYALTHIA LONGIFOLIA* AND *ACALYPHA WILKESIANA* POWDER ON COWPEA WEEVIL (*CALLOSOBRUHUS MACULATES)*

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ABSTRACT

Concerns over synthetic pesticides' environmental impact have shifted focus towards bioactive plant products for stored product insect pest control. This laboratory study investigated the insecticidal efficacy of Polyalthia longifolia and Acalypha wilkesiana leaf powders against cowpea weevil Callosobruchus maculatus. The study's objectives were to evaluate mortality effects, assess damage reduction, and examine emergence inhibition. Four treatments with concentrations of 0%, 1%, 2%, and 3% of each plant leaf powder were used, with three replicates. Each treatment consisted of 100g sterilized cowpea grains, arranged in a completely randomized design. Results showed that A. wilkesiana caused the highest mortality rate of 30.23% at 3%, 23.35% at 2%, and 20.76% at 1%. P. longifolia showed 25.46% mortality at 3%, 21.65% at 2%, and 16.65% at 1%. Both plant powders exhibited significantly higher mortalities than controls ($P<0.05$). Damage reduction was significant, with A. wilkesiana reducing damage to 25.80% at 3% and P. longifolia to 32.35% at 3%. Emergence inhibition was impressive, with A. wilkesiana inhibiting F1 progeny at 78.74% at 3% and P. longifolia at 71.15% at 3%. The study concludes that both plants have insecticidal properties to suppress Beans weevil, which demonstrate potential for sustainable pest management, ensuring food security and environmental safety.

INTRODUCTION

Cowpea grain (*Vigna unguiculata*) is a vital pulse crop in Africa's semi-arid and sub-humid regions, serving as a primary food source and economic staple for numerous rural communities (Kabeh and Lale, 2004). Its significance extends beyond its market value, offering exceptional nutritional benefits. As a staple crop in West and East Africa, Latin America, and the Caribbean, cowpea grain is deeply ingrained in local diets (Langyintuo *et al.,* 2003). Furthermore, it provides essential dietary protein in areas where animal protein is scarce, making it a critical component of global food security (Ito & Ighere, 2017).

Despite global efforts to enhance agricultural productivity through various control programs, post-harvest losses continue to threaten food security in many developing countries. An effective post-harvest system is crucial for ensuring food security, as it guarantees that harvested produce reaches consumers and meets their expectations (Oni *et al.,* 2019).

The impact of insect pests on food security is substantial, particularly during storage, where their damage exceeds that caused in the field. Achieving food security requires countries to successfully store large amounts of agricultural produce, protecting it from pest infestations (Adamu, 2015).

Callosbruchus maculatus causes significant cowpea losses (50-90%) during storage (Ogungbite *et al.,* 2014; Ajayi *et al.,* 2015). However, conventional insecticides' harmful effects have led to their decline and ban in many countries. This has prompted a search for alternatives. Natural pesticides, in forms like dusts and extracts, offer a cost-effective and eco-friendly solution, showing promising results as crop protectants (Isman, 2018).

In recent years, different researchers have successfully examined the efficiency of various plants resources as possible entomotoxicants: Powders of leaves of *Afromomum melegueta, Dennettia tripetala* and *Xylopia aethiopica* showed insecticidal efficacy on *Cylas punctiocllis* a sweet potato weevil (Nta *et al.,* 2018). Also, the extracts from other plants which include Azadirachta indica, Lantana camara and *Tephrosia vogelli* had toxic effects on the groundnut bruchid *Caryedon serratus* (Idoko *et al.,* 2016). Powders of both *Chenopodium ambrosoides* leaves and seeds of *Afromomum melegueta* individually and in mixture have both tested positive in the control of *Callosobruchus maculatus* an insect pest of cowpea (Chougourou *et al.,* 2016).

Phytochemicals such as Tannin, Saponin, Alkaloids, Anthraquinone etc may be responsible for the insecticidal efficacy of most plant products (Yang *et al.,* 2006; Chaieb, 2010., Chogourou *et al.,* 2015; Nta *et al.,* 2018; Oni, 2019).

This study seeks to expand the scope of research on sustainable pest management and enhance global food security by assessing the potential of *A. wilkesiana* and *P. longifollia* leaf powders as eco-friendly insecticides against *C. maculatus.*

MATERIALS AND METHODS

Description of Study Area

The experiment was conducted at Room 249 in the department of Zoology and environmental Biology, University of Calabar, Calabar Municipality Cross River State ($5^0$45'N $8^0$30'E) Nigeria, between June 2021 and August 2021. Calabar is 46 metres above sea level and its climate is classified as tropical. Rainfall is significant most months of the year and the short dry season has little effect. In Calabar, the average temperature (annually) is 25.8^0C/78.5^0F. The annual rainfall is 3306mm/130.2inch with an average relative humidity in the range 68-92%.

Cowpea Seeds Preparation

The cowpea seeds (*Vigna unguiculata*) used were purchased from Marian market (a local market within Calabar municipality) Calabar. The cowpea seeds were selected to ensure that none was perforated and then disinfected in a freezer at -18°c for 48 hours and air dried in the open laboratory to prevent molding and kept in dry polythene bags prior bioassay.

Insect Rearing

The culturing of *C. maculatus* adults used for this study were obtained from an existing cowpea infested with weevils from a shop along Etagbor layout, Calabar municipality and reared at ZEB Room 249 in the department of Zoology and Environmental Biology, University of Calabar. Uninfested cowpea were being added to culture at intervals to ensure the insect had enough to feed on so as to avoid starvation. The insects were reared in a perforated lid jar from where the stock was obtained and used for the experiment.

Collection of Test Plant Materials

The leaves of *A. wilkesiana* and *P. longifollia* used in the study were obtained from Ikot Ansa axis of Calabar Municipality and within the University of Calabar campus respectively. The leaves were air dried for two weeks in the laboratory before milling into fine powder with an electric blender and sieved through a mesh (250úm size).

Experimental Design

Laboratory-based assays were conducted in a completely randomized design using leaves powder of *Acalypha wilkesiana* and *Polyalthia longifollia* applied at three treatment doses (1%,

2% and 3%) for each plant and a control, giving a total of seven treatment groups. Each treatment was replicated three times giving a total of 21 treatment units.

Weevil Mortality

In a bid to determine the efficacy of *Acalypha wilkesiana* and *Polyalthia longifolia* powders on the mortality of *Callosbruchus maculatus* (insect pest pests of Cowpea), disinfected cowpea grains without feeding holes were weighed at 100g into a plastic container. Each container of 100g of cowpea was treated with various plant powders using different concentrations of the powder at (0%, 1%, 2% and 3%) and replicated three times each. The percentage concentrations of the powders were calculated using weight of test plant powder to weight of the cowpea while. The treatment with 0% concentration of the powder served as the control from which the comparison was made.

Twenty (20) adult *C. maculatus* were introduced into the transparent test containers uniformly to mate and oviposit for five days. The covers of the test containers were bored through and covered by nylon mesh (0.25mm mesh size) to ensure the weevils were confined within and secondly to ensure effective ventilation. Adult mortality count was carried out in four days at intervals of 24, 48, 72 and 96h after plant powders were applied. At each count, the numbers of dead weevils were noted and removed while those that were still alive were left to continue the experiment. In order to ascertain if an insect was still alive or not, an insect under the study was pricked using an entomology needle and any insect which couldn't respond after continuous pricking was considered dead and removed immediately.

From the data obtained, percentage weevil mortality at 24, 48, 72 and 96 succeeding treatment was calculated as:

$$\text{PWM} = \frac{Number\ of\ dead\ weevils\ per\ treatment}{Total\ number\ of\ weevils\ introduced}\ X\ 100 \qquad \text{(Nta } et\ al.\text{, 2018)}$$

Weevil Damage Test

The degree of damage caused by the weevil was assessed based on the number of seeds perforated with one or more conspicuous exit holes at three weeks post treatment. Seeds examined were 30 sample seeds randomly selected from each treatment. Count data were taken on the number of seeds perforated. All biological assays were repeated three times and data obtained were pooled out and subjected to analysis. The percentage damage caused by *C. maculatus* to seeds was computed following the method used by Adedire & Ajayi (1996) i.e.

(i) Percentage Damage (PD) = Number or treated perforated seeds sampled / Total number of sample seeds X 100

(ii) Weevils perforation index (WPI) was also calculated from the data obtained using the method by Fatope *et al.* (1995)

$$\text{WPI} = \frac{Perforated\ seeds\ in\ treament}{Perforated\ seeds\ in\ control + Perforated\ seeds\ in\ treatment.}\ X\ 100$$

Adult Cowpea Weevils Emergence

The emergence and percentage reproductive potential inhibition test of adult *C. maculatus* were determined based on the emergence of the first filial generation (F1) progeny, five weeks following the removal of the weevil from the mortality bioassay. The full grown weevils coming out from each treatment were numbered and noted. These count data gave a measure of the effect of the powder on weevil's reproduction (reproductive Capacity inhibition test). Emerged weevils were sieved out daily to prevent mating and subsequent oviposition by F1 progeny (Stathers *et al.*, 2005).

The bioassay was concluded after seven weeks when there was no more emergence of adults and cumulative emergence for each unit was recorded accordingly. All data obtained for the RPI test were determined from the adult emergence using the formula:

$$RPI = \frac{No.Of\ adult\ emerging\ in\ control - Adults\ emerging\ in\ treatment}{No.of\ adults\ emerging\ in\ control} X\ 100$$

(Nta *et al.*, 2018)

Statistical analysis

Data obtained for respective study parameters were evaluated employing one-way analysis of variance (ANOVA) to check for significant difference between the various treatments. All data analyses were undertaken using SPSS version 17.0 software for windows, and conclusions drawn at 95% probability level.

RESULTS AND DISCUSSION

Weevil Mortality

After 96h of application of plant powder, significant differences (P>0.005) were observed among the plant leaves powder of *Acalypha wilkesiana and Polyalthia longifolia* and control on cumulative mean mortality (%) of adult *C. maculatus*. Results from table two showed that both powders had lethal contact effects on the insect though at varying degrees and their effects were time dependent. After 24h of exposure of the insects to both powders at 1% concentration, no mortality case was recorded but at 48h on exposure to same concentrations of the powders, mortality cases were noted with 3.35% mortality *C. maculatus* in cowpea treated with *Polyalthia longifolia* and 6.65% mortality of the weevils in the cowpea treated with *Acalypha wilkesiana* powder. Highest percentage mortality recorded in 1% concentration of both powders was recorded after 96h of treatment with *P. longifolia* at 16.65% and *A. wilkesiana* at 20.76%.

Also, it was noticed that the highest percentage mortality recorded in the control was 8.35% after 96 h and was similar to the result recorded in 24h with weevils treated with *A. wikesiana* and 72h with *P. longifolia* powder. It was also noticed that the percentage mortality (25.46) recorded in 3% of *P. longifolia* at 96h post treatment observation was less than that at the same concentration with *A. wilkesiana* at 72h.

From the overall mortality test, the highest rate of *C. maculatus* mortality to both powders was each recorded at 3% concentration after 96h of treatment with *P. longifolia* recording 25.46% and *A. wilkesiana* recording 30.23%. It is observed from the table that when compared to the control, both powders of *A. wilkesiana* and *P. longifolia* were potent but powder of *A. wilkesiana* proved to be more effective yielding significantly higher mortalities (P>0.05) than the powders of *P. longifolia.*

Table Two:

Effects of *Polyalthia longifolia* and *Acalypha wilkesiana* leaves powder on mortality of *C. maculatus*

Plants	Conc % (w/w)	24hr	48hr	72hr	96hr
Polyalthia longifolia	1	0.00 ± 0.00^{a}	3.35 ± 0.33^{b}	8.35 ± 0.33^{b}	16.65 ± 0.67^{b}
	2	1.65 ± 0.33^{b}	13.35 ± 0.67^{c}	16.65 ± 0.33^{c}	21.65 ± 0.33^{c}
	3	6.65 ± 0.67^{c}	18.35 ± 0.33^{d}	21.65 ± 0.88^{d}	25.46 ± 0.58^{d}

Acalypha wilkesiana	1	0±0.00^{a}	6.65±0.67^{bc}	15.58±0.58^{c}	20.76±0.58^{c}
	2	8.35±0.33^{c}	13.35±0.67^{c}	20.75±0.58^{d}	23.35±0.33^{cd}
	3	15±0.58^{d}	18.30±1.20^{d}	26.65±0.33^{e}	30.23±1.00^{e}
Control	0	0.00±0.00^{a}	0.00±0.00^{a}	1.65±0.33^{a}	8.35±0.33^{a}

Values are presented as Mean ± Standard Error.Values in each column having similar superscript are not significantly different based on Waller-Duncan post hoc test.

Weevil Damage and weevil perforation index

In assessing the effect of the test plant's powders on the grain damage by *C. maculatus*, the units that were treated with powders were compared to the control. All powders were discovered to have induced significantly lower ($P<0.05$) percentage seed damage. The control which wasn't applied any of either plant powders recorded the highest percentage of cowpea damage at 51.10% caused by the weevils. This was followed by the cowpea grains treated with *P. longifolia* powders which recorded 37.77%, 28.87% and 24.43% at 1%, 2% and 3% powder concentrations respectively. The lowest damage reports were recorded by the grains treated with powders of *A. wilkesiana* which were 32.23%, 24.43% and 17.77% at 1%, 2% and 3% powder concentrations respectively. It was observed that at 3% concentration of *P. longifolia*, the damage recorded (24.43%) was the same as that recorded in the 2% powder concentration of *A. wilkesiana*.

The weevil perforation index was recorded highest in *P. longifolia* at 42.50% which was higher as compared to same concentration of *A. wilkesiana* powder which gave 38.68%. The lowest perforation index was recorded in 3% of *Acalypha wilkesiana* at 25.80% lower than at 3% of *P. longifolia* which was 32.25%. Both powders had suppression on weevil damage ability and perforation index but powder of *A. wilkesiana* proved to be more effective than *P. longifolia*.

Table three:

Effects of powders of *Acalypha wilkesiana* and *Polyalthia longofolia* on *C. maculatus* damage and weevil perforation index of cowpea seeds.

Plants	Conc % (w/w)	Weevil Damage (%)	WPI (%)
Polyalthia longifolia	1	37.77±0.33^{c}	42.50±0.33^{d}
	2	28.87±0.33^{b}	36.10±0.33^{bc}
	3	24.43±0.33^{ab}	32.35±0.33^{b}
Acalypha wilkesiana	1	32.23±0.33^{b}	38.68±0.88^{c}
	2	24.43±0.33^{ab}	32.35±0.33^{b}
	3	17.77±0.88^{a}	25.80±0.33^{a}
Control	0	51.10±1.23^{d}	54.23±1.02^{e}

Values are presented as Mean ± Standard Error.Values in each column having similar superscript are not significantly different based on Waller-Duncan post hoc test.

Cumulative Adult Emergence

Both test plants powders used for the experiment individually showed significant effects ($P<0.05$) on progeny emergence when compared with the control. In the control, it was observed that the highest cumulative mean of emerged progeny of *C. maculatus* (45.66) was significantly higher ($P>0.05$) than emerged progeny in all experimental units. With the treatments, the lowest mean of emerged adults and highest reproduction potential inhibition were 3% with *A. wilkesiana* (12.34, RPI = 78.74); 2% with *A. wilkesiana* (23.02, RPI = 72.40) and 3% with *P. longifolia* (23.51, RPI = 71.15).

It was noted from the result that the cumulative emergence in 3% powder concentration of *P. longifolia* (23.51) wasn't significantly different from that 2% concentration of *A. wikesiana*. The reproductive inhibition was very high in *A. wilkesiana* treatments as compared to *P. longifolia* and the control. In all the treatments, the highest emergence and lowest reproductive potential inhibition was 1% with *P. longifolia* (37.25, RPI = 18.46%). While the highest reproductive inhibition and lowest emergence (12.34, RPI = 78.74%) was recorded in *A. wilkesiana*. This goes to show that both plants have reproductive potential inhibition properties on C. *maculatus, A. wilkesiana* has a higher effect than *P. longifollia*.

Table four:

Effect of Powders of *Polyalthia longifolia* and *Acalypha wilkesiana* on progeny emergence and reproductive potential inhibition (RPI) of *C. maculatus*.

Plants	Conc. % (w/w)	Cumulative emergence	RPI
Polyalthia longifolia	1	37.25 ± 0.09^{c}	18.46 ± 0.12^{b}
	2	28.89 ± 2.70^{bc}	61.40 ± 0.14^{cd}
	3	23.51 ± 2.59^{b}	71.15 ± 0.18^{d}
Acalypha wilkesiana	1	29.70 ± 2.46^{bc}	38.57 ± 0.26^{c}
	2	23.02 ± 2.62^{b}	72.40 ± 0.26^{d}
	3	12.34 ± 1.64^{a}	78.74 ± 0.15^{e}
Control	0	45.66 ± 0.09^{d}	0.00 ± 0.00^{a}

Values are presented as Mean ± Standard Error.Values in each column having similar superscript are not significantly different based on Waller-Duncan post hoc test.

The present study and results obtained from this research reveals that the leaves of *Polyalthia longifollia* and *Acalypha wilkesiana* had insecticidal activities against *Calosobruchus maculatus* and can be used in the control of the bruchid.

When compared to the control, all the test plants' powders were effective in reducing insect population under laboratory conditions however; their effectiveness was directly proportional to concentration and exposure periods. This was evidenced by highest mortality recorded at

highest concentration of 3% and at 96h post treatment by *A. wilkesiana* and though slightly lower but significantly different mortality recorded by 3% if *P. longifollia* at the same post treatment time. Earlier authors had also reported dose-related mortalities in similar treatments (Ukeh *et al.* 2012; Nta *et al.* 2018). Plants have been reported to have Phytochemicals which acts as chemical defenses against herbivores and other organisms in the environment (Ogunwenmo *et al.* 2007). It is therefore possible that the strong pungent odour produced by these plants prevented the weevil from normal feeding which resulted in starvation and their subsequent death (Lee *et al.* 2001; Kouninki *et al.* 2007).

The bioactivities of these plants may have been due to contact toxicity of the plants powders to the insect or stomach poisoning during feeding. Furthermore, at higher concentrations, the powder may have blocked the insect's spiracles resulting in suffocation and death. This probable action was also reported by Oparaeke & Kuhiep (2006). This study thus confirms the reports of Rayapakse (2006) and Asawalem *et al.* (2012) who reported that these tropical plants (*A. wilkesiana* and *P. longifollia*) have strong anti-feedant and anti - survival effects on different storage pest species including Coleopterans such as *C. maculatus*. *Callosobruchus maculatus* on exposure to 1% of *A. wilkesiana*, there was no record of mortality which contradicts reports by Oni (2009) where it was reported that there was significant loss at 24h post treatment. This could be due to the fact that oil had more phytochemicals present in larger volume as compared to the powder used in this study.

Plant products including essential oils and powders are a mixture of biologically active substances or secondary metabolites of defensive nature that have been broadly studied for pest management purposes (Isman, 2006; Pavela 2011). Just like the essential oils, botanics powders are a very complex mixture of terpenes, sesquiterpenes, their oxygenated derivatives and other aromatic compounds and their chemical composition often varies among species, chemotype, climate, soil conditions, geographical location and the method of extraction (Nerio *et al.*, 2010; Zapata and Smagghe, 2010). The mechanism of activity of plants powders and their chemical component could affect the biochemical process and disrupt the endocrine balance of insects (Rattan, 2010). The action of botanics and its chemical constituent may also produce neurotoxicity in insects giving symptoms similar to those produce by organophosphate and carbamate insecticides (Ukeh and Umoetok 2011), which are often charactetized by hyperexcitation leading to rapid knock-down and immobilization (Rattan, 2010).

The phytochemicals screening of *A. wilkesiana* leaves conducted by Madziga et al. (2010) showed the presence of Tannin, phenol, Saponin, flavonoid, Cardiac Glycoliside, Phytate, Anthraquinones, Terpenoids, Oxalate and Alkaloids. The Physico - chemical and phytochemical evaluation of leaves powder of *P. longifollia* also showed the presence of Alkaloids, steroids, tannins, phenols and flavonoids (Jayaveera *et al.* 2010). The presence of Saponins in the Copper leaf may have been the major reasons behind the higher mortality recorded from the experiment (Chaieb, 2010).
Significant reproductive inhibition of *C. maculatus* due to the plant powders was exhibited by the significantly lower cumulative progeny emergence but higher reproductive potential inhibition in treated experiments, unlike the control which recorded up to 45.66 progeny emergence and a low RPI of 0.00

Polyalthia longifollia has earlier been reported to have to have demonstrated larvicidal and repellent activities on mosquito (Sosan *et al.* 2001; Lara *et al.* 2010) while research has also proven the inhibitory effects of *A. wilkesiana* oil extract on the antioxidant, detoxifying and neurotransmitter enzymes in *C. maculatus*. The Alkaloid present in the powder from qualitative

phytochemical analysis may have been the major reason behind the potency of the plant in the control of *C. maculatus* (Oni, 2019).

Results obtained from this study clearly indicates that *A. wilkesiana* and *Polyalthia longifolia* powder elicited direct adult mortality, reduced level of weevil damage and perforation index of the insect (*C. maculatus*) as well as exert an inhibition on the emergence of a new generation. This therefore proves the efficacy of the plants in control of insect infestation.

CONCLUSION AND RECOMMENDATION

The findings from this study showed that mortality increased as concentration and exposure time increased. The study also revealed mortality, controlled damage effect and reproduction inhibition potentials against *C. maculatus*. *Acalypha wilkesiana* caused the highest mortality rate followed by the second test plant *P. longifollia* in all concentrations evaluated. Unlike the mortality case, the damage effects on the cowpea seeds treated with *A. wilkesiana* by *C. maculatus* was lesser and there was an obvious reduction in damage as the plant powder concentration increased. Inhibition rate was found to be higher in cowpea seeds treated with plant powders when compared with the control. It can be concluded that these local plants can be advertised to replace synthetic chemicals used in insect pest control in stored grains which may likely pose serious health threats to humans and damage to the environment.

Based on the findings of this study, it is recommended that due to their availability and environmental friendliness, plant powders should replace synthetic pesticides in the control of insect pests. Furthermore, since all test plants exhibited insecticidal properties, a similar study should also be carried out by combining powders of both plants to know the combined effects in the control of pests.

REFERENCES

Adamu, A. (2015). Role of food security in achieving national security. *The Punch newspaper*, 39: 24.

Ajayi, O. E. Balusa, R. Morawo, T.O. Zebelo, S. & Fadamiro, H. (2015). *Semio chemical* modulation of host preference of *Callosobruchus maculatus* on legume seeds. *Journal of stored products research*, 63: 31-37.

Asawalam, E. F., Emosairue, S. O., Ekeleme, F. & Wokocha, R. C. (2006). Insecticidal effects of powdered parts of eight Nigerian plant species against maize weevil, Sitophilus zeamais Motsch. (Coleoptera: Curculionidae). *Nigerian Agricultural Journal* 3: 106–113.

Chaieb, I. (2010). Saponins as insecticides, *A review. Tunisia J. Plant protect.* 5: 39-50.

Chougourou C. D., Zoclanclounon, Y. A., Agbaka, A. & Togola, A. (2015). Toxicity of two plant powders as biopesticides in the management of Calloeobruch maculatus F. (Coleoptera: Chrysomelidae, Bruchidae) on two stored grain legumes. *Journal of Applied Bioscience*, 86: 7900-7908.

Idoko, S. O., Bassey, S. U. & Ukatu, P. (2016). Comparative efficiency of insecticidal plants on the management of groundnut *Bruchid* (*caryedon serratus*). *Journal of Agricultural studies* 4(3): 47

Isman, M. B. (2006). Botanical insecticides, deterrent and repellents in modern Agriculture and an increasing regulated worl, Animal Review of Entomology. 51: 45-46

Isman, M. B. (2008) Percept botanical insecticides for richer, for poorer. *Journal of Pest management science*, 64: 8-11.

Ito, E. E and Ighere, E. J, (2017). Bio-insecticidal potency of five plants extracts against cowpea weevil, *Callosobruchus maculatus*, on stored cowpea, *Vigna unguiculata*. *JORDAN Journal of Biological sciences*. 104:317-322.

Jayaveera, K. N. Sridhar, C. Kumanan, R. Yogananda, R. K. (2010). Phytochemical, antibacterial and *anti-helminthic* potential of flowers of *Polyalthia longifolia* Var. *Pendula.Natural product communications* 4(3):327-330.

Kabeh, J. D. and Lale, N. E. (2004). Effects of pre-harvest sprays of Neem (Azadirachta indica) seed products and pirimiphos-Methyl and harvest time modification on infestation by storage Bruchids in the field and store in Maiduguri, Nigeria. *Nigerian journal of Entomology* 22: 104 – 116

Kouninki, H., Haubruge, E., Noudjou, F. C., Lognnay, G., Malaisse, F., Ngassoum, M. B., Goudoum, A., Mapongmetsem, P. M., Ngamo, L. S. & Hance, T. (2007). Toxicity of some terpenoids of essential oils of *Xylopia aethiopica* from Cameroon against *Sitoplihus zeamais* Motschulsky. *Journal of Applied Entomology* 13(4): 269–274.

Langyintuo, A. S., Lowenberg-Deboer, J., Faye, M., Lambert, D. (2003). Cowpea demand and supply in West and Central Africa. *Field Crops Research* 82: 215-231

Lee, S. E., Lee, B. H., Choi, W. S., Park, B. S., Kim, J. G. & Campbell, B. C. (2001). Fumigant toxicity of volatile natural products from Korean spices and medicinal plants towards the rice weevil *Sitophilus oryzae* (L.). *Pest Management Science* 57: 548–553.

Madziga, H. A., Sanni, S. & Sandabe, U. K. (2010). Phytochemical and elemental analysis of Acalypha wilkesiana leaf. *Journal of American Science*. 6(11): 510-514

Nerio, L. S., Olivero, J & Stashenko, E. (2011). Repellent activities of essential oils: *A Review Bio Resources Technology* 101: 372 - 378.

Nta, A. I., Okweche, S. I., & Umoetok, S. B. (2018). Efficacy of three plants powders in the control of *Cylas puncticollis* (*Boheman*) (*coleopteran*: *curculionidae*) on sweet potato during storage. *Journal of African Entomology* 26(1):141-149.

Ogungbite, O. C., Odeyemi, O.O. & Ashamo, M. O. (2014). Powders of *Newboulder laevis* as protectants of cowpea seeds against infestation by *callosobruchus maculatus* (Fab) for poor resource farmers. *Octa journal of Bioscience* 2(1): 40-48

Ogunwemmo, K. O. Idowa, O. A., Innocent, C, Essan, E. B. & Oyelana, O. A. (2007). Cultivation of *codiaum variegatum* Blume (*Euphorbiacae*) show variability in phytochemical and cytological characteristics. *African journal of biotechnology* 6(2): 2400-2405.

Oni, M.O. (2019). Efficiency of *Acalypha wilkesians* leaf oil extract applied as a biocide against *Callosobruchus maculatus*. *Brazilian journal of biological science*, 6(12): 171-180.

Oni, M. O., Ogungbite, O. C., Oguntuase, S. O., Bamidele, O. S. & Ofuya, T. I. (2019). Inhibitory effects of oil extract of green Acalypha (Acalypha wilkesiana) on antioxidant and neurotransmitter enzymes in *Callosobruchus maculatus*. *The journal of Basis and Applied Zoology*. 80: 47

Oparaeke, A. M. And Kuhiep, G. C. (2006). Toxicity of powders from indigenous plants against *Sitophilus zeamais* Motsch. on stored grains. *Journal of Entomology* **3**: 216–221.

Pavela, R. (2011). Insecticidal and repellent activity of selected essential oils against the pollen beetle, Mengethes aeneus (Fabricius) adults. Industrial Crops and product 34: 888-892

Rayapaske, R. H. (2006). The potential of plants and plant products in stored insect pests' management. Journal of Agricultural Sciences 2(1): 11–21.

Sosan, M. B, Adewoyin, F. B, Adewunmi, C.O. (2001). Larvicidal properties of three indigenous plants oil on the mosquito *Aedes aegypti*. *Nig. J. Nat. And med* 05: 30-31.

Ukeh, D.A. (2009). Repellent effects of five *monoterpenoid* odurs against two stored products insects' pest. *Nigerian Journal of Entomology* 26: 11-19.

Ukeh, D. A. & Umoetok, S. B. (2011). Repellent effects of five monoterpenoid odours against *Tribolium casterneum* (F) in Calabar, Nigeria. Crop protection, 30: 1351-1355

Yangg, Z., Zhao, B., Zhu, L., Fang, J., Xia, L. (2006). Inhibitory effects of alkaloids from *Sophora alopecuroids* on feeding, development and reproduction of *Clostera anastomosis*. Front for China. 1(2): 190-195.

Zapata, N. and Smagghe, G. (2010). Repellency and toxicity of essential oils from the leaves and bark of *Laurelia sempervirens* and *Drinys winteri* against *Tribolium casteneum*. *Scientific Journal of Biosciences* 32: 405-410.

AGRITOURISM: UNLOCKING A WORTHWHILE VENTURE IN NIGERIA

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Abstract

Agritourism, an intersection of agriculture and tourism, holds immense potential for Nigeria's economic diversification and rural development. Leveraging its rich agricultural landscapes and vibrant cultural heritage, Nigeria can harness agritourism to create jobs, preserve culture, and improve food security. However, the sector faces significant challenges, including inadequate infrastructure, limited awareness, and weak policy frameworks. This paper explores the potential of agritourism in Nigeria through a review of existing literature and case studies, offering strategic recommendations. Key proposals include sustainable practices, policy reforms, and the adoption of modern technologies to maximize agritourism's socio-economic and cultural benefits.

Key words: Agritourism, economic diversification, rural development, job creation, environmental preservation, Nigeria.

Introduction

Nigeria's economy, predominantly reliant on oil, remains highly vulnerable to market fluctuations, underscoring the urgent need for diversification. Agritourism offers a promising solution, blending the nation's abundant agricultural resources with its largely untapped tourism potential. By enabling visitors to engage in rural life, partake in farm activities, and enjoy traditional culinary experiences, agritourism fosters cultural exchange while driving economic growth.

Agritourism is a unique concept that combines agricultural and tourism sectors, offering tourists immersive experiences in rural settings while showcasing the agricultural heritage and traditions of a region. An agritourism venture integrates agriculture and tourism, offering visitors authentic farm experiences while supporting rural development and economic growth. Agritourism ventures, therefore, serve as catalysts for economic diversification, providing rural communities with opportunities to improve livelihoods, preserve cultural practices, and promote sustainable farming methods. Agritourism venture integrates agriculture and tourism, offering visitors authentic farm experiences while supporting rural development and economic growth.

Globally, agritourism has demonstrated its capacity to boost rural economies and preserve cultural practices. Successful examples from Kenya and South Africa illustrate its potential for creating rural employment, attracting tourists, and generating additional income for farmers. Nigeria has notable initiatives, such as the Songhai Farms network in states like Enugu, Delta, Rivers, Lagos, and Cross River, which serve as foundational models for agritourism development. This paper examines the challenges and opportunities of agritourism venture in Nigeria and presents actionable strategies to ensure its sustainable integration into the national economy.

Statement of the Problem

Despite its promise, agritourism in Nigeria is hindered by numerous challenges. Rural areas, the epicenter of agritourism activities, often lack essential infrastructure such as good roads, clean water, and reliable electricity. This limits accessibility for potential tourists. Additionally, limited awareness among farmers and rural communities about the economic and social benefits of agritourism discourages its adoption.

Policy gaps and inadequate government support further impede the sector's development. The disconnect between agriculture and tourism sectors leads to uncoordinated efforts, underutilizing cultural and ecological resources. Addressing these challenges requires strategic intervention, focusing on infrastructure development, awareness creation, and fostering collaborations among stakeholders.

Literature Review

Agritourism is increasingly recognized as a driver of rural development and cultural exchange. Studies such as Carpio et al. (2020) highlight its global potential, especially in developing economies, where it serves as a tool for poverty alleviation and environmental sustainability.
In Africa, countries like Kenya have successfully integrated agritourism into their tourism strategies, resulting in economic growth and increased rural investments (Mburu et al., 2022). Nigeria, with its agricultural abundance, is well-positioned to replicate such successes. Adesina et al. (2023) emphasize agritourism's potential to boost farmers' incomes while conserving traditional farming practices. However, poor infrastructure and policy inefficiencies remain significant barriers (Aniah, Obong & Uttah, 2016; Ekpo & Udom, 2021).

Emerging technologies, such as digital marketing and farm-to-table initiatives, present opportunities for expanding Nigeria's agritourism footprint (Okafor et al., 2024). Ogunleye and Olatunji (2023) stress the importance of capacity-building programs to bridge skill gaps and ensure effective stakeholder participation. A strategic, inclusive approach is vital for addressing these challenges and optimizing agritourism's benefits.

Methodology

A qualitative approach was adopted, drawing insights from academic journals and published policy documents. Comparative analysis of successful agritourism models in Kenya and South Africa provides a framework for identifying best practices. Additional literature from

government reports and case studies informed the proposed strategies, ensuring they are tailored to Nigeria's unique socio-economic, cultural context and environmental assets.

Findings and Discussion

Agritourism has the potential to drive sustainable economic diversification in Nigeria. Key benefits include job creation, cultural preservation, and enhanced agricultural productivity. For example, Songhai Farms, with its innovative blend of farming, tourism, and training activities, demonstrates the viability of agritourism as a transformative economic tool.

However, infrastructural deficits in rural areas remain a significant obstacle. Poor road networks and unreliable transportation hinder access to agritourism sites. Moreover, the lack of collaboration between the agriculture and tourism sectors limits the development of integrated agritourism experiences. Lessons from South Africa underscore the importance of awareness campaigns and capacity-building initiatives to bridge these gaps (Mburu et al., 2022).
Public-private partnerships (PPPs) and targeted policy interventions are critical for overcoming these challenges. Investments in infrastructure, skill development, and digital marketing could significantly enhance Nigeria's agritourism landscape.

Conclusion and Recommendations

Agritourism is more than an economic venture, it is a platform for cultural exchange, environmental conservation, and rural empowerment. By addressing infrastructural and policy-related barriers, Nigeria can unlock the full potential of its agritourism sector, integrating it as a cornerstone of national economic and rural development strategies.

Recommendations

To bridge the gaps in agritourism development, Federal, State, and Local governments in Nigeria, along with agriculturists and tourism practitioners, should:

1. Develop rural infrastructure by investing in roads, electricity, and water supply to improve rural accessibility and create a welcoming environment for tourists.
2. Establish supportive policies through formulating and implementing agritourism-focused policies emphasizing sustainability, local community involvement, and collaborative public-private partnerships.
3. Build stakeholder capacity by offering tailored workshops and skill-development programmes to empower farmers and rural communities with expertise to manage agritourism effectively.
1. Leverage digital platforms such as websites, mobile apps, and social media to market Nigeria's agritourism globally, increasing visibility and attracting diverse visitors.

References

Aniah, E. J., Obong, L. B. & Uttah, C. (2016). Urban agriculture and sustainable livelihoods in Calabar, Nigeria. *Multi-Disciplinary Journal of Research and Development Perspectives,* 5(2), 23-38.

Adesina, O., Olufemi, J., & Adebayo, K. (2023). Agritourism as a tool for economicdiversification in Nigeria. *African Journal of Tourism Studies*, 9(1), 34-47.

Carpio, C., Wohlegemuth, S., & Scott, J. (2020). Agritourism in developing economies: A review of opportunities and constraints. *Tourism Economics*, 26(2), 113-128.

Ekpo, M., & Udom, R. (2021). Policy challenges in agritourism development in Nigeria. *Journal of Sustainable Agriculture*, 15(4), 45-60.

Mburu, L., Kamau, E., & Mugo, J. (2022). Harnessing agritourism for rural development: Lessons from Kenya. *African Development Review*, 30(3), 212-228.

Ndubisi, C., & Obinna, O. (2021). Agritourism and food security in Africa: Opportunities and challenges. *International Journal of Agricultural Economics*, 8(5), 98-110.

Ogunleye, T., & Olatunji, B. (2023). Addressing capacity gaps in Nigeria's agritourism sector. *Nigerian Journal of Rural Development*, 12(1), 78-92.

Okafor, N., & Ibe, E. (2024). Digital innovation in promoting agritourism: A Nigerian perspective. *Journal of Tourism and Technology*, 11(2), 23-39.

WILDLIFE CONSERVATION IN CROSS RIVER STATE: AN ASSESSMENT OF TERRACING AND ANIMAL HUSBANDRY PRACTICES

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Abstract

This study is on wildlife conservation in Cross River State: An Assessment of terracing and animal husbandry practices. Two research questions and hypotheses were formulated to guide the study. The population of this study consist of all 73,755 farmers in Cross River State, Nigeria that are registered under the Agricultural Development Programmes across various Local Government Areas. Stratified and proportionate sampling was used for this study to select a total of two hundred and ninety-five (295) registered farmers with the Agricultural Development Programme in Cross River State. Terracing and Animal Husbandry Practices Questionnaire (TAHPQ) was used for data collection. The data were analysed with simple linear regression. The results revealed that terracing significantly contribute to wildlife conservation in Cross River State and there is a significant contribution of animal husbandry on wildlife conservation in Cross River State. Based on the findings and conclusion, it was recommended that policy makers and conservation stakeholders in Cross River State should prioritize and incentivize terracing practices among local communities and farmers, providing training and resources to enhance its adoption and effectiveness in wildlife conservation. And animal husbandry should be integrated into wildlife conservation strategies in Cross River State, with initiatives focused on sustainable livestock management, habitat preservation, and conflict mitigation between human and wildlife populations.

Keywords: Wildlife, Conservation, Assessment Terracing, Animal Husbandry Practices

Introduction

While wildlife has a wide array of benefits to society, economic benefits in many cases are perhaps the most emphasized as compared to the other benefits and uses (Soury, 2017). Its importance and benefits comprise its consumptive uses, non-consumptive uses and its intrinsic value; and may be summarized as follows: Its ecological role in biodiversity as a gene bank, as well as its significance as an integral part of the ecosystem, and component of the food chain; its use as a source of food and nutrition for humankind; its cultural and socio-economic uses;

its use in modern medicine and in folk medicine; its use for educational study and scientific research; as well as its intrinsic beauty and recreational use for viewing and photography.

Wildlife therefore is a valuable resource, with numerous benefits to society in terms of its contribution to the economy, ecosystem, nutrition, medicine, recreation, socio-cultural purposes, educational and scientific development. Despite these benefits however, it also imposes negative costs to societal life and livelihoods in terms of competition for resources (such as land and space), disruption of normal life, as well as direct damage to people and their property (predation and depredation) (Takon & Amalu, 2013). There are dangerous wild animals that are known to attack humans and cause them deaths and bodily harm, or attack livestock (sometimes fatally), damage crops and other property (movable and immovable) as well as public infrastructure. The menace of damage by these problem animals (nuisance wildlife) as well as its solutions have been extensively discussed by many authors (Godson, & Uchenna, 2021; Forestry Association of Nigeria, 2013).

Despite growing global conservation efforts, the rate of species extinctions continues to accelerate (Parrotta, 2011). Combatting wildlife loss is a "wicked" problem (Parrotta, 2011).) that is difficult to solve as it is often complex and requires collaborative, transdisciplinary solutions. Conservation disciplines have never been more challenged than they are today by the wickedness of interacting and sometimes synergistic drivers of wildlife loss (Chan & Mead, 2018).). Fatokum, Porawali, Sing, Kormata and Pamo (2016). went so far as to state "conservation is not rocket science; it is far more complex. The author equally stated that conservation practitioners must adopt multidisciplinary approaches that bridge not only academic disciplines but will also reach political and social realms (Fatokum, Porawali, Sing, Kormata & Pamo, 2016)

According to Enuoh and Bisong (2014), Cross River State had 17 forest reserves as at when Nigeria attained independence from her colonial masters and most of them are situated within the geographical location of the present study area which is Cross River State. The Forest Reserves (FR), where they are located and their sizes in terms of landmass are stated as follows – Afi River forest reserves (Boki – 383.32 km^2);some part of Agro-forest reserves (Akamkpa, Biase&Yakurr46.62 km^2); Boshi FR (Boki 41.44 km^2); Boshi Extension forest reserves(Boki – 67.34 km^2);Cross River North forest reserves (Etung – 129.50 km^2);Cross River South forest reserves (Etung&Ikom349.65 km^2); Ikom Fuel-wood Plantation (Ikom – 1.06 km^2); Ikrigonforest reserves (Ikom – 5.29 km^2); Okwangwo forest reserves (Boki 468.79 km^2), and the Ukpon River forest reserves (Obubra&Yakurr, 313.39 km^2).

It is important to state clearly from research reports that wildlife resources are exploited unsustainably in Cross River State without thinking about conserving these resources. Wildlife conversation is defined as actions taken in management of wildlife that result in maintenance of the possibilities for future forest related benefits (Wollenberg, Nawir, Uluk & Pramono, 2015). In principle, local people own the forest, but the management and control of forest, reserves, which cover around three quarter of forest area, is rested on the state governments (Status of tropical forest management, 2015). Before the colonial era the former eastern Nigeria

had successfully managed their forest resources with little or no threat to the environment. This was checked by using traditional institutions such as the family (kinship) religions, town unions, clubs, clan and kindred meetings among others. Participatory resource management is often seen as an appropriate solution to reducing resource degradation and it is generally assumed that it would ensure the equitable and sustainable use of environmental resources. Through local participation, nearby communities would be engaged as stakeholders in managing the resources thus ensuring commitment to long term management goals (Chukwuone, 2017). Wildlife conservation world over is changing from the traditional forest management approach with technical details and absolute concentration on trees, to managing the forest in a way that ensures greater benefit flow to all stakeholders especially the forest communities (Forest Association of Nigeria, 2013).

Terraces are created to intercept surface runoff, encourage it to infiltrate, evaporate or be diverted towards a predetermined and protected safe outlet at a controlled velocity to avoid soil erosion and this enables forest trees to be deep rooted in a way that it becomes difficult to have them fall. Terraces belong to the type of soil management practices that aim to protect an area against runoff by systematic land planning. The same accounts for storm water drains and permanent vegetation barriers (Sobral, 2010). Terracing refers to building a mechanical structure of a channel and a bank or a single terrace wall, such as an earthen ridge or a stone wall. Terracing reduces slope steepness and divides the slope into short gently sloping sections (Morgan, 2016). Terraces are created to intercept surface runoff, encourage it to infiltrate, evaporate or be diverted towards a predetermined and protected safe outlet at a controlled velocity to avoid soil erosion (USDA Soil Conservation Service, 1992; FAO, 2000). During an intense storm, a large part of the rainfall arriving at the soil surface infiltrates, depending on the soil type. The remainder becomes runoff, which concentrates in natural depressions and runs downhill until it reaches natural zones of deposition. If runoff increases, so does velocity, volume and erosive force. The critical runoff velocity, at which soil particles that have been detached from soil aggregates begin to be transported over the surface, is 5 m/s in sandy soils and 8 m/s in clay soils (Rufino, 2012; FAO, 2000).

Animal husbandry is the branch of agriculture concerned with animals that are raised for meat, fibre, milk, or other products. Domesticated livestock have been, and continue to be, subject to the interaction of natural and artificial selection. Livestock interfaces between human activities and the ecosystem, and are physical expressions of cultural heritage. Particularly in traditional systems, the economic performance of livestock is made more efficient, and sustainable, by the availability of a great diversity of local breeds (Hoffmann, 2013)

Animal husbandry adversely impact all major environmental media, including water, soil, and air. Key issues of concern for ecological and human health include the contamination of ground and surface water resources with nutrients, industrial and agricultural chemicals, and microorganisms such as viruses, bacteria, and parasites. Unsustainable use of freshwater for feed production, animal care, and slaughterhouses contributes to water scarcity and is depleting precious resources needed by future generations (Walker et al., 2015). Contamination of soil is another pervasive problem caused by the unsustainable, year-round deposition of excess

nutrients, chemicals, and pathogens on land in the vicinity of industrial feeding operations. Poor air quality results from the localized release of significant quantities of toxic gases and odorous substances, as well as particulates and bioaerosols containing a variety of microorganisms and human pathogens. Adverse ecological outcomes include excessive nutrient loading and euthrophication of surface waters resulting in oxygen-depleted dead zones in both inland and marine surface waters, recurring algal blooms, fish kills, and a decline in species populations and biodiversity. Livestock are fundamental to the sustainable conservation and practical management, through conservation grazing, of some of the most highly valued European landscapes. Particularly in high nature value pastures and marginal lands, livestock play key roles notably by maintaining semi natural ecosystems in conditions that favour important species, habitats and ecological interactions—in the terminology of ecosystems services, these are regulating functions

Theoretical background

Clarkson's anthropocentric theory (1967)

This theory was propounded by Clarkson (1967). Anthropocentrism is a philosophical perspective which expresses that individuals remain the focal significant groups on earth. This fundamental conviction is implanted in numerous beliefs and theories. The theory views people as different from other creatures and it is also believed that the life of man as a being is mostly respected whereas other creatures (faunas, floras, mineral assets, etc.) are assets that may reasonably be exploited for the advantage of mankind. In other words, the theory states that man is supreme in the environment, that the environment was created for man. Exponents of this view maintain that man has the right to exploit natural resources and use or convert it to his own needs. They also believe that the environment or natural resources can on their own take care of themselves without any conscious effort by man at protecting or conserving it. The anthropocentric worldview of nature quotes the Bible to justify the actions. They maintain that in the book of Genesis, when God created the world, he put man above all his creation and said to him "be fruitful and increase in number, fill the earth and subdue it, rule over the fish of the sea, birds of the air and over everything or creature that moves on the ground" (Oji, 2009). This belief has to a lager extent contributed to biodiversity depletion and has really affected government's effort toward biodiversity conservation.

The implication of this theory to the study lies in the premise that people do not feel guilty about their negative impacts on the environment and do not have the consciousness of protecting the environment and conserving forest resources because after all, it is a commandment given to them by God to survive from the environment. This further implies that people do not see their activities in the direction that it can contribute to environmental changes and forest resource depletion, thus, influencing forest resource conservation. To this reason, more effort through creation of awareness is needed to make man see the need to safeguard the environment and conserve the resources around them

Clarkson's anthropocentric theory, proposed in 1967, posits that organizations exist primarily to serve human needs, emphasizing the importance of considering stakeholder interests. This human-centered approach resonates with wildlife conservation's ultimate goal of preserving ecosystems for human well-being. Clarkson's theory recognizes interdependencies among stakeholders,

including local communities, farmers, and conservationists, highlighting the need for community-based conservation initiatives. By applying this theory, terracing and animal husbandry practices should prioritize stakeholder interests and needs, promoting human-wildlife coexistence. Ultimately, Clarkson's theory informs effective conservation strategies that balance human needs with environmental considerations, resolving conflicts through mutually beneficial solutions.

Statement of the problem

The effectiveness of wildlife conservation efforts in Cross River State is compromised by inadequate consideration of human activities, particularly terracing and animal husbandry, which are pivotal to the livelihoods of local communities. Despite their significance, the impact of these practices on wildlife conservation remains poorly understood, leading to potential conflicts between human needs and environmental preservation. The lack of clarity on the contributions of terracing and animal husbandry to wildlife conservation hinders the development of inclusive and sustainable strategies, ultimately threatening the long-term viability of conservation initiatives. This knowledge gap necessitates an in-depth examination of the relationship between these land-use practices and wildlife conservation, informing evidence-based policies that harmonize human activities with environmental protection..

Objective of the study

Specifically, the study seeks to:

1. find out the extent to which terracing contributes to wildlife conservation
2. ascertain the extent to which animal husbandry contribute to wildlife conservation

Research questions

The following research questions were posed to guide the study;

1. How does terracing contribute to wildlife conservation in Cross River State?
2. To what extent does animal husbandry contribute to conservation in Cross River State?

Statement of hypotheses

The following hypotheses were formulated to guide the study:

1. Terracing does no significantly contribute to wildlife conservation in Cross River State
2. There is no significant contribution of animal husbandry on wildlife conservation in Cross River State.

Methodology

Descriptive survey research design was used for the study. The research design studies situations as they exist at the time of a research. This research design is therefore considered appropriate for this study because it will allow the researcher to make use of a representative sample of the population from where generalization of the study result will be made. Stratified and proportionate sampling was used for this study to select a total of two hundred and ninety-five (295) registered farmers with the Agricultural Development Programme in Cross River State. Terracing and Animal Husbandry Practices Questionnaire (TAHPQ) was used for data collection. The data were analysed with simple linear regression. The data were analyzed at .05 level of significance 1 and 293 degrees of freedom'

Analyses and Results

Results

Hypotheses 1: Terracing does not significantly contribute to wildlife conservation in Cross River State. The result of the analysis is shown in Table 1.

TABLE 1: Summary of data and simple regression analysis on the contribution of terracing to wildlife conservation in Cross River State.

Model	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Regression	121.112	1	121.112	16.221	.000[a]
Residual	4578.780	293	6.817		
Total	4696.892	294			

Significant at .05 , adjusted R^2 of .107

The simple regression analysis in Table 1 showed the contribution of terracing to wildlife conservation in Cross River State which produced an adjusted R^2 of .107. This implies that only 10.7 percent of the variance of the dependent variable (wild life conservation) can be contributed by the independent variable (terracing). The F-value value of 16.221 of the Analysis of Variance (ANOVA) obtained from the regression table with a p-value .000 with 1 and 293 degrees of freedom at .05 level of significance showed that the null hypothesis was rejected. This result therefore signifies that Terracing does significantly contribute to wildlife conservation in Cross River State

Hypotheses 2: There is no significant contribution of animal husbandry on wildlife conservation in Cross River State. The result of the analysis is shown in Table 2.

TABLE 2: Summary of data and simple regression analysis on the contribution of animal husbandry to wildlife conservation in Cross River State.

Model	Sum of Squares	Df	Mean Square	F-ratio	Sig.
Regression	97.332	1	97.332	9.182	.021[a]
Residual	4599.560	293	5.0332		
Total	4696.892	294			

*Significant at .05, adjusted R^2 of .098

The simple regression analysis in Table 1 showed the contribution of animal husbandry to wildlife conservation in Cross River State produced an adjusted R^2 of .098. This implies that only 9.8 percent of the variance of the dependent variable (wild life conservation) can be contributed by the independent variable (animal husbandry). The F-value value of 9.182 of the Analysis of Variance (ANOVA) obtained from the regression table with a p-value .021 is significant at 1 and 293 degrees of freedom at .05 level of significance showed that the null hypothesis was rejected. This result therefore signifies that there is a significant contribution of animal husbandry on wildlife conservation in Cross River State

Discussion of findings

Data in Table 1 showed that Terracing does significantly contribute to wildlife conservation in Cross River State. This result is in tandem with Amna Sobral (2010) who stated that Terraces are created to intercept surface runoff, encourage it to infiltrate, evaporate or be diverted

towards a predetermined and protected safe outlet at a controlled velocity to avoid soil erosion and this enables forest trees to be deep rooted in a way that it becomes difficult to have them fall. Terraces belong to the type of soil management practices that aim to protect an area against runoff by systematic land planning. The same accounts for storm water drains and permanent vegetation barriers (Sobral, 2010). Terracing refers to building a mechanical structure of a channel and a bank or a single terrace wall, such as an earthen ridge or a stone wall. Terracing reduces slope steepness and divides the slope into short gently sloping sections (Morgan, 2016).

Data in Table 2 showed that there is no significant contribution of animal husbandry on wildlife conservation in Cross River State. This result conforms the study of Walker et al. (2015) sating that Animal husbandry adversely impact all major environmental media, including water, soil, and air. Key issues of concern for ecological and human health include the contamination of ground and surface water resources with nutrients, industrial and agricultural chemicals, and microorganisms such as viruses, bacteria, and parasites. Unsustainable use of freshwater for feed production, animal care, and slaughterhouses contributes to water scarcity and is depleting precious resources needed by future generations (Walker et al., 2015). According to the author contamination of soil is another pervasive problem caused by the unsustainable, year-round deposition of excess nutrients, chemicals, and pathogens on land in the vicinity of industrial feeding operations. Poor air quality results from the localized release of significant quantities of toxic gases and odorous substances, as well as particulates and bioacrosols containing a variety of microorganisms and human pathogens

Conclusion

In view of the findings of the study the study conclusively this study conclusively establishes that terracing and animal husbandry, two pivotal land-use practices in Cross River State, make significant contributions to wildlife conservation, underscoring the importance of integrating these activities into conservation strategies. By recognizing the positive impact of terracing and animal husbandry on wildlife conservation, policymakers and stakeholders can develop more effective, inclusive, and sustainable conservation initiatives that balance human livelihoods with environmental protection in Cross River State..

Recommendations

Based on the findings of the study, the following recommendations were given by the researcher

1. Policy makers and conservation stakeholders in Cross River State should prioritize and incentivize terracing practices among local communities and farmers, providing training and resources to enhance its adoption and effectiveness in wildlife conservation.
2. And animal husbandry should be integrated into wildlife conservation strategies in Cross River State, with initiatives focused on sustainable livestock management, habitat preservation, and conflict mitigation between human and wildlife populations.

REFERENCES

Chan, K. Y. & Mead, J. A. (2018). "Surface physical properties of a sandy loam soil under different tillage practices," *Australian Journal of Soil Research, 26* (3), 549–559.

Chukwuone, N.A. (2017). Analysis of conservation and utilization of non-wood forest products in Enugu and Cross River State; Implication for forest management and poverty alleviation. Unpublished PhD thesis: Department of Agricultural economics, University of Nigeria, Nsukka.

Enuoh, O. O. O. &Bisong, F. E. (2014). Global sustainable development agenda: an implication for conservation challenges in Cross River State, Nigeria. *Journal of Sustainable Development, 7*(4), 211-224

FAO, (2000). Manual on integrated soil management and conservation practices. FAO Land and Water Bulletin 8, Rome, Italy:.

Fatokum, C., Porawali, C., Sing, B., Kormata, P., Pamo, M. (2016). Challenges and opportunities for enhancing sustainable cowpea production. *Proceedings of the World Cowpea Conference 111 held in International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria*, 301-318.

Forestry Association of Nigeria (2013). "Community forestry and stakeholders participation in sustainable development." *Proceeding of the 28th Annual conference of Forestry Association of Nigeria,* 16, 17.

Godson, C. A. &Uchenna, P. O. (2021). Bio-resources conservation and anthropogenic drivers of biodiversity depletion in IsialaNgwa, Southeastern, Nigeria. *International Journal of Physical and Human Geography, 9*(1), 25-35.

Morgan, R. P. C. (2016). Soil erosion and conservation. Longman Group UK Ltd., Essex: 295.

Parrotta, J.A., (2011).. Productivity, nutrient cycling, and succession in single-and mixed- species plantations of Casuarina equisetifolia, Eucalyptus robusta, and

Leucaena leucocephala in Puerto Rico. *Forest Ecology and Management,* 124(1): 45-77.

Rufino, R. L. (2012). Terraceamento. In: Manual Técnico do Subprograma de Manejo e Conservação do Solo, Curitiba. *Secretaria da Agricultura e do Abastecimento, Paraná,* 218-235

Soury A (2017). Sacred forests: a sustainable conservation strategy. The case of sacred forests in the Ouémé Valley, Benin. Netherland: Wageningen University

Takon, T. J. &Amalu, T. E. (2013).Assessment of natural resource conservation in Boki Local Government, Cross River State, Nigeria. *ESAIJ, 8*(4), 123-131

USDA Soil Conservation Service, (1980). Save soil with terraces. Des Moines.

Walter, M., Heber, S., Riedelbauch, S., Lien, J. L. & Muhlenberg, M. (2016). Estimates of Blue Duiker (*Cephalophusmonticola*) Densities from Diurnal and Nocturnal Line Transects in the Korup Region, South-Western Cameroon. *African Journal of Ecology, 44*, 290-292.

Wollenberg E. A. A., Nawir, A., Uluk & Pramono, H. (2015). Income is not enough: The effect of economic incentives on forest product conservation, CIFOR: Indonesia.

OPTIMIZING FOREST BIOMASS ESTIMATION FROM STAND FEATURES: A COST-EFFECTIVE APPROACH TO CLIMATE CHANGE MITIGATION IN CROSS RIVER STATE, NIGERIA

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ABSTRACT

The study estimated above ground biomass from stand features; diameter at breast height (DBH), height, density and specific wood density in a tropical forest of Cross River State. Forests biomass is recognized as a climate essential variable, hence understanding pertinent tree features in biomass accumulation will aid in climate change mitigation plans, monitoring, evaluation and reporting for effective carbon offset. In view of this, 72 nested plots of 20cm X 20cm were established in three delineated land cover types (Undisturbed, disturbed and cultivated land fields). DBH (1.3m) of trees of >50cm, 20cm-49cm and 19cm -5cm were inventoried in the 20m X 20m plots and subplots of 15m X 15m and 7m X 7m respectively while tree height was obtained using a Trupulse Creterion RD 100. Wood specific gravity was gotten from the literature. All the sample plots were geo-tagged using Global Positioning System with 3m accuracy. Descriptive statistics of mean, standard deviation, and coefficient of variability was used to analyse stand features variability while stepwise linear regression was used to determine the best predictors of forest biomass. The result revealed that plot based AGB, DBH, Height and tree density mean values are 121.72, 438, 06, 239.92, 6.85, and 12.15ha^{-1} respectively. AGB was highly variable as it recorded CV of 102.9ha^{-1} while tree density was the least variable stand feature. The overall regression model was statistically significant at 0.05, suggesting that the predictors (TD, H and SWD), collectively accounted for 82 % of the variation in forest biomass. Tree height surprisingly, was the best predictor of biomass. The study calls on the Cross River State Forestry Commission and other stakeholders to encourage enhancement in practices that will boost tree density and biomass accumulation as cost effective strategy to climate change mitigation.

Key words: Climate change mitigation, Forest biomass, food security, Cross River State, Stand features.

1. INTRODUCTION

Anthropogenic climate change is one of the fundamental contemporary environmental challenges face by mankind. The uncertainty on the onset and cessation of rainfall, excessive or scanty rainfall, prolong droughts, among others with the attendant widespread socioeconomic issues (Apraku et al., 2021) makes the direct need for climate mitigation action inevitable (Ortiz-bobea et al., 2021; IPPC, 2014). These environmental challenges are made

worst by other multiple stressors such as poor governance, poor infrastructures, and high prevalence of acute and relative poverty which in combination further intensify the burden of food insecurity in Africa (Madaki et al., 2023; Ajiere et al., 2020; Tume et al., 2019). More so, these marked environmental megatrends makes' climate mitigation action rightly plausible given that a large proportion of Nigerian rural populace like other African nations rely on agriculture as the main livelihood source (Apraku et al., 2021).

The uncertainty in weather and climate has led to a massive reduction in crop yield in Africa. Specifically, it is on record that the region has experienced a reduction in total agricultural productivity growth by 34 % since 1961, which is above the records of other regions (Ortiz-bobea et al., 2021). The high uncertainty, variability, and interconnectivity of the climate system and the associated impacts in the event of any extreme on food systems call for nature dependent strategies in reducing if not stopping climate change onslaught in the region. Forests are reckoned to be a low-carbon climate resilient and cost-effective strategy that can reduce the quantity of carbon dioxide in the environment and subsequently boost the agricultural productivity (Amuyou et al., 2022; Donkor & Mears, 2022).

The maintenance of forest structure is very relevant in mitigating global climate change. Forest structure which encompasses forest composition, forest spatial extent, trees dimension (height and girth size) among others are dynamic in nature, hence the changing carbon sequestration capacity of the forest with time (Amara et al., 2023; Pluton, 2017). In addition, forest structure is the most important indicator of biomass productivity and quality especially in mixed forest stands of the tropics (Aghababaei et al., 2020). The production and distribution of biomass vary with the forest type and components parts. For instance, Zhang et al. (2015) opined that net primary production of biomass through photosynthesis, and its subsequent allocation to new biomass leaves, branches, stems and roots, leads to the relational sharing of standing biomass carbon among these biomass parts. The growth of healthy trees leads to high forest biomass accumulation.

Extant studies have revealed that the quantity of tropical forests AGB is dominantly modulated by large size trees. Amara et al. (2023), Bordin et al. (2021), Bradford and Murphy (2019), conferred that trees with diameter at breast height (DBH) great than 70 meters (DBH>70 m) in the tropics stores large quantities of AGB. It was stated further that on average, such trees have capacity to store 44.5 % of AGB in Africa, 39.1 % in Southeast Asia and 25.1 % in South America. The huge AGB storage potentials of large tree sizes in the tropics confirm that the fact that such trees are keystone to global climate change mitigation, ecosystem productivity and sustainability.

More so, tree height is the other important structural characteristic in forest ecology and in the approximation of AGB though it accurate estimation in mixed dense tropical forest is often difficulty. Laurin et al. (2019) reported that tree height is pertinent in assessing tropical forests health status, productivity and it provides a clue on the right management strategy to adopt. The inclusion of tree height in the parametization of AGB estimation models has proven to boost the model results accuracy. Chave et al. (2019), Mensah et al. (2016), Feldpausch et al. (2012), Chave et al. (2005), posited that the inclusion of DBH and height as compound variables in the estimation of tropical forest AGB at plot level enhances its accuracy as tree biomass is partly a

function of tree volume, which in turn is fundamental to tree height, trunk taper and trunk basal area. On a nutshell, it has been opined that stand variables of tree size, basal area and wood specific gravity were observed to be strong predictor of spatial variation in AGB in the Amazonia forest (Baraloto et al., 2011). On the same vein, Agboola and Ovie (2022) contended that WSG is a proxy that is very useful in providing insight into the forests stature and functions of tropical tree species.

It is in view of this that it becomes imperative for the measurement of forests tree-by-dimensions for effective monitoring and as a means of ascertaining the available aboveground biomass and keeping track of any change. Moreover, AGB is touted to be the most important pool in the Clean Development Mechanism (CDM) within the Kyoto protocol, a key component in the REDD+ project, and achieving Intended Nationally Determined Contributions (Fararoda et al., 2024) and most importantly it is recognized as the most cost-effective natural strategy of global climate change impacts abatement (Fawzy et al., 2020). The quantification of biomass from stand parameters has become inevitable with the increasing reduction in the total carbon stocks attributable to anthropogenic factors especially in tropical Cross River State (Amuyou et al., 2022). Therefore, the estimation of plot level AGB at sub-regional scale is pertinent in reducing uncertainty in the total carbon stock per region and planning on the effective management of available stocks.

The aim of the study is to estimate the total aboveground biomass in the tropical forest of Cross River State, in southeast Nigeria. Specifically, the study focused in achieving the following objectives;

1. To carry out plot level measurement of stand structures of diameter at breast height, and tree height in predetermined plots in Cross River State.
2. To determine the implication of the spatial distribution of AGB and its climate change mitigation implications on food security in the study area.

2.0 Materials and Methods

2. 1 Study area

The study was carried out in Cross River State of Nigeria in West Africa (Figure 1). The region is located on latitude $4^0\ 34^I\ 59.99^{11}$ N and longitude $8^0\ 24^I\ 59.99^{11}$ E. It has an area of 20,156 sq. km. It is bounded in the north by Benue State and south by Akwa Ibom State and the Atlantic Ocean while in the east and west, the region shares boundary with the Republic of Cameroon, Ebonyi and Abia States respectively (UN-REDD+ Nigeria, 2018). In terms of land cover regionalization, the influence of Continental Tropical (cT), Maritime Tropical (mT) and the east west equatorial Easterlies delineate the region into three Agro-ecological zones; Southern, Central and Northern agroecological zones (Bulktrade, 1989).These broad regions have five different vegetation types: mangrove, swamp, tropical rain forest, montane vegetation, and savanna woodlands (UN-REDD+ Nigeria, 2018).

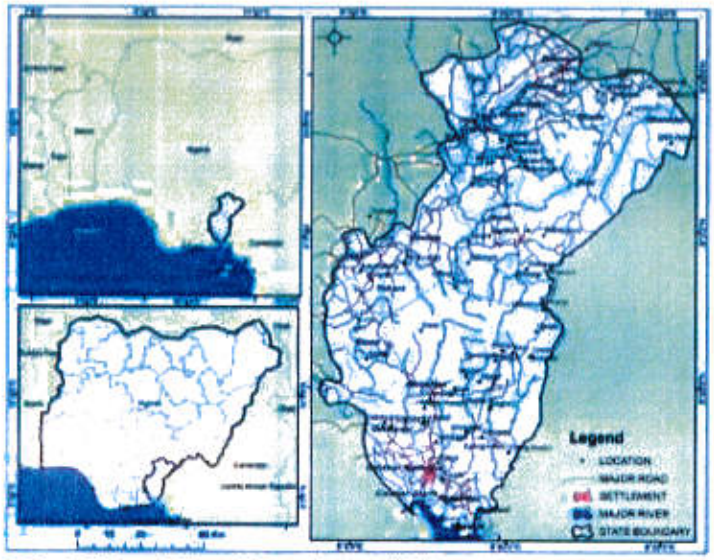

FIG. 1: Map of Cross River State with insert location in West Africa and Nigeria with sample plots locations overlaid (black dots).
Source: Culled from the Cross River State Forestry Commission (2019)

Rainfall in the CRS is bimodal with varying durations of sessions across the three agro-ecological zones (AEZs). The southern AEZ has a monsoon tropical climate with an annual mean rainfall of 3500 mm which sometimes peaked at 4000 mm around the Oban Massif (Jimoh et al., 2012). The mean annual air temperature of the zone averages around 27 ^{0} C with little variation throughout the year, and with humidity between 78 % and 91 % (Aigbe & Omokhua, 2015). In the central AEZ, the mean annual rainfall varies from 2300 mm to 3000 mm. The zone records mean annual air temperature ranging from 26.9 ^{0}C to 30 ^{0}C and the humidity of the zone in most parts of the year is about 68 % (Jimoh et al., 2012). In the northern AEZ, the savanna ecosystem is common with a mean annual rainfall of 1120 mm and air temperature ranging from 15 to 30 ^{0} C (NIMET, 2017). In the montane ecoregion of Obanliku Mountains within the northern AEZ, climatic conditions are markedly different from other parts of the region. Air temperature has a mean annual range of 4 ^{0} C to 10 ^{0} C. The terrain is rugged with hilly escarpments, steep valleys and mountains that peaked at about 1800 km^2 above sea levels with an elongation into the southwest region of Cameroons (Jimoh et al. 2012).

2.2 Methods

2.2.1 Forest Inventory Survey

A land cover map (Figure 2) developed by the Cross River State Forestry Commission (CRSFC 2019) was used in establishing the plots for tree parameters inventory. The study area delineated into; Undisturbed Forest (UF), Disturbed Forest (DF) and croplands based on the Cross River State Forestry Commission staff guide and with modification of Gautam and Mandal (2016) delineation.

The Global Positioning System (GPS) points of purposively chosen locations were overlaid on a map of the CRS across the land cover types identified for this study. Thereafter, GPS

coordinates of each chosen sample point were inserted into the GPS Garmin eTrex model (with accuracy of 3 meters), and on the ground, the Goto function was used to locate the plot for the inventory.

In all sample locations, entry point was through a known community (UN-REDD+ Nigeria, 2018). Accordingly, 29 plots were established in undisturbed land cover, 18 in disturbed land cover and 25 were established in croplands. It should be noted that chosen plots that were difficult to assess on account of geomorphic features like river, flooded streams, steep slopes, or security challenges like intercommunity or interstate clashes, resulted in other alternative locations being chosen.

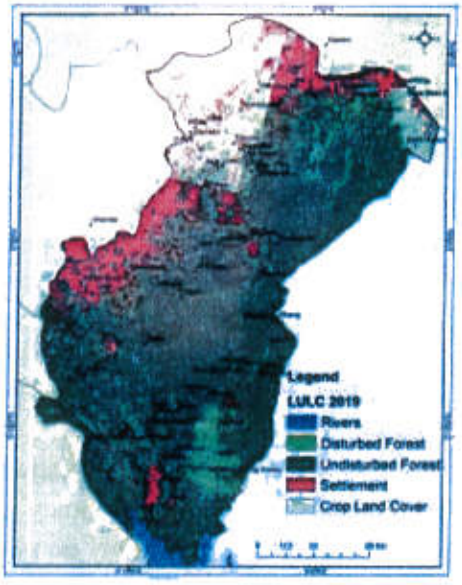

FIG. 1: Land use/cover map of Cross River State, Nigeria.

Source: Culled from the Cross River State Forestry Commission (2019).

In this study, 72 nested square plots of 20 m X 20 m were established. Trees of sizes >50 cm, 20 cm-50 cm and <20 cm diameter at breast height (1.3 m) were inventoried in the 20 m X 20 m plots and subplots of 15 m X 15 m and 7 m X 7 m respectively (UN-REDD+ Nigeria, 2015). In each of the 72 plots, all tree species were identified, numbered and DBH measured using a measuring tape and the total height was taken with Trupulse Criterion RD 1000. Given that the wood density of tropical trees species is erratic (Wieman & William, 2013), the study extracted wood density of each tree species identified from the African Wood density Database provided by the World Agro-forestry Centre (Chave et al., 2014; Carson et al., 2012) and the African Wood Density of the Food and Agricultural Organization (FAO, 1997). However, where the tree species wood density was not found in either of these databases, the mean wood density of the plot was used as the wood density of the tree species (UN-REDD+ Nigeria, 2015).

The allometric equation of Chave et al. (2014) was used to estimate the AGB of each tree in each forest inventory plots. Chave's allometric equation requires total height H (m), species wood density ρ (g/cm^{-3}) and diameter at breast height DBH (cm) to estimate tree-level AGB. Chave et al. AGB estimation equation is given as:

$$AGB_{est.}\ (kg) = 0.0673*(\rho*DBH^2*H)^{0.976} \quad (1)$$

The biomass of each tree within a plot was summed up to get the total biomass per 400 m^2 plot ($Plot_{AGB}$) in Kilogram (kg/m^2) (UN-REDD+ Nigeria, 2016). This is converted to tons per hectare.

2.2.2 Statistical analysis

The collected data were analysis in SPSS version 22. Descriptive statistics of mean, standard deviation and coefficient of variation (derived by dividing standard deviation by the mean value and multiplied by 100) was used to analysis the data. Inferential statistics of multiple regression formula in equation 2 below was used:

$$Y = b_0 + b_1x_1 + b_2+x_2 + \ldots b_nx_n+\varepsilon \quad (2)$$

Where; Y is the dependent variable, b_0 is the regression constant (intercept coefficient) which is usually the value of 'y' whenever 'x' is 0 and b

3.0 Result and Discussion

3.1 Summary statistics of stand features and aboveground biomass

The result of the summary statistics of the variables of interest is presented in Table 1. The table indicates that AGB has a minimum and maximum value of 3.00 and 588.25 tons/ha, a mean value of 121.72 tons/ha with standard deviation of 125.32 tons/ha and coefficient of variation of 109.9 tons/ha was obtained. It is imperative to note that plot level AGB estimate accuracy is very pertinent in the fight for climate change mitigation. The mean AGB of this study do not significantly vary from the mean values of 131 tons/ha from 90 plots obtained by Yam et al. (2024) in tropical forest of Nepal. However, it is imperative to note that the accuracy of plot based AGB estimate is dependent on the plot size. In our study, the plot size of 0.04 ha (20m X 20m) may not result in the very best of results as a recent study by Fararoda et al. (2024) in tropical Indian forest reveal that increasing a plot size from 0.04 t/ha to 0.5 t/ha boost AGB estimate accuracy as error margin reduces from 22 % to 5 %.

The minimum DBH is 39.70 cm, maximum values of 1208.70 cm was recorded while the mean and standard deviation of the DBH is 438.06 and 274.52 cm respectively. More so, table 1 revealed that minimum and maximum values of tree height are 15.60 meters respectively while the mean height value is 239.92 m and standard deviation is 183.96. More so, table 1 show that specific wood density has minimum value of 1.55 g/m^3, maximum value is 16.21 g/m^3 while the mean and standard deviation is 6.85 and 3.59 g/m^3 respectively. On the distribution of tree density per plot, table 1 indicates that minimum tree density per plot is 3 while maximum tree 26. More so, the mean tree density per plot is 12.15 and standard deviation is 5.46.

Table 1: Summary statistics of plot based measured stand structures and AGB

Variables	Minimum	Maximum	Mean	Standard deviation	CV
AGB (t/ha)	3.00	588.25	121.72	125.32	102.9

DBH (cm)	39.70	1208.70	438.06	274.52	62.66
Height (m)	15.60	782.50	239.92	183.96	76.7
Specific wood density	1.55	16.21	6.85	3.59	52.4
Tree density	3.0	26	12.15	5.46	44.9

Source: Analysis by authors (2024).

3.2 Stand features as predictors of AGB in tropical forest of Cross River State

Table 2 is the summary statistics of step wise multiple regression of the relation between plot AGB and selected stand features. The table revealed that the correlation coefficient (R^2) ranged between 0.79 to 0.82 whereas the Pearson's r varied 0.62 to 0.68. Among the variables entered, the integration of tree height, tree density and specific wood density have shown a better correlation (r=0.68, R2=82). It was evident that all the selected variables have a significant and positive correlation with AGB.

Unexpectedly, DBH was not a significant predictor of AGB in our study. However, this may not be unconnected to the fact that stepwise multi-linear regression has the weakness of not always selecting the best combination of variables while estimating the dependent variable (Del Serrone & Moretti, 2023). This may possible explain the elimination of DBH as a significant variable in the prediction of forest biomass in the study despite our efforts at ensuring all the variables entered meet the parametric condition for inclusion. Specifically, our study relied on the low variance inflation factor of 1.6, implying no serious collinearity problem was associated with our data.

3.3 Spatial distribution of AGB over CRS: implications for climate change mitigation for sustainable agriculture

The spatial distribution of AGB values over the CRS are presented in Figure 3. Over the CRS, high AGB is concentrated in two pockets: the southern eastern areas of the state (Oban area) and the north-eastern areas (Okwango area) coinciding with much of the CRS National Park. This area sees AGB above 200 t/ha and up to 500 t/ha. Areas around the Cross River to the south of the state, and scattered areas to the west of the state see AGB values of 150-350 t/ha. Areas to the far south, far west and north of the state have the lowest AGB below 100 t/ha.

Table 2: Summary of model statistics

Model	R	R^2	F-ratio	P. Value
1	0.790[a]	0.624	116.20	Significant
2	0.812[b]	0.660	66.92	Significant
3	0.828[c]	0.686	49.43	Significant

*predictors of model 1, 2 and 3 (Height, Height and specific wood density, Height, specific wood density and tree density)
Source: Compilation from the computer printout by the authors (2024).

The sustenance of high biomass estates (landscape) and enhancement of biomass scanty areas has been acknowledged to be an effective natural means of carbon sink and subsequent

reduction of emission volume in the atmosphere (Schmid et al., 2021). Using this natural strategy in climate change mitigation can aid in the amelioration of the series of environmental issues faced by Nigerians especially food insecurity. Nigeria like other African countries are at the epicentre of the 'perfect storm'; high incidence of food insecurity, high cost of energy, high inflation rate, increased tribal conflicts, ideological conflicts, and extreme weather (). These interlinked challenges tilt heavily in favour of food insecurity and sprawling poverty in the continent.

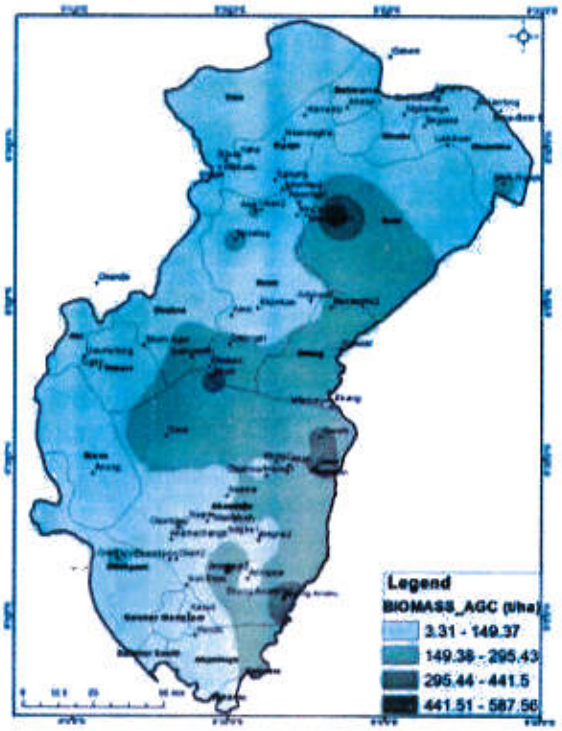

FIG. 3: Spatial distribution of AGB in the study area.

Source: Analysis by authors (2023).

Analysis of panel data revealed that in 2022, it was estimated that about 140 million Africans faced acute food insecurity, translating to one in five Africans sleeping without food (FAO, 2023) and by 2023, the number of people faced by food crisis jumped to 146 million (IFRC, 2024). The gloomy acute food insecurity scenario was attributed largely to climate change shocked (Anderegg et al., 2022). Today, smart forestry and agricultural land use (Schmid et al., 2021) options are available technologies that can be integrated to boost food production.

4. Conclusion and policy recommendations.

This study acknowledged the relevance of enhanced forest biomass to climate change impacts mitigation and emphasized the need to discourage farmers especially those in forest fringes from converting forest lands to farmlands. This is imperative given that protecting forests will increase the carbon sequestration potentials of forest lands, reverse climate change trend and improve weather and climate conditions to the benefit farmers.

To reduce the incessant conflicts between farmers and conservation authority, government should map out certain zones out of the conservation lands as food security corridors. This will mean government aid farmers in reclaiming barren lands through effective management such as cultivation of cash crops, improved varieties of staple food crops and vegetables. In addition, the Cross River State government should create a window of opportunity were surpluses can be sold for cash to meet other household needs. More so, the adoption of smart farming practices will help in reducing the 30 % greenhouse gases contributed by farmers globally (World Bank Group, 2024).

Reference

Aghababaei H., Ferraioli G., Ferro-Famil L., Huang Y., d'Alessandro M.M., Pas V., Schirinzi G., Tebaldini S., (2020). Forest SAR tomography: Principles and applications. IEEE Geosci. *Remote Sens. Mag.* 8, 30–45.

Agboola O.O. & Ovie, E.A. (2022). Specific gravity and carbon content of woody species in lowland moist forest and savanna vegetation of parts of Osun State, *Nigerian Journal of Botany*,35 (2), 173-189. dx.doi.org/10.4314/njbot.v35i2.8.

Aigbe H.I & Omokhua G.E. (2015). Tree species composition and diversity in Oban Forest Reserve, Nigeria. *Journal of Agricultural Studies;* 3(1) 10-24.

Amuyou U.A., Wang Y., Ebuta B.F., Iheaturu C.J. & Antonarakis A.S. (2022). Quantification of Above-Ground Biomass over the Cross-River State, Nigeria, Using Sentinel-2 Data. *Remote Sens.*, 14, 5741. https://doi.org/10.3390/ rs14225741

Anderegg W.R.L., Trugman A.T., Badgley G., Anderson C.M., Bartuska A., Ciais P., Cullenward D. et al. (2020). Climate-driven risks to the climate mitigation potential of forests. *Science*, 368(6497 Apraku A., Morton J.F. & Apraku G. B. (2021).Climate change and small-scale agriculture in Africa: Does indigenous knowledge matter? Insights from Kenya and South Africa. *Scientific African*, 12 (2022) e00821 https://doi.org/10.1016/j.sciaf.2021.e00821

Ajiere S., Nwaerema P., D., & Diagi B.E.(2020). Climate change anomalies and its prospects on agriculture in Cross Rivers State, Nigeria. *International Journal of Research and Innovation in Applied Science*, 5(IX), 13-17.

Amara E., Adhikari H., Mwamodenyi J.M., Pellikka P.K.E., & Heiskanen J. (2023). Contribution of tree size and species on Aboveground Biomass across land cover types in the Taita Hills, Southern Kenya. *Forests*, 14, 642. https:// doi.org/10.3390/f14030642.

Baraloto C., Suzanne R.Z., Molto Q., Blanc L., Fortunel C., Rault R., Vilak D., Italo M.K., Marcos R., Valderrama E., & Finek P. (2011). Disentangling stand and environmental correlates of aboveground biomass in Amazonian forests. *Global Change Biology*, 17, 2677–2688, doi: 10.1111/j.1365-2486.2011.02432.x

Bordin I.M., Muelbert A.E., Bergamin R.S., Muller S.C. et al. (2021).Climate and large-sized trees, but not diversity, drive above-ground biomass in subtropical forests. Forest *Ecology and Management*, 490, 119126. https://doi.org/10.1016/j.foreco.2021.119126

Bulktrade and Investment Company Limited (1989). *Soil and Land use Survey of Cross River State.* Main Report, Ministry of Agriculture and Natural Resources. Cross River State, Nigeria. p. 376.

Carsan S., Orwa C., Harwood C., Kindt R., Stroebel A., Neufeldt H. & Jamnadass R. (2012). *African Wood Density Database.* World Agroforestry Centre, Nairobi. Retrieved from http://www.worldagroforestry.org/output/african-wood-density-database on the 22/12/2023.

Chave, J. et. al. (2019). Ground data are essential for biomass remote sensing missions. *Surveys in Geophysics*. https://doi.org/10.1007/s10712-019-09528-w

Chave J., Andalo C., Brown S., Cairns M.A., Chambers J.Q., Eamus D., Folster, H., Fromard F., Higuchi N., Kira T., Lescure J.P., Nelson B.W., Ogawa H., Puig H., Riera B. & Yamakura T. (2005). Tree Allometry and Improved Estimation of Carbon Stocks and Balance in Tropical Forests. *Oecologia*, 145, 87-99. https://doi.org/10.1007/s00442-005-0100-x *Cross River State Forestry Commission Forestry Manual (CRSFC* 2019). *Unpublished.*

Donkor F. K., & Mearns K. (2022). Harnessing indigenous knowledge systems for enhanced climate change adaptation and governance: Perspectives from Sub-Saharan Africa. In E.E., Ebhuoma & L. Leonard (Eds.), *Indigenous Knowledge and Climate Governance*. Springer. https://doi.org/10.1007/978-3-030-99411-2_14

Fararoda P., Reddy R.S., Rajashekar G., Mayamanikandan T., Mutyala P., Satish KV., Wajeed S., P., & Jha C.J. (2024). Improving plot-level above ground biomass estimation in tropical Indian forests. *Ecological Informatics,* 81, 102621.

Fawzy S., · Ahmed I.O·, John D., & David W.R. (2020). Strategies for mitigation of climate change: a review. *Environmental Chemistry Letters*,18:2069–2094. https://doi.org/10.1007/s10311-020-01059-w

Feldpausch T.R., Lloyd J., Lewis S.L.& Brienen J.W. (2012). Tree height integrated into pantropical forest biomass estimates. *Biogeosciences.* 9, 3381–3403.

Food and Agricultural Organization (FAO 1997). *List of wood density for tree species from tropical America Africa, and Asia.* FAO Forestry paper 134.

Gautam T.P. & Mandal T.N. (2016). Effect of disturbance on biomass, production, and carbon dynamics in moist tropical forest of eastern Nepal. *Forest Ecosystems*, 3:11. DOI 10.1186/s40663-016-0070-y.

Intergovernmental Panel on Climate Change (IPCC, 2014). Climate change: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. In: Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press; 2014.

International Federation of Red Crescent (IFRC, 2024). African hunger crisis.

Jimoh S., Peter A. & Adeyemi A. (2012). Forest structure analysis in the Oban Division of Cross River National Park, Nigeria. *Journal of Agricultural Science and Technology*: B 2 510-518.

Laurin, G.V., Ding, J., Disney, M., Valentin, R. et al. (2019). Tree height in tropical forest as measured by different ground, proximal, and remote sensing instruments, and impacts on above ground biomass estimates. *International Journal of Applied Earth Observationa and Geoinformation*, 82, 101899. https://doi.org/10.1016/j.jag.2019.101899

Madaki M.Y., Muench S., Kaechele H., & Bavorova M. (2023). Climate change knowledge and perception among farming households in Nigeria. *Climate*, 11, 115. https://doi.org/10.3390/cli11060115.

Mensah S., Veldtman R., Toit B.B., Kakaï R.G., & Seifert R. (2016). Aboveground biomass and carbon in a South African Mistbelt Forest and the relationships with tree species diversity and forest structures. *Forests*, 7(79), 1-17.

NIMET (2017). Obudu weather outlook. Unpublished data.

Ploton P. (2017). Improving tropical forest aboveground biomass estimations: insights from canopy trees structure and spatial organization. *Biodiversity and Ecology*, Agro Paris Tech; Technische Universität (Dresde, Allemagne).

Ortiz-Bobea A., Ault T.R., Carrillo C.M., Chambers R.G., & Lobell D.B. (2021). Anthropogenic climate change has slowed global agricultural productivity growth. *Nature Climate Change*, *11*, 306–312. https://doi.org/10.1038/s41558-021-01000-1

Serrone G., & Moretti L. (2023). A stepwise regression to identify relevant variables affecting the environmental impacts of clinker production. *Journal of Cleaner Production*, 398, 136564. https://doi.org/10.1016/j.jclepro.2023.136564

Schmid B., Mosley F., Hassegawa M., Leskinen P & Johannes V.P. (2021). Forest-based bioeconomy and climate change mitigation. European Forest Institute

Tume J.P., Kimengsi J.N., & Zephania Z.N. (2019). Climate and Ecological Changes in the Bamenda Highlands of Cameroon: Insights from the Bui Plateau. *Climate*, 7(138), 1-18.

UN-REDD+ Nigeria (2015). *National Annual Program Report, Nigeria 2015*. January to December 2015. http://www.unredd.org/

UN-REDD+ Nigeria (2016). *Handbook for forest carbon inventory: Standard operation procedures*. 2016. Publication of the Cross River State Government, Nigeria.

UN REDD+ Nigeria (2018). *Forest Reference Emission Levels (FRELs) for the Federal Republic of Nigeria: A Jurisdictional Approach focused on Cross River State.*

Publication of the Federal Department of Forestry, Federal Ministry of Environment 2018.

Wiemann M.C. & Williamson G.B. (2013). *Biomass determination using wood specific gravity from increment Cores.* General Technical Report FPL–GTR–225, 2013. Publication of the United States Department of Agriculture.

World Bank Group (2024). World Bank responds to rising food insecurity. Retrieved from: food security | rising food insecurity.

Yam K.C., Liu Q., Saud P., Gaire D., & Adhikari H. (2024). Estimation of Above-Ground Forest Biomass in Nepal by the Use of Airborne LiDAR, and Forest Inventory Data. *Land*, 13, 213. https://doi.org/10.3390/land13020213

Zhang G., Zheng C.Y., Wang Y., Li Y.F. & Xin Y. (2015). Soil organic carbon and microbial community structure exhibit different responses to three land use types in the North China Plain. *Agric. Scand. Sect. B Soil Plant Sci.* 65, 341–349

EVALUATION OF PROPETIES OF SOIL DERIVED FROM SHALESTONE PARENT MATERIAL IN EKENKPON ODUKPANI LOCAL GOVERNEMNT AREA, CROSS RIVER STATE.

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ABSTRACT

Understanding the fertility levels of soils is critical for their management and productivity. Properties of shalestone soils in Ekenkpon Odukpani Local Government Area of Cross River State Nigeria were evaluated. Three profile pits were dug on a toposequence in the area and soil sampled were obtained for physicochemical analysis. The results showed that the texture ranged from loam, silt loam, sandy loam and silty clay loam. The soils had slightly acid pH. OC varied from low to moderate (<1.5-2.0). TN was low and ranged from 0.01 to 0.31% with mean value of 0.25% while available P was high in surface soils (>20 mg/kg) and moderate in subsoils (8-20 mg/kg) Exchangeable bases were high in the soils except Na and K that were low. The exchangeable acidity Al^{+} ranged from 0.0 to 2.72cmol/kg and H^{+} ranged from 0.32 to 2.12cmol/kg with mean value of 0.37cmol/kg and 15.96cmol/kg. ECEC was moderate (10-20 cmol/kg) while base saturation was low (<20 %). Copper, Mn, Zn and Fe had means of 1.93 and 2.72 mg/kg, 6.63 and 11.74 mg/kg, 10.23 and 11.67 mg/kg and 2.4 and 2.35 mg/kg in the surface and subsurface soil. Micronutrient decreased with profile depth and above critical limit. Organic matter buildup and fertilizer application are required to improve the fertility of the soils.

Keywords: shalestone, toposequence, fertility, micronutrient.

INTRODUCTION

Soil parent materials are considered as geological or organic precursors of soils. The compositions of parent materials have direct impact on physical, chemical, morphological, biological and mineralogical characteristics of soils (Brady and Weil 2013). In small regions with uniform climate, the nature of parent materials is probably more important than any other single factor of soil formation in determining the characteristics and productivity of a soil (Maniyunda*et al,* 2014). Shaley soils constitute the dominant soils in Odukpani Area of Cross River State, Southeastern Nigeria. Shale is a fine-grained, clastic sedimentary rock composed of mud that is a mixture of flakes of clay minerals and tiny fragments (silt-sized) comprising particles of other minerals, especially quartz and calcite (Blatt *et al,* 1996). Ojo-Atere *et al.* (2011) stated that shale is the most abundant sedimentary rock in all the continents. It is formed by the lithification of particles like mud and clay minerals. Abidemi (2016) posited that soils developed on shale constitute the dominant soil in Odukpani Local Government Area of Cross River State, Southeastern Nigeria. Provision of information about the properties including micronutrient concentrations of these shalestone soils is very critical for their utilization.

Micronutrients are nutrient elements needed by plants in small quantities (Mustapha *et al.*, 2021). These nutrients even though are used in small quantities by plants play critical roles in their nutrition and performance (Havin *et al.*, 2012) because their deficiency causes decrease in plant metabolic functions. This amongst other factors has necessitated recent consideration by agricultural sectors of different countries to include micronutrients in their fertilizer formulation programme. However, despite the importance of these nutrients in plant growth and development, they have not been well quantified in most soils of southern Nigeria especially in soils derived from shale parent materials in Cross River State. Berkhout *et al.* (2019 stated that micronutrients deficiencies in African soils are assuming alarming rates and may be responsible for the decline in yields and quality of crops. This has serious negative implication on the attainment of Sustainable Development Goals (SDGs) 2030 to end hunger, achieve food security, improve nutrition and promote sustainable agriculture in Africa (Ibia *et al.*, 2020).

Studying the physicochemical properties of soils developed on shale parent material is crucial for optimizing agricultural productivity. Since it could also be used to develop appropriate management strategies and best land use option to enhance soil productivity. Therefore, the objective of this study is to determine the physico-chemical properties and micronutrient elements of soils developed on shale parent material in Odukpani Local Government Area of Cross River State

2. MATERIALS AND METHODS

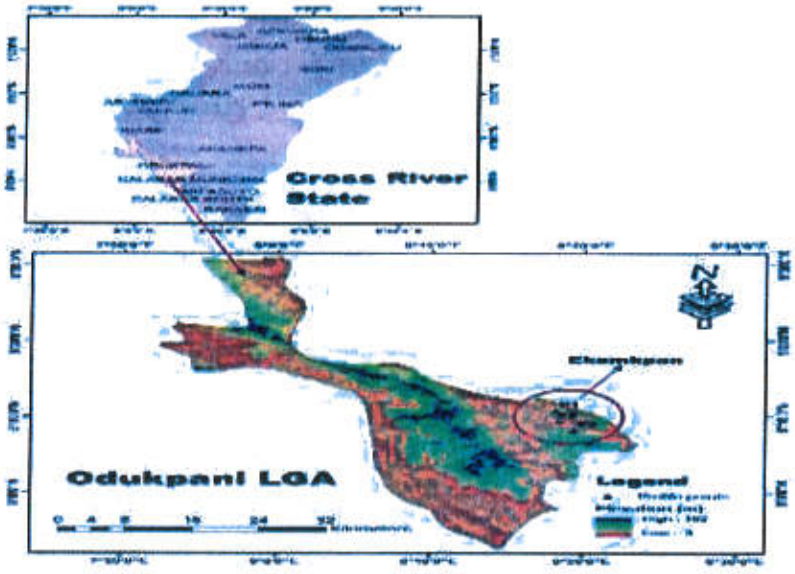
2.1 The study area

This study was carried out in Ekenkpon, Odukpani Local Government Area, Cross River State (Fig 1). The area lies at latitude 5°7'0'' N and longitude 8°20'0 E and has tropical humid climate with mean annual rainfall of 2650 mm. The area has two well-defined seasons; the rainy season which begins in April and ends in October and dry season which starts from November to March. The area has mean temperature and relative humidity of 26.3 °C and 85 %, respectively (Afu *et al.*, 2020). The geology of the study area is shalestone developed on the Odukpani formation of the Calabar flank (Bulktrade 1989).

Soil sample collection and preparation

Twelve profile samples were collected from three (3) profile pits dug along a toposequence in the study. Twelve undisturbed core samples were also collected for bulk density determination. The soil samples were properly bagged, labelled and transported to the laboratory for physicochemical and micronutrients determination.

Fig. 1: Map showing location of the study



Laboratory analysis

In the laboratory, soil samples were processed using standard procedures. Particle size distribution was determined by Bouyoucos hydrometer method as outlined by Gee and Or (2002). Soil pH was determined potentiometrically in a soil: water suspension (1:2.5) ratio using the procedure outlined by Udo *et al.* (2009). Organic carbon was determined by Walkley-Black wet oxidation method using potassium dichromate($K_2Cr_20_7$) method outlined by Nelson and Sommers (1996). Total nitrogen was determined using modified micro-Kjeldhal digestion method, while available phosphorus was determined using Bray P-1 procedures of Kuo (1996). Exchangeable cations were determined as outlined by Udo *et al.* (2009). Effective cation exchange capacity (ECEC) was obtained by summation of exchangeable bases and acidity whereas base saturation was obtained by expressing exchangeable bases as a percentage of ECEC. Bulk density was determined by the core method as described by Grossman and Reinsh (2002). Particle density was determined with the use of pycometer as described by Bowles (1992), while total porosity was determined by the calculation method. Micronutrients including; iron, zinc, copper and manganese were determined as outlined by Udo *et al.* (2009).

RESULTS AND DISCUSSION

Physical properties of the soils

The physical properties of the soils are presented in Table 1. The texture of the soils varied from loam to silty clay loam in the surface horizons and sandy loam to loam in the subsurface. Sand content ranged from 39.0 to 71.0% for the surface soil with mean value of 61.3% and 46.6% in the subsurface soils and decreased irregularly with depth in the crest, and increased irregularly with depth in the middle slope and valley bottom positions. The silt content had mean values of 26% and 29.6% in the surface and subsurface soils. Similarly, clay had averages of 12.7% and 23.9% for the surface and subsurface soils. In all the slope positions, clay content increased with soil depth, with comparatively higher contents in the valley bottom than in the crest and middle slope positions. This may be due to the transportation of clay materials from crest and middle slope and deposition at valley bottom via surficial erosion. The observations of this study are consistent with the report of Abam and Orji (2019) and Afu *et al.* (2020).

The bulk density (BD) of the study area ranged from 0.63 to 1.28g/cm^3 and 1.11 to 1.22g/cm^3 with mean values of 0.91g/cm^3 and 1.19g/cm^3 in the surface and subsurface soils, respectively. The result of the study revealed that BD increased irregularly with soil depth in all the slope positions with no indications of mechanical impedance to plant root. The observations of this study are in line with the finding of Ande *et al.* (2015) who reported BD range of 1.30 to 1.98g/cm^3 and 1.41 to 1.86g/cm^3 with mean values of 1.64g/cm^3 and 1.64g/cm3 in the surface and subsurface soils.

Furthermore, particle density (PD) had means of 2.5g/cm^3 and 2.20g/cm3 in the surface and subsurface soils. The result is in agreement with mean of 1.19g/cm^3 obtained in shale soils by Egbucha (2014). Total porosity (TP) had means of 63.63 and 45.94 % in the surface and subsurface soils, respectively and was higher in the crest than middle slope and valley bottom. This disagrees with the study of Sharu *et al.* (2013) on soils developed from shalestone in Dingyadi district of Sokoto state who obtained range of 25 to 40% with mean value of 33% in the surface soils. The silt/clay ratio had means of 2.1 and 1.3. Similar mean of 1.27 has been reported by Sharu *et al.* (2013).

Chemical properties of the soils

The results of chemical properties of the soils are given in Table 2. The values of soil pH were similar irrespective slope position and had means of 6.4 and 5.9 in surface and subsurface soils, respectively. These values indicate that soils are slightly acidic (5.5 – 7.0) on the scale of Foth (2006) and fall within the tolerant range for optimal growth and performance of arable crops according to Enwezor *et al.* (1990). The organic carbon content of the soils is low to moderate (<1.5-2.0) on the scale of Landon (1991). Low to moderate organic carbon (OC) may be due to warmer climate that facilitate organic matter decomposition.

Like OC, total nitrogen was higher in surface than subsurface soils and had mean values of 0.25 and 0.06% in the surface and subsurface soils, respectively. Based on the rating of Landon (1991), the total nitrogen was low in the surface soils and moderate in the subsurface soils. The available phosphorus was high in the surface soils with values that exceed 20 mg/kg, and moderate in the subsurface soils with values within 8-20 mg/kg (Landon, 1991). Exchangeable bases were high in the soils except Na and K that were low. Abah *et al.* (2016) also reported low exchangeable bases in their studies. Both H and Al ions contributed to the acidity of the soils, however Al ion was higher in concentration than H ion. Effective cation exchange capacity (ECEC) was moderate (10-20 cmol/kg), while base saturation was low (<20 %) (Landon, 1991). Moderate values of ECEC and low values of base saturation are suggestive of poorly fertile soils, and may require the addition of organic and inorganic soil amendments.

Table 1: Physical properties of soils developed in shale parent paterial in Ekenkpon Odukpani L.G.A

Profile description	% Sand	% Silt	% Clay	Textural class	Silt/Clay ratio	g/cm3 Bulk density	g/cm3	% particle density Total porosity
Crest								
Ap	57.0	31.0	12.0	L	2.6	0.93	2.14	56.5
Btl	49.0	37.0	14.0	L	2.6	1.12	2.17	48.4
Bt2	41.0	35.0	24.0	SL	1.5	1.22	2.29	46.7
Crt	39.0	27.0	34.0	SCL	0.8	1.31	2.0	34.5
Middle Slope								
AP	71.0	20.0	9.0	SL	2.2	0.63	2.1	70.0
Btl	54.0	27.0	19.0	L	1.4	1.13	2.24	49.6

Bt2	47.0	27.0	26.0	L	1.10	1. 11	2.28	51.3
Crt	42.0	33.0	25.0	SL	1.3	1.28	2.31	44.6
Valley bottom								
AP	56.0	27.0	17.0	L	1.6	1.16	3.26	64.4
Bt	54.0	21.0	25.0	L	0.8	1.14	2.13	46.5
Range	39.0 - 71.0	20.0-37	9.0-34.0		0.8-2.6	0.63-1.28	2.0-3.26	34.5-70.0
Surface Mean	61.3	26	12.7		2.1	0.91	2.5	63.63
SubSurface Mean	46.6	29.6	23.9		1.3	1.19	2.20	45.94

Keys: L - Loam
SL - Silt Loam SCL - Silty Clay Loam
SL - Sandy Loam

Extractable Micronutrients

The results of micronutrients of the study area are presented in Table 3. Micronutrients were higher in surface than in subsurface soils. These results further show that micronutrients were higher in the crest and middle slope than in the valley bottom. Copper, Mn, Zn and Fe had means of 1.93 and 2.72 mg/kg, 6.63 and 11.74 mg/kg, 10.23 and 11.67 mg/kg and 2.4 and 2.35 mg/kg in the surface and subsurface soils, respectively. These values are high compared to the ones reported in literatures by Ahukaemere *et al.*(2017), Ijah *et al.* (2024) and Babalola *et al.* (2011). However, Mustapha (2021) obtained Mn range of 15.40 to 92.73 mg/kg with mean of 31.75 mg/kg in Ultisols of northern Nigeria which is quite higher than values obtained in this study. The results obtained for Zn in this study are high compared to Zn and exceed the critical limit of > 1.5 mg/kg by Reddy *et al.* (2017) and >2.4 mg/kg by Wani *et al.* (2013).

Table 2: Chemical Properties of Soils Developed in Shale Parent Material in Ekenkpon Odukpani L.G.A

Horizontal Designation	Depth (cm)	pH	OC	TN	Mg/Kg Avail. P	Cmol/kg Ca	Cmol/kg Mg	Cmol/kg K	Cmol/kg Na^+	Cmol/kg Al^{3+}	Cmol/kg H+	Cmol/kg ECEC	Cmol/kg CEC	B.S
	Pedon 1													
ApBtl	0-11	6.0	3.61	0.31	14.50	7.8	4.0	0.12	0.10	0.24	0.84	13.10	70.0	17.1
	11-34	5.9	1.58	0.14	0.87	4.8	4.6	0.09	0.07	0.0	2.12	11.68	68.0	14.0
Bt2	34-71	6.8	0.62	0.05	9.50	17.8	5.8	0.13	0.10	0.0	0.56	24.39	82.0	29.0
Crt	71-120	5.9	0.12	0.01	0.50	4.0	3.2	0,08	0.06	2.44	0.44	10.22	72.0	10.1
	Pedon 2													
ApBtl	0-22	6.8	2.83	0.24	67.75	9.8	7.2	0.12	0.10	0.48	0.32	18.02	97.0	17.7
	22-40	5.9	0.52	0.04	21.62	4.2	1.4	0.09	0.07	1.48	0.40	7.64	83.0	6.9
Bt2	40-75	5.6	0.54	0.04	36.25	2.2	1.0	0.08	0.06	2.0	0.32	5.66	79.0	4.2
Crt	75-136	5.2	0.26	0.01	13.62	2.4	2.8	0.09	0.07	2.72	0.40	8.78	71.0	7.5
	Pedon 3													
ApBt	0-20	6.4	2.47	0.21	19.00	8.6	7.2	0.14	0.11	0.40	0.32	16.77	72.0	22.2
	20-40	5.9	1.46	0.12	15.50	8.2	2.6	0.13	0.00	1.04	0.80	12.87	59.0	18.6
	Range	5.2-6.8	0.12-3.61	0.01-0.31	0.50-67.75	2.2-17.8	1.0-7.2	0.09-0.14	0.06-0.11	0.0-2.72	0.37 0.32-2.12	5.66-24.39	59.0-97.0	4.2-29.0
	Surface mean	6.4	2,97	0.25	33.75	8.73	6,13	0.13	0.10		0.49	15.96	79.67	19
	Subsurface mean	5.89	0.73	0.06	13.98	6.23	3.06	0.10	0.08	1.38	0.72	11.61	73.43	11.9

Legends: OC – Organic Carbon TN - Total Nitrogen Avail.P – Available Phosphorus Ca - Calcuim Mg - Magnesium K - Potassium Na – Sodium Al – Aluminum H – Hydrogen ECEC - Effective Cation Exchange Capacity
CEC - Cation Exchange Capacity BS - Base Saturation

Table 3: Micro Nutrient Elements

Horizon	Depth (cm)	Cu	Mn (Mg/kg)	Zn	Fe
	Pedon 1				
Ap	0-11	2.2	1.4	23.7	3.6
Btl	11-34	1.4	1.4	18.7	1.4
Bt2	34-71	6.4	25.1	19.4	5.0
Crt	71-120	2.9	20.4	7.9	2.2
	Pedon 2				
Ap	0-22	1.4	10.1	5.6	1.4
Btl	22-40	1.4	2.3	5.6	1.4

Bt2	40-75	2.90	20.20	12.9	2.2
Crt	75-136	2.70	11.40	9.3	2.9
	Pedon 3				
Ap	0-20	2.20	8.40	1.4	2.2
Bt	20-40	1.40	1.40	7.9	1.4
	Range	1.4-6.4	1.40-25.1	1.4-23.7	1.4-5.0
	Surface mean	1.93	6.63	10.23	2.4
	Subsurface mean	2.72	11.74	11.67	2.35

Legend: Cu – Copper Mn - Manganese Zn - Zinc Fe - Iron

SUMMARY AND RECOMMENDATION

The texture of the soils varied from loam to silty clay loam in the surface horizons and sandy loam to loam in the subsurface. Sand fraction dominated the soil separate and was higher in surface than in subsurface soils, however, clay was higher in the valley botton than crest and middle slope positions. The result of the study revealed that bulk density increased irregularly with depth in all the slope positions and the soils have no mechanical impedance to plant root. The soils had slightly acid pH (5.5 – 7.0) and fall within the tolerant range for optimal growth and performance of arable crops, low to moderate organic carbon, total nitrogen, high available phosphorus, high Mg and Ca, but low K, Na, base saturation and moderate ECEC. Furthermore, micronutrient concentrations were above critical limits in the soils.

This study recommends that practices such as bush fallowing, crop residue incorporation into the soil after harvest, mulching, organic matter application and use of nitrogen and potassium fertilizers should be encouraged to boost organic matter, nitrogen and potassium levels and overall fertility status of the soils. When these interventions are to be carried out, more attention should be given to crest and middle slope positions than valley bottom soils since it was revealed that valley bottom is higher in some fertility indices.

REFERENCES

Afu, S.M., Olim, D.M.,Akpa, E.A. and Nwangwu, B.C. (2020) Fertility status of soils developed on shale and sandstone parent materials in Odukpani Local Government Area of Cross River State, Nigeria. Proceeding of the 44th annual conference of SSSN, 9-14

Abam, P.O. and Orji, A.O. (2019). Morphological and physicochemical properties of soils formed from diverse parent materials in Cross River State, Nigeria. IOSR Journal of Applied Geology and Geophysics.7(1):1-7

Abidemi, O. I (2016). Occurrence of shale soils along the Calabar Itu Highway, Southeastern Nigeria and their implication for the Subgrade Construction. Retrieved 2nd November, 2016 from https://www.ncbi.mm.nih.aov/pinc/ articlespmc 4770003.

Ahukaemere, C.M., Donald, N.O and Bernardine, N.N (2017). Horizon differences in Micronutrient Contents of soils of the coastal plain sands in Imo state, South-east Nigeria, Micronutrient Contents of pedons formed under coastal plain sands -*Bulgarian Journal of soil science*., 2(2).

Ande, 0. T., Are, K.S., Adeyolanu O.D., Ojo, O.A., Oke, A., Adelana, A., Adetayo, A.A & Oluwatosin, G.A (2015). Morpho-genetic characterization of floodplain soils in North central Nigeria. *Nigeria Journal of Soil Science*. 26,133-137.

Berkhout, E.D., Malan, M. and Kram, T. (2019). Better soils for healthier lives? An econometric assessment of the link between soil nutrients and malnutrition in SubSaharan Africa. PLoS ONE, e0210642.https://doi.org/10.1371/journal.ponc.0210642

Blatt, Harvey and Robert J. Tracy (1996) petrology: igneous, sedimentary and metamorphic, 2nd Ed., Freeman. 281-292 ISBN 0-7167-2438-3.

Bowles, J.E(1992). Engineering properties of soil and their measurement 4th (Ed): McGraw Hills, Boston, Inc.

Brady N.C and Weil R.R (2007). The nature and properties of soil. Pearson Education INC. and Darling kindersley publishing. (56,857).

Brady, N. C. and Weil, R. C. (2013). The nature and properties of soils. 14th Edition. New Delhi: Pearson Education, INC.123

Egbucha, C. N (2014). Morphological and physical characteristics of soils developed on a Toposequence derived from Coarse-grained pegmatites in a Tropical Region, Delta State, Nigeria. *Asian Journal of Agriculture and Rural Development.* Vol.4 (5). 6-11.

Enwezor, W. O., Ohiri, A.C., Opuwaribo, E.E.and Udo, J.E. (1990). Literature Review on Soil Fertility Investigation in Nigeria, Federal Ministry of Agriculture and Natural Resources, Lagos.

Foth, H.D. (2006). Fundamentals of soil science. 8Ed. John Wiley and Sons. New York.

Gee, G.W. and Or, D.(2002).Particle size analysis. In: Methods of Soil Analysis, Dane, J.H and G.C Topp (Eds.) Part 4. Physical Methods, Soils Science Amer. Book Series 5, ASA and SSSA, Madison, Wiscousin. 255-293.

Havin, J.L., Beaton, J. D., Tisdale, S. L and Nelson, W.L. (2012). Soil fertility and fertilizers: An introduction to nutrient management. 7thedition. PHI Private Limited, New Delhi- 110001, 513.

Ibia, T.O., Chude, V.O., Nafiu, A. and Essien, G.N. (2020). Importance of micronutrients in agriculture in Africa and their impacts on health: A review. *Journal of Agriculture and Environment.*16(1):155-172

Landon, J. R. (1991). Booker Tropical Soil Manual. A handbook for soil survey and agricultural land evaluation in the tropics and sub tropics. John Wiley and Sons, New York. 474.

Maniyunda L. m., Raji, B. A., Odunze, A. C. and Malgwi W. B. (2014). Geochemistry of Local elementary oxides on a lithosequence in Kaduna state Nigeria. *Nigeria Journal of Soil Science* Vol.24 (1), Pp 30-31.

Murphy J, and Riley JR. (1992). A modified single solution method for the determination of phosphorus in natural waters. *An. Chem. Acta*. 1962;27:31-36.

Mustapha, A.A. (2021). Status and Distribution of Micronutrients in Selected Soil Orders of the Northern Savannah Region of Nigeria. *Journal of Agricultural Economics, Environment and Social Science* 7(1):189-201.

Nelson, D.W. and Sommers, L.E. (1996). Total carbon, organic carbon and organic matter. In D.L. Sparks (Eds.) Methods of Soil Analysis. Part 3. Chemical Methods. SSSA Book Ser. 5. SSSA. Madison, WI. 1996;961-1010.

Ojo-Atere, J. 0., Ogunwale, J. A and Oluwatosin, G. A. (2011). Fundamentals of Tropical soil science. Ibadan: Evans brothers publishers Limited Pp 91-100.

Reddy, T.P., Lakshmi, V., Kamalakar, J. and Rao, C.S. (2017). Critical levels of micro and secondary nutrients in soils and crops for optimum plant nutrition. *International Journal of Scientific Research*, 6(5):2277-8179

Sharu, M.B., Yakubu, M., Noma, S.S &Tsafe, A.I (2013). Characterization and classification of soils on an Agricultural Landscape in Dingyadi District, Sokoto state, *Nigeria Journal of Basic and Applied Science*. 21(2). 5-11.

Udo EJ, Ibia TO, Ogunwale JO, Ano AO, & Esu I. Manual of soil, plant and water analysis. Lagos: Sibon Books Limited; 2009.

Udoh, E. J., Udom, G. N., Udo, E. S., & Ibanga, E. J. (2016). Variability and distribution of soil nutrients and heavy metals in old and new palm oil estates in Southeastern Nigeria-Applied and environmental soil science, 2016, 1-6.

Wani, M.A., Wani, J. A., Bhat, M. A., Kirmani, N. A., Wani, Z.M. & Bhat, S.N. (2013). Mapping of Soil Micronutrients in Kashmir Agricultural Landscape Using Ordinary Kriging and Indicator Approach. *J Indian Soc Remote Sens*, 41(2):319–329

FATTY ACID COMPOSITION, pH AND WATER HOLDING CAPACITY OF BROILER CHICKEN FED DIETS CONTAINING GRADED LEVELS OF BLACK SOLDIER FLY LARVAE (*HERNETIA ILLUCENS*)

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ABSTRACT
The objective of the study was to evaluate the effect of dietary supplementation of Black Soldier Fly Larvae (Hernetia illucens) meal on the fatty acid content, water holding capacity and pH of broiler chickens. The study was carried out in the Poultry Unit of the Teaching and Research Farm, University of Calabar, Calabar. A total of one hundred and twenty (120), day-old broiler chicks of Ross 308 Strain, were used in this study. The chicks were divided into 4 groups of 30 chickens. Each group was replicated 3 times with 10 chicks per replicate. Each was randomly assigned to the four (4) dietary treatments containing 0% BSFL, 25 % BSFL, 50 % BSFL and 75% of BSFL as T1, T2, T3 and T4, respectively in a Completely Randomized Design (CRD). The birds were fed starter and finisher diets respectively. Meat samples were collected from the chicken breast upon slaughter, which were taken to the lab for analysis of fatty acid content, Water holding capacity (WHC) and the pH levels. Data obtained were subjected to one way analysis of variance, where significant (P<0.05) mean were separated using Duncan's Multiply Range Test. The result of fatty acid showed that palmitic acid was not significantly (P>0.05) influenced by BSFL meal. However, oleic and linoleic acid were significantly (P<0.05) influenced by the BSFL meal. Also, the water holding capacity and pH were not significantly (p>0.05) influenced by the dietary treatments. The results suggested that at 25% level, BSFL meal can successfully substitute SBM in feed formulation without any adverse effect on broiler chickens and meat physicochemical qualities.

INTRODUCTION
Nutrition is one of the most critical challenges faced by many livestock producers in Nigeria, due to high cost of feed and unavailability of some essential feed materials within a particular region. The growing global demand for poultry meat has led to the exploration of alternative, sustainable feed sources to replace traditional feed ingredients, such as soybean meal and fishmeal, which are often expensive and environmentally taxing (Newton *et al.*, 2021). One such alternative is the use of *Hermetia illucens* (Black Soldier Fly, BSF) larvae, which can be produced from organic waste and has high nutritional value. BSF larvae are rich in protein and fat, making them an attractive source for poultry feed formulation (Spranghers *et al.*, 2017).
According to (Smith 2020) Broiler chickens are a type of poultry specifically bred for meat production. Unlike layers, which are raised primarily for egg production, broilers are bred for rapid growth, convert feed into body weight efficiency, and tender meat. They are usually raised in large-scale, controlled environments to maximize their growth potential.

The use of insects as an alternative protein or energy source in poultry nutrition has been frequently studied, mostly with satisfactory results (Kiero´nczyk *et al.*, 2022). Under experimental conditions, mainly full-fat or defatted insect meals are provided in animal diets, overlooking that the lipid content is the second most abundant nutrient in the invertebrate body, reaching up to 47% on a dry matter (DM) basis (Benzertiha *et al.* 2020). The use of BSF larvae fat alone or in combination with soybean oil does not impair the growth performance of broiler

chickens (Gasco *et al.*, 2018), turkeys (Kiero´nczyk *et al.*, 2022). or laying hen (Gasco *et al.*, 2020).

However, limited attention has been given to specific meat quality parameters such as fatty acid composition, pH, and water holding capacity (WHC) factors that are critical in determining the nutritional value, taste, and shelf life of broiler meat (Bose *et al.*, 2019).

Fatty acid composition is particularly important, as it influences the health benefits and stability of meat during storage. Diets rich in BSF larvae may alter the fatty acid profile of the meat due to the larvae's unique fat content, which is high in lauric acid (Makkar *et al.*, 2014). In addition, pH levels of meat affect tenderness and water holding capacity, which in turn influence the juiciness and overall eating quality of the meat (Kim *et al.*,2018). Understanding these parameters is crucial for assessing the suitability of BSF larvae as a sustainable feed option in broiler production.

MATERIALS AND METHODS

The study was carried out at the Poultry Unit of the Teaching and Research Farm, while the laboratory analysis was conducted at the Department of Animal Science Laboratory, University of Calabar, Calabar, Cross River State.

The experiment was performed on 120 Ross 308 broiler chickens over a period of Eight weeks. The birds were housed in an experimental facility at the Department of Animal Science, University of Calabar, Calabar, Nigeria. For optimal room temperature for the chicks, the facility was equipped with mechanical ventilation and artificial lighting (a photoperiod of 6 h dark and 18h light). Heat lamps were used during the first three weeks for optimal temperature regulation. The chickens were vaccinated against Newcastle disease, Marek's disease, avian infectious bronchitis and coccidiosis. The chickens were transported to the experimental facility and placed in pens measuring 1.00- 1.30m. The pens were bedded with straw pellets and equipped with drinkers and feeders. Birds were randomly divided into four groups-dietary treatments (4 pens/treatment and 10 birds/pen) in order to determine the effect of Black Soldier Fly (*Hermetia illucens*) Larvae Meal (BSFLM) sourced from a local farmer in Calabar, Cross River State. Control group chickens were fed diets without BSFLM 0% (T_1), whereas birds in three experimental groups received diets where SBM protein was replaced with BSFLM in the amount of 25% (T_2), 50% (T_3) and 75% (T_4). The ingredients, chemical composition and energy value of starter and finisher diets fed to broiler chickens are presented on Tables 1 and 2.

Determination of the Proximate Composition Experimental Diets and BSFLM

The proximate analysis typically includes the determination of moisture, crude protein, crude fat, crude fibre, ash, and nitrogen-free extract. The proximate fraction of experimental diets and BSFLM were determined by standard methods (AOAC,2016).

Sample Collection

At the end of the feeding trials, three birds per treatment were randomly selected, fasted for 12 hours and individually exsanguinated by slashing the jugular vein. The birds were allowed to bleed thoroughly followed by defeathering in water of about 70 to 80°C temperature for about one minute. The Carcass were eviscerated through the vent, dressed bird were thereafter cut into different parts and the meat muscle were obtained from the breast part using shape knife.

Table 1: Gross Composition of the broiler starter diet

Ingredients	T_1 (0%)	T_2 (25%)	T_3 (50%)	T_4 (75%)
Yellow maize	50.00	50.00	50.00	50.00
Soybeans meal	30.00	22.50	15.00	7.50
BSFM	00.00	7.50	15.00	22.50
Cray fish	5.00	5.00	5.00	5.00
Wheat offal	7.00	7.00	7.00	7.00
Brewers Dried Grain	2.00	2.00	2.00	2.00
Bone meal	2.50	2.50	2.50	2.50
Limestone	1.00	1.00	1.00	1.00
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Toxin Binder	0.50	0.50	0.50	0.50
Palm Oil	1.00	1.00	1.00	1.00
Total	100	100	100	100
%CP	23.22	22.90	22.57	22.25
%CF	3.29	3.49	3.70	3.90
ME(kcal/kg)	2,856.08	2,739.63	2,623.18	2,506.73

Bio: Supreme Broiler Premix Vitamin A-12,000000I.U, VitD3–3,0000001.U, VitE-30,000mg, Vit.k3–2500mg, FolicAcid–100mg, Niacin–40,000mg, Calpan-10.000mg, Vit.B250,000mg, vit.B12-20mg,VitB12000mg, Vit.B6-3500mg, Biotin–80mg Antioxidant-125,00mg, Cobalt-250mg, selenium–250mg, Iodine-1200mg, Iron 40000mg, Manganese-70,000mg, Copper-8,000mg, Zinc-60,000mg, Choline chlorides200,00omg.Manufactured by Animal Care Services Konsuit (Nigeria). LTD.

Table 2: Gross Composition of broiler finisher diet

Ingredients	T_1 (0%)	T_2 (25%)	T_3 (50%)	T_4 (75%)
Yellow maize	48.00	48.00	48.00	50.00
Soybeans meal	25.00	18.75	12.50	6.25
BSFM	0.00	6.25	12.50	18.75
Cray fish	2.00	2.00	2.00	2.00
Wheat offal	9.00	9.00	9.00	9.000
BDG	10.00	10.00	10.00	10.00
Bone meal	2.50	2.50	2.50	2.50
Limestone	1.00	1.00	1.00	1.00
Meth.	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
T.Binder	0.50	0.50	0.50	0.50
P.Oil	1.00	1.00	1.00	1.00
Total	100	100	100	100
%CP	21.20	20.94	20.67	20.40
%CF	4.16	4.33	4.50	4.67
ME (kcal/kg)	2,841.63	2,744.59	2,647.55	2,550.51

Bio: Supreme Broiler Premix Vitamin A-12,000000I.U, VitD3–3,000000I.U, VitE-30,000mg, Vit.k3–2500mg, Folic Acid–100mg, Niacin–40,000mg, Calpan-10.000mg, Vit.B250,000mg, vit.B12-20mg, VitB1–2000mg, Vit.B6-3500mg, Biotin–80mg, Antioxidant-125,00mg, Cobalt-250mg, selenium–250mg, Iodine-1200mg, Iron40000mg, Manganese-70,000mg, Copper-8,000mg, Zinc-60,000mg, Choline chlorides–200,00omg.
Manufactured by Animal Care Services Konsuit (Nigeria) LTD.

Determination of pH Black Soldier Fly Larvae and Meat Sample

Small samples of meat and larvae were minced at each procedure. This was to ensure total sampling of the inner and outer part of the samples. They were placed on the LAQUAtwin pocket pH meter and measured. To repeat sampling, the pH meter probe was washed with

diluted soap water and dried with a paper tissue. New sample was again placed on the meter probe and the procedure was repeated for all samples.

Determination of Water Holding Capacity

Water holding capacity was determined using Salt- induced water uptake measurements and was measured at 6 and 24h post mortem according to the modified procedure of Wardlaw *et al.* (1973). Duplicate 10g sample of the chopped muscle sample were mixed with 15ml of cold 0.6m Nacl solution in 50ml centrifuge tube. Sample were vortex mixed for 1 minutes, stored at 4°C for 15minutes, and then centrifuged at 7000g for 15minutes at 4°C. The excess liquid was decanted and the sample reweighed. Salt induced water uptake was expressed as the percentage of weight gained by the pellet [100× (final weight - initial weight)/ initial weight].

Determination of Fatty Acid Composition

Fat extraction was carried out according to AOAC (2016). Fatty acids methyl esters (FAME) were prepared after saponification, followed by esterification with the appropriate amount of methanolic boron trifluoride solution. The final concentration of the FAME was approximately 7 mg/mL in heptane and all other procedure to obtain data ensued using AOAC (1995).

Statistical analysis

The data obtained were analyzed using analysis of variance (ANOVA) in SPSS statistical package program and differences among the means were compared using the Duncan's multiple range tests (Soysal, 1992).

RESULTS AND DISCUSSION

Proximate Composition of Black Soldier Fly Larvae (BSFL) Meal and pH

Table 3 summaries the result of proximate composition of Black soldier fly larvae *(Hermetia illucens)* and its pH. It shows the dry matter as (84.35%), crude protein (33.87%) crude fibre (6.31%), ether extract (34.74%), ash (5.06%), nitrogen free extract (20.02%) and metabolizable energy (4805.63 Kcal/kg), while the pH recorded a value of 6.3.

Fatty Acids Profile, Water Holding Capacity and pH of Broiler Meat Fed BSFL

Results of the effect of BSFL on fatty acid, water holding capacity and pH of broiler meat is presented in **Table 4**. The result of fatty acid showed that palmitic acid was not significantly ($P>0.05$) influenced by BSFL while oleic and linoleic acids were significantly ($P<0.05$) influenced by BSFL. Water holding capacity and pH were not significantly ($P>0.05$) influenced by dietary treatments

Table 3: Proximate Composition of Black Soldier Fly Larvae (BSFL) Meal and pH

Parameter	% Composition
Dry matter	84.35
Crude protein	33.87
Crude fibre	6.31
Ether extract	34.74
Ash	5.06
Nitrogen free extract	20.02
Metabolizable energy (Kcal/kg)	4805.63
pH	6.3

Each parameter was obtained from triplicate determinations. Metabolizable energy calculated from Pauzenga (1985) equation: [37% × Protein + 81.8 × % fat + 35.5 × % NFE]

Table 4: Fatty acids profile, water holding capacity and pH of broiler meat fed BSFL

Parameters	T_1 (0%)	T_2 (25%)	T_3 (50%)	T_4 (75%)	SEM
Palmitic	21.23	21.24	20.67	31.86	2.43
Oleic	20.66b	22.23b	29.10ab	38.83a	2.88
Linoleic	19.42b	20.77b	23.26b	39.21a	2.86
Water holding capacity	56.35	58.58	60.33	60.67	4.33
pH	6.10	6.27	6.33	6.60	0.08

SEM: standard error of means a, b: means with different superscripts differ significantly ($P<0.05$). BSFL: black soldier fly larvae

Proximate Composition of Black Soldier Fly Larvae (BSFL) Meal and pH

The result of proximate composition of BSFLM is shown in **Table 3**. The dry matter content of 84.35% gotten from this study can be compared to the result reported by Chia *et al.*, (2020) which shows moisture content of 9.1% equivalent to dry matter of 90.9%. The dry matter content of BSFLM in this study was found to be lower than that reported by Chia, likely attributable to variations in drying methods or initial moisture levels. The crude protein content of 33.87% is comparable to the 37.40% reported by Chia *et al.* (2020), with discrepancies likely resulting from differences in larval substrate. The protein content of BSFL is heavily influenced by dietary factors. The crude fibre content of 6.31% was slightly lower than the 6.8% reported by Chia *et al.* (2020). This reduced fibre content may indicate enhanced digestibility, given the significant contribution of chitin to the insect's exoskeletal structure. Ether extract was 34.74%, this corresponds closely with the report by Surendra *et al.* (2016) with 32.5%. BSFL fat content can vary based on diet, particularly if the larvae are fed on lipid-rich substrates. Higher fat content in this sample makes BSFL a valuable source of energy, particularly in high-energy diets for poultry. Ash was 5.06% which corresponds with the report by Surendra *et al.* (2016) with 5.9%. Ash content in BSFL represents the mineral component, and lower values in your study could indicate fewer minerals in the larvae's diet or the substrate used. Nitrogen free extract (NFE) was 20.02%. This value is lower as compared to the report by Meneguz *et al.* (2023) with 15.1%. The higher NFE in our result could indicate a more carbohydrate-rich diet or a different method of calculating NFE. Metabolizable energy was 4885 Kcal/kg which is relatively higher than 4600 Kcal/kg as reported by Mwaniki *et al.* (2020).

The pH value of the meat is an important parameter regarding the transformation of muscle tissue in meat and depends on the rate of decomposition of glycogen deposits in the muscles. The very rapid decline of pH early post mortem is associated with the abnormal pale colour and reduced water holding capacity (PSE) meat. In poultry meat such abnormalities exist, as broilers are most prone to them, due to the rapid growth rates and the hypertrophy of muscles, especially breast. Studies on broiler meat quality report different values for the pH in normal and PSE meat in breast, and such have not been pointed for thigh muscles. The pH values of the breast (6.10 – 6.60) in this study are within the normal range and the range of 5.81 – 6.23 reported by Fletcher 1999, Zhang and Barbut (2005), however it was lower ($P>0.05$) in the control and highest with those fed 75% BSFL. The pH values of 6.10 and 6.27 for birds fed control and 25% BSFL recorded in this study is within the range of 5.81 – 6.23 reported by Qiao *et al.* (2001) in effect of broiler breast meat color, pH, moisture, water-holding capacity, and emulsification capacity although birds fed 50% BSFL (6.33) and 75% BSFL (6.60) recorded higher pH values. The pH level of the meat increased with increase in the level of BSF. It is known that BSF larvae are rich in lauric acid and hence the products derived by them would have considerable levels of this fatty acid. It could be suggested that the augmented content of lauric acid in the

full fat BSF meal is responsible for the lower values of pH in the broilers meat, however the results so far have been inconsistent. Zeiger *et al.* (2017) reported significantly lower pH in the breast muscles in broilers receiving lauric acid in the diet but dependent on the broiler strain. On the other hand, Schiavone *et al.* (2017) did not find any changes in pH in meat of broilers fed diets with partial or total replacement of the soya with BSF larvae fat. Cullere *et al.* (2016), reported significant decrease in the pH value in quails breast meat when receiving defatted BSF meal in the diet, similar trends were further observed in quails with 10 % dried and ground BSF larvae in the diet (Cullere *et al.* 2019b). The pH values although not significant increased with increase in BSFL in the diets.

Fatty Acids Profile and Water Holding Capacity of Broiler Meat Fed BSFL

The fatty acid profile is of great importance for the healthy value of food. One of the factors that greatly affect the fatty acid composition of meat is the nutrition of the animals it is derived from. Palmitic range of 21.23 to 31.86 was obtained with birds fed 75% BSFL recording the highest ($P>0.05$) while the least was recorded for control diets. The values obtained for birds fed BSFL were at variance with the range of 20.35 – 21.90 reported by Kim *et al.* (2020) in evaluation of black soldier fly larvae oil as a dietary fat source in broiler chicken diets. Oleic acid (20.66 – 38.83) in this study were below the range of 39.13 to 43.32 reported by Kim *et al.* (2020) but higher than the range of 19.90 to 15.61 reported by Popova *et al.* (2020). Linoleic acids recorded for birds fed 50 % BSFL (23.26) was within the range of 20.90 to 26.88 as reported by Kim *et al.* (2020), those reported for control is lower while other treatment groups recorded higher values.

In this study, the fatty acid profile of breast meat revealed dramatic increase in the content of palmitic acid. This is expected since the BSF meals contain lauric acid. The increase of the proportion of palmitic acid was accompanied by higher oleic and linoleic acids. Our results coincide with those reported by Schiavone *et al.* (2017), Cullere *et al.* (2019a) and Schiavone *et al.* (2019). This result is at variance with the report of Cullere *et al.* (2018) which did not observe any effect of BSF in the diet on the linoleic but agreed with Schiavone *et al.* (2017) who reported increase of linoleic in the meat of broilers with increased levels of BSF in the diet.

WHC recorded for birds fed BSFL was higher than the range of 38.50 – 51.73% reported by Qiao *et al.* (2001). The higher pH value in this study did not cause a decrease of WHC. This is not in agreement with the findings of Cullere *et al.* (2016) who reported that lower pH increases WHC in meat. The results of WHC which are related to pH value had no significant differences among treatments. However, the increase in BSFL in a broiler diet, the more the WHC. It seems that the high inclusion level of BSFLM may affect the physical measurements of chicken breast meat.

CONCLUSION AND RECOMMENDATION

Conclusion

The study shows that the inclusion of BSFL meal at about 25% affected considerably the quality characteristic and fatty acid content of the broiler meat, while the 50% and 75% replacement level increased fatty acid profile of the broiler bird, possibly due to differences in digestibility and nutrient balance compared to soybean meal. Furthermore, BSFL meal inclusion maintained the pH and WHC of the meat.

Recommendation

Based on the findings of this study, BSFLM can successfully replace SBM at 25% level of inclusion without causing any harmful effect on broiler chickens. Further researched is encouraged to ascertain measures to increase inclusion level of BSFLM to higher amounts thereby curtailing high cost SBM in poultry feeds and at the same time not compromising the meat quality.

REFERENCES

Benzertiha, A., Kiero´nczyk, B., Rawski, M., Mikołajczak, Z., Urba ´nski, A., Nogowski, L. and Józefiak, D. (2020). Insect fat in animal nutrition: A review. *Ann. Anim. Sci.*, 20: 1217 – 1240.

Bose, S., Ghosh, T. and Mandal, D. (2019). Impact of alternative protein sources on broiler meat quality: A review. *Poultry Research Journal*, 17 (2): 53 - 60.

Chia, S. Y., Tanga, C. M., Osuga, I. M., Cheseto, X., Ekesi, S., Dicke, M., & van Loon, J. J. (2020). Nutritional composition of black soldier fly larvae feeding on agro-industrial by-products. *Entomologia Experimentalis et Applicata*, *168*(6-7), 472-481.

Cullere, M., Schiavone, A., Dabbou, S., Gasco, L. & Dalle Zotte, A. 2019a. Meat quality and sensory traits of finisher broiler chickens fed with Black Soldier Fly (*Hermetia Illucens L.*) larvae fat as alternative fat source. Animals (Basel) 9: 140. https://doi.org/10.3390/ani9040140

Cullere, M., Tasoniero, G., Giaccone, V., Acuti, G., Marangon, A. and Dalle Zotte, A. (2016). Black soldier fly larvae (Hermetia illucens L.) as protein source for broiler quails: A preliminary study. *Animal Feed Science and Technology*, 220: 254-260.

Cullere, M., Tasoniero, G., Giaccone, V., Acuti, G., Marangon, A. & Dalle Zotte, A. 2018. Black soldier fly as dietary protein source for broiler quails: meat proximate composition, fatty acid and amino acid profile, oxidative status and sensory traits. Animal 12: 640–647. https://doi.org/10.1017/S1751731117001860

Cullere, M., Tasoniero, G., Giaccone, V., Miotti-Scapin, R., Claeys, E., De Smet, S. & Dalle Zotte, A. 2016. Black soldier fly as dietary protein source for broiler quails: apparent digestibility, excreta microbial load, feed choice, performance, carcassand meat traits. Animal 10: 1923–1930. https://doi.org/10.1017/S1751731116001270

Cullere, M., Woods, M.J., van Emmenes, L., Pieterse, E., Hoffman, L.C. & Dalle Zotte, A. 2019b. Hermetia illucens larvae reared on different substrates in broiler quail diets: effect on physicochemical and sensory quality of the quail meat. Animals (Basel) 9: 525. https://doi.org/10.3390/ani9080525

Fletcher, D.L. 1999. Broiler breast meat color variation, pH and texture. Poultry Science 78: 1323–1327. https://doi.org/10.1093/ps/78.9.1323

Gasco, L., Finke, M. and van Huis, A. (2018). Can diets containing insects promote animal health? *J. Insects Food Feed*, 4: 1–4.

Gasco, L., Józefiak, A. and Henry, M. (2020). Beyond the protein concept: Health aspects of using edible insects on animals. *J. Insects Food Feed*, 7: 715 – 741.

Kiero´nczyk, B., Rawski, M., Stuper-Szablewska, K. and Józefiak, D. (2022). First report of the pparent metabolisable energy value of black soldier fly larvae fat used in broiler chicken diets. *Animal*, 16: 100656.

Kim et al., 2020 Y.B. Kim, D.H. Kim, S.B. Jeong, J.W. Lee, T.H. Kim, H.G. Lee, K.W. Lee Influence of pH and water-holding capacity on the quality and shelf life of meat. *Meat Science*, 144: 120-130.

Makkar, H. P. S., Tran, G., Heuzé, V. and Ankers, P. (2014). State-of-the-art on use of insects as animal feed. *Animal Feed Science and Technology*, 197: 1 - 33.

Meneguz, M., Miranda, C. D., Cammack, J. A., & Tomberlin, J. K. (2023). Adult behaviour as the next frontier for optimising industrial production of the black soldier fly Hermetia illucens L.)(Diptera: Stratiomyidae). Journal of Insects as Food and Feed, 9(4), 399-414.

Mwaniki, Z., Shoveller, A. K., Huber, L. A., and Kiarie, E. G. (2020). Complete replacement of soybean meal with defatted black soldier fly larvae meal in Shaver White hens feeding program (28–43 wks of age): impact on egg production, egg quality, organ weight, and apparent retention of components. *Poultry Science*, 99(2), 959-965.

Newton, G. L., Sheppard, D. C., Watson, D. W., Burtle, G. J., Dove, C. R., and Tomberlin, J. K. (2021). The use of black soldier fly larvae as a sustainable feed ingredient in animal diets. *Sustainability Science*, 15 (1): 34 - 47.

Schiavone, A., Cullere, M., De Marco, M., Meneguz, M., Biasato, I., Bergagna, S., Dezzutto, D., Gai, F., Dabbou, S., Gasco, L. & Dalle Zotte, A. 2017. Partial or total replacement soybean oil by black soldier fly larvae (Hermetia illucens L.) fat in broiler diets: effect on growth performances, feed-choice, blood traits, carcass characteristics and meat quality. Italian Journal of Animal Science 16: 93–100. https://doi.org/10.1080/1828051X.2016.1249968

Schiavone, A., Cullere, M., Meneguz, M., Dabbou, S., Gasco, L. and Dalle Zotte, A. (2017). Black nosoldier fly as dietary protein source for broiler quails: Apparent digestibility, excreta microbial load, feed-choice, performance, carcass and meat traits. *Animal*, 11 (12): 2270 - 2278.

Schiavone, A., Dabbou, S., Petracci, M., Zampiga, M., Sirri, F., Biasato, I., Gai, F. & Gasco, L. 2019. Black soldier fly defatted meal as a dietary protein source for broiler chickens: effects on carcass traits, breast meat quality and safety. Animal 13: 2397–2405 https://doi.org/10.1017/S1751731119000685

Smith, D. (2020). Poultry for profit: The rise of the broiler industry. *Global Poultry Report*, 8 (1): 34 - 42.

Spranghers, T., Ottoboni, M., Klootwijk, C., Ovyn, A., Deboosere, S., De Meulenaer, B., Michiels, J., Eeckhout, M., De Clercq, P. and Smet, S. (2017). Nutritional composition of black soldier fly larvae and its suitability as animal feed. *Journal of Insects as Food and Feed*, 3 (2): 141 - 150.

Surendra, K. C., and N. T. (2016). Bioconversion of organic waste into protein-rich feed through black soldier fly larvae. Waste Management, 59, 138-145.

Zhang, L. & Barbut, S. 2005. Rheological characteristics of fresh and frozen PSE, normal and DFD chicken breast meat. Poultry Science 46: 687–693. https://doi.org/10.1080/00071660500391516

DETERMINANTS OF USAGE OF SOCIAL MEDIA FOR MARKETING BY MICRO-RESTAURANT OWNERS IN CALABAR METROPOLIS, CALABAR, CROSS RIVER STATE, NIGERIA

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ABSTRACT
Social media platforms enable users to create, share content, and interact with others, promoting products or services and increasing visibility. This study examines the determinants of social media usage for marketing by micro-restaurant owners in Calabar Metropolis, Cross River State, Nigeria. The objectives were to describe the socioeconomic characteristics of micro-restaurant owners, analyze the platforms used, assess how socioeconomic factors influence usage, and identify challenges faced in utilizing social media for marketing. Purposive sampling was used to select respondents, and data was collected using semi-structured questionnaire. Descriptive statistics (frequency, percentages, means) were used for objectives 1, 2, and 4, while binary logistic regression analyzed objective 3. Results showed an average age of 30 years, with 72% being female, most holding at least a bachelors degree. The average monthly income was N145,300 Naira, and 64% of the micro-restaurant owners used social media for business. WhatsApp (93%) was the most used platform, followed by Facebook (50%) and Instagram (38%). The logistic regression analysis revealed that hours worked, education, income, and years in business significantly influenced social media usage. Challenges faced by users included high internet costs and limited workforce. The study recommended diversifying social media presence, providing training on marketing strategies, and reducing data costs for small businesses.

***Key words**: social media, marketing, micro-restaurants*

INTRODUCTION

Carr and Hayes (2015) defined social media as internet-based channels that allow users to resourcefully interact and selectively self-present, either in real-time or asynchronously, with both broad and narrow audiences who derive value from user-generated content and the perception of interaction with others. According to Salem and Salem (2019), social media allows customers to find useful information about other brands, and if this information meets the customers' expectations for the competitor's product, strong customer satisfaction can develop, leading to the customer choosing or continuing to patronize. More so, marketing is a process of communicating the value of a product or service to customers, for the purpose of selling the product or service (Neeraja *et al.*,2013). The role of marketing in the development of business is intact but the way it was executed is radically changing due to contributions made by satellite communication and extensively developed scientific devices (Saravanakumar and SuganthaLakshmi 2012).

Further to this, platforms such as Facebook, Instagram, YouTube, Twitter and WhatsApp have become handy and convenient tools for marketing, communication with customers, their stakeholders as well as inside their firms. The agrifood sector is a wide and diverse sector in the economy. It is a combination of agricultural and food sectors, encompassing all activities related to production, processing, distribution, marketing, and consumption of food and

agricultural products (FAO 2015). This term highlights the interconnectedness of agriculture and food systems, including everything from farming and fishing to food processing, packaging, transportation, retailing, and food service. A major subsector of the agrifood system is the restaurant industry. According to Mehta and Maniam (2002), people are choosing to spend less time in their kitchens. As the demand for food away from home increases, there is opportunity for growth in the restaurant industry. Ebiringa (2012) opined that Nigeria has developed several enterprises in agriculture/agro-allied activities especially in areas like foodstuff, restaurant, and fast-food vending. Cross River State parades a wide range of micro and small businesses as a major source of economic gain to individuals and families. As defined by SMEDAN micro restaurant typically refers to a small-scale dining establishment with less than 10 employees and less than 5 assets that caters to a limited number of customers.

Despite the growing importance of social media in business, limited research has specifically explored the determinants of social media usage among micro-restaurant owners, especially in the context of Calabar metropolis, Cross River State, Nigeria. However, understanding the factors that influence their usage of these platforms remains essential for effective implementation and sustainability in businesses. The specific objectives of the study were to; describe the socioeconomic characteristics of micro restaurant owners, examine the social media platforms used by micro-restaurant owners in Calabar metropolis and the marketing services they are used for, investigate the extent to which socioeconomic characteristics (age, education, gender, income, marital status, access to Smart phone technology, number of employees and hours spent by micro restaurant owners on the business daily, influence the usage of social media marketing platforms by micro restaurant owners , and discuss the challenges faced by micro restaurant owners in utilizing social media marketing platforms in Calabar metropolis.

MATERIALS AND METHODS

The study was carried out in Calabar Metropolis, the study area is located in Calabar, Cross River State. It encompasses Calabar Municipality and Calabar South Local Government Areas and lies between latitudes 4˚50'N and 5˚10'N and longitudes 8˚17'E and 8˚20'E; bounded to the north by Odukpani Local Government Area (LGA) and to the East by Akpabuyo LGA. Calabar Metropolis is sandwiched between the Great Kwa River to the East and the Calabar River to the West. The urban area is on the eastern bank of the Calabar River. Its growth of the southern part is hindered by the mangrove swamps. It covers an estimated land area of about 274.593 km2 (. Calabar falls within tropical equatorial climate of high temperature, high relative humidity and abundant annual rainfall (Inyang, 1980). The annual rainfall is 2750 mm and mean annual average temperature is 26.1˚C. The study area has witnessed a tremendous increase in the population of 10,000 estimated at the pre-colonial, to 99,352 in 1993; 328,876, in 1991. The last census in 2006 put the population to 371,022 (National population commission (NPC),2006). Calabar in Cross River state is well-known across Nigeria for its exciting and rich culinary culture and also a salivating variety of standard dishes which will whet any appetite and Calabar metropolis being a major area in Calabar is known for its irresistible cuisines ranging from, Edikang ikong to Abak soup, Edikang Ekong soup, Afang soup, Okro soup, White soup, Editan soup, Fish soup, and even Ekpang kwukwo.

This study employed a non-probability sampling technique, purposive sampling to select micro restaurant owners. This is due to the difficulty in ascertaining in specific the population size. The study therefore used micro restaurants owners that were easily accessible and willing to participate in research. In this study primary data was gotten using well-structured questionnaires. Data was analyzed using descriptive and inferential statistics. Specifically,

objective 1, 2 and 4 were analyzed using descriptive statistics such as frequency distribution tables, percentages and mean while inferential statistics such as the binary logistic regression model was used to analyze objective 3.

MODEL SPECIFICATION

The binary logistic regression model used in determining the extent to which the selected factors influence the usage of social media for marketing by micro restaurant owners.
Explicitly the model is empirically estimated as:

$$Y = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta 9 X9 + \varepsilon$$

Where,
Y= Usage of social media marketing platforms by micro restaurant owners (dummy; 1 indicates usage of social media marketing platforms 0, indicates no usage of social media marketing platforms)
X_1 = Age (years)
X_2 = Education (years spent in school)
X_3 = Gender (1 for female 0 for male)
X_4 = Income level (Naira)
X_5 = Marital status (1 for married 0 for not married)
X_6 = Access to smart phone technology (1 for yes access, 0 for no access)
X_7 = Number of employees (number of staff)
X_8 = Hours spent by micro-restaurant owners on business (number of hours)
X9 = No of years in Business

RESULTS AND DISCUSSION

1 Socio-economic characteristics of respondents
Table 1: socio -economic characteristics of respondents

Variables	Frequency	Percentage	Mean
AGE			30
11-20	1	2	
21-30	29	58	
31-40	14	28	
41-50	6	12	
EDUCATION			13.36
Primary school	0	0	
Secondary school	18	36	
Bachelor's degree	30	60	
Master's degree	2	4	
INCOME			145,300
15,000-100,000	18	36	
101,000-200,000	24	48	
201,000-300,000	7	14	
301,000-400,000	1	2	
GENDER			
Male	14	28	
Female	36	72	

MARITAL STATUS			
Single	38	76	
Married	10	20	
Divorced	2	4	
ACCESS TO SMARTPHONE			
YES	50	100	
NO	0	0	
NO. OF EMPLOYEES			
1-5	42	84	3.1200
6-10	8	16	
DAIL YWORKING HOURS			
Less than 2 hours	0	0	4.04
2-4 hours	2	4	
4-6 hours	13	26	
6-8 hours	18	36	
8-10 hours	15	30	
More than 10	2	4	
EXPERIENCE (YEARS)			
1-5	26	92	3.42
6-10	4	8	
HOUSEHOLD SIZE			
1-5	22	44	
6-10	27	54	
OWNERSHIP OF BUSINESS SOCIALMEDIA ACCOUNT			
YES	32	64	
NO	18	36	
FREQUENCY OF USAGE OF BUSINESS SOCIALMEDIA ACCOUNT			
Rarely	9	28	
Occasionally	18	56	
Always	5	15	

Source: Field Survey, 2024

Table 1 presents a summary of the socio-economic characteristics of micro-restaurant owners in Calabar Metropolis, based on data collected from 50 respondents. The results indicated that the mean age of micro-restaurant owners was 30 years, implying that the majority of micro-restaurant owners were middle age. It also suggests that those in the prime of their age (31-40) are involved in the business as a means of livelihood. This result is not in line with the findings of Umeze & Ohen which suggest that majority of the entrepreneurs are within the age category of 41-50 years. In terms of educational level of respondents, the majority of respondents have

received some form of formal education, with 36% having completed secondary education, 60% holding a bachelor's degree and 4% having a master's degree. The relevance of this to the study is that since majority of the respondents are literate, they will more likely be able to understand the questions of this research and provide correct answers to them and as well indicate a strong likelihood of familiarity with social media platforms and their application in marketing strategies. This educational background suggests that they are better equipped to leverage digital tools for business promotion. The income level of respondents in Naira range from 15,000 to 100,000 for 36%, 101,000 to 200,000 for 48%, and 201,000 to 300,000 for 14%, while 1% earned between 301,000 to 400,000. The average monthly income was calculated at 145,300 Naira. Regarding gender, the findings revealed that females dominate micro-restaurant ownership, accounting for 72% of the sample. This is consistent with the findings of Umeze & Ohen (2014) which stated that the ownership of micro-restaurants in Calabar metropolis is largely female driven. In terms of marital status, 76% of respondents were single, 20% were married and 4% were divorced. Also, all respondents reported having access to smartphone technology. The 100% smartphone access reported among the 50 respondents is consistent with findings by Iyanda (2017), which indicate that urban dwellers are more likely to adopt smartphones due to better socio-economic conditions and infrastructure. This suggests that the favorable urban environment in the study area contributes to high smartphone penetration rates among its residents. Additionally, 84% of respondents had a total number of employees ranging between 1 to 5 people, and 16% had 6 to 10 employees. This small workforce reflects the typical scale of micro-enterprises, where owners often manage limited resources and rely heavily on family members or a small staff to operate efficiently (Akinwumi et al, 2018). Furthermore, the majority of micro-restaurant owners (52%) reported working 6 to 8 hours a day. This limited work schedule can significantly reduce the time available for engaging in essential marketing activities, which are crucial for business growth. In terms of business experience, 92% of respondents had between 1 to 5 years of experience while 8% had been in business for 6 to 10 years. This suggests a relatively young entrepreneurial landscape among micro-restaurant owners, indicating that many are still in the process of developing their marketing strategies. Household size varied, with 54% of respondents having between 6 to 10 household members and 44% having 1 to 5 members, regarding the use of social media, 64% of respondents reported having business social-media account while 36% did not. Of those with accounts 24% used them rarely, 46% used them occasionally, and 30% used them regularly for business purposes.

2. Social media platforms used

Table 2: Usage of social media for marketing by micro- restaurant owners

Statement (Do you use social media)	Frequency	Percentage
YES	34	68
NO	16	32

Source: Field Survey, 2024

Table 2.1 SOCIAL MEDIA PLATFORMS USED BY MICRO-RESTAURANT OWNERS IN CALABAR METROPOLIS

SOCIAL MEDIA PLATFORMS	FREQUENCY	PERCENTAGES
FACEBOOK	17	50
INSTAGRAM	13	38.2
TWITTER	2	5

LINKEDIN	3	8
TIKTOK	7	20
WHATSAPP	30	93
YOUTUBE	1	2.9

Source: Field Survey, 2024

Table 2.1 showed the frequency distribution of social media platforms commonly used by micro-restaurant owners in the study area. The table shows that WhatsApp, with 93% usage, is the most frequently used platform. This aligns with the findings of Morah & Omojola(2018), which highlighted the preponderance of WhatsApp usage due to its simplicity. Facebook follows as the second most used platform with 50%, while Instagram comes in third at 38.2%. These findings are consistent with Martoyo (2023), who also observed the popularity of these platforms among small business owners. Tiktok, used by 20% of respondents, is a rapidly growing social media platform, primarily popular for sharing short videos and photos (Pew research center, 2021) although its adoption among micro-restaurant owners is still limited in the study area it shows a promising tool for social media marketing. Meanwhile, twitter (5%) and LinkedIn (8%) are less commonly used in this study area as shown from the results. Lastly, YouTube (2.9%) has the least usage among micro-restaurant owners in Calabar Metropolis.

Table 2.2 Marketing services used by respondents

Uses	Frequency	Percentages
Food photos/videos	30	88
Special promotions	6	19
Customer testimonials	22	64.7
Behind the scenes	8	23.5
Chef profiles	20	58.8
Polls/ questions for audience engagement	10	29.4

Source: Field Survey, 2024

Table 2.2 showed that respondents who use social media for marketing predominantly post food photos/videos (88%), indicating that visual content is a top strategy for engaging potential customers. Customers' testimonials follow closely with 64.7% of respondents using this type of content, which builds trust. The table shows that chef profiles 58.8% of respondents while polls and questions at 29.4% and behind the scenes at 23.5% are used less frequently.

3. Determinants of usage of social media for marketing by micro -restaurant owners

Table 3 Logistic Regression results on determinants of usage of social media for marketing by micro -restaurant owners

Variable	**Coefficient(B)**	**SE**	**Z-Statistics**	**Significance**	**Exp(B)**
X_1-Age	-0.062	0.067	-0.925	0.348	0.940
X_2-Education	0.016	0.312	0.051	0.059 **	1.016
X_3-Gender	-0.301	0.751	-0.400	0.688	0.740
X_4-Income level	1.670	0.570	2.930	0.090**	5.312
X_5-Marital status	0.177	0.746	0.237	0.813	1.193
X_6-Number of employees	-0.002	0.136	-0.015	0.990	0.998
X_7-Number of hours	-0.077	0.377	-0.204	0.038**	0.926

X_8- Number of years in business	0.125	0.221	0.566	0.071**	1.133

Source: Field Survey, 2024

Nagelkerke $R^2 = 0.045$
LR statistic (8df) = 15.51
**significant at 5% ***significant at 1%, *significant at 10%

Table 3 showed the result of the regression (logistic) model for determinants of usage of social media. Each coefficient is a partial slope coefficient that measures the change in the estimated logistic for a unit change in the values of a predictor variable (holding other predictors constant), (Gujarrati, 2007).

The educational level coefficient 0.016, meaning that for each additional year of education, the likelihood of using social media increases by 1.6%. The p-value of 0.059 indicates that this relationship is borderline significant at the 10% significance level, suggesting that educational level has a positive role in predicting whether micro-restaurants owners use social media for marketing. Owners with more years of education are more likely to adopt social media for marketing. This finding aligns with studies such as Odoom *et al*, (2017), which highlights that business owners with higher education levels are more likely to adopt social media due to their greater familiarity with technology.

The income level coefficient is 1.670, indicating a positive relationship with the social media usage. This means that as income increases the likelihood of the event occurring also increases. Specifically, for each one-unit increase in income, the log odds of using social media for marketing increase by 1.670, holding all other variables constant. However, the p-value of 0.090 suggests that this variable is borderline significant at the 10% significance level, similar to the findings by oztamur and karakadilar (2014), which noted that while financial resources influence traditional marketing choices, income might not significantly drive social media usage, especially in cost-conscious micro businesses.

The coefficient of Hours spent at work is -0.077, which translate to a 7.7% decrease in the likelihood social media usage for each additional hour spent at work. This result is statistically significant (p= 0.038), indicating that restaurant owners who work longer hours are less likely to use social media for marketing. This negative relationship could suggest that time constraint reduces the likelihood of investing in social media marketing efforts, as owners with more working hours have less time or energy to engage with social media platforms. A study by Odoom *et al.* (2017), confirms the negative relationship, showing that business owners with more time constraints are less likely to engage in social media marketing.

The coefficient for years in business is 0.125, which means that for each additional year the restaurant has been in business, the likelihood of social media usage increases by 12.5%. The p-value for this variable is 0.071, making it significant at the 10% level. This result suggests that more established businesses are more likely to adopt social media for marketing, potentially because of increased experience and the ability to explore new marketing strategies as the business matures. Furthermore, the number of hours spent at work was significant at 5%, educational level, income and number of years in business were significant at 10%.

To test the null hypothesis that all the coefficients are simultaneously equal to zero, the likelihood ratio (LR) statistics is used (Gujarati, 2004). Given the null hypothesis, the LR statistic follows the chi-square (X^2) distribution with degree of freedom equal to the number of

explanatory variables, eight in this case. The chi-square value from the omnibus tests of model coefficients is 1.682, with a p-value of 0.989. Since the critical value of chi-square at the 5% level of significance is with 8 degrees of freedom is 15.51, and the calculated LR statistic (1.682) is lower than this critical value, we accept the null hypothesis. We conclude that age, educational level, gender, income, marital status, number of employees, hours spent at work, and years in business are not significantly different from zero. In other words, they do not significantly affect the likelihood of using social media for marketing by micro restaurant owners.

4. Challenges faced by micro -restaurant owners in utilizing social media marketing platforms

Table 4 Challenges faced by micro -restaurant owners in utilizing social media marketing platforms

CHALLENGES	MEAN	RANK	DECISION
High cost of data	4.50	1st	Serious challenge
Limited workforce	3.91	2nd	Serious challenge
Time consuming	3.56	3rd	Serious challenge
Lack of expertise	3.24	4th	Serious challenge
Trust and reliability	2.74	5th	Challenge
Difficulty in management	2.59	6th	Challenge
Poor infrastructure	2.59	6th	Challenge
Poor network coverage	2.40	7th	Challenge
Cyberbullying	2.29	8th	Challenge

Source: Field Survey, 2024

Mean scores on a 5 -point Likert scale were computed. A mean score of 3.0 or higher was considered indicative of a serious challenge, based on the scale's midpoint

Table 4 above revealed the distribution of respondents based on challenges faced in utilizing social media for marketing. The result shows that the most significant challenge faced by respondents were high cost of data/internet and limited workforce ranking 1st and 2nd with mean score of 4.50 and 3.91 respectively. These findings align with previous studies such as Donner et al., (2008) emphasized that high data costs are major barriers to technology adoption in developing regions. A study conducted by Isiaka, Adeosun, and Okewale (2022) found that while social media positively impacts the performance of SMEs in Nigeria, issues like the high cost of internet services provided by ISPs and the quality of internet access are significant barriers. Additionally, the limited workforce challenge mirrors the findings of Jose and Duffet(2021), who cited the lack of human resources and expertise as key barriers to social media use among independent food retailers. Furthermore, poor network coverage and cyberbullying ranking 8th and 9th with me with mean score and 2.40 and 2.29 respectively were the least significant challenges hindering the effective utilization of social media for marketing by respondents. However, other challenges fell between these two extremes.

Conclusion and Recommendation

Understanding the factors that influence usage of these social media platforms remains essential for effective implementation and sustainability in businesses. In conclusion, the study highlights that micro-restaurant owners in calabar metropolis are predominantly middle aged and well educated, with the most having completed secondary or higher education. Female ownership is prominent among the respondents, and all have access to smartphones. However, the majority work long hours, which limits their ability to engage in marketing activities. Social media usage for business is widespread, with WhatsApp being the most popular platform,

followed by Facebook and Instagram. The analysis indicates that socioeconomic factors such as education, income, hours worked, and years in business significantly influence social media usage for marketing. The main challenges faced by these owners include the high cost of data and limited workforce, which hinder effective utilization of social media for marketing purposes.

Based on the results obtained, this study therefore recommends that.

1) Micro-restaurant owners should diversify their social media presence by exploring additional platforms such as tiktok, twitter and LinkedIn. This can help them reach different demographics and increase brand awareness.

2) There should be the establishment of training workshops organized by government or community organizations. These programs should focus on social media marketing strategies, content creation, and digital engagement techniques to help owners maximize their online presence.

3) Service providers should explore ways to reduce data cost or provide subsidized internet access for small business owners. This would alleviate one of the major barriers to effective social media utilization.

REFERENCES

Akinwumi, J. O., et al. (2018). The role of micro and small enterprises in employment generation in Nigeria: A study of micro-restaurant owners in urban areas. Journal of Small Business and Enterprise Development.

Anang, M. (2020). Adoption of social media as a digital marketing tool for micro food and beverage enterprises in South Jakarta City. Journal of Business Management, 1(2), 1–14.

Carr, C. T., & Hayes, R. A. (2015). Social media: Defining, developing, and divining. Atlantic Journal of Communication, 23(1), 46–65. https://doi.org/10.1080/15456870.2015.972282

Donner, J., Gitau, S., & Marsden, G. (2008). Internet use on mobile phones in Africa: Appropriation, innovation, and poverty reduction. The Electronic Journal of Information Systems in Developing Countries, 36(1), 1–16. https://doi.org/10.1002/j.1681-4835.2008.tb00245.x

Doris, N., & Oladokun, O. (2018). Social media use and entrepreneurship development in Nigeria: Lagos and Onitsha in focus. Journal of Social Media Studies, 1(5).

Ebiringa, T. (2012). Perspectives: Entrepreneurship development and growth of enterprises in Nigeria. Entrepreneurial Practice Review, 2(2), 1–5.

Gujarati, D. N. (2004). Basic econometrics (4th ed.). McGraw-Hill.

Gujarati, D. N. (2007). Basic econometrics (4th ed.). McGraw-Hill.

Internet World Stats. (2022). Internet world stats: Usage and population statistics. Miniwatts Marketing Group. https://www.internetworldstats.com/stats.htm

Isiaka, M. A., Adeosun, O. T., & Okewale, A. T. (2022). Social media usage and performance of small and medium enterprises in Nigeria. International Journal of Entrepreneurship and Business Innovation, 5(2), 94–103. https://doi.org/10.52589/ijebi-ua02u9u3

Iyanda, O. A. (2017). A quantitative model of smartphone adoption among urban and rural Nigerians: The role of social context in ensuring continuous usage. African Journal of Computer Science and Applications, 1(1). https://doi.org/10.28933/ajcsa-2017-09-13-01

Mehta, S. S., & Maniam, B. (2002). Marketing determinants of customers' attitudes towards selecting a restaurant. Academy of Marketing Studies Journal, 6(1–2).

Neeraja, B., Chandani, A., & Mehta, M. (2013). Marketing: Past, present, and future theoretical framework.

Odoom, R., Anning-Dorson, T., & Acheampong, G. (2017). Antecedents of social media usage and performance benefits in small and medium-sized enterprises (SMEs). Journal of Enterprise Information Management, 30(3), 383–399. https://doi.org/10.1108/jeim-04-2016-0088

Öztamur, D., & Karakadılar, İ. S. (2014). Exploring the role of social media for SMEs: As a new marketing strategy tool for firm performance perspective. Procedia - Social and Behavioral Sciences, 150, 511–520. https://doi.org/10.1016/j.sbspro.2014.09.052

Pew Research Center. (2021, April 7). Social media use in 2021. Pew Research Center. https://www.pewresearch.org/internet/2021/04/07/social-media-use-in-2021

Salem, S. F., & Salem, S. O. (2021). Effects of social media marketing and selected marketing constructs on stages of brand loyalty. Global Business Review, 22(3), 650–673. https://doi.org/10.1177/0972150919830863

Saravanakumar, M., & SuganthaLakshmi, T. (2012). Social media marketing. Life Science Journal, 9(4).

Umeze, E., & Ohen, S. B. (2014). Performance of micro restaurant enterprises in Cross River State, Nigeria. The Journal of Agricultural Science, 6(11), 118–128. https://doi.org/10.5539/jas.v6n11p118

Dos Santos, J., & Duffett, R. G. (2021). Exploring social media usage as a communication channel among independent food retailer SMEs in South Africa. Small Business and Innovation Research, 5(2), 3–20. https://doi.org/10.26784/sbir.v5i2.392