

Physico-chemical and sensory qualities of functional bread produced from wholemeal wheat and unripe plantain composite flours

Abstract

Unripe plantain flour was incorporated into whole meal wheat flour at 10, 20, 30, 40 and 50% levels to evaluate the effect on some functional properties of the flour and nutrient composition, physical and organoleptic qualities of bread samples produced from the composite flours. A control (100% wholemeal wheat flour) was used for comparison. Water absorption capacity and swelling capacity of the flour increased while the bulk density and oil absorption capacity decreased with increasing levels of unripe plantain flour substitution. The protein, fat and crude fibre contents of the composite breads decreased with increasing levels of unripe plantain flour substitution ranging from 12.88%, 3.45% and 2.75% in whole meal wheat bread to 6.53%, 2.24% and 2.17% in 50% unripe plantain flour substituted bread, respectively. Conversely, the moisture, ash and carbohydrate contents increased with increasing levels of unripe plantain flour substitution ranging from 27.76%, 1.92% and 51.24% in wholemeal wheat bread to 32.14%, 2.16% and 54.76% in 50% unripe plantain flour substituted bread, respectively. The caloric value decreased with unripe plantain flour addition. Ca, Na and Zn contents decreased from 129.92mg/100g, 253.43mg/100g and 1.98mg/100g in the wholemeal wheat bread to 98.40mg/100g, 218.62mg/100g and 1.61mg/100g in 50% unripe plantain flour substituted bread, respectively. Conversely, K, Mg and Fe contents increased from 391.13mg/100g, 133.91mg/100g and 4.08mg/100g in wholemeal wheat bread to 482.17mg/100g, 161.39mg/100g and 5.63mg/100g in 50% unripe plantain flour substituted bread, respectively. The loaf volume, specific volume and loaf height decreased while the loaf weight increased with increasing levels of unripe plantain flour substitution. Substitution of wholemeal wheat flour with unripe plantain flour upto a level of 20% had no significant ($p>0.05$) effect on the crust colour, crumb texture and overall acceptability of the bread samples. The panelists gave lower scores for bread samples produced from 30 - 50% unripe plantain flour substitution levels.

Keywords: wholemeal wheat flour, unripe plantain flour, composite bread, physico-chemical properties, sensory attributes

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Introduction

Bread is an exotic food which has for years gained wide consumer acceptance in Nigeria.^{1,2} The product is basically made of hard wheat flour, yeast, fat, sugar, salt and water.³ Bread is the most popular among all the wheat-based products. In Nigeria, bread is consumed by people in every socio-economic class and it is acceptable to both children and adults. Nutritionally it is rated as a good source of carbohydrate, minerals and vitamins. Bread is made from either white wheat flour or wholemeal wheat flour. Bread produced from wholemeal wheat flour contains higher minerals and fibre contents than the one made from white wheat flour.⁴ Wholemeal wheat bread is designed for people with blood sugar challenges. In Nigeria, majority of bakers produce bread from white wheat flour because of its palatability, acceptability by the consumers and lower price relative to bread made from wholemeal wheat flour. Only few bakers produce wholemeal wheat bread which is sold to the aged and people with some health challenges such as diabetes mellitus, obesity and high blood pressure.¹

Cereal grains have similar proximate composition but only wheat flour dough is capable of retaining gas during proofing and baking and therefore forms a typical aerated foam structure that is

known as bread. The uniqueness of wheat flour for making aerated baked product is largely due to its gluten protein.⁵ Due to increasing population, urbanization and changing food habits, the consumption of leavened and unleavened wheat flour products has increased tremendously in developing countries in recent years.⁶ However, as a result of climatic reasons, wheat does not grow well in the tropics and has to be imported. Though wheat cultivation in Nigeria dates back to the 16th century, it is grown only in the Sahel and Sudan savannah zones.⁷ Only about 3% of Nigerian's total consumption of this grain is produced locally.⁸ As a result, 97% of wheat used for producing wheat based products are imported. The amount of money spent on wheat importation annually constitutes a very substantial drain in Nigerian's foreign exchange earnings and reserve. This has warranted extensive research into the use of composite flours in which flours from locally grown crops such as cassava, corn, sorghum, legumes and oil seeds are used to partially substitute wheat flour in bakery products in order to reduce import duties on wheat.^{9,10} Production of bread from blends of wholemeal wheat flour and flour from locally produced crops that will meet the needs of people who consume wholemeal wheat bread is highly desirable. One of such flour is from the unripe plantain pulp.

Plantain (*Musa paradisiaca*) is widely cultivated in most of the Eastern and Southern parts of Nigeria. A common method of preserving unripe plantain is by processing it into flour. Processing unripe plantain fruit into flour is a means of value addition, increasing product diversification, utilization and enhancing market price.^{11,12} Nutritionally, plantain flour is a good source of carbohydrate, vitamins such as pro-vitamin A carotenoid, vitamin C and folate and minerals such as potassium, magnesium, iron and phosphorus but low in sodium and protein contents.¹¹ The flour also contains a high amount of fibre and resistant starch fraction that cannot be digested in the small intestine. Including food such as unripe plantain flour that is high in resistant starch may reduce the risk of diabetes by aiding in blood sugar control.¹³ The flour is also recommended for low sodium diets because of its low sodium content. Most of the researches on the use of composite flour for baking have been on the use of white wheat flour substituted with flours from indigenous crops like cassava,^{14,15} Soyabeans¹⁶ acha,¹⁷ African bread fruits,^{8,10,18} among other crops. Limited information is however available on the production of bread from wholemeal wheat flour and unripe plantain flour blends. This study was aimed at assessing the physical, chemical and organoleptic qualities of bread produced from wholemeal wheat and unripe plantain composite flours.

Materials and methods

Material procurement

The wholemeal wheat flour, unripe plantain and ingredient used for making the bread were purchased from Akpan Andem market in Uyo metropolis, Akwalbom State, Nigeria.

Preparation of unripe plantain flour

Plantain flour was prepared following the processing steps described by Kure et al.¹³ The plantain fruits were removed from bunches, washed, peeled manually, sliced (5mm width) using a slicer, steam blanched at 100°C for 15min and dried in a conventional oven (model pp 22US, Genlab, England) at 60°C to constant weight. The dried slices were milled, sieved to pass through 0.25mm mesh sieve, packaged in a low density polyethylene bag, sealed and stored at 4°C for subsequent use.

Composite flour blending ratios

The wholemeal wheat flour was thoroughly blended with unripe plantain flour in ratios of 90:10, 80:20, 70:30, 60:40 and 50:50 (w/w) respectively using a ken wood food blender. The 100% wholemeal wheat flour was used as the control sample.

Bread production

Six batches of bread loaves were made, comprising of 100% wholemeal wheat bread and composite breads produced from 10%, 20%, 30%, 40% and 50% unripe plantain flour substitution levels, respectively for wholemeal wheat flour. The straight dough method of bread making as described by Williams¹⁹ was used to produce the bread samples. The proportions of ingredients used for making the bread were flour (500g), sugar (16.67g), salt (8.33g), fat (15.00g), yeast (18.00g), and water (250ml). All the ingredients were mixed in a kenwood mixer at speed 3 for 4min. The dough was fermented at room temperature (26±2°C) for 60min and then punched back, scaled, rooled, shaped, proofed for 60 min in light greased bread pans at room temperature (26±2°C) and baked in a preheated oven operating

at 200°C for 20min. The baked breads were allowed to cool, packaged in low density polyethylene bags and stored at 4°C for analysis.

Methods of analysis

The methods described by Abbey et al.²⁰ were followed for the determination of water absorption capacity, oil absorption capacity and swelling capacity of the flours. Bulk density of the flours was determined following the method described by Okezie et al.²¹ The protein, fat, ash and crude fibre contents of the breads were determined following the methods described in AOAC.²² Carbohydrate was calculated by difference.²³ The caloric value was calculated using the Atwater factor formula.²⁴ Mineral elements (Ca, K, Na, Mg, Fe and Zn) in the bread were determined using atomic absorption spectrophotometer (UNICAM Model 939, UK) as described in AOAC.²² The weights of bread samples were determined using an electronic weighing balance. The methods described by Badifu et al.¹ were used for the determination of loaf height, loaf volume and specific volume of the breads.

Sensory evaluation of the coded bread samples was carried out by a twenty member semi-trained panel drawn from the university community. All panel members were regular consumers of wholemeal wheat bread. The attributes evaluated were crack formation, crust colour, crumb texture, taste and overall acceptability. Scoring was done on 9-point Hedonic scale where 9 represents liked extremely and 1 disliked extremely.²³

Statistical analysis

All determinations were done in triplicate and subjected to statistical Analysis of Variance (ANOVA) using SPSS version 18 statistical package (SPSS, Inc., USA) to determine variation between means. Duncan Multiple Range Test (DMRT) was used to separate means. Significant variation was accepted at $p < 0.05$.

Results and discussion

Functional properties of the flours

The functional properties of the flour samples are presented in Table 1. The bulk density values ranged from 0.30±0.10 to 0.35±0.03g/ml with 100% wholemeal wheat flour having the highest value. The bulk density decreased as the level of dilution of wholemeal wheat flour with unripe plantain flour increased. However, no significant differences ($p > 0.05$) were observed among the samples. Similar decreases in bulk density with wheat flour dilution were reported by Adebowale et al.²⁵ for sorghum wheat flour composite and Onabanjo et al.²⁶ for wheat-sweet potato composite flours. Bulk density gives an indication of the relative volume of packaging materials required. It is also important in determining raw material handling and application in wet processing in the food industry.²⁷ The composite flours exhibited higher water absorption capacity and swelling capacity than the 100% wholemeal wheat flour. Both the water absorption capacity and swelling capacity increased with increasing levels of unripe plantain flour substitution ranging from 1.59±0.02g/g and 0.61±0.20g/ml for 10% substitution to 1.79±0.02g/g and 0.71±0.05g/ml for 50% substitution, respectively. This could be due to higher carbohydrate content in the unripe plantain flour than in the wholemeal wheat flour. Water absorption index is an important processing parameter and has implications for bulking, viscosity and consistency of products.²⁸ The baking quality of flours had been associated with water absorption capacity of such flours.¹⁴ Both water absorption capacity and swelling

capacity contribute to dough formation and stability.³ On the contrary, the 100% wholemeal wheat flour exhibited significantly ($p < 0.05$) higher oil absorption capacity than the flours substituted with levels of unripe plantain flour. The oil absorption capacity values decreased with increasing levels of unripe plantain flour substitution ranging from 1.68 ± 0.02 g/g for 10% substitution level to 1.52 ± 0.05 g/g for 50% substitution level. Similar result was reported for wheat and sweet potato flour blends.²⁹ The major chemical affection oil absorption index is protein, which is composed of both hydrophilic and hydrophobic parts.³⁰ Non-polar amino acid side chains can form hydrophobic interactions with hydrocarbon chains of lipids³¹ and has implication in functional properties of flours. Oil absorption capacity is important since oil acts as flavour retainer, increases the mouth feel and improves the palatability of foods.^{32,33} Fat acts as lubricating agent which improves the quality of the bread in terms of texture and flavor.^{3,34} Also, fat provides energy and is essential as it carries along fat soluble vitamins A, D, E and K.

Results of the nutrient contents of wholemeal wheat bread and composite bread made from varied blends of wholemeal wheat and unripe plantain flours are presented in Table 2. Moisture content in the bread samples increased with increasing levels of unripe plantain flour substitution ranging from 27.76% in wholemeal wheat bread to 32.14% in bread from 50% level of unripe plantain flour substitution. This could be due to greater water holding capacity of unripe plantain flour than the wheat flour. This trend is similar to the findings reported by Amandikwa et al.³² and Njintang et al.³⁵ for wheat-yam flour and wheat-taro flour composite bread, respectively. Bread made from 100% wholemeal wheat flour had significantly ($p < 0.05$) higher protein content (12.88%) than bread samples made from composite flours. The protein content of the composite bread decreased with increasing levels of unripe plantain flour substitution ranging from 11.76% for bread made from 10% unripe plantain flour substitution to 6.53% for bread made from 50% unripe plantain flour substitution. This may have been due to the lower content of protein in the plantain flour which caused dilution of protein in the wholemeal wheat flour with increasing levels of unripe plantain flour substitution leading to the observed decreases in protein content in the bread with levels of unripe plantain flour addition. Similar findings were reported for wheat-yam flour composite bread,^{32,36} bread from wheat, maize and orange fleshed sweet potato flour³⁷ and composite bread from taro and wheat flour.³⁸ The 100% whole wheat bread had higher contents of fat (3.45%) and crude fibre (2.75%) but lower contents of ash (1.92%) and carbohydrate (51.24%) than the composite bread samples. The higher fat content in the wholemeal wheat bread could be attributed to the fat derived from bran and germ inclusion during milling of the wholemeal wheat flour. Both the fat and fibre contents in the composite breads decreased with increasing levels of unripe plantain flour substitution ranging from 3.24% and 2.69% for 10% unripe plantain flour substituted composite bread to 2.24% and 2.17% for 50% unripe plantain flour substituted composite bread, respectively. The bran inclusion in the wholemeal wheat flour might have contributed to the higher fibre content in the whole wheat bread than in the composite bread. Fibre consumption has been linked to decreased incidence of heart disease, various types of cancer and diverticulosis.^{39,40} Also, high levels of fibre in foods help in digestion. The high fibre content of both the whole wheat bread and the composite breads suggests that they would be ideal food for people suffering from obesity, diabetes, cancer and gastrointestinal disorders.⁴⁰ According to Schnceman⁴¹ the crude fibre contributes to the health of the gastrointestinal system and

metabolic system in man. The ash and carbohydrate contents increased with increasing levels of unripe plantain flour substitution ranging from 1.92% and 51.76% for 10% unripe plantain flour substituted composite bread to 2.16% and 54.76% for 50% unripe plantain flour substituted composite bread, respectively. The higher ash and carbohydrate contents in the composite bread than in the whole wheat bread is an indication of higher mineral and carbohydrate contents in the unripe plantain flour than in the wheat flour. The results obtained in this study are in agreement with similar reports by Mongi et al.³⁶ for wheat - cocoyam composite bread. The caloric value of the bread samples decreased with increasing levels of unripe plantain flour substitution due possibly to the decreases in protein and fat contents.

The contents of each mineral element in both the wholemeal wheat and composite bread samples are presented in Table 2. All the bread samples appeared to be good source of Ca, K, Na, Mg, Fe and Zn. However, the 100% wheat bread had the highest contents of Ca (129.92 ± 1.03 mg/100g), Na (253.43 ± 1.00 mg/100g) and Zn (1.98 ± 0.94 mg/100g) and lowest contents of K (391.13 ± 1.61 mg/100g), Mg (133.91 ± 0.85 mg/100g) and Fe (4.08 ± 1.21 mg/100g). Calcium, sodium and zinc contents in the composite bread samples decreased while potassium, magnesium and iron contents increased with increasing levels of unripe plantain flour substitution. The decreases in Ca, Na and Zn contents ranged from 121.00 ± 0.85 mg/100g, 244.10 ± 1.10 mg/100g and 1.87 ± 1.00 mg/100g for 10% unripe plantain flour substitution to 98.40 ± 0.90 mg/100g, 218.62 ± 1.25 mg/100g and 1.61 ± 1.03 mg/100g for 50% unripe plantain flour substitution, respectively. On the contrary, the increases in K, Mg and Fe ranged from 409.90 ± 1.25 mg/100g, 137.63 ± 1.04 mg/100g and 4.39 ± 0.55 mg/100g for 10% unripe plantain flour substitution to 482.17 ± 1.10 mg/100g, 161.39 ± 1.06 mg/100g and 5.63 ± 0.62 mg/100g for 50% unripe plantain flour substitution. The result is an indication that the plantain flour contained higher K, Mg and Fe than the wholemeal wheat flour. The physiological roles of mineral elements in human diets have been documented.^{23,42} The consumption of wholemeal wheat-unripe plantain flour bread is recommended because of its rich mineral content. Also, the low sodium and fat contents of the whole wheat-unripe plantain flour composite bread makes it a good product for people with high blood pressure and heart disease problems.⁴³

The physical and sensory qualities of the prepared bread samples are presented in Table 3. The results showed that the qualities of the composite breads decreased as the level of dilution of wholemeal wheat flour with unripe plantain flour increased. The loaf volume, specific volume and height of the composite bread decreased with increasing levels of unripe plantain flour substitution ranging from 441.00 cm³, 2.02 cm³/g and 6.00 cm for 100% whole wheat bread to 335.16 cm³, 1.44 cm³/g and 4.56 cm for 50:50 wheat-unripe plantain flour composite bread, respectively. The less loaf volume and specific volume of the composite bread relative to the 100% wheat bread were probably due to the dilution effects on gluten with addition of unripe plantain flour to wholemeal wheat flour since plantain flour does not contain gluten. The gluten fraction is responsible for the elasticity of the dough by causing it to extend and trap the carbon dioxide produced during fermentation. Abdelghafor et al.⁴⁴ attributed decreased in the loaf volume, specific volume and height of wheat-sorghum composite bread to lower levels of gluten network in the dough and consequently, less ability of the dough to rise due to weaker cell wall structure. When the gluten coagulates under the influence of heat during baking, it serves as a framework of the loaf which becomes relatively rigid

and does not collapse.³⁶ In contrast, there were appreciable increases in the weight of the composite bread samples with increasing levels of unripe plantain flour substitution. This might be due to less retention of carbon dioxide gas in the blended dough, thereby providing dense bread texture. Also, the higher water absorption capacity of the

composite flour [Table 1] could have contributed to the higher loaf weight relative to 100% whole wheat bread. Trends similar to the results obtained in the present study were reported for breads from wheat flour supplemented with non- wheat flours.^{16,36,37}

Table 1 Functional properties of wholemeal wheat and unripe plantain flour blends

| Blending ratios WWF:UPF | Parameters | | | |
|----------------------------|-------------------------|---------------------------------|-------------------------------|--------------------------|
| | Bulk density (g/ml) | Water absorption capacity (g/g) | Oil absorption capacity (g/g) | Swelling capacity (g/ml) |
| 100:00:00 | 0.35 ^a ±0.03 | 1.54 ^a ±0.06 | 1.77 ^a ±0.01 | 0.59 ^b ±0.20 |
| 90:10:00 | 0.35 ^a ±0.11 | 1.59 ^c ±0.02 | 1.68 ^b ±0.02 | 0.61 ^b ±0.16 |
| 80:20:00 | 0.34 ^a ±0.05 | 1.61 ^c ±0.04 | 1.62 ^b ±0.00 | 0.63 ^b ±0.23 |
| 70:30:00 | 0.33 ^a ±0.01 | 1.68 ^b ±0.11 | 1.59 ^c ±0.11 | 0.66 ^a ±0.12 |
| 60:40:00 | 0.32 ^a ±0.12 | 1.73 ^b ±0.02 | 1.57 ^c ±0.04 | 0.69 ^a ±0.13 |
| 50:50:00 | 0.30 ^a ±0.10 | 1.79 ^a ±0.03 | 1.52 ^d ±0.05 | 0.71 ^a ±0.05 |

WWF, wholemeal wheat flour; UPF, unripe plantain flour

Values are Means±standard deviation of triplicate determinations. Means on the same column not followed by the same superscript are significantly different at p<0.05.

Table 2 Nutrient composition and caloric value of bread prepared from wholemeal wheat and unripe plantain composite flours (dry matter basis)

| Parameters | Proportions of unripe plantain flour substitution (%) | | | | | |
|-----------------------|---|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | 0 | 10 | 20 | 30 | 40 | 50 |
| Moisture (%) | 27.76 ^b ±0.11 | 28.59 ^b ±0.32 | 30.42 ^a ±0.05 | 31.05 ^a ±0.02 | 31.68 ^a ±0.30 | 32.14 ^a ±0.23 |
| Protein (%) | 12.88 ^a ±0.04 | 11.76 ^b ±0.25 | 10.09 ^c ±0.08 | 9.25 ^d ±0.04 | 8.01 ^e ±0.01 | 6.53 ^f ±0.05 |
| Fat (%) | 3.45 ^a ±0.00 | 3.24 ^a ±0.02 | 3.01 ^a ±0.01 | 2.86 ^b ±0.08 | 2.51 ^b ±0.04 | 2.24 ^b ±0.12 |
| Ash (%) | 1.92 ^b ±0.01 | 1.96 ^b ±0.00 | 2.03 ^a ±0.03 | 2.09 ^a ±0.01 | 2.14 ^a ±0.05 | 2.16 ^a ±0.00 |
| Crude fibre (%) | 2.75 ^a ±0.09 | 2.69 ^a ±0.08 | 2.60 ^a ±0.05 | 2.55 ^a ±0.10 | 2.38 ^a ±0.09 | 2.17 ^a ±0.03 |
| Carbohydrate (%) | 51.24 ^c ±0.52 | 51.76 ^c ±0.43 | 51.85 ^b ±0.16 | 52.20 ^b ±0.81 | 53.28 ^a ±0.61 | 54.76 ^a ±0.85 |
| Caloric value (K Cal) | 287.53 ^a ±0.15 | 283.24 ^a ±0.09 | 274.85 ^b ±0.22 | 271.54 ^b ±1.10 | 267.75 ^c ±0.50 | 265.32 ^c ±0.78 |
| Ca (mg/100g) | 129.92 ^a ±1.03 | 121.00 ^b ±0.85 | 116.21 ^c ±1.11 | 109.64 ^d ±0.98 | 102.59 ^e ±1.32 | 98.40 ^f ±0.90 |
| K (mg/100g) | 391.13 ^c ±1.61 | 409.90 ^c ±1.25 | 431.50 ^d ±1.85 | 450.63 ^c ±1.34 | 467.85 ^b ±1.15 | 482.17 ^a ±1.10 |
| Na (mg/100g) | 253.43 ^a ±1.00 | 244.10 ^b ±1.10 | 237.57 ^c ±0.90 | 229.22 ^d ±1.04 | 223.95 ^e ±1.03 | 218.62 ^f ±1.25 |
| Mg (mg/100g) | 133.91 ^c ±0.85 | 137.63 ^c ±1.04 | 149.04 ^d ±1.15 | 154.16 ^c ±0.90 | 157.52 ^b ±1.04 | 161.39 ^a ±1.06 |
| Fe (mg/100g) | 4.08 ^b ±1.21 | 4.39 ^b ±0.55 | 4.70 ^b ±0.81 | 5.02 ^a ±1.10 | 5.46 ^a ±0.90 | 5.63 ^a ±0.62 |
| Zn (mg/100g) | 1.98 ^a ±0.94 | 1.87 ^a ±1.00 | 1.84 ^a ±0.59 | 1.80 ^a ±0.61 | 1.78 ^b ±1.25 | 1.61 ^b ±1.03 |

Values are Means ± standard deviation of triplicate determinations. Means on the same row not followed by the same superscript are significantly different at p<0.05

Table 3 Physical and sensory qualities of breads prepared from wholemeal wheat and unripe plantain composite flours

| Parameters | Proportions of unripe plantain flour substitution (%) | | | | | |
|--------------------------------------|---|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | 0 | 10 | 20 | 30 | 40 | 50 |
| Loaf weight (g) | 218.13 ^a ±0.83 | 220.51 ^c ±1.15 | 225.26 ^d ±1.29 | 228.11 ^a ±1.04 | 230.38 ^b ±2.13 | 233.41 ^a ±1.37 |
| Loaf height (cm) | 6.00 ^a ±1.02 | 5.90 ^a ±1.29 | 5.50 ^a ±0.95 | 5.02 ^d ±1.00 | 4.75 ^b ±1.38 | 4.56 ^b ±1.13 |
| Loaf volume (cm ³) | 441.00 ^a ±1.39 | 443.65 ^b ±2.13 | 404.25 ^c ±1.04 | 368.97 ^b ±2.11 | 349.13 ^c ±2.08 | 335.16 ^c ±1.65 |
| Specific volume (cm ³ /g) | 2.02 ^a ±0.04 | 1.97 ^a ±0.00 | 1.80 ^b ±0.02 | 1.62 ^a ±0.01 | 1.52 ^c ±0.04 | 1.44 ^c ±0.01 |
| Crack formation | No crack | No crack | No crack | Small cracks | Small cracks | Small cracks |
| Crust colour | 6.85 ^a ±0.10 | 6.80 ^a ±0.16 | 6.79 ^a ±0.09 | 5.96 ^b ±0.13 | 5.93 ^b ±0.06 | 5.89 ^b ±0.15 |
| Crumb texture | 5.41 ^a ±0.11 | 5.33 ^a ±0.05 | 5.05 ^a ±0.02 | 4.55 ^b ±0.08 | 4.42 ^b ±0.12 | 4.20 ^b ±0.20 |
| Taste | 5.90 ^a ±1.14 | 5.95 ^a ±1.10 | 5.93 ^a ±1.05 | 4.60 ^b ±1.21 | 4.35 ^b ±0.08 | 4.31 ^b ±1.06 |
| Aroma | 7.13 ^a ±1.03 | 7.15 ^a ±1.19 | 7.15 ^a ±1.04 | 7.19 ^a ±1.06 | 7.20 ^a ±0.11 | 7.24 ^a ±1.03 |
| Overall acceptability | 6.68 ^a ±1.21 | 6.66 ^a ±1.05 | 6.62 ^a ±1.03 | 5.95 ^b ±1.12 | 5.41 ^b ±0.20 | 4.32 ^c ±0.09 |

Means on the same row not followed by the same superscript are significantly different at $p < 0.05$.

The mean sensory scores of the bread samples are presented in Table 3. There were no significant differences ($p > 0.05$) in all the organoleptic attributes evaluated in this study between the 100% wholemeal wheat bread and composite bread samples made from 10% and 20% unripe plantain flour substitution. However, bread samples produced from 30% to 50% unripe plantain flour substitution had significantly ($p < 0.05$) lower scores for the crust colour, crumb texture and overall acceptability than the 100% whole wheat bread as well as breads produced from 10% and 20% composite flour blends. There was no significant difference ($p > 0.05$) in the aroma among the bread samples. The results showed that unripe plantain flour substitution level up to 20% for wholemeal wheat flour gave acceptable bread loaves that compared favourably with the 100% wholemeal wheat bread.

Conclusion

The results revealed that substitution of wholemeal wheat flour with unripe plantain flour in bread making resulted in reduced loaf volume, specific volume and height of the composite breads relative to the 100% wholemeal wheat bread. Although the sensory scores for attributes such as crust colour, crumb texture, and overall acceptability of the bread samples decreased with increasing levels of unripe plantain flour substitution, they were only significantly different ($p < 0.05$) at 20% level of substitution while sensory score for aroma was not significantly ($p > 0.05$) affected at all levels of substitution. It is evidence from the results of the study that composite bread of good nutritional quality, high fibre content and with sensory attributes comparable to 100% wholemeal wheat bread can be produced with unripe plantain flour substitution level up to 20%. The high fibre, low sodium and fat contents of the composite bread suggest that the bread could be ideal food for people suffering from obesity, diabetes, cancer and gastrointestinal disorders. The production and consumption of

wholemeal wheat-unripe plantain flour composite bread should be encouraged to help diversify the food use of unripe plantain as well as reduce the amount of money usually spent on wheat importation and increase the nation's foreign reserve.

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None.

Conflict of interest

The author declares no conflict of interest.

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