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Nutrient composition and influence of cooking methods on organoleptic properties of Muscovy duck meat

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Abstract
This study was conducted to determine the proximate and mineral contents of intensively raised Muscovy ducks as well as the influence of cooking methods (boiling, microwaving and oven-drying) on the organoleptic properties of duck meat. Sixty adult ducks aged 18 months (30 males and 30 females were used for the study. Raw meat samples from thigh and breast muscles were analyzed for proximate and mineral composition. Sensory properties such as flavour, colour, tenderness, juiciness, number of chews and remains after chewing were also determined. Data collected were subjected to analysis of variance. Results showed that crude protein (83.57%), nitrogen-free extract (10.27%) and moisture content (67.21%) in the breast muscle of drake were significantly higher than that of thigh muscle. Fat content was however, highest in the thigh muscles of female ducks. Analysis of mineral content revealed that breast muscles had the highest levels of calcium, magnesium and potassium, while sodium, zinc and iron were higher in the thigh muscles of female ducks and male breast muscles, respectively. Except for colour and number of chews in drake muscles, cooking methods significantly affected all other sensory properties (flavour, tenderness, juiciness, remains after chewing) of the meat. Muscovy ducks' high proximate and mineral contents, and sensory evaluation values indicated overall acceptability by the panelists for boiling and oven-drying methods. Based on these findings, it is recommended that breast meat of male ducks can serve as a veritable source of protein and minerals in human diet; boiling and oven-drying as alternative cooking methods of Muscovy duck meat.

Keywords: Duck, meat, mineral, nutrition, poultry, proximate, sensory

Introduction

The demand for protein is increasing with geometric rise in population. Meat consumption is high and consumers have a preference for high quality meat products (Valavan *et al.*, 2016). Poultry meat is an important source of protein for humans as it plays a vital role in our nutrition (Islam *et al.*, 2012. The value of poultry meat is determined by its nutrients content (Ikeme, 1990). Poultry meat is valued for its nutritional properties as it is a good source of essential amino acids, B - vitamins and minerals (Krempa *et al.*, 2019). There is an upsurge in duck meat consumption with an increased demand for processed duck meat products, indicative of movement towards large scale production of duck products (Hird *et al.*, 2005). Duck meat consumption in Nigeria is however not very common, as a result of unfounded stigmatization against duck meat and eggs (Omojola *et al.*, 2014; Ebegbulem and Ugochukwu, 2024).

Cooking has been defined as the application of heat to meat, to temperature sufficient enough to denature proteins (Tonberg, 2005). Kadurumba *et al.* (2019) reported that quality of cooked meat depends on the composition and texture of the muscles, the cooking method, as well as the time and or temperature during cooking. The quality of poultry meat can be assessed by sensory properties (such as colour, tenderness, flavour, juiciness) and proximate composition (nutrient content such as protein, fat and ash) (Khawaja *et al.*, 2013). Tonberg (2005) reported that sensory properties of meat like colour, texture and taste are altered during heat processing. Heat improves digestibility of meat by breaking down its structures allowing the permeation of digestive enzymes (Nikmaram *et al.*, 2011). Nikmaram *et al.* (2011) reported that changes in meat connective tissues engendered by heat application exerts a tenderizing effect, whereas meat toughening is caused by hardening of myofibrillar proteins upon cooking. Borela *et al.* (2022) noted that cooking of meat, among other things, enhances its taste, improves tenderness and increases the storage duration. Omojola *et al.* (2014) reported a moisture content of 71.64% in raw Muscovy drake meat. Protein, Fat and Ash contents of the meat were 21.91, 12.92 and 2.12 g/100g, respectively of raw Muscovy drake (Omojola *et al.*, 2014). Huda *et al.* (2011) reported protein, fat and ash contents of 19.41, 2.32 and 0.86 %, respectively for raw Muscovy duck breast meat.

This research sought to determine the proximate and mineral compositions of Muscovy duck meat and its organoleptic properties as influenced by different cooking methods. The findings will provide scientific information that may serve as reference data for proximate and mineral compositions of duck meat as well as evaluate the quality of cooked duck meat under different cooking methods.

Materials and Methods

In this study, ethical approval on Animal Welfare and Rights was obtained from the University of Calabar Committee on Animal Care and Welfare based on the Australian Code for Care and Use of Animals for Scientific Purposes.

This study was carried out at the Poultry Unit of the Teaching and Research Farm, University of Calabar, Calabar, located within the tropical rain forest zone of Nigeria on latitude 3°N and longitude 7°E with temperature range of 22.47° - 38.83°C, average rainfall of 273.93 mm per annum and relative humidity of 85.92% (NMA, 2021).

Thirty adult Muscovy ducks aged 18 months (average weight of 2.59 kg) were used for the research. They were intensively raised on deep litter system for 84 days, fed *ad libitum* on a commercial chicken feed (Vital feed® Nigeria) having 16.34% crude protein and 2465 kcal/kg metabolizable energy contents. Drinking water was also provided *ad libitum.*

The ducks were starved overnight and slaughtered by severing the jugular vein using a sharp knife. Slaughtered ducks were allowed to bleed completely, defeathered after soaking in hot water (75°C) and eviscerated into carcass cuts (Ebegbulem and Asuquo, 2018). Meat samples of 100 - 120 g each were excised from the thigh and breast portions of the male and female ducks and labelled appropriately before prior to use.

Fresh duck meat samples from the breast and thigh of male and female ducks were analyzed to determine proximate and mineral compositions. Moisture content was determined by drying the samples in an oven at 105°C for 24 hours (AOAC, 2005). Crude protein of meat samples was determined by

Kjeldal method by digesting the sample with concentrated H_2SO_4, distilled the digestion solution using steam and titrated the distillate according to AOAC (2005). Fat (ether extract) content of the meat samples was determined using Soxhlet method, where sample was extracted for 4 – 6 hours and heated in an oven at a temperature 65°C for 24 hours (AOAC, 2005). Meat samples were dried at 6000°C for a period of six hours to determine their ash content (AOAC, 2005). Mineral content of the duck meat samples was analyzed using atomic absorption spectrophotometer (Akinnusi *et al.*, 2018).

Duck meat samples for sensory evaluation were taken from breast and thighs muscle of male and female ducks, deboned and washed thoroughly. Meat samples were cut into sizes of 3 by 4 cm and subjected to three different cooking methods: Boiling in water using an aluminum pot at 100°C for 15 minutes using a kerosene stove. Microwaving was done at medium-high temperature with an electric microwave oven (Teka model ME-20FL, made in Spain) for a cooking time of 20 minutes. Oven-drying cooking was done at a temperature of 80°C for 20 minutes using an electric oven (Bruhm model BGC-5540SB, made in Germany).

The organoleptic/sensory evaluation was done by the method described by Akinnusi and Alade (2011). Duck meat samples subjected to each of the cooking methods were offered to a group of 12 untrained panelists between the ages of 25 and 45 years for assessment of the cooked meat samples. The panelists were served the samples immediately after cooking and cooling. They evaluated each meat sample for colour, flavour, tenderness, juiciness, number of chews, remains after chewing and overall acceptability based on the 4-point hedonic scale, where 4 = desirable, 3 = slightly acceptable, 2 = unacceptable, 1 = very unacceptable (Ozung, 2016).

All data collected were subjected to a one-way analysis of variance (ANOVA). Significant means were separated using Duncan's Multiple Range Test of Genstat Release 8.1 software (GENSTAT, 2011).

Results and Discussion

The results of proximate composition of duck meat are presented in Table 1. Crude protein content among meat samples differed ($p < 0.05$). Thigh muscle samples were significantly lower in crude protein than breast samples. The male thigh showed superiority in this regard. The values recorded in the present study are similar to the report of Adeyeye (2020), who recorded crude protein content of 79.9%. Huda *et al.* (2011) reported that the protein content of the breast muscle is generally higher than that of the thigh muscle which agrees with the findings of this research. The high crude protein values obtained in the present research are indicative of the nutritional superiority of duck meat, as the protein content of food samples and its digestibility determine the amino acid availability and cell growth promotion capacity of the food sample (Borela *et al.*, 2022).

Ether extract (fat) content of duck thigh muscle samples was significant ($p<0.05$) among the meat samples tested. Drake thigh and female duck breast samples were statistically similar but higher than the content recorded for the drake breast muscle sample. Ether extract content of duck meat samples obtained in this study (4.33 – 12.92%) fall within the range reported by previous authors (Omojola *et al.*, 2014, Adeyeye, 2020) who reported 12.92 and 5.38 % respectively; but lower than the range of 3.86 - 3.92% reported by Galal *et al.* (2011). Ash content of duck meat samples in this study was not significant and ranged from 1.50 – 1.83% which is similar to 1.35 – 2.14% reported by Galal *et al.* (2011). Biswas *et al.* (2019) and Krempa *et al.* (2019) however reported lower ash content (1.2 and 1.14%) for Pekin and Mallard duck meat samples, respectively. Though carbohydrate is the major energy source in human diet, fat has been proven to be an efficient energy source, containing twice the amount of energy in carbohydrate (Trisyani and Yusan, 2020).

Nitrogen free extracts (NFE) tell the relative abundance of water-soluble polysaccharides in a food sample (Krempa *et al*., 2019). NFE content of duck meat samples differed ($p < 0.05$) with the thigh muscles having the highest NFE content (14.12 and 13.04 % for male and female respectively). The range (10.27 – 14.12%) obtained in this research is lower than 85.5% reported by Kardaya *et al.* (2022). The percentage moisture content obtained in this study, ranged from 63.70 – 70.28% which is slightly lower than 71.64% reported by Omojola *et al.* (2014) but however, higher than the range of 49.40 – 56.60% reported by Slobodyanik *et al.* (2021). Higher moisture content of raw duck meat samples (71.64 and 72.2 % respectively) had been reported by previous authors (Omojola *et al*., 2014; Kokoszynski *et al*., 2020). The moisture content of meat has remarkable effects on factors such as juiciness, colour, texture, taste and even the weight of the meat which may indirectly determine the price a consumer will be willing to pay for the meat sample. The moisture content of duck meat samples recorded in the present study was within permissible levels of 66 – 75% for raw poultry meat (FSIS, 2013) which also goes to show that the meat samples were in optimum nutritional standards.

Result of the proximate composition of duck meat samples (Table 1) in the present study also elucidated the influence of sex on duck meat samples. Crude protein content of the male was significantly ($p < 0.05$) higher in both thigh and breast meat samples than in the female. The finding of the present study contradicts the report of Hailemariam *et al.* (2022) that female broiler chicken breast muscle had significantly ($p < 0.05$) higher crude protein content than the male (21.64 and 19.91% for female and male respectively). Male sex hormone, testosterone could be implicated in this disparity as male animals have higher muscle building capacity than females (Ozung, 2016). Kokoszynski *et al.* (2020) however did not find significant differences in crude protein content between both sexes.

Ether extract content in the female thigh and breast meat samples were found to be significantly ($p < 0.05$) higher (12.92 and 7.42% for thigh and breast respectively) than the male meat samples (7.25 and 4.33% thigh and breast respectively). This finding is in line with the report of Oyinlola *et al.* (2017) that ether extract composition of female poultry meat sample has been adjudged to be generally higher than in the male. The authors (Oyinlola *et al*., 2017) reported values of 4.80 and 4.46% respectively of ether extract composition in female and male post rigor broiler chicken meat.

Ash content and nitrogen free extract content of meat samples did not differ significantly between the male and female thigh and breast meat samples in this study. Similar with the present research finding, Oyinlola *et al.* (2017) reported non-significant differences in ash content between post rigor meat samples from male and female broiler chickens. Souza et al. (2011) and Hailemariam *et al.* (2022) however reported significantly ($p<0.05$) higher ash content in male than female broiler breast muscle.

Moisture composition of male thigh muscles in the present study was found to differ significantly ($p < 0.5$) with that in the female (70.28 and 63.70% respectively); but did not differ significantly ($p > 0.05$) in the breast meat samples of the ducks. Baeza *et al.* (2010) reported significantly ($p < 0.05$) higher moisture content in male (74%) broiler chicken breast meat than in female (73%); while Hailemariam *et al.* (2022) reported values of 74.06 and 72.76% moisture content in male and female broiler chicken breast meat respectively. Variations between the results of the present research and previous authors reports could be due to differences in breed and species of birds used, nutrition and differences in methodology of carrying out the researches.

The results of mineral composition of meat samples are presented in Table 2. The calcium content differed significantly among duck meat samples. The magnesium content in this study ranged from 0.18 % in the duck thigh muscle to 0.31% in the breast muscle. The magnesium content in duck breast muscle was different ($p<0.05$) from that of the thigh muscle of both duck and drake. Slobodyanik *et al.* (2021) reported a magnesium content of 0.015% which is lower than the magnesium content in this study; but the reports of Krempa *et al.* (2019) and Kokozynski *et al.* (2021) are in consonance with results of this present study that breast muscle had more magnesium content compared to thigh muscles. The zinc content of this study is generally high and ranged from 5.50 mg/kg in drake to 8.4 mg/kg in duck thigh muscle. The zinc content in duck thigh muscle showed a significant ($p<0.05$) difference from the breast muscle. Slobodyanik *et al.* (2021) reported a lower value of 3.0 and 3.28 mg/kg for Muscovy Pekin ducks respectively. Similarly, Kokozynski *et al.* (2021) reported 3.7 and 4.0 mg/kg zinc content in drake and duck meat, respectively. Zinc, though a micro-nutrient, can be adjudged as an essential mineral nutrient in the human diet as it is a constituent of many enzymes that function in boosting body immune system, cell division, growth and healing of wound (Ahmad *et al.*, 2018).

Phosphorus and calcium had been recognized as essential for the sustenance of optimal bone formation in children, whereas manganese, zinc and iron are considered important for prevention of disease, growth and basic cellular functions (Nkasah *et al.* 2021). The iron content among the meat samples analyzed was significantly ($p<0.05$) higher in the breast muscles compared to the thigh muscles, values ranged from 15.53 – 20.22 mg/kg. Kokoszynski *et al.* (2021) however, reported lower content of zinc in duck meat samples (3.7 and 4.0 mg/kg, for drake and duck respectively). The report of Kokoszynski *et al.* (2021) agreed with the finding of the present study that iron content of duck breast muscle is higher than that in the thigh muscle. Iron deficiency in human growing child diet can engender anemia and retarded growth (Ahmad *et al.*, 2018). The iron content obtained in the present study underscores the importance of incorporating Muscovy duck meat in the diet of humans to improve its quality.

Results for the influence of cooking methods on sensory properties of male Muscovy duck meat in Nigeria are presented in Table 3. Cooking methods affected meat flavour, tenderness, juiciness and remains after chewing. Meat acceptability is often determined by colour, which is mainly influenced by myoglobin (Krempa *et al.*, 2019). The panelists exhibited a desirable acceptance of flavour for the oven-dried meat samples more than other cooking methods. In consonance with the finding of the present study, Tanganyika and Webb (2019) reported that oven-drying gave a better colour to duck meat than boiling. Tenderness which is the most important sensory property affecting meat acceptability ranged from 2.00 for microwaving to 3.33 for boiling method. This finding is in agreement with the report of Tanganyika and Webb (2019) that boiling gave the best tenderness of meat among the cooking methods employed in their research. According to Pathare and Roskilly (2016), cooking methods play an important role in the sensory characteristics of food products. The overall effect of cooking on tenderness in this study revealed that boiling produced more tender meat than microwaving and oven-drying methods. This observation is in tandem with an earlier report by Ikeme (1990), who explained that meat may be tenderized by cooking in water. The author emphasized that the connective tissue (collagen) which determines the toughness of meat, hydrolyzes and forms a tender protein (gelatin) when boiled in water. On the contrary, dry heat such as microwaving and oven-drying, does not improve the tenderness of meat (Ikeme 1990). Banaszak *et al.* (2020) opined that meat tenderness/toughness is a function of different factors, including age of bird, diet and collagen content. lower collagen content results in greater tenderness of meat (Banaszak *et al.*, 2020).

Table 4 shows the results for the influence of cooking methods on sensory evaluation of female Muscovy duck meat in Nigeria. There were significant differences ($p<0.05$) among the cooking methods and the panelists judged oven-dried duck meat samples to be most acceptable, followed by the boiled and lastly microwaved meat samples, with mean values of 3.25, 2.50 and 2.17, respectively. The observed alteration of colour of meat samples caused by the different cooking methods in this study was corroborated by the report of Ikeme (1990) who stated that cooking is a technique where heat energy in form of high temperature is applied to change meat colour. Biscelgia *et al.* (2013) affirmed that oven-drying was the method of choice employed in the catering industry. Cooking methods must guarantee the acceptability of meat both in taste and microbial safety (Biscelgia *et al.*, 2013). Tenderness of duck meat samples in this study as determined by the taste panelists was significantly ($p<0.05$) affected by the cooking methods. The results revealed that boiled meat samples were most tender, followed by oven-dried meat samples, while microwaved meat samples were adjudged to be least tender. Similarly, boiled meat samples in this study had the least remains after chewing. Previous studies confirmed the findings of this research, that meat may be tendered by boiling (Ikeme, 1990; Tanganyika & Webb, 2019). In line with the findings of the present study, Bruwer and Novacofski (2008) and Banaszak *et al.* (2020) reported that the more tender the meat, the less the residues remain in the mouth after chewing. Differences between the present research findings and reports of previous studies could be attributed to differences in methodology of research, nutrition of the experimental animals, as well as differences in taste of the panelists.

Conclusion

This study indicated that Muscovy duck's meat have high nutritional qualities (proteins and minerals). The sensory evaluation showed overall acceptability for boiling and oven-drying cooking methods. This portends that Muscovy duck meat can serve as a healthy alternative poultry source to chicken and can help mitigate the challenges of food and nutritional security for Nigerians. Oven-drying and boiling are recommended for the cooking of duck meat, as both cooking methods have shown to be more acceptable based on sensory properties (tenderness, juiciness and remains after chewing).

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Table 1: Proximate composition of Muscovy duck meat samples

Parameters (%)						
Meat samples	**CP**	**EE**	**CF**	**ASH**	**NFE**	**Moisture**
Thigh (male)	77.13[c]	7.25[b]	0.0	1.50	14.12[a]	70.28[a]
Thigh (female)	72.41[d]	12.92[a]	0.0	1.67	13.04[a]	63.70[c]
Breast (male)	83.57[a]	4.33[c]	0.0	1.83	10.27[c]	67.21[b]
Breast (female)	79.34[b]	7.42[b]	0.0	1.83	11.41[b]	65.40[b]
SEM	0.21	0.19	0.0	0.14	0.33	0.16

[abcd]Means bearing different superscripts along the same column are significantly different ($p<0.05$)

Table 2: Mineral composition of Muscovy duck meat samples

Parameters	**Ca (%)**	**Mg (%)**	**K (%)**	**Na (%)**	**Zn (mg/kg)**	**Fe (mg/kg)**
Thigh (male)	0.34[c]	0.24[b]	0.87[b]	0.05	5.50[c]	15.53[d]
Thigh (female)	0.23[d]	0.18[c]	0.93[a]	0.05	8.45[a]	17.30[c]
Breast (male)	0.46[b]	0.26[b]	0.92[a]	0.05	6.28[b]	20.22[a]
Breast (female)	0.53[a]	0.31[a]	0.95[a]	0.04	7.26[b]	19.32[b]
SEM	0.02	0.01	0.02	0.003	0.18	0.13

[abcd]Means bearing different superscripts along the same column are significantly different ($p<0.05$).
Ca = calcium, Mg = Manganese, K = Potassium, Na = Sodium Zn = zinc, Fe = Iron

Table 3: Sensory evaluation of Muscovy drake meat samples

	Cooking methods

Parameters	Boiling	Microwaving	Oven drying	SEM
Colour	3.00	2.67	3.25	0.42
Flavour	2.67[b]	2.83[b]	3.67[a]	0.36
Tenderness	3.33[a]	2.00[b]	3.17[a]	0.34
Juiciness	3.33[a]	2.00[b]	3.50[a]	0.35
Number of chews	32.50[a]	24.83[b]	36.50[a]	7.73
Remain after chew	3.17[a]	2.83[b]	3.42[a]	0.43

[ab]Means bearing different superscripts along the same row are significantly different ($p<0.05$). SEM = standard error of mean

Table 4: Sensory evaluation of female Muscovy duck meat samples

	Cooking methods			
Parameters	**Boiling**	**Microwaving**	**Oven drying**	**SEM**
Colour	2.50[b]	2.17[b]	3.25[a]	0.28
Flavour	3.17[a]	2.67[b]	3.17[a]	0.35
Tenderness	3.67[a]	1.67[b]	2.92[a]	0.31
Juiciness	3.33[a]	2.00[b]	3.42[a]	0.27
Number of chews	22.56[c]	31.00[b]	35.33[a]	7.20
Remain after chew	3.17[a]	2.33[b]	3.42[b]	0.40

[ab]Means bearing different superscripts along the same row are significantly different ($P<0.05$). SEM = standard error of mean.