
**PRODUCTION AND QUALITY EVALUATION OF BREAD SAMPLES
PRODUCED FROM WHEAT, ROASTED FRESHWATER CLAM
AND UNRIPE PLANTAIN FLOURS**

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DOI: <https://doi-doi.org/101555/ijrpa.4377>**ABSTRACT**

The study was undertaken to evaluate the nutrient composition, physical and sensory properties of bread samples produced from wheat, roasted clam and unripe plantain flour blends. The freshwater clam was washed, sliced, parboiled, roasted and milled while the unripe plantain was sorted, cleaned, sliced, blanched, drained and milled separately. The individual flour obtained was blended together in the ratios of 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25 and used for the production of functional bread while 100% wheat flour served as control. The composite flour blends were evaluated for proximate composition, energy content, mineral and vitamin composition while the physical, microbial and sensory properties of the functional bread samples produced were determined using standard methods. The moisture, crude protein, fat, crude fibre and ash contents of the bread samples increased significantly ($p < 0.05$) with increase in the addition of roasted clam and unripe plantain flours from 10.53-18.03%, 9.06-34.52%, 3.12-4.68%, 3.42-5.15% and 2.41-3.04, respectively, while the carbohydrate and energy contents decreased from 71.46-34.64% and 355.16 - 318.52 KJ/100g, respectively. The mineral composition of the bread samples also increased significantly ($p < 0.05$) with increase in substitution of ground bean and sweet potato flours from 76.32-102.33 mg/100 g (calcium), 86.33-106.76 mg/100 g (potassium), 43.17-70.79 mg / 100 g (phosphorus), 92.14-112.15 mg / 100 g (magnesium), 1.52-2.05 mg / 100 g (iron) and 2.13-2.98 mg/100 g (zinc), respectively. The thiamine, riboflavin, niacin, ascorbic acid, vitamin A and vitamin E contents of the bread samples increased significantly ($p < 0.05$) with increase in the addition of ground bean and sweet potato flours from 42.17-59.19 mg/100 g, 62.31-80.69 mg/100 g, 24.15-47.57 mg/100 g, 12.15-12.15-12.73 mg/100 g, 18.32-47.33 mg/100 g and 15.31-43.67 mg/100 g, respectively. The physical properties (loaf

volume, loaf height, loaf weight, oven spring and specific loaf volume) of the bread samples decreased significantly ($p < 0.05$) with corresponding increase in the addition of ground bean and sweet potato flours from 310.21-115.41 cm³, 6.82-3.84 cm; 410.21-246.31g, 458.15-407.94 cm and 0.76-0.26 cm³/g, respectively. The results of the microbial assessment showed that the total viable count for the samples varied between 0.33×10^4 and 1.20×10^4 cfu/g and there were no detectable coliform or fungal counts. The sensory properties of the samples showed that the control sample (100% wheat flour bread) was the most acceptable to the panelists and also differed significantly ($p < 0.05$) from the composite flour breads in colour, texture, taste and flavour. Although the 100% wheat flour bread (control) had better sensory and physical properties, it had the least values in nutrient contents compared to the composite flour bread loaves. However, the study showed that the nutrient contents of wheat flour breads could be improved by enriching wheat flour with ground bean and sweet potato flours at the levels of 5-25% and 5-25%, respectively in the production of bread loaves.

INTRODUCTION

Bread is a widely consumed staple food produced from baked dough made from flour, yeast, salt, water, and other ingredients, and it is popular among all socio-economic groups in Nigeria (Abdelghafor et al., 2011). Although bread provides carbohydrates, minerals, and vitamins, the use of refined wheat flour reduces its nutritional value because the milling process removes the bran and germ where most vitamins and fibre are concentrated (Heshe et al., 2015). Wheat remains the main ingredient in bread making due to its gluten content, which provides the visco-elastic properties necessary for producing quality baked products (Browns et al., 2011). However, the high cost and dependence on imported wheat in developing countries have encouraged the use of composite flours from locally available crops to partially substitute wheat flour (Igbabul et al., 2013). Nigeria also faces challenges of protein and mineral deficiencies, making it necessary to explore alternative nutrient sources such as seafood and other local agricultural products (Grazyna & Bonnie, 2010). Freshwater clam (*Ergeria radiata*) is known to be rich in protein and essential minerals, making it a valuable and affordable source of animal protein (Ofem et al., 2011). Similarly, unripe plantain contains high fibre, resistant starch, and important minerals that contribute to improved nutrition and reduced risk of certain degenerative diseases (Adepoju et al., 2012). Therefore, this study focuses on the production of functional wheat bread enriched with roasted freshwater clam and unripe plantain flours to improve its nutritional quality.

MATERIALS AND METHOD

Procurement of Raw Materials

Freshwater clam and unripe plantain that were purchased from farmers within Ekowe community, Southern Ijaw while whole wheat flour that was used for the study and all other baking ingredients including granulated sugar (Dangote Group Nigeria), baking fat (Topper margarine), instant dry yeast (STK Royal Brand) and salt (Dangote Group, Nigeria) were purchased from Swali market, Yenagoa, Bayelsa State. The samples were conveyed to the Biochemistry Laboratory of Science Laboratory Technology Department, Federal Polytechnic Ekowe for processing after collection.

Sample Preparation

Preparation of Roasted Freshwater Clam Flour

The roasted clam flour was prepared according to the method described by Ofem et al. (2014) with slight modifications. Five kilogrammes (5kg) of freshwater clam were manually washed with clean tap water to remove sand and other particles. Each edible portion of the *Ergeria radiata* was removed by making a bilateral incision to expose their content of the stomach which were flushed out with clean tap water and then boiled for 30 mins in an electric heating mantle. The boiled pieces were drained and sprayed on meat-roasting pan placed over burning-charcoal. The clam-slices were stirred at every 3 min interval for 90 min before being transferred for continuation of drying to a blast-air electric oven (NAAF CO B5, model OVH 102, Germany) set at 50 °C for 24 h with occasional stirring of slices of meat at intervals of 30 min to ensure uniform drying. The dried sample was dry-milled using (Binatone Grinder BL 1500 PRO, China) and sieved with a 425 mm aperture in order to obtain smooth powder which was packaged in an air tight plastic container, labeled and kept in a refrigerator until needed for further use.

Production of Plantain flour

The unripe plantain flour was prepared according to the method of Chinmah et al. (2004). Five kilograms (5kg) of matured unripe plantain fruits was thoroughly cleaned and peeled manually with a kitchen knife. The peeled plantain fruits were cut into smaller sizes with a knife. The slices were rinsed, placed in a stainless pot and blanched with 3 liters of potable water at 85 °C for 20 min on a hot plate. The blanched slices were drained, rinsed and spread on the trays and dried in a hot air oven (Model DHG 9101 ISA) at 60 °C for 10 h with occasional stirring of slices at intervals of 30 min to ensure uniform drying. The dried slices

were milled in the attrition mill and sieved through a 40µm mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and kept in a refrigerator until needed for further use.

Table 1: Formulation of Bread Flour Blends.

| Samples | Whole Wheat (%) | Clam (%) | Unripe plantain (%) |
|---------|-----------------|----------|---------------------|
| A | 100 | 0 | 0 |
| B | 90 | 5 | 5 |
| C | 80 | 10 | 10 |
| D | 70 | 15 | 15 |
| E | 60 | 20 | 20 |
| F | 50 | 25 | 25 |

Preparation of Bread Samples

The bread loaves were prepared according to the straight dough development method described by Okaka (2009). The recipe used for the production of bread samples contained 100% flour, 60% fat, 40% sugar (sucrose), 20% dried yeast, 5% salt and 200 mL distilled water. During the bread making, all the ingredients with the exception of the yeast were thoroughly mixed together in a micro dough mixer (Model KSM 850G, USA). After that, the yeast was activated by putting 20 g of yeast in a sealed plastic container containing 30mL of warm distilled water, 25 g of sugar and 15 g of flour and allowed to rest at room temperature (30 ± 2 °C) for 25 min to form the yeast-in-water dispersion. The dough produced was transferred into a plastic bowl and pierced carefully at the centre. The yeast in-water dispersion was poured into the pierced hole and the dough containing the yeast-in-water dispersion was continuously kneaded manually for 10 min to introduce oxygen for rigorous fermentation and to facilitate the development of gluten. The kneaded dough was quietly divided and moulded manually into uniform shapes of similar sizes. The moulded dough's were placed separately into baking pans smeared with vegetable oil and covered with greased bread wrapper. The bread doughs were allowed to ferment at room temperature (30 ± 2 °C) for 1 h. The fermented doughs were proofed at 40°C in a cabinet proofer for 85 min and baked in an electric oven (Salva, USA) at 200 °C for 50 min. The bread loaves were removed from the oven, taken out of the baking pans and allowed to cool at ambient temperature for 1 h. The cooled bread samples were divided into two (2) lots. The first lot was wrapped with aluminum foils and used for sensory evaluation after 2 h. The second lot was packaged in low density polyethylene bags and kept in a refrigerator until needed for analysis. The bread loaves produced from 100% wheat flour were used as control.

Methods of Analytical

Analysis was carried out on both the composite flour blends and the produced bread samples. All analysis was done in duplicates. Proximate composition (moisture, ash, fibre, lipid, crude protein, carbohydrate), energy content, calcium, potassium, iron, phosphorus, magnesium, sodium, ascorbic acid, thiamine, riboflavin, niacin, β -carotenoid and vitamin E content were determined using AOAC (2010) method.

Evaluation of Physical and Microbial Properties of Bread Samples

The loaf weight, volume and specific loaf volume were determined using the method described by AACC (2000). Total viable bacterial, yeast and mold counts were carried out to determine the microbial load of developed bread samples as described by American Public Health Association (2015) while the sensory properties were determined using the method described by Okaka (2010).

Statistical Analysis

The data generated were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS, Version 20) software. Significant means were separated using Duncan's New Multiple Range Test (DNMRT) at $p < 0.05$.

RESULTS AND DISCUSSION

Results and Discussion Proximate Composition of Bread Samples

The proximate composition of the bread samples were presented in Table 2.

Table 4.1: Proximate composition (%) of bread loaves

| Samples | Moisture | Protein | Ash | Crude fiber | Fat | Carbohydrate | Energy (KJ / 100 g) |
|---------|--------------------------|--------------------------|-------------------------|-------------------------|-------------------------|--------------------------|---------------------------|
| A | 10.53 ^e ±0.03 | 9.06 ^f ±0.01 | 2.41 ^f ±0.01 | 3.42 ^f ±0.06 | 3.12 ^f ±0.02 | 71.46 ^a ±0.01 | 355.16 ^a ±0.01 |
| B | 12.58 ^d ±0.06 | 19.13 ^e ±0.02 | 2.55 ^e ±0.06 | 3.77 ^e ±0.01 | 3.54 ^e ±0.04 | 58.43 ^b ±0.03 | 352.10 ^b ±0.08 |
| C | 14.62 ^c ±0.04 | 24.33 ^d ±0.04 | 2.68 ^d ±0.02 | 3.98 ^d ±0.04 | 3.76 ^d ±0.06 | 57.31 ^c ±0.04 | 350.40 ^c ±0.02 |
| D | 15.66 ^c ±0.01 | 28.20 ^c ±0.03 | 2.83 ^c ±0.04 | 4.30 ^c ±0.03 | 4.17 ^c ±0.03 | 44.84 ^d ±0.02 | 329.69 ^d ±0.04 |
| E | 17.83 ^b ±0.05 | 32.42 ^b ±0.00 | 2.98 ^b ±0.01 | 4.88 ^b ±0.05 | 4.41 ^b ±0.05 | 37.48 ^e ±0.06 | 319.92 ^e ±0.06 |
| F | 18.03 ^a ±0.01 | 34.64 ^a ±0.05 | 3.04 ^a ±0.02 | 5.15 ^a ±0.02 | 4.68 ^a ±0.00 | 34.46 ^f ±0.03 | 318.52 ^f ±0.05 |

Values are mean± standard deviation of duplicate. Means in the same column with different superscripts are significantly different ($p < 0.05$).

A- Bread made with 100% wheat flour.

- B- Bread made with 90% wheat flour, 5% roasted clam flour and 5% unripe plantain flour.
C- Bread made with 80% wheat flour, 10% roasted clam flour and 10% unripe plantain flour.
D- Bread made with 70% wheat flour, 15% roasted clam flour and 15% unripe plantain flour.
E- Bread made with 60% wheat flour, 20% roasted clam flour and 20% unripe plantain flour.
F- Bread made with 50% wheat flour, 25% roasted clam flour and 25% unripe plantain flour.
WF- Wheat Flour, roasted clam Flour, unripe plantain Flour.

Proximate Composition

The moisture content of the bread samples ranged from 10.53–18.03%, with the control sample (100% wheat flour) having the least value (10.53%) and the sample containing 25% roasted clam and 25% unripe plantain flours having the highest (18.03%). Moisture increased with higher substitution levels, likely due to greater water absorption capacity of the composite flours, and the relatively low moisture values suggest better shelf stability by limiting microbial growth (Giami et al., 2004; Okechukwu & Akpan, 2025). Protein content increased significantly ($p < 0.05$) from 9.06% in the control sample to 34.64% in the sample containing 25% roasted clam and 25% unripe plantain flours. The increase reflects the high protein contribution of roasted clam flour, highlighting the nutritional advantage of the composite bread for body tissue growth and metabolic functions (Okon et al., 2021; Okaka et al., 2006). The fat content of the bread samples ranged from 3.12–4.68%, increasing significantly ($p < 0.05$) with higher substitution of roasted clam and unripe plantain flours. These values are slightly lower than the 4.12–5.46% reported for whole wheat–soybean breads, but still provide essential fatty acids and energy needed for normal body functions (Ndife et al., 2011; Michaelsen et al., 2000). Crude fibre increased from 3.42% in the control bread to 5.15% in the bread containing 25% roasted clam and 25% unripe plantain flours, indicating improved dietary fibre with composite flour inclusion. Increased fibre content is beneficial for digestion and may help reduce risks of conditions such as diabetes and cardiovascular diseases (Olaoye et al., 2007). The ash content ranged from 2.41% in the control sample to 3.04% in the bread with 25% roasted clam and 25% unripe plantain flours, indicating significant variation ($p < 0.05$). These values are higher than the 1.25–1.36% reported for wheat–bean composite bread, suggesting improved mineral content in the composite bread samples (Chikwendu et al., 2015). Carbohydrate content ranged from 34.46–71.46% and decreased significantly ($p < 0.05$) as substitution with roasted clam and unripe plantain flours increased. This reduction indicates that wheat flour remains the major carbohydrate contributor in bread formulations, and similar trends have been observed in

other composite flour breads (Oluwalana et al., 2012). The energy content of the bread samples ranged from 318.52–355.16 kJ/100 g, but decreased significantly ($p < 0.05$) with increased substitution of roasted clam and unripe plantain flours. This decline is linked to the relatively lower carbohydrate, protein, and fat contents of the composite flours, although the substitution improved the bread's overall nutritional profile in terms of protein, fibre, fat, and mineral contents.

Mineral Composition of Bread Samples

The mineral composition of the bread samples are presented in Table 3.

Table 3: Mineral composition (mg/100g) of bread loaves

| Samples | Calcium | Potassium | Phosphorus | Magnesium | Iron | Zinc |
|---------|---------------------------|---------------------------|--------------------------|---------------------------|-------------------------|-------------------------|
| A | 76.32 ^f ±0.01 | 86.33 ^f ±0.02 | 43.17 ^f ±0.02 | 92.14 ^f ±0.00 | 1.52 ^f ±0.04 | 2.13 ^f ±0.01 |
| B | 78.46 ^e ±0.03 | 93.93 ^e ±0.01 | 58.15 ^e ±0.01 | 96.31 ^e ±0.03 | 1.58 ^e ±0.01 | 2.20 ^e ±0.05 |
| C | 83.54 ^d ±0.02 | 93.13 ^d ±0.03 | 60.31 ^d ±0.03 | 99.01 ^d ±0.05 | 1.66 ^d ±0.03 | 2.38 ^d ±0.03 |
| D | 89.72 ^c ±0.05 | 98.63 ^c ±0.05 | 66.15 ^c ±0.01 | 104.21 ^c ±0.02 | 1.78 ^c ±0.05 | 2.52 ^c ±0.01 |
| E | 95.29 ^b ±0.06 | 103.44 ^b ±0.04 | 68.23 ^b ±0.04 | 108.55 ^b ±0.04 | 1.96 ^b ±0.02 | 2.78 ^b ±0.02 |
| F | 102.33 ^a ±0.01 | 106.76 ^a ±0.03 | 70.79 ^a ±0.01 | 112.15 ^a ±0.03 | 2.05 ^a ±0.01 | 2.98 ^a ±0.04 |

Values are mean± standard deviation of duplicate. Means in the same column with different superscripts are significantly different ($p < 0.05$).

A- Bread made with 100% wheat flour.

B- Bread made with 90% wheat flour, 5% roasted clam flour and 5% unripe plantain flour.

C- Bread made with 80% wheat flour, 10% roasted clam flour and 10% unripe plantain flour.

D- Bread made with 70% wheat flour, 15% roasted clam flour and 15% unripe plantain flour.

E- Bread made with 60% wheat flour, 20% roasted clam flour and 20% unripe plantain flour.

F- Bread made with 50% wheat flour, 25% roasted clam flour and 25% unripe plantain flour.

WF- Wheat Flour, roasted clam Flour, unripe plantain Flour.

Mineral Composition of Bread Samples

The calcium content of the bread samples (76.32–102.33 mg/100 g) increased significantly with higher substitution of roasted clam and unripe plantain flours, with the control sample having the least value and the 25% clam–25% plantain blend showing the highest. This increase indicates that roasted clam and unripe plantain are good dietary sources of calcium, which is essential for the proper development of bones and teeth in humans (Okon et al., 2021; Okaka et al., 2006). The potassium content of the bread samples (86.33–106.76 mg/100

g) increased significantly as the proportion of roasted clam and unripe plantain flours increased. Potassium is an important mineral that plays a vital role in muscle contraction, relaxation, and blood clotting in the human body (Onoja et al., 2014). The phosphorus content of the bread samples ranged from 43.17 to 70.79 mg/100 g, with higher values observed as the levels of roasted clam and unripe plantain flours increased. This suggests that both ingredients are good sources of phosphorus, a mineral essential for energy metabolism and ATP formation in the body (Aremu et al., 2006; Okaka et al., 2006). The magnesium content of the bread samples (92.14–112.15 mg/100 g) increased significantly with the substitution of roasted clam and unripe plantain flours, with the highest value recorded in the 25% clam–25% plantain sample. Magnesium is important for maintaining cardiovascular health and may help reduce the risk of conditions such as migraine and heart attack (Onoja et al., 2011). The iron content of the bread samples ranged from 1.52 to 2.05 mg/100 g and increased with the addition of roasted clam and unripe plantain flours. Iron is a vital mineral required for haemoglobin formation and plays a significant role in preventing anaemia, especially in infants and young children (Okaka et al., 2006). The zinc content of the bread samples ranged from 2.13 to 2.98 mg/100 g and increased steadily with higher substitution levels of roasted clam and unripe plantain flours. Zinc is essential for normal growth, immune function, and development during pregnancy, childhood, and adolescence (Ravichandran et al., 2010).

Vitamin Composition of Bread Samples

The vitamin composition of the bread samples are presented in Table 4.

Table 4: Vitamin composition (mg /100g) of bread loaves

| Samples | Thiamine | Riboflavin | Niacin | Ascorbic acid | β -carotenoid | Vitamin E |
|---------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| A | 42.17 ^f ±0.03 | 62.31 ^f ±0.01 | 24.15 ^f ±0.01 | 12.15 ^e ±0.02 | 18.32 ^f ±0.05 | 15.31 ^f ±0.01 |
| B | 46.25 ^e ±0.05 | 64.43 ^e ±0.01 | 28.31 ^e ±0.03 | 12.23 ^d ±0.03 | 22.18 ^e ±0.01 | 19.23 ^e ±0.05 |
| C | 48.31 ^d ±0.01 | 68.12 ^d ±0.02 | 33.13 ^d ±0.01 | 12.35 ^c ±0.05 | 26.41 ^d ±0.03 | 25.16 ^d ±0.02 |
| D | 51.42 ^c ±0.02 | 72.92 ^c ±0.06 | 40.73 ^c ±3.05 | 12.56 ^b ±0.03 | 34.77 ^c ±0.04 | 31.21 ^c ±0.03 |
| E | 55.61 ^b ±0.01 | 76.51 ^b ±0.01 | 43.71 ^b ±0.04 | 12.73 ^a ±0.04 | 40.15 ^b ±0.02 | 38.43 ^b ±0.05 |
| F | 59.19 ^a ±0.06 | 80.69 ^a ±0.04 | 46.57 ^a ±0.02 | 12.74 ^a ±0.01 | 47.33 ^a ±0.01 | 43.67 ^a ±0.04 |

Values are mean± standard deviation of duplicate. Means in the same column with different superscripts are significantly different (p< 0.05).

A- Bread made with 100% wheat flour.

B- Bread made with 90% wheat flour, 5% roasted clam flour and 5% unripe plantain flour.

C- Bread made with 80% wheat flour, 10% roasted clam flour and 10% unripe plantain flour.

D- Bread made with 70% wheat flour, 15% roasted clam flour and 15% unripe plantain flour.

E- Bread made with 60% wheat flour, 20% roasted clam flour and 20% unripe plantain flour.

F- Bread made with 50% wheat flour, 25% roasted clam flour and 25% unripe plantain flour.

WF- Wheat Flour, roasted clam Flour, unripe plantain Flour.

Vitamin Composition of Bread Samples

The thiamine content of the bread samples ranged from 42.17 to 59.19 mg/100 g, increasing with higher substitution of roasted clam and unripe plantain flours, with the control sample having the least value. This indicates that the added ingredients contributed to the enrichment of thiamine, a vitamin essential for glucose metabolism and proper functioning of the nerves, muscles, and heart (Lonsdale, 2006). The riboflavin content of the bread samples (62.31–80.69 mg/100 g) increased significantly with the inclusion of roasted clam and unripe plantain flours, with the highest value observed in the 25% clam–25% plantain blend. Riboflavin plays an important role in maintaining healthy eyes, skin, and nerves, and is essential for the metabolism of proteins, fats, and carbohydrates (Chikwendu et al., 2015; Okwu, 2004). The niacin content of the bread samples ranged from 24.15 to 47.57 mg/100 g, increasing with higher substitution levels of roasted clam and unripe plantain flours. Niacin is important for maintaining a healthy liver, supporting the nervous system, and acting as a component of the respiratory co-enzyme involved in tissue oxidation (Hathorn et al., 2008; Campos-Vega et al., 2010). The ascorbic acid content of the bread samples ranged from 12.15 to 12.74 mg/100 g, with slightly higher values observed as the proportion of roasted clam and unripe plantain flours increased. Ascorbic acid functions as a powerful antioxidant that aids tissue repair and protects cells from oxidative damage (Oduro et al., 2000; Oyetayo & Ajayi, 2005). The β -carotenoid content of the bread samples increased significantly with greater substitution of roasted clam and unripe plantain flours, ranging from 18.32 to 47.33 mg/100 g. β -Carotenoid is important for maintaining good vision and may help in the prevention and management of diseases such as cancer and diabetes (Okaka et al., 2006). The vitamin E content of the bread samples increased markedly from 15.31 mg/100 g in the control to 43.67 mg/100 g in the sample containing 25% roasted clam and 25% unripe plantain flours. Vitamin

E acts as a potent antioxidant that protects body cells by inhibiting free radical reactions and oxidative damage (Oduro et al., 2000; Aremu et al., 2011).

Physical Properties of Bread Samples

The physical properties of the bread samples are presented in Table 5.

Table 5: Physical properties of bread loaves

| Samples | Loaf Volume (cm ³) | Loaf Height (cm) | Loaf Weight (g) | Oven Spring (cm) | Specific Loaf Volume (cm ³ /g) |
|----------|--------------------------------|-------------------------|---------------------------|---------------------------|---|
| A | 310.21 ^a ±0.02 | 6.82 ^a ±0.04 | 410.21 ^a ±0.01 | 458.15 ^a ±0.01 | 0.76 ^a ±0.05 |
| B | 282.15 ^b ±0.01 | 6.38 ^b ±0.02 | 398.52 ^b ±0.04 | 446.19 ^b ±0.02 | 0.68 ^b ±0.03 |
| C | 230.19 ^c ±0.03 | 5.86 ^c ±0.01 | 346.16 ^c ±0.01 | 434.31 ^c ±0.01 | 0.54 ^c ±0.01 |
| D | 210.31 ^d ±0.01 | 5.24 ^d ±0.03 | 318.31 ^d ±0.05 | 426.51 ^d ±0.03 | 0.44 ^d ±0.02 |
| E | 100.24 ^e ±0.05 | 4.78 ^e ±0.04 | 284.16 ^e ±0.01 | 418.21 ^e ±0.01 | 0.32 ^e ±0.00 |
| F | 115.41 ^f ±0.02 | 3.84 ^f ±0.01 | 246.31 ^f ±0.03 | 407.94 ^f ±0.07 | 0.26 ^f ±0.04 |

Values are mean± standard deviation of duplicate. Means in the same column with different superscripts are significantly different (p< 0.05).

A- Bread made with 100% wheat flour.

B- Bread made with 90% wheat flour, 5% roasted clam flour and 5% unripe plantain flour.

C- Bread made with 80% wheat flour, 10% roasted clam flour and 10% unripe plantain flour.

D- Bread made with 70% wheat flour, 15% roasted clam flour and 15% unripe plantain flour.

E- Bread made with 60% wheat flour, 20% roasted clam flour and 20% unripe plantain flour.

F- Bread made with 50% wheat flour, 25% roasted clam flour and 25% unripe plantain flour.

WF- Wheat Flour, roasted clam Flour, unripe plantain Flour.

Physical Properties of Bread Samples

The loaf volume of the bread samples ranged from 115.41 to 310.21 cm³ and decreased significantly (p<0.05) as the level of roasted clam and unripe plantain flour substitution increased. The control sample made from 100% wheat flour recorded the highest loaf volume, while the sample containing 25% roasted clam and 25% unripe plantain flours had the lowest value. This reduction in loaf volume may be attributed to the absence or low level of gluten in roasted clam and unripe plantain flours, which reduces the dough's ability to retain gas during fermentation and baking (Okon et al., 2021; Olayiwola et al., 2020). The loaf height of the bread samples decreased significantly (p<0.05) with increasing substitution of roasted clam and unripe plantain flours, with values ranging from 3.84 to 6.82 cm. Although a decrease was observed, the values obtained in this study were higher than those reported for wheat–sweet potato composite flour breads by Hathorn et al. (2008). The

reduction in loaf height may be associated with the weakening of the gluten network as more non-wheat flours were incorporated into the formulation. Similar findings were reported by Malomo et al. (2012) in breads produced from wheat flour partially substituted with breadfruit and breadnut flours. The loaf weight of the bread samples decreased significantly ($p < 0.05$) with increased substitution of roasted clam and unripe plantain flours. This reduction may be linked to the lower carbon dioxide retention capacity of composite flours compared to wheat flour during fermentation and proofing. As a result, the dough structure becomes less stable, leading to lower loaf expansion and weight in the finished product (Shittu et al., 2007). The oven spring of the bread samples ranged from 407.94 to 458.15 cm, with the control sample recording the highest value and the bread containing 25% roasted clam and 25% unripe plantain flours having the lowest value. The observed reduction in oven spring can be attributed to the dilution of gluten in the composite flour blends. Since gluten plays a crucial role in trapping gases during baking, its reduction leads to decreased dough expansion and lower oven spring values. This observation is consistent with the findings of Malomo et al. (2012) for wheat–breadfruit–breadnut composite breads. The specific loaf volume of the bread samples ranged from 0.26 to 0.76 cm³/g and decreased significantly ($p < 0.05$) with increasing substitution of roasted clam and unripe plantain flours. The reduction in specific loaf volume can be attributed to the absence of gluten protein in the composite flours, which negatively affects the dough's ability to retain carbon dioxide during fermentation and proofing. Similar reductions in specific loaf volume have been reported for composite breads made from non-wheat flour blends (Onoja et al., 2011). Overall, the substitution of wheat flour with roasted clam and unripe plantain flours reduced the physical properties of the bread samples.

Microbial Evaluation of Functional Bread Samples

The microbial counts of the functional bread samples produced from the blends of wheat, roasted clam and unripe plantain was presented in Table 6. The total viable count for the samples varied between 0.33×10^4 and 1.20×10^4 cfu/g. The control sample exhibited the lowest total viable count at 0.33×10^4 cfu/g, whereas the formulation containing 50 % wheat, 25 % roasted clam, and 25 % unripe plantain flours recorded the highest total viable count of 1.20×10^4 cfu/g. The relatively low total viable counts across all samples may be attributed to the production of the functional bread being conducted in a clean and hygienic environment. The absence of these microorganisms in all functional bread samples suggests that they are safe for human consumption and can be stored for extended periods without

negative effects. Also, the Standard Organization of Nigeria, the maximum permissible level of aerobic bacteria in bread is 100 cfu/g and that of coliform must be zero (Ijah et al., 2014). Therefore, the counts recorded in this study conform to the regulatory standard, which suggests that the bread is safe for human consumption in terms of microbial quality.

Table 6: Microbial Count (cfu/g) of the Functional Bread Samples

| Samples | Total Viable Count (cfu/g) | Coliform Count (cfu/g) | Fungal Count (cfu/g) |
|----------|----------------------------|------------------------|----------------------|
| A | 0.33 x 10 ⁴ | Nil | Nil |
| B | 0.48 x 10 ⁴ | Nil | Nil |
| C | 0.61 x 10 ⁴ | Nil | Nil |
| D | 0.83 x 10 ⁴ | Nil | Nil |
| E | 1.10 x 10 ⁴ | Nil | Nil |
| F | 1.20 x 10 ⁴ | Nil | Nil |

Values are mean± standard deviation of duplicate. Means in the same column with different superscripts are significantly different (p< 0.05).

A- Bread made with 100% wheat flour.

B- Bread made with 90% wheat flour, 5% roasted clam flour and 5% unripe plantain flour.

C- Bread made with 80% wheat flour, 10% roasted clam flour and 10% unripe plantain flour.

D- Bread made with 70% wheat flour, 15% roasted clam flour and 15% unripe plantain flour.

E- Bread made with 60% wheat flour, 20% roasted clam flour and 20% unripe plantain flour.

F- Bread made with 50% wheat flour, 25% roasted clam flour and 25% unripe plantain flour.

WF- Wheat Flour, roasted clam Flour, unripe plantain Flour.

Sensory Properties of Bread Samples

The sensory properties of the bread samples are presented in Table 7. Significant differences (p<0.05) were observed between the control and composite breads in colour, taste, aroma, texture, and overall acceptability. The colour scores of the bread samples ranged from 6.45 to 7.45. The control sample recorded the highest score, while the bread containing 25% roasted clam and 25% unripe plantain flours had the lowest value. The darker colour of the composite breads may be attributed to Maillard browning and caramelization reactions during baking (Fayle & Gerrard, 2002; Onimawo & Akubor, 2005). Colour is an important quality attribute that influences the initial acceptance of baked products (Olanipekun et al., 2018). Taste scores ranged from 6.25 to 8.01, with the control bread being the most preferred. The reduction in taste scores with increased substitution may be linked to the earthy flavour of unripe plantain and the briny flavour of roasted clam (Ehigiator & Akise, 2016). Taste plays an important role

in determining consumer preference for food products. The aroma scores ranged from 6.10 to 7.55, with the control sample receiving the highest rating. The composite breads recorded slightly lower values due to the flavour characteristics of the added flours. Aroma is a key sensory attribute that influences the desirability and acceptance of food products (Okache et al., 2020). Texture scores ranged from 6.20 to 7.40, with the control bread having the highest score. Increased substitution of roasted clam and unripe plantain flours slightly affected the texture of the breads. However, acceptable texture was observed when substitution levels were kept at moderate levels (Ouazib, 2017). Overall acceptability scores ranged from 6.20 to 7.85, with the control bread being the most preferred by the panelists. The results indicate that acceptable bread can still be produced with moderate incorporation of roasted clam and unripe plantain flours. Generally, substitution levels up to about 10% each produced breads that were still well accepted by consumers.

Table 7: Sensory properties of bread loaves

| Samples | Colour | Taste | Aroma | Mouthfeel | Overall Acceptability |
|---------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| A | 7.45 ^a ±1.06 | 7.65 ^a ±1.04 | 7.55 ^a ±1.02 | 7.40 ^a ±1.02 | 7.85 ^a ±1.02 |
| B | 7.39 ^b ±1.01 | 7.58 ^b ±0.03 | 7.45 ^b ±1.00 | 7.35 ^a ±1.00 | 7.75 ^b ±1.03 |
| C | 7.25 ^c ±1.04 | 7.45 ^c ±1.02 | 7.25 ^c ±1.05 | 6.85 ^b ±1.02 | 6.95 ^c ±1.01 |
| D | 6.99 ^d ±1.03 | 6.70 ^d ±1.03 | 6.85 ^d ±1.03 | 6.60 ^c ±1.03 | 6.75 ^d ±1.04 |
| E | 6.50 ^e ±1.01 | 6.40 ^e ±1.05 | 6.35 ^e ±1.06 | 6.55 ^c ±1.02 | 6.45 ^e ±1.05 |
| F | 6.45 ^e ±0.04 | 6.15 ^f ±1.03 | 6.10 ^f ±1.02 | 6.20 ^d ±1.07 | 6.20 ^f ±1.03 |

Values are mean± standard deviation of twenty (20) semi-trained judges. Means in the same column with different superscripts are significantly different ($p < 0.05$).

A- Bread made with 100% wheat flour.

B- Bread made with 90% wheat flour, 5% roasted clam flour and 5% unripe plantain flour.

C- Bread made with 80% wheat flour, 10% roasted clam flour and 10% unripe plantain flour.

D- Bread made with 70% wheat flour, 15% roasted clam flour and 15% unripe plantain flour.

E- Bread made with 60% wheat flour, 20% roasted clam flour and 20% unripe plantain flour.

F- Bread made with 50% wheat flour, 25% roasted clam flour and 25% unripe plantain flour.

WF- Wheat Flour, roasted clam Flour, unripe plantain Flour.

CONCLUSION

The study revealed that bread produced from composite flours of wheat, roasted clam, and unripe plantain can improve the nutritional quality of bread by increasing protein, minerals, and vitamin contents. However, increasing the substitution levels reduced some physical properties and slightly lowered sensory acceptability of the bread samples. Overall, the bread

containing 15% roasted clam and 5% unripe plantain flours was found to be the most organoleptically acceptable among the composite samples.

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