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Proximate and Sensory Evaluation of Wheat Plantain Bread

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Abstract: *The high import cost of wheat and the need for nutritional diversification in staple foods have spurred increasing research into composite flours. This study investigated the proximate composition, functional properties, and sensory qualities of bread produced from wheat–plantain composite flours. Wheat flour was partially substituted with unripe plantain flour at 10%, 20%, and 30% levels, alongside a 100% wheat control. Proximate composition (moisture, protein, fat, ash, fiber, carbohydrate), functional properties (bulk density, water/oil absorption, foaming capacity, dispersibility, and emulsion capacity), and sensory attributes (color, aroma, taste, texture, overall acceptability) were assessed using standard methods. Results revealed significant differences ($p < 0.05$) among samples. Plantain incorporation increased crude fiber and ash but reduced protein content. Functional properties were slightly affected at higher substitution levels, while sensory evaluation showed that breads with up to 20% substitution were comparable to the control. At 30% substitution, loaf quality and consumer acceptability declined. The study concludes that wheat–plantain composite bread is feasible, nutritionally beneficial, and supports reduced wheat import dependence while promoting local crop utilization.*

Keywords: *Composite flour, functional properties, plantain, proximate composition, sensory evaluation, wheat*

1.0 Introduction

Bread is one of the most widely consumed staple foods worldwide, prized for its convenience, sensory appeal, and role as a major source of dietary carbohydrates (Oluwajoba et al., 2021). In Nigeria, bread ranks as the second most consumed staple after rice, with its demand rising steadily due to rapid urbanization, population growth, and changing food habits. Conventionally, bread is made from wheat flour, which contains gluten proteins that confer unique viscoelastic properties essential for dough development and leavening (Dewettinck et al., 2020). However, wheat cultivation is unsuitable for tropical climates, including Nigeria, resulting in a near-total dependence on costly imports. This heavy reliance contributes significantly to the country's foreign exchange burden and exposes the food supply chain to global market fluctuations (Edema et al., 2021).

In addition to economic challenges, refined wheat flour is often nutritionally limited, lacking sufficient dietary fiber and certain essential micronutrients because of the removal of bran and germ during milling (Adebowale & Sanni, 2021). These limitations underscore the urgent need to explore composite flours—blends of wheat with locally available crops—to both reduce wheat importation and enhance nutritional quality (Hasmadi et al., 2020; Adeyeye et al., 2022).

Plantain (Musa paradisiaca), a tropical staple abundantly cultivated in Nigeria, presents a promising substitute. It is rich in resistant starch, dietary fiber, potassium, iron, and vitamins A and C, while also having a lower glycemic index than wheat (Otegbayo et al., 2021). Processing unripe plantain into flour provides a shelf-stable, nutrient-dense ingredient that can be used in bread-making. Recent studies suggest that incorporating plantain flour improves crude fiber and mineral content, but its effects on bread texture, loaf volume, and consumer acceptability vary depending on the substitution level (Oboh et al., 2023; Adeola et al., 2025).

While several investigations have assessed composite flours, many focused on proximate, functional, or sensory qualities in isolation. A comprehensive analysis that integrates these three dimensions is necessary for a holistic evaluation of composite bread's technological feasibility and consumer acceptance (Famakinwa et al., 2024; Ojo et al., 2025; Balogun et al., 2025).

Nigeria's heavy dependence on imported wheat flour poses both economic and nutritional challenges. There is a need to identify suitable local substitutes like plantain flour that can partially replace wheat without compromising bread quality. In view of this, the study aimed to evaluate the proximate composition, functional properties, and sensory qualities of bread produced from wheat–plantain composite flours, and to determine substitution levels that maintain acceptable nutritional and sensory standards.

2.0 Materials and Methods

2.1 Raw Material Procurement and Preparation

Commercial bakery-grade wheat flour was procured from a registered supplier in Osun State, Nigeria. Mature unripe plantains (Musa paradisiaca) were sourced from Ilobu Market, Osun State. Plantains were washed, peeled, sliced (1–2 mm thickness), blanched at 70 °C for 10 minutes to reduce enzymatic browning, oven-dried at 60 °C for 24 hours, milled, and sieved through a 500 µm mesh to obtain fine flour. Wheat grains were cleaned, oven-dried at 60 °C for 8 hours, milled, and sieved (2 mm) into wheat flour. All flours were packaged in airtight containers and stored at room temperature until use (AOAC, 2019; Otegbayo et al., 2021).

2.2 Composite Flour Formulation

Wheat and plantain flours were blended into four formulations:

Sample A (Control): 100% wheat flour

Sample B: 90% wheat flour + 10% plantain flour

Sample C: 80% wheat flour + 20% plantain flour

Sample D: 70% wheat flour + 30% plantain flour

Flour blends were homogenized using a laboratory blender to ensure uniformity (Adeyeye et al., 2022).

2.3 Bread Production

Bread samples were produced using the standard straight-dough method (Ayo et al., 2020). The recipe included 1000 g composite flour, 30 g yeast, 15 g salt, 50 g margarine, 10 g sugar, and 600 ml water. Ingredients were mixed in a laboratory dough mixer for 10 minutes, kneaded, and allowed to proof at 30 °C and 85% relative humidity for 90 minutes. The dough was molded, placed in greased pans, and baked in a preheated oven at 220 °C for 25 minutes. Loaves were cooled at room temperature for 2 hours, packaged in polyethylene bags, and stored for analysis.

2.4 Proximate Composition Analysis

Moisture, crude protein (Kjeldahl, N × 6.25), crude fat (Soxhlet), crude fiber, total ash, and carbohydrate (by difference) contents were determined according to AOAC (2019) protocols. All measurements were conducted in triplicate for accuracy.

2.5 Functional Properties of Flour

Functional properties of composite flours were evaluated using standard methods (Adeola et al., 2025):

- Loose and packed bulk densities (g/cm³) by tapping method.

- Water absorption capacity (WAC) and oil absorption capacity (OAC) by centrifugation.
- Foaming capacity and stability.
- Dispersibility in water.
- Emulsion capacity.

2.6 Sensory Evaluation

Twenty (20) semi-trained panelists (staff and students of the Federal Polytechnic Ede, Nigeria) were recruited following ethical approval and informed consent. Bread samples were evaluated for color, aroma, taste, texture, and overall acceptability using a 9-point hedonic scale (1 = dislike extremely; 9 = like extremely) as described by Otegbayo et al. (2021). Panelists were provided with water to rinse between samples.

2.7 Statistical Analysis

All analyses were performed in triplicate and data expressed as mean ± standard deviation. Statistical evaluation was conducted using SPSS software (version 26.0, IBM Corp., Armonk, NY, USA). One-way Analysis of Variance (ANOVA) was used to determine significant differences among samples, and means were separated using Duncan's Multiple Range Test at a 95% confidence level ($p < 0.05$) (Oboh et al., 2023)

3.0 Results and Discussion

3.1 Proximate Composition of Composite Breads

Table 1. Proximate composition of wheat–plantain composite bread

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate (%)
A	11.2 ± 0.2	12.5 ± 0.1	3.5 ± 0.2	1.2 ± 0.1	0.6 ± 0.1	71.0 ± 0.3
B	11.4 ± 0.3	11.9 ± 0.2	3.6 ± 0.2	1.4 ± 0.1	0.8 ± 0.1	70.9 ± 0.2
C	11.6 ± 0.2	11.2 ± 0.2	3.7 ± 0.1	1.6 ± 0.1	1.1 ± 0.2	70.8 ± 0.3
D	11.8 ± 0.2	10.6 ± 0.3	3.9 ± 0.2	1.9 ± 0.1	1.3 ± 0.1	70.5 ± 0.2

The proximate composition of wheat–plantain composite breads is presented in Table 1. Moisture content increased slightly with higher plantain substitution, ranging from 11.2% in the control (100% wheat) to 11.8% in the 70:30 blend. This trend suggests that plantain flour, being more hygroscopic due to its higher fiber content, enhances water retention in baked products (Otegbayo et al., 2021). Increased moisture may contribute to softer crumb structure but could also reduce shelf stability if storage conditions are not optimal (Olawoye et al., 2023).

Protein content decreased progressively from 12.5% in the control to 10.6% at 30% substitution. This reduction is expected since wheat flour contains gluten proteins critical for viscoelasticity, whereas plantain flour is relatively low in protein (Adeyeye et al., 2022). The nutritional implication is a moderate decline in protein quality; however, composite flours can still contribute meaningfully to protein intake when complemented with legumes or other fortifiers, as recommended in functional food development (Oyeyinka & Kayitesi, 2020).

Fat content increased slightly with substitution, which may be attributed to endogenous lipids in plantain flour. Ash and fiber contents increased steadily, consistent with the mineral- and fiber-rich profile of unripe plantain (Famakinwa et al., 2024). Elevated fiber enhances gastrointestinal health and has been linked to reduced postprandial glycemic response, making the composite bread a potential functional food for metabolic health (Balogun et al., 2025). Carbohydrate content showed marginal decreases across substitution levels, reflecting the partial replacement of starchy wheat with plantain components.

Overall, the proximate data highlight that moderate inclusion (≤20%) of plantain flour enhances the micronutrient and fiber content of bread without substantial compromise in macronutrient balance. These findings corroborate earlier works on wheat–plantain and wheat–cassava breads, which reported similar nutritional shifts (Ayo et al., 2020; Oboh et al., 2023).

3.2 Functional Properties of Wheat–Plantain Composite Flours

Table 2. Functional properties of wheat–plantain composite flours

Sample	LBD (g/cm³)	PBD (g/cm³)	WAC (g/g)	OAC (%)	Foaming (%)	Emulsion (%)	Dispersibility (%)
A	29.0 ± 0.3	0.62 ± 0.01	1.27 ± 0.02	96.8± 0.4	9.5 ± 0.2	60.1 ± 0.5	74.5 ± 0.3
B	28.4 ± 0.4	0.61 ± 0.02	1.25 ± 0.01	95.2 ± 0.3	9.2 ± 0.1	59.2 ± 0.4	73.2 ± 0.2
C	27.1 ± 0.2	0.60 ± 0.02	1.24 ± 0.02	94.3 ± 0.3	8.9 ± 0.3	58.1 ± 0.3	72.4 ± 0.3
D	26.0 ± 0.3	0.59 ± 0.01	1.23 ± 0.01	92.1 ± 0.5	8.4 ± 0.2	57.0 ± 0.4	71.1 ± 0.2

Functional properties of the flour blends are presented in Table 2. Bulk density (loose and packed) decreased with higher plantain inclusion, from 29.0 g/cm³ in the control to 26.0 g/cm³ at 30% substitution. Reduced bulk density suggests lighter flour particles with greater porosity, which may affect handling during dough mixing (Adeola et al., 2025).

Water absorption capacity (WAC) and oil absorption capacity (OAC) both declined slightly as plantain levels increased. Since WAC is linked to protein–water interactions and starch swelling, the decline reflects the reduced gluten matrix of composite flours (Oboh et al., 2023). Similarly, reduced OAC in composite flours may influence mouthfeel and shelf stability, as fat-binding capacity contributes to flavor retention (Kaushal et al., 2012).

Foaming and emulsion capacities also decreased with substitution, likely due to reduced protein solubility and surface activity of plantain proteins compared with wheat gluten (Hasmadi et al., 2020). Despite these reductions, the values remained within acceptable functional ranges for breadmaking, reinforcing the feasibility of composite formulations.

Thus, while plantain flour reduces some functional attributes of wheat flour, its effects remain manageable up to 20% inclusion, in agreement with reports on wheat–banana and wheat–sweet potato composites (Olagunju et al., 2022).

3.3 Sensory Evaluation of Composite Breads

Table 3. Sensory evaluation of composite breads (9-point hedonic scale)

Sample	Color	Aroma	Taste	Texture	Overall Acceptability
A	8.5 ± 0.1	8.3 ± 0.2	8.6 ± 0.1	8.4 ± 0.1	8.7 ± 0.1
B	8.2 ± 0.2	8.1 ± 0.1	8.3 ± 0.2	8.2 ± 0.1	8.4 ± 0.1
C	7.9 ± 0.2	7.8 ± 0.1	7.7 ± 0.2	7.8 ± 0.2	7.9 ± 0.2
D	7.2 ± 0.3	7.0 ± 0.2	7.1 ± 0.2	7.0 ± 0.3	7.2 ± 0.2

The sensory scores (Table 3) indicate that the control bread (100% wheat) received the highest ratings across all attributes, with overall acceptability of 8.7 on the hedonic scale. However, breads with 10–20% substitution remained within the "like moderately" to "like very much" range, showing no significant difference ($p > 0.05$) in overall acceptability compared to the control. This suggests that consumers are willing to accept moderate plantain substitution without perceiving significant compromise in taste, texture, or aroma (Ayo et al., 2020).

At 30% substitution, scores for color, taste, and texture declined significantly. Panelists noted darker crumb color and denser texture, consistent with the higher fiber and reduced gluten quality of plantain flour (Ojo et al., 2025). While such characteristics may limit consumer appeal in conventional bread markets, they could be advantageous in niche markets targeting functional or high-fiber foods.

These results align with prior studies where substitution levels above 20–25% typically compromised loaf volume, crumb softness, and flavor, leading to reduced consumer preference (Ndife et al., 2014; Oluwajoba et al., 2021). Therefore, a substitution threshold of ≤20% appears optimal for balancing nutrition, functionality, and sensory acceptance.

3.4 Overall Interpretation

The study demonstrates that wheat–plantain composite bread is nutritionally enriched with fiber and minerals, maintains functional viability, and is sensorially acceptable at up to 20% substitution. Beyond this threshold, reduced gluten quality and darker crumb color diminish bread quality. These findings provide a scientific basis for encouraging plantain utilization in composite flour technologies, with implications for reducing wheat import dependency, enhancing local food security, and promoting functional food development in Nigeria and other wheat-importing nations.

4.0 Conclusion

The study demonstrated that wheat–plantain composite breads are nutritionally superior in fiber and ash but reduced in protein compared to 100% wheat bread. Functional properties and sensory quality were best maintained at substitution levels up to 20%. Adoption of composite flour can reduce wheat dependency, support local agriculture, and promote food security in Nigeria.

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