



Nutritional and Functional Properties of Wheat, Unripe Banana and Pigeon Pea Flour Blend and Physical and Quality of Bread Made from the Blend

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Abstract

Flour blends were produced from wheat, unripe banana and pigeon pea. They were formulated into the ratios (w/w) 100:0:0, 70:10:20, 60:15:25 and 50:20:30, designated as sample A, B, C, and D respectively. Formulated samples were analysed for their nutritional and functional properties, and the physical and chemical properties of bread produced from the blends were also investigated which were compared to 100% wheat flour. There was no significant difference ($P>0.05$) in the moisture content among the samples. There was an increase in the protein and ash contents as unripe banana and pigeon flours were increased. For functional properties, there was no significant difference ($P>0.05$) between the formulated samples and the control (100% wheat) in bulk density. Wettability decreased with increasing addition of unripe banana and pigeon pea. For the mineral composition, iron and potassium content were higher in the formulated samples, there was an increase with increasing addition of unripe banana in iron and potassium contents. The sensory mean scores values showed that in terms of overall acceptability, bread produced from 100% wheat flour was the most preferred by the panellists. This study has shown that flour which is higher in protein than the conventional wheat flour can be produced from wheat, unripe banana and pigeon pea flour. Consumption of the bread could help to alleviate the problem of protein-energy malnutrition that is still prevalent in some communities in Nigeria and could also promote the utilization of these crops.

Keywords: flour blends, functional properties, sensory properties, pigeon pea flour.

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1. Introduction

Bread is an important staple food in both developing and developed countries which constitutes one of the most important sources of nutrients such as carbohydrate, protein, fibre, vitamins and minerals in the diets of many people worldwide [1]. It can be described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of processes involving mixing, kneading, proofing, shaping and baking [2].

In Nigeria, reliance on wheat flour in the pastry and bakery industries has over the years restricted the use of other cereals and tuber crops available to domestic use. Recently, government has collaborated with the research institutes to encourage the use of composite flours in the production of food products such as bread, cookies etc. Several studies have reported the use of composite flour in bread production [3]. All

these efforts were aimed at improving the nutritional values of the bread and also to enhance crop utilization.

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 [4]. Average wheat grain composition is approximately 84% endosperm 13% husk and 2% embryo. 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. It is therefore imperative to use wheat and locally, cheap available crops for baking purposes. The most obvious result

of such blending is that the mixture is higher in protein than the cereal component alone. The legumes also improve the quality of cereal protein by supplementing them with limiting amino acids such as lysine and sometimes tryptophan and threonine. On the other hand, legumes which are deficient in methionine can be supplemented by cereal grains which are not deficient in the amino acid. The existing problem of food insecurity and malnutrition and high cost of animal-based food supplies have made it necessary to incorporate unconventional protein sources into bread and to enrich the traditional formulations [5].

Bananas (*Musa sapientum*) are grown worldwide in tropical countries and are fourth most important food crop after rice, wheat and maize [6]. It is a climacteric fruit with short shelf-life after harvest. Banana fruits are usually traded in the fresh form and the populations in general have the habit of consuming only the ripe fruits. High postharvest losses in quantity and quality are usually encountered due to poor handling, bulk transportation, rapid ripening and lack of processing technologies. Processing of fresh banana fruits into flour is an excellent alternative to minimize postharvest losses and add value to the product [7]. The flour could be incorporated into various innovative products such as high fibre bread [8], slowly digestible cookies [9] and edible films. Nutritionally, banana flour is a good source of carbohydrate with high level of resistant starch that may help control blood sugar, manage weight and lower blood cholesterol [7]. It also contains minerals and vitamins. Consumption of green bananas has been reported to have beneficial effects on diseases such as colorectal cancer, diarrhea, insulin response, dyslipidaemia, cardiovascular disease and celiac disease [10].

Pigeon pea (*Cajanus cajan*) is an important underutilized legume in south- west Nigeria [11], 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 [12]. 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 [13]. Sukanya and Sopade [14] 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 hemorrhoids and effective management of diabetes, high blood pressure, and obesity [15]. 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 [16].

Wheat flour is the main ingredient used in the production of bakery products including bread. However, Nigeria does not produce sufficient quantity of wheat to meet local demand due to unfavourable climatic conditions. For this reason, wheat is still imported into the country to augment local production and this has negative effect on the economy of the country. Also, consumption of wheat products may trigger celiac disease in genetically predisposed individuals caused by the gluten in wheat flour. Despite the reported nutritional and health

promoting constituents in pigeon pea and unripe banana, both food crops are underutilized in food formulation and product development. Both wheat and unripe banana are high in carbohydrate but low in protein content and quality. Like other carbohydrates, their proteins are deficient in essential amino acid, lysine. Regular consumption of carbohydrate-based diets may lead to protein-energy malnutrition. Also, bread produced from refined flours are low in dietary fibre and other constituents of medicinal importance. The supplementation of wheat with other composite flours from locally grown crops in the production of bread would serve as alternative means of diversifying these flours, add value to the products, increase the utilization of these crops in Nigeria, generate more income to farmers, reduce the quantity of wheat importation into the country as well as reduce dependency on wheat for production of bakery products. Inclusion of pigeon pea flour in the formulation would enhance the quantity and quality of protein in the bread. Like most cereals and carbohydrates, wheat and unripe banana are deficient in essential amino acid lysine. Hence, the cereals and legume proteins would be complemented in the essential amino acids, lysine and methionine. The produced bread would help to alleviate the problem of protein-energy malnutrition that is prevalent in most communities in Nigeria. However, with all these limitations of using refined wheat flour for bread production, and possible benefits of incorporating unripe banana which is rich in dietary fibre and pigeon pea which is rich in essential amino acid; lysine, hence the reason for this research.

2. Materials and Methods

2.1 Procurement of materials

The materials used for this study were wheat flour, unripe banana and pigeon pea flour. The wheat flour was obtained from Niger flour mills, Calabar at the point of production. While pigeon and unripe banana were purchased from watt market Calabar and processed into flour as shown in figures 1 and 2 respectively.

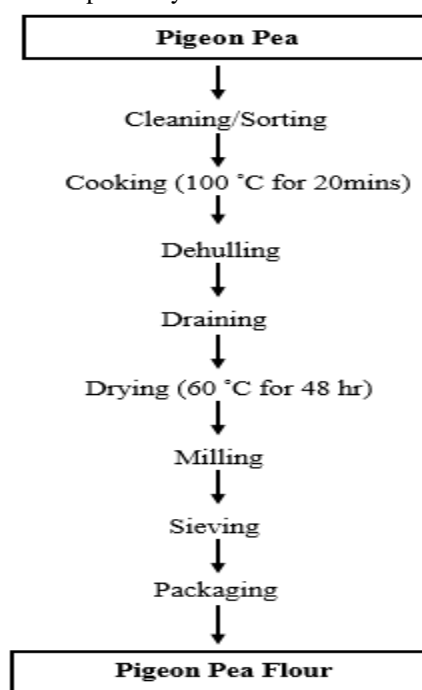


Figure 1: Production of Pigeon Pea Flour [17]

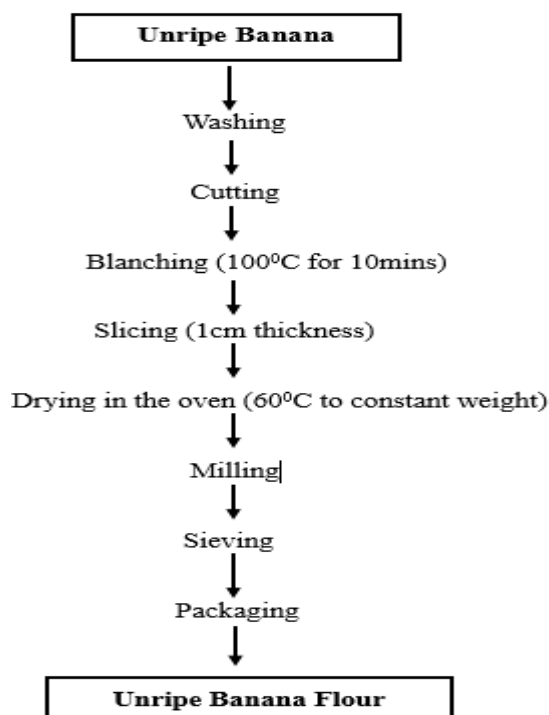


Figure 2: Production of Unripe Banana Flour [4]

Table 1. Sample formulation (%)

Samples	A	B	C	D
Wheat Flour	100	70	60	50
Unripe Banana Flour	0	10	15	20
Pigeon Pea Flour	0	20	25	30

2.5 Functional properties analysis

Bulk density, water and oil absorption capacities and wettability of the flours were analyzed according to a method described by Onwuka [19]. While swelling power and solubility were determined using the method described by Pranoto [20] with slight modification.

2.6 Mineral analysis

The mineral compositions (iron, potassium, magnesium, zinc and manganese) of the samples were analyzed according to the method of [18].

2.7 Determination of Physical Characteristics of Bread

The oven spring of bread was determined from the difference in height of the dough just before baking and height of loaf after baking. Bread loaf volume was measured 50 mins after the loaves were removed from the oven using the rapeseeds displacement method as modified by Giami [21].

2.8 Sensory Evaluation of Bread Produced

Sensory characteristics of the coded bread samples was evaluated for different sensory attributes by fifteen (15) semi-trained panelists drawn from the Department of Food Science and Technology, University of Calabar. All the panelists were briefed before the commencement of the evaluation process. The following sensory attributes was evaluated: taste, flavour, colour, texture and overall acceptability. The rating was on a nine-point hedonic scale ranging from 9 (like extremely) to 1 (dislike extremely) [22].

2.2 Methods of experimentation and analyses

Four samples (A, B, C and D) were formulated from wheat, unripe banana and pigeon pea flours at different ratios as shown in Table 1.

2.3 Analyses and methods of experiment

The analyses carried out on the formulated flour blends were proximate composition (carbohydrate, ash, protein, moisture, crude fibre), functional properties (bulk density, water and oil absorption capacities, wettability, solubility and swelling power) and mineral composition (iron, potassium, magnesium, zinc and manganese). Analyses done on the bread were physical characteristics of the bread (loaf volume, loaf weight, specific volume and oven spring) and sensory evaluation (colour, taste, aroma, texture and overall acceptability).

2.4 Proximate analysis

Moisture, Protein, Fat, Ash and crude fibre contents were determined using the method described by [18]. While carbohydrate content on a dry weight basis was determined by difference using the method of Onwuka [19].

The caloric value was calculated using Atwater factor shown in Eq. (1).

$$\text{Caloric value} = \text{crude protein} \times 4 + \text{crude fat} \times 9 + \text{carbohydrate} \times 4 \quad (1)$$

2.9 Statistical Analysis

All the data were subjected to statistical analysis using Analysis of Variance (ANOVA). The means were separated with the use of Duncan New Multiple Range Test (DMRT) using the Statistical Package for the Social Sciences (SPSS) 23.0 software.

3. Results and Discussion

3.1 Proximate composition of wheat, unripe banana and pigeon flour blends

The result of the proximate composition of the flour blend is presented in Table 2. The results showed that there was no significant difference ($P > 0.05$) in the moisture content. The moisture content of the composite flour ranged from 8.40 to 9.60% with sample A (control, 100% wheat flour) having the lowest (8.40%) and sample D having the highest value (9.60%). The result of the moisture content of the flour increased with as unripe banana and pigeon pea flour were added. Moisture content determines to a great extent the handling of food and its shelf life [23]. It has also been used as a measure of stability and susceptibility to microbial contamination. In this study, it shows that the control sample (A) will have a longer shelf life than the formulated samples because of its lower moisture content.

The crude protein content of the composite flour ranged from 12.40% to 13.40% with sample A (control) having the least protein content (12.40%) and sample D having the highest protein content (13.40%). Protein content increased with

increasing addition of pigeon pea flour. This could be due to the higher protein content in pigeon pea flour than in wheat flour. The crude protein values in this study were within the values (12.61% - 15.03%) reported by Adeyanju [24] in cookies from wheat, acha and pigeon pea flour blends. The high level of protein in the formulated samples indicates the effect of supplementing flour with legumes. Protein from plant sources is nevertheless “complete” because they contain at least trace amounts of amino acids that are essential in human nutrition, eating various plant foods in combination can provide a protein of higher biological value [25].

The ash content of the composite flour ranged from 0.40% to 1.30% with sample D having the highest ash content. Sample A (control) had lowest ash content (0.40%) while sample D had the highest (1.30%) ash content. The Ash content increased with increase in unripe banana and pigeon pea flour addition. The values obtained in this present study were lower than the values (1.36 – 1.49) reported by [26] for cookies from wheat, acha and African yam beans flour blends. Ash is an indication of mineral content in food materials. The high ash values recorded in this work may be attributed to the increasing levels of unripe banana and pigeon pea in the formulations. This is because unripe banana is high in minerals e.g., potassium and iron [27].

The crude fibre content ranged from 0.75% – 2.00%. Sample A (control) had the lowest value (0.75%) while sample D had the highest value (2.00%). There was no significant difference ($P>0.05$) among the samples. The fibre content of the blend increased with increase substitution of unripe banana and pigeon pea. These values were similar to the values reported by [26] for cookies from wheat, acha and African yam beans flour blends. Fibre is needed to assist in digestion and keep the gastrointestinal tract healthy, it aids in lowering blood cholesterol levels and slows down the process of absorption of glucose, thereby helping in blood glucose level control [28]. It also ensures smooth bowel movements and thus helps in easy

flushing out of waste products from the body, increase satiety and hence impacts some degree of weight management [29]. It slows down the release of glucose during digestion, so cells require less insulin to absorb that glucose. The American Diabetes Association recommends that people with diabetes should consume 25 g-50 g of fibre per day [30]. The faecal bulking action of insoluble fibre makes it useful in the treatment of constipation and diverticular disease [31].

The fat content of the flour blends significantly ($P<0.05$) increased with increasing addition of unripe banana and pigeon pea flours. The fat content of the flours ranged from 4.00% for sample A (control) to 7.00% for sample D. There were no significant differences ($p>0.05$) among the fat content of the flour blend samples. The values were higher than (16.50 – 20.29%) reported by [32] for cookies from wheat, unripe banana and pigeon pea flour blends. Fat in food will not only increase the energy density but is also a transport vehicle for fat soluble vitamins [33]. Excessive fat intake however may result to childhood obesity and cardiovascular diseases [34]. Also, high fat content in foods affect the shelf stability of such food as it could lead to the development of rancid flavour as a result of auto-oxidation.

The carbohydrate content decreased insignificantly ($P>0.05$) among samples as unripe banana and pigeon pea levels increased. The values decreased from 74.00% in the control sample to 66.70% in sample D. The carbohydrate content in the samples depended on other parameters since it was calculated by difference. The caloric (energy) value of the flour blends ranged from 363.15 to 399.80 (Kcal/100 g). Sample D had the lowest value (363.15 Kcal/100 g) while sample B had the highest value (399.80 Kcal/100 g). There was no significant difference ($P>0.05$) in the caloric (energy) value among the samples. The protein, fat and carbohydrate constituents contributed to the calculated caloric value of the samples with fat as the major contributor (9 kcal/g) while protein and carbohydrate have about 4 kcal/g.

Table 2. Proximate composition of Flour blends (wheat, unripe banana and pigeon pea) Dry matter.

Parameters	Samples			
	A	B	C	D
Moisture content (%)	8.45 ± 0.78 ^a	8.70 ± 1.56 ^a	8.60 ± 0.00 ^a	9.60 ± 1.70 ^a
Protein (%)	12.40 ± 0.00 ^b	13.05 ± 0.07 ^a	13.30 ± 0.14 ^a	13.40 ± 0.14 ^a
Ash (%)	0.40 ± 0.00 ^a	1.10 ± 0.14 ^a	1.20 ± 0.00 ^a	1.30 ± 0.42 ^a
Fibre (%)	0.75 ± 0.35 ^a	1.25 ± 0.35 ^a	1.50 ± 0.00 ^a	2.00 ± 1.41 ^a
Fat (%)	4.00 ± 3.54 ^a	4.75 ± 2.47 ^a	5.00 ± 2.12 ^a	7.00 ± 0.71 ^a
Carbohydrate (%)	74.00 ± 4.67 ^a	71.15 ± 1.20 ^a	70.40 ± 2.26 ^a	66.70 ± 4.38 ^a
Caloric value (Kcal/100g)	390.60 ± 0.42 ^a	399.80 ± 1.83 ^a	370.80 ± 23.33 ^a	363.15 ± 5.30 ^a

Values are expressed as mean ± SD (n=3). Means with different superscripts (a, b) are significantly different from each other at $p<0.05$.

Key: A = (100% WF, 0% UBF, 0% PPF) B = (70% WF, 10% UBF, 20% PPF)

C = (60% WF, 15% UBF, 25% PPF) D = (50% WF, 20% UBF, 30% PPF)

Where: WF = wheat flour, UBF = unripe banana flour, PPF = pigeon pea flour

3.2 Functional properties of wheat, unripe banana and pigeon pea flour blends

The result of the functional properties of wheat, unripe banana and pigeon pea flour blends is presented in Table 3. The result showed that bulk density ranged from 0.56 g/cm³ to 0.61 g/cm³ with sample A having the lowest value (0.56 g/cm³) and sample D having the highest value (0.61 g/cm³). There was no

significant difference ($P>0.05$) among the samples analysed. The result was within the range of values (0.42 – 0.94 g/cm³) reported by [35] for unripe banana, pigeon pea and sweet potato composite flour. Also, similar findings (0.77 – 0.81 g/cm³) were reported by [26] for composite flour from wheat, African yam beans and acha flours. The bulk density of flour is the density measured without the influence of any

compression [26]. It is clear that decreased in the proportion of wheat flour leads to an increase in bulk density of composite flours. The high bulk density makes the flour suitable for use in food preparations. Bulk density of composite flours increased as unripe banana and pigeon pea incorporated with wheat flour increased.

Water absorption capacity (WAC) varied ranged from 0.20 (g/g) for sample A to 1.40 g/g for sample D. The WAC was observed to be lowest in the sample A (control) and highest in sample D. The result indicates that the addition of unripe banana and pigeon pea flour to wheat flour has effect on the amount of water absorption. This could be as a result of the molecular structure of the starch of the grain which prevented water absorption, as could be seen from the higher values of WAC, with the increase in proportions of other flours compared to wheat flours. A similar observation (1.42 g/ml – 1.79 g/ml) was reported by Ubbor et al. [36] for composite flour from wheat, acha and whole orange fleshed sweet potato flours. High WAC of composite flours shows that the flours can be used in the preparation of some foods such as sausage, dough, processed cheese and other bakery products [26].

There was no significant difference in oil absorption capacity (OAC) among the samples which ranged from 1.39 (g/g) for sample D to 1.67 (g/g) for sample A. The lowest OAC was observed in sample D (1.39 g/g), while the highest value was observed in sample A (1.67 g/g). [36] reported similar values (1.46 g/ml – 1.74 g/ml) for composite flour from wheat, acha and whole orange fleshed sweet potato flours. The presence of high-fat content in flours might have affected adversely the OAC of the composite flours. However, the flours in this study may be potentially useful in the interaction of structural components in food most especially in flavour retention, improvement of palatability and extension of shelf life particularly in bakery or meat products where fat absorption is desired [37].

Wettability ranged from 74.40 seconds in sample D to 141.90 seconds in sample A. This implies that sample D will absorb

water faster than the rest of the samples. Lower values (0.92 – 1.27 sec.) for wettability was reported by [36] for composite flour from wheat, acha and whole orange fleshed sweet potato flours. Wettability is related to the ability of a solid to absorb liquid, such as water, as it spreads over the surface of the solid [38]. The variations in wettability values could be attributed to the polarity of the flour molecules, their contact surfaces and their porosity [39].

The result of swelling power and solubility of the flour blends at different temperatures as presented in Table 3 showed that the swelling power (60°C) ranged from 1.75% in sample A to 2.10% in sample D while the swelling power (70°C, 80°C) varied insignificantly ($P>0.05$) from 2.60% and 3.40% in sample C and D respectively to 2.80% and 4.05% in sample A respectively. The solubility (60°C, 70°C and 80°C) varied insignificantly ($P>0.05$) and ranged from 1.95%, 4.30% and 5.30% for sample A, D and B respectively to 3.65%, 7.60% and 8.30% B, B and D respectively. Bolaji [40] reported higher swelling power 60 °C (3.02 – 4.49%), 70°C (7.01 – 8.43%) and 80°C (8.95 – 10.59) for flour from different varieties of maize. Swelling is a function of ratio of amylose to amylopectin, the characteristics of each fraction in terms of molecular weight - distribution degree length of branching and confirmation [41]. The swelling power of the flours increased with increase in temperature. The swelling power of the flours at 80 °C had the highest values. This may have been as a result of fallen gelatinization temperature of the flours. The swelling pattern of the flour suggests the level of crystalline packing of the starch granules [40]. This indicated that the swelling power granules reflect the extent of the association forces within the granules. An increase in solubility was also noticed in the samples as the temperature increased. There was no significant difference ($P>0.05$) in solubility of the samples. Solubility of the samples may be a function of processing and reconstitution. Higher solubility values [60 °C (0.10 – 0.40%), 70°C (0.06 – 0.30%) and 80 °C (0.05 – 0.20)] were also reported by Bolaji [40] for flour from different varieties of maize. The higher the solubility, the more the flours may reconstitute well in water.

Table 3. Functional Properties of Flour blends (wheat, unripe banana and pigeon pea) Dry matter

Parameters	Samples			
	A	B	C	D
Bulk density (g/cm³)	0.57 ± 0.03 ^a	0.59 ± 0.00 ^a	0.56 ± 0.01 ^a	0.61 ± 0.02 ^a
Water absorption capacity (g/g)	0.20 ± 0.00 ^c	0.60 ± 0.00 ^b	1.30 ± 0.14 ^a	1.40 ± 0.00 ^a
Oil absorption capacity (g/g)	1.67 ± 0.27 ^a	1.58 ± 0.13 ^a	1.58 ± 0.40 ^a	1.39 ± 0.13 ^a
Wettability (sec)	141.90 ± 10.61 ^a	135.60 ± 22.06 ^a	129.00 ± 0.85 ^a	74.40 ± 30.24 ^b
Swelling index (%)	60°C	1.75 ± 0.07 ^{ab}	1.95 ± 0.07 ^{ab}	2.05 ± 0.07 ^a
	70°C	2.80 ± 0.85 ^a	2.65 ± 0.64 ^a	2.60 ± 0.57 ^a
	80°C	4.05 ± 0.21 ^a	3.50 ± 0.14 ^a	3.40 ± 0.28 ^a
Solubility (%)	60°C	1.95 ± 1.91 ^a	3.65 ± 0.49 ^a	2.30 ± 0.07 ^a
	70°C	6.30 ± 2.40 ^a	7.60 ± 4.24 ^a	6.30 ± 2.40 ^a
	80°C	6.00 ± 0.00 ^a	5.30 ± 0.00 ^a	6.95 ± 0.49 ^a

Values are expressed as mean ± SD (n=3). Means with different superscripts (a, b) are significantly different from each other at $p<0.05$.

Key: A = (100% WF, 0% UBF, 0% PPF); B = (70% WF, 10% UBF, 20% PPF); C = (60% WF, 15% UBF, 25% PPF); D = (50% WF, 20% UBF, 30% PPF)
Where: WF = wheat flour, UBF = unripe banana flour, PPF = pigeon pea flour

3.3 Mineral composition of wheat, unripe banana and pigeon pea flour blends

The result of the mineral composition of the flour samples is presented in Table 4. The result showed that the iron content ranged from 3.36 to 4.06 mg/100g. The iron content in the samples significantly ($P < 0.05$) increased with increasing substitution of unripe banana and pigeon pea. Sample A (control) had the lowest content (3.36 mg/100g) and Sample D recorded the highest value (4.06 mg/100g). The high value in iron content recorded in sample D could be attributed to the higher proportion of unripe banana substitution. The results of this study are comparable to that of [42] (3.46 – 5.89 mg/100g) in biscuits from wheat-sweet potato-soybean composite flour. Iron contributes to the formation of red blood cells. It also provides oxygen transport or catalyses electron transfer reactions, nitrogen fixation for the synthesis of deoxyribonucleic acid [42].

The potassium content ranged from 0.19mg/100g to 0.85mg/100g. Sample A had the least potassium content 0.19 mg/100g and sample D has the highest potassium content of 0.85 mg/100 g. The potassium content of the flours was lower than 130.71 mg/100g - 211.76 mg/100g reported by [26] for cookies from wheat, acha and African yam beans flour blends. The potassium in this study increase in unripe banana and pigeon pea substitution. According to [43], potassium intake is required in relatively large amount in the body because it functions as an important electrolyte in the nervous system. Dietary potassium has been shown to exert a powerful, dose dependent inhibitory effect on sodium sensitivity [43]. Studies have shown that increasing the potassium intake of hypertensive rats that were fed high sodium diets lowered blood pressure, reduced incidence of stroke and stroke-related death, and prevented cardiac hypertrophy, mesenteric vascular damage, and renal injury [44].

The manganese content ranged from 0.27 mg/100 g to 0.35 mg/100 g. The manganese content in the samples increased with pigeon pea and unripe banana substitution. Sample A

(control) had the highest value (0.35 mg) while sample B had the lowest value (0.27 mg). The results obtained are lower compared to those (0.91 – 0.98 mg/100g) reported by [42]. Manganese plays a role in the formation of hormones including the synthesis of sex hormones and the functioning of the nervous system [42].

The magnesium content ranged from 4.67 to 4.76 mg/100g. The magnesium content in the samples also significantly increased with substitution ($P < 0.05$) of pigeon pea and unripe banana. Sample D had the highest value (4.76 mg) while sample A (control) had the lowest value (4.67 mg). The values are low compared to 32 – 49 mg/100g obtained by [42] in biscuits from wheat-sweet potato-soybean composite flour. Magnesium is necessary for biochemical reactions in the body, helping to maintain muscle, improving the functioning of the nerve, maintaining the heart rate, and regulating the blood sugar [45].

The zinc content ranged from 4.23 mg/100 g in sample D to 4.54 mg/100 g in sample A. Sample A (control) records the highest content (4.54 mg/100 g), and sample D records the lowest score (4.23 mg/100 g). The zinc contents were within the range reported by [1] (2.27 – 6.52mg/100 g) for bread from wheat, acha and mungbean flour blends. Zinc plays a catalytic and metabolic role by making the active site of nearly 300 enzymes. It also participates in the storage and release of insulin, in the secretion of digestive enzymes [46].

Generally, Minerals are essential for the maintenance of the overall mental physical wellbeing and are important constituents for the development and maintenance of bones, teeth, tissues, muscles, blood, and nerve cells. They aid acid base balance, response of the nerves to physiological stimulation and blood clotting [47]. The K, Mn and Mg contents were higher in the composite flours than in the control sample (A). This could be attributed to the increase in unripe banana and pigeon pea flour levels.

Table 4. Mineral Content of Wheat, Unripe Banana and Pigeon Pea Flour blends (mg/100g)

Parameters	Samples			
	A	B	C	D
Iron	3.36 ± 0.03 ^a	3.45 ± 0.02 ^b	3.52 ± 0.02 ^{bc}	4.06 ± 0.02 ^c
Potassium	0.19 ± 0.01 ^c	0.39 ± 0.01 ^b	0.45 ± 0.03 ^b	0.85 ± 0.04 ^a
Manganese	0.27 ± 0.00 ^c	0.35 ± 0.01 ^a	0.32 ± 0.01 ^b	0.34 ± 0.00 ^a
Magnesium	4.67 ± 0.14 ^b	4.73 ± 0.14 ^a	4.73 ± 0.01 ^a	4.76 ± 0.01 ^a
Zinc	4.54 ± 0.03 ^a	4.51 ± 0.01 ^a	4.31 ± 0.03 ^b	4.23 ± 0.02 ^b

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at ($P < 0.05$).

Key: A = (100% WF, 0% UBF, 0% PPF), B = (70% WF, 10% UBF, 20% PPF), C = (60% WF, 15% UBF, 25% PPF), D = (50% WF, 20% UBF, 30% PPF) Where: WF = wheat flour, UBF = unripe banana flour, PPF = pigeon pea flour

3.4 Physical properties of bread made from wheat, unripe banana and pigeon pea flour blends

The result of the physical properties of bread made from wheat, unripe banana and pigeon pea flour blends is presented in Table 5. The result showed that there was no significant difference ($P > 0.05$) in the loaf weight of the bread among the samples. The loaf weight values ranged from 313.2 g to 350.80 g. Sample A (control) had the highest value while Sample B had the lowest value. The loaf weight was higher in the control

sample (100% wheat flour) than in the composite samples. [1] reported lower loaf weight (243.5 – 271.0g) for bread from wheat, acha and mung bean composite flour.

The loaf volume values ranged from 325.00 to 1100.00 cm³. The volumes of the bread made from the composite flours were lower than those made from 100% wheat flour. This is in agreement with the results (376.00 – 391.00cm³) of Igbabu [2] where they found lower bread volumes associated with

composite flour as opposed to 100% wheat flour. The lower loaf volumes can be attributed to lower levels of gluten network in the dough because of decrease in structure forming proteins; glutenin and gliadin in the composite flour and consequently less ability of the dough to rise due to the weak cell structure [2].

The specific volume values ranged from 0.93 to 3.13 cm³/g. Bread specific volume decreased with increase in the level of substitution of wheat flour with unripe banana and pigeon pea (3.13cm³/g to 0.93cm³/g). The highest bread specific volume was 3.13cm³/g recorded in sample A which was 100% wheat, while the sample with the lowest specific volume was the one made from 50% wheat, 20% unripe banana and 30% pigeon pea (D). However, the specific volume of 100% wheat flour and 70% wheat, 10% unripe banana and 20% pigeon pea (B), were not significantly different from each other. Same could be said for the specific volume of 60% wheat, 15% unripe

banana and 25% pigeon pea (C) and 50% wheat, 20% unripe banana and 30% pigeon pea (D). Igbabu [2] reported lower specific loaf volumes of 1.77 – 196cm³/g for bread from wheat, defatted soy and banana flours. The low specific in the composite flour can be attributed to lower levels of gluten network in the dough because of decrease in structure forming proteins; glutenin and gliadin in the composite flour and consequently less ability of the dough to rise due to the weak cell structure [2].

The oven spring of the bread ranged from 1.65 to 3.50 cm. The oven spring also decreased significantly as the level of substitution of wheat flour with unripe banana and pigeon pea increased. This could also be due to poor gluten framework in the composite flours. Lower values (0.35- 2.35cm) were reported by [1] for bread from wheat, acha and mung bean composite flour.

Table 5. Physical Properties of Bread made from Wheat, Unripe Banana and Pigeon Pea Flour blends (Dry Matter)

Parameters	Samples			
	A	B	C	D
Loaf Weight (g)	350.80 ± 14.14 ^a	313.2 ± 18.38 ^a	333.85 ± 14.21 ^a	348.4 ± 14.14 ^a
Loaf Volume (cm ³)	1100.00 ± 141.42 ^a	850.00 ± 70.71 ^a	475.00 ± 35.35 ^b	325.00 ± 35.35 ^b
Specific Volume (cm ³ /g)	3.13 ± 0.28 ^a	2.71 ± 0.06 ^a	1.42 ± 0.05 ^b	0.93 ± 0.14 ^b
Oven Spring (cm)	3.50 ± 0.14 ^a	2.95 ± 0.07 ^a	2.30 ± 0.14 ^b	1.65 ± 0.21 ^c

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with different superscripts are significantly different at (P<0.05).

Key: A = (100% WF, 0% UBF, 0% PPF), B = (70% WF, 10% UBF, 20% PPF), C = (60% WF, 15% UBF, 25% PPF), D = (50% WF, 20% UBF, 30% PPF)
Where: WF = wheat flour, UBF = unripe banana flour, PPF = pigeon pea flour

3.6 Mean sensory scores of breads made from wheat, unripe banana and pigeon pea flour blends

The mean sensory scores of breads made from wheat, unripe banana and pigeon pea flour blends are presented in Table 6. The results showed that the means scores for colour, taste, aroma, texture and overall acceptability ranged from 5.60 - 8.33, 5.93 - 7.22, 5.93 - 7.47, 6.53 - 7.93 and 6.67 - 8.20 for

samples A, B, C and D respectively. There was no significant difference among samples B, C and D in terms of colour, but significantly different from sample A. The sensory mean score for sample B was most acceptable in terms of colour, taste, aroma, texture and overall acceptability among the formulated samples, it had the closest value to sample A after (100% wheat) which served as the control.

Table 6. Mean Sensory Scores of Breads made from Wheat, Unripe Banana and Pigeon Pea Flour blends

Parameters	Samples			
	A	B	C	D
Colour	8.33 ± 0.72 ^a	6.47 ± 1.81 ^b	6.27 ± 1.67 ^b	5.60 ± 1.96 ^b
Taste	7.27 ± 0.96 ^a	6.53 ± 1.24 ^{ab}	6.67 ± 1.59 ^{ab}	5.93 ± 1.33 ^b
Aroma	7.47 ± 1.13 ^a	6.33 ± 1.50 ^{ab}	6.47 ± 1.81 ^{ab}	5.93 ± 1.71 ^b
Texture	7.93 ± 0.70 ^a	7.27 ± 0.80 ^{ab}	7.20 ± 1.21 ^{ab}	6.53 ± 2.07 ^b
Overall acceptability	8.20 ± 0.68 ^a	7.07 ± 1.10 ^b	6.80 ± 1.47 ^b	6.67 ± 1.05 ^b

Values are means ± SD (standard deviation) of triplicate determinations. Means on the same row with same superscripts are not significantly different at (P>0.05).

Key: A = (100% WF, 0% UBF, 0% PPF), B = (70% WF, 10% UBF, 20% PPF), C = (60% WF, 15% UBF, 25% PPF), D = (50% WF, 20% UBF, 30% PPF)
Where: WF = wheat flour, UBF = unripe banana flour, PPF = pigeon pea flour

4. Conclusions

The result of the present study has shown that formulation of wheat, unripe banana and pigeon pea flours have various effect on the physical properties of the bread as well as the functional properties of the flour blends. The crude protein, crude fibre, fat and ash content of the flour blends increased while the carbohydrate content decreased with increase in unripe banana and pigeon pea flours in the blends. The iron and zinc content of the flour blends decreased with increasing unripe banana and pigeon pea levels while the potassium, manganese and

magnesium content of the flour blends increased with increasing unripe banana and pigeon pea levels. The mean score values for the sensory attributes of the bread showed that bread produced from 70% wheat, 10% unripe banana and 20% pigeon flour blend (Sample B) was the most acceptable. Consumption of the produced bread can help to address the problem of protein-energy malnutrition that is still prevalent in some communities in Nigeria as well as bring about the availability of wheat flour substitute made from locally available yet very affordable crops. This will also increase the economic value of these crops.

Further study should be carried out to determine the microbiological safety of the composite flour. Also, shelf-life study should be carried out to determine the shelf-life stability of flour blend made from wheat, unripe banana and pigeon pea. and shelf – life of the bread made from the formulated flour blends.

Research on the antinutrient and microbiological safety of this study is currently in progress.

Conflict of interest

The authors declare no conflicts of interest.

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