FUNCTIONAL AND NUTRIENT COMPOSITION OF WHEAT, PIGEON PEA AND *Moringa oleifera* LEAF FLOUR

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Abstract
This study aimed at evaluating the nutrient composition of wheat, pigeon pea and Moringa oleifera leaf flour. Four samples of composite flour were formulated, containing 80:15:5 (P1), 70:20:10 (P2), 60:25:15(P3) and 100:0:0 (P4) of wheat, pigeon pea and moringa oleifera, respectively. The composite flours were analysed for functional, proximate and mineral composition. The result showed that bulk density, water absorption capacity, oil absorption capacity, wettability and pH ranged from 0.56 to 0.67 g/ml, 1.33 to 1.53 g/m, 0.43 to 0.87 g/ml, 1.48 to 3.44 sec and 5.90 to 6.10 respectively. Proximate composition showed that moisture, ash, protein, fat, fibre and carbohydrate content ranged from 10.33 to 11.07%, 1.33 to 2.50%, 5.34 to 13.30%, 9.50 to 11.50%, 1.10 to 1.79% and 61.27 to 70.80% respectively. The result of the mineral composition showed that magnesium, sodium, manganese, iron and zinc ranged from 3.44 to 7.71 ppm, 3.83 to 5.45 ppm, 0.14 to 0.50 ppm, 2.32 to 2.93 ppm and 0.11 to 0.22 ppm respectively. In conclusion, the composite flour formulated in this study, showed potentials for pastry production, evident by its comparable functional and nutrient properties with wheat flour which is the traditional raw material utilized in pastry and other confectionery production.
Keywords: *Pigeon pea, Wheat, Moringa oleifera, cookies, composite flour*

Introduction

In Nigeria, the consumption of ready-to-eat baked products is continually growing and the production of these products has laid a burden on imported wheat as the sole raw material (Inyang and Elijah, 2020). This importation places a considerable burden on the foreign exchange reserve of Nigeria's economy (Inyang and Elijah, 2020) hence, making the wheat expensive. However, cookies and other baked products made from wheat flour are not suitable for individuals suffering from celiac disease (Kurniadi *et al*., 2019), due to its high gluten content of gluten.

Composite flour can be defined as a mixture of several flours obtained from roots, tubes, cereals and legumes with or without the addition of wheat flour (Shittu *et al*., 2007). Composite flours have been used extensively and successfully in the production of bread, cakes, cookies, biscuits, crackers etc. These flours can be utilized to create innovative and nutritious food formulations to meet diverse consumer preferences and dietary needs.

Wheat (*Triticum aestivum*) is a common cereal in the world which plays an important role as global commodity due to its gluten forming proteins, which are capable of having extensibility and elasticity required for bakery products and pasta (Inyang *et al.*, 2018). Average wheat grain composition is approximately 84% endosperm 13% husk and 2% embryo (Christine, 2019). Wheat, however has to be imported to tropical countries where climatic conditions are not conducive for growing it. This often leads to loss of huge foreign exchange of the importing countries like Nigeria. Wheat grains are also relatively low in protein and generally low in lysine and certain other amino acids, but these could be complemented with legumes such as pigeon pea.

Pigeon pea (*Cajanus cajan*) is an important underutilized legume in south- west Nigeria (Fasoyiro and Arowora, 2013), where it is locally known as otinli. It contains 20%–22% of all essential amino acids particularly lysine and 18%–35% protein, and therefore desirable in overcoming the incidence of protein- energy malnutrition in Nigeria (Jigam, and Ndaceko, 2012). Pigeon pea is rich in dietary minerals such as calcium, copper, phosphorus, magnesium, iron, sulfur, and potassium, and water- soluble vitamins such as thiamine, ascorbic acid, riboflavin, and niacin (Kaushal *et al*.,2012). It is a good source of slow- release carbohydrates, making it a suitable raw material for the formulation of low glycemic index food product. Srikaeo and Sopade (2011) reported that composite flours from legumes (such as cowpea, pigeon pea) and unripe banana are good sources of dietary fiber, and can be used in the preparation of functional foods product. Consumption of high fiber food products has been linked to reduction in hermorrhoids and effective management of diabetes, high blood pressure, and obesity (Jaja and Yarhere, 2015). Also, addition of legumes to cereals improves the amino acid balance of the product since legume and cereal proteins are complemented in the essential amino acids, lysine and methionine (Qadri *et al*., 2018).

Moringa oleifera is universally referred to as the miracle plant or the tree of life. The Moringa plant derives this name base on its uses, particularly with regard to medicine and nutrition. It is a native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. *Moringa oleifera* is the most widely cultivated among the 13 species of the Moringacea family and it is exceptionally nutritious with a variety of uses. Almost all the parts of this miracle tree have been found to be very useful. Leaves are used as forage, tree trunk for making gums, flower nectar in honey and powdered seeds for water purification and also used as an alternative food source to combat malnutrition, especially among children and infants (Anwar *et al.,* 2007). *Moringa oleifera* leaves are reported to contain substantial amounts of vitamin A, C and E (Hekmat *et al.,* 2015). The leaves of *Moringa oleifera* have also been found to contain appreciable amounts of total phenols, proteins, calcium, potassium, magnesium, iron, manganese and copper (Hekmat *et al.*, 2015). *Moringa oleifera* leaves are also good sources of phyto nutrients such as carotenoids, tocopherols and ascorbic acid (Saini *et al.*, 2014). These nutrients are known to scavenge free radicals when combined with a balanced diet and may have immune suppressive effects (Dan-Malam *et al.,* 2001).
The use of these crops in the production of cookies, helps to enhance the nutritional quality and functional properties of food products, while also diversifying their utilization.

The objective of this study was to produce a composite flour from wheat, pigeon pea and *Moringa oleifera* leaves.

Materials and Methods

Materials

Pigeon pea and fresh moringa leaves were purchased from Watt Market, Calabar, Cross River State. Wheat flour was obtained from Flour Mill Limited, Calabar, Cross River State.

Sample Preparation

Production of Pigeon Pea Flour

Pigeon pea flour was produced following the method described by Fasoyiro *et al*. (2010) with slight modifications. Pigeon pea seeds were sorted, washed and boiled in boiling water for 20 mins. The seed coats were dehulled using a blender, washed, drained and dried in the Genlab Cabinet dryer at 60 °C for 5 hr. The dried pigeon pea seeds were allowed to cool at room temperature, milled and sieved through a 500 µm mesh. The flour was then packaged in an airtight container for further analysis.

Preparation of *Moringa oleifera* leaf powder

Moringa leaves were produced following the method described by Mishra *et al*. (2012) with slight modification. Fresh moringa leaf was separated from stalk and washed to remove dirts. The leaves were soaked in 1 % brine solution for 5 minutes to remove microbes and further washed with distilled water; it was dried at a room temperature under a shade for 16 days. The leaves were turned over several times with hand to improve uniform drying at room temperature. Dried leaves were milled and sieved through 500 µm mesh to remove large particles or impurities to get moringa leaf flour, the flour was packaged in a tight container for further analysis.

Formulation of Samples
The different flours were formulated into four samples in the ratios as shown in Table 1

Table 1: Sample formulation

Sample	Wheat	Pigeon pea	*Moringa oleifera*
P1	80	15	5
P2	70	20	10
P3	60	25	15
P4	100	0	0

Methods of Analysis
Functional properties (Bulk density, Water absorption capacity, oil absorption capacity, wettability and pH) were analysed using the methods of Fayemi (2010).
Proximate analysis (moisture, ash, crude protein, fibre) was done according to the methods described by AOAC (2010). Carbohydrate contents were determined by difference.
Minerals (Magnesium, Sodium, Manganese, Iron and Zinc) were determined according to the method of Onwuka (2018).

Results and Discussion
Functional properties of wheat-pigeon pea-*moringa oleifera* leaves flour
The result of the functional properties (Table 2) showed that bulk density ranged from 0.56 g/ml to 0.67 g/ml, the bulk density subsequently decreased with increased substitution with moringa leaf. The result obtained in this study was observed to be lower than result of Asaam *et al.,* (2018) who recorded 0.61-0.68g/ml for maize-soya pumpkin flour formulations. This could be attributed to the incorporation of vegetables as they have a low bulk density. Bulk density of flours is critical in determining packaging and material handling requirements (Oppong *et al.,* 2015).

Water Absorption Capacity (WAC) ranged from 1.33 g/ml to 1.53 g/ml, with sample P4 and P1 having the lowest WAC (1.33 g/ml) and sample P3 having the highest WAC (1.53 g/ml). WAC is necessary in food compositions especially in dough creation because, it indicates the ability of protein in flours to physically bind with water (Ikpeme-Emmanuel *et al.,* 2010).

Oil Absorption Capacity (OAC) ranged from 0.43 g/ml to 0.87 g/ml, sample P1 had the lowest OAC (0.43 g/ml) and sample P3 had the highest (0.87 g/ml). The OAC increased considerably with increase in pigeon pea and Moringa oleifera flour blends inclusion, this is because *moringa leaf* flour is related to lipophilic protein, which has a great affinity for holding fat globules (Efuribe *et al.,* 2018). High oil absorption capacity flours are better flavour retainers (Chandra and Samsher, 2013).

Wettability ranged from 1.48sec to 3.44 sec with sample P4 having the shortest time (1.48 sec) and sample P3 having the longest time (3.44 sec). Wettability shows how proficient a flour sample will be distributed reconstituted (Kaji Hausa *et al.,* 2023). Higher values of wettability indicate lower reconstitution properties (Junfu *et al.,* 2016). Hence, sample P4 (control) dissolved faster.

pH ranged from 5.90 to 6.10, where sample P1 had the lowest pH (5.90) and the highest pH (6.10) was observed in sample P4 (control). The pH of the composite flours is also affected due to ratio of individual flours and nutritional properties, similar trends were reported by Deepika *et al.,* (2022).

Table 2: Functional properties and pH of the flour blends

Samples	Bulk density (g/ml)	Water Absorption capacity (g/ml)	Oil Absorption capacity (g/ml)	Wettability(s)	pH
P1	0.65±0.02^{a}	1.33±0.12^{a}	0.43±0.25^{b}	1.51±0.00^{c}	5.96±0.01^{ab}
P2	0.59±0.02^{ab}	1.47±0.12^{a}	0.67±0.25^{d}	2.12±0.03^{b}	6.00±0.06^{b}
P3	0.56±0.00^{b}	1.53±0.12^{a}	0.87±0.37^{cd}	3.44±0.05^{a}	5.90±0.00^{a}
P4	0.67±0.03^{a}	1.33±0.12^{a}	0.87±0.25^{a}	1.48±0.01^{c}	6.10±0.02^{b}

Values are mean ± SD of three replicate. Means in the same column with different superscript are significantly different (p<0.05)

Keys

P1= 80% Wheat +15% Pigeon pea + 5% Moringa leaf flour
P2= 70% Wheat + 20% Pigeon pea + 10% Moringa leaf flour
P3 = 60% Wheat + 25% Pigeon pea + 15% Moringa leaf flour
P4 = 100% Wheat flour

Proximate composition of wheat-pigeon pea-moringa oleifera leaves flour

The result of proximate composition (Table 3) showed that moisture content ranged from 10.33 to 11.07%, where sample P3 had the lowest moisture content (10.33%) while sample P4 had the highest moisture content (11.07%). The study revealed that moisture content of composite flours decreased with decrease in proportion of wheat, similar trends were reported by Kaushal *et al.,* (2012). Moisture content and water activity in a dry sample greatly determines the keeping quality of a product.

The ash content ranged from 1.33 to 2.50% with sample P1 having the lowest ash content (1.33%) and sample P3 having the highest ash content (2.50%). Ash content of food is a determinant of mineral content of that particular food (Kiin-Kabari *et al.,* 2015).

Crude Protein content varied significantly ranging from 5.34% in sample P4 having the lowest protein content and 13.30% in sample P3 having the highest protein content. The high protein content in sample P3 as a result of high substitution of pigeon pea. Similar trends were reported by Adeyanju *et al.,* (2018) in wheat, acha and pigeon pea flour blends.

Crude fat content of the flours increased with increasing addition of pigeon pea and Moringa leaf flour. The values ranged from 9.50 to 11.50% with sample P4 having the lowest fat content (9.50%) while sample P3 had the highest fat content (11.50%). Fat in food will not only increase the energy density but is also a transport vehicle for fat soluble vitamins (Eka *et al.,* 2010).

Crude fibre content ranged from 1.10 to 1.79 % with sample P3 having the lowest fibre content (1.10%) while sample P4 had the highest fibre content (1.79%). The fibre content significantly (P<0.05) decreased with increase in substitution of flour blends. Fibre aids in lowering blood cholesterol levels and enhancing the gastro intestinal tract (GIT), American Academy of pediatrics (2012).

The carbohydrate content values ranged from 61.27 to 70.80% with sample P3 having the lowest carbohydrate content (61.27%) while sample P4 had the highest carbohydrate content (70.80%). Carbohydrate content decreased due to increase in protein content as the percentage level of the flour blends were increased. Also, as a result of moringa leaf dilution effect on carbohydrate content of wheat (Sengev *et al*, 2013).

Table 3: Proximate composition of the flour blends

Sample	**Moisture (%)**	**Ash (%)**	**Protein (%)**	**Fat (%)**	Fiber (%)	Carbohydrate (%)
P1	11.00 ± 0.40^{a}	1.33 ± 0.29^{b}	7.44 ± 0.35^{c}	10.50 ± 0.50^{a}	1.50 ± 0.06^{b}	68.23 ± 0.54^{b}
P2	10.87 ± 0.01^{a}	1.67 ± 0.29^{b}	11.57 ± 0.40^{b}	10.67 ± 0.29^{a}	1.18 ± 0.03^{c}	64.04 ± 0.56^{c}
P3	10.33 ± 0.81^{a}	2.50 ± 08.00^{a}	13.30± 0.40^{a}	11.50 ± 0.80^{ab}	1.10 ± 0.01^{d}	61.27 ± 0.31^{d}
P4	11.07 ± 0.42^{a}	1.50 ± 0.00^{b}	5.34 ± 0.75^{d}	9.50 ± 0.50^{b}	1.79± 0.02^{a}	70.80 ± 0.20^{a}

Values are mean ± SD of three replicate. Means in the same column with different superscript are significantly different ($p<0.05$)

Keys

P1= 80% Wheat +15% Pigeon pea + 5% Moringa leaf flour
P2= 70% Wheat + 20% Pigeon pea + 10% Moringa leaf flour
P3 = 60% Wheat + 25% Pigeon pea + 15% Moringa leaf flour
P4 = 100% Wheat flour

Mineral composition of wheat-pigeon pea-moringa oleifera leaves flour

The result of the mineral composition (Table 4) showed that magnesium ranged from 3.44 ppm to 7.71 ppm. Sample P4 had the lowest content (3.44 ppm) and sample P2 had the highest content (7.71 ppm).

The sodium content increased significantly ($P<0.05$) as the substitution increased, ranging from 3.83 ppm to 5.45 ppm. Sample P4 had the lowest content (3.83 ppm) while sample P2 and P3 had the highest content (5.45 ppm), this could be due to the variation in wheat flour.

Manganese content ranged from 0.14 ppm in sample (P4) being the lowest to 0.50 ppm in sample (P1) being the highest.

The zinc content ranged from 0.11 ppm to 0.22 ppm. The values increased subsequently as substitution increases, with sample P4 having the lowest zinc content (0.11 ppm) and sample P3 having the highest zinc content (0.22 ppm). Zinc is very important to humans for its role in enhancing immune function.

Conclusion

The result of this study showed that formulation of flour blends of wheat incorporated with pigeon pea and moringa leaf had varying effect on the functional properties, proximate and mineral composition of the flour blends. It was observed from the result that the moisture content was within the recommended standard (<14%) for cereals and legume products which ensures a stable shelf life of the flour. The high levels of protein and ash signify the inclusion of pigeon pea and *moringa oleifera* leaves. In essence, the composite flour formulated in this study, showed potentials for the production of several pastry products evident by its comparable functional and nutrient properties with wheat flour which is the traditional raw material utilized in their production.

Table 4: Mineral composition of the flour blends (ppm)

Sample	Mg	Na	Mn	Fe	Zn
P1	6.76±0.01[b]	5.36±0.01[b]	0.50±0.01[c]	2.60±0.01[c]	0.14±0.01[c]
P2	7.71±0.01[a]	5.45±0.01[a]	0.18±0.01[a]	2.93±0.01[a]	0.17±0.01[b]
P3	6.73±0.01[c]	5.45±0.01[a]	0.17±0.01[b]	2.75±0.01[b]	0.22±0.01[a]
P4	3.44±0.01[d]	3.83±0.00[c]	0.14±0.01[d]	2.32±0.01[d]	0.11±0.01[d]

Values are mean ± SD of three replicate. Means in the same column with different superscript are significantly different ($p<0.05$)

Keys

P1= 80% Wheat +15% Pigeon pea + 5% Moringa leaf flour
P2= 70% Wheat + 20% Pigeon pea + 10% Moringa leaf flour
P3 = 60% Wheat + 25% Pigeon pea + 15% Moringa leaf flour
P4 = 100% Wheat flour

Recommendation

Further analysis such as anti-nutrient, vitamins and amino acid profile should be carried out on the flour samples. Furthermore, cookies should be made from the formulated flour samples to ascertain its baking potentials.

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