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Reseach Article

Tigernut-Pigeon Pea Bread Enriched with Guava and Scent leaf Powders: Nutritional, Functional and Sensory Qualities

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ABSTRACT

The dependency on wheat for bread production presents nutritional and economic challenges in sub-Saharan Africa, particularly in Nigeria. This study evaluated the functional properties of raw flours and the proximate composition, mineral, and sensory attributes of composite bread produced from tigernut (Cyperus ecsulentus) and pigeon pea (Cajanus cajan) flours, further enriched with guava leaf (Psidium guajava) and scent leaf (Ocimum gratissimum) powders. Four bread formulations were produced: a 100% wheat flour control and three composite blends (PTN1: 30, 65, 3, and 2%; PTN2: 30, 65, 5 and 0 % PTN3: 30, 65, 0 and 5% of pigeon pea, tigernut, guava and scent leaf powders respectively). Proximate, functional, mineral, and sensory properties evaluation were conducted using standard AOAC methods. The fortified bread exhibited significantly higher ($p<0.05$) crude fiber (4.92-5.94 vs 1.64 mg/100g), ash (1.84-2.64 mg/100g vs 1.59 mg/100g), and fat contents compared to the control, with notably reduced carbohydrate content (39.24-41.91 mg/100g vs 57.50 mg/100g). Mineral analysis showed marginal improvements in iron, copper, and zinc. Sensory scores for the enriched breads were significantly lower than the control, though PTN1 achieved the highest overall acceptability (4.54/9) among the fortified samples. The preliminary results from the functional analysis of the leaf powders showed that pigeon pea powder exhibited the highest water absorption capacity, bulk density and flour yield (3.81 g/g; 0.70 g/mL and 80.06 %), while tigernut recorded the highest oil absorption capacity (3.29 g/g). Guava leaf and scent leaf powders had the least flour yield (23.17 %) and bulk density (0.36 g/mL) respectively. These findings demonstrate that tigernut-pigeon pea bread enriched with guava and scent leaf powders are nutritionally superior alternative to 100% wheat bread. This contributes to food security and dietary diversification.

1. Introduction

Bread is one of the most widely consumed food products globally. It is a dietary staple for millions of people across sub-Saharan Africa and beyond (Nwosu et al., 2014). However, conventional bread production is almost entirely reliant on refined wheat (*Triticum aestivum*). Wheat is not cultivated in tropical West Africa. It is also not nutritionally optimal in its refined form. However, Nigeria relies solely on wheat for its bakery industry. Wheat importation alone costs billions of dollars annually in Nigeria. This creates a severe foreign exchange burden and food import dependency (FAO, 2022). The nutritional deficiencies inherent in refined wheat flour, especially low fiber, micronutrient density, and essential fatty acids, create further grave public health consequences. The World Health Organization reports that anemia, zinc deficiency, and dietary fiber inadequacy remain significant nutritional challenges in Nigeria. This challenge affects an estimated 68% of children under five and a substantial proportion of women of reproductive age (WHO, 2023; Nwagbo et al., 2025). This situation highlights the need for an alternative, locally sourced, nutrient-dense flour composite as a functional substitute for wheat in bread production.

Composite flour technology has gained significant traction over the past decades as a sustainable strategy to reduce the economic burden of wheat importation and promote the nutritional quality of bread. It also enhances the utilization of underexploited indigenous crops (Chinma et al., 2015). In recent developments of composite flour technologies, tigernut (*Cyperus esculentus*) and Pigeon pea (*Cajanus cajan*) are gaining traction. This is due to their remarkable nutritional and functional properties. Tigernut is a tuber crop with rich dietary fiber, oleic acid, resistant starch and a variety of minerals such as phosphorus and magnesium (Adel and Prakash, 2015). Tigernut has been associated with hypoglycaemic, hypocholesterolaemic, and prebiotic effects. This makes it relevant for the formulation of functional foods (Benitez et al., 2011). Pigeon pea is widely cultivated in tropical Africa. It has been established as an important source of protein (20-22%), essential amino acids, iron, and zinc. The deficiency of these nutrients is critical and common in Nigeria (Adeola and Ohazuruike, 2016; Nwagbo et al., 2025).

Beyond starchy and proteinaceous base ingredients, food fortification using phytochemically-rich plant materials has proved promising. This approach has been used to develop the nutritional and functional values of food products. Guava leaf (*Psidium guajava* L.) and scent leaf (Ocimum gratissimum) are widely distributed across tropical West Africa. Their antioxidant, antimicrobial, antidiabetic, and anti-inflammatory properties have been documented (Abubakar et al., 2018; Luo et al., 2019; Ijeh and Ejike, 2011; Santos et al. 2023;). Guava leaves contain quercetin, catechins, gallic acid, and abundant dietary fiber (Akuru et al., 2024). Scent leaf is rich in phenolic flavonoids and essential oils with demonstrated biological activity (Ochieng et al., 2024). The addition of powders from these leaves improves the nutritional, shelf stability, and functional potentials of the products they are used in (Nwagbo et al. 2025). This presents a multidimensional solution to nutritious new food development.

Despite these scientific rationales, the existing literature reveals a significant gap. Numerous studies examined tigernut or pigeon pea composite flour in bread making (Chinma et al., 2015; Ogunlakin et al., 2012; Nwosu et al., 2014). On the other hand, other studies evaluated the use of plant leaf powders as food additives (Abubakar et al., 2018; Ijeh and Ejike, 2011), no published study has investigated the enrichment of a tigernut-pigeon pea bread system with both guava and scent leaf powders. This is a substantive research gap. The effects of the synergistic or antagonistic interactions of these four ingredients on the proximate, mineral, and sensory quality of enriched functional bread is unknown. Moreover, the knowledge of the bread-making performance of these nutrient-dense, West African food materials is important for local utilization. No study has evaluated the functional properties of the leaf flours or the proximate, mineral and sensory properties of guava-leaf and scent-leaf-enriched tigernut-pigeon pea bread within a single study. The present study was done to address these gaps by the evaluation of the functional properties of the individual flours and the proximate and, mineral composition and sensory acceptability of guava-leaf and scent-leaf-enriched tigernut-pigeon pea bread. The specific objectives of the study were to: (i) determine the flour yield, water absorption capacity, oil absorption capacity and bulk density of tigernut, pigeon pea, guava leaf and scent leaf flours; (ii) determine the proximate composition of the bread formulations; (iii) assess the mineral content of the bread samples and (iv) evaluate the sensory acceptability of the bread by a semi-trained sensory panel. The study contributes novel data to the composite food technology literature; insights for food product developers and policy stakeholders in Nigeria and comparable settings. It also establishes a scientific baseline for further bioavailability and clinical investigation tigernut-pigeon pea leaf-enriched composite foods.

2. Materials and Methods

2.1 Raw Material Procurement and Preparation

Tigernut (*Cyperus esculentus*) and pigeon pea (*Cajanus cajan*) were bought from a local vendor in Ose market Onishaa, Anambra State, while fresh guava leaves (*Psidium guajava*) and fresh scent leaves (*Ocimum gratissimum*) were procured from a farm and identified by horticulturists in the department of Crop Science and Horticulture, Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus. The pigeon pea and tigernuts were sorted and cleaned to remove foreign materials using the methods of AOAC (2016). Tigernuts were washed, soaked for 24 hours, dried at 60 ^{0}C for 36 hours, milled into flour, and sifted (250 µm mesh). The pigeon pea seeds were soaked for 12 hours, dried at 60 ^{0}C for 36 hours, milled into flour, and sifted (250 µm mesh). The fresh scent and guava leaves were washed, shade-dried at room temperature (28-32 ^{0}C) to minimize heat-induced phytochemical losses, ground to powder, and sifted (250 µm mesh). The flours were stored at 4 ^{0}C in sealed polyethylene bags until use.

2.2 Bread Formulation

Four bread formulations were prepared as shown in Tables 1 and 2. All composite blends were incorporated at ratios established in preliminary baking trials. Standard bread-making ingredients such as instant dry yeast, salt, sugar, fat, and water were added at uniform levels across all formulations. Breads were produced using the straight-dough method: ingredients were mixed, dough was proofed at 30 °C for 45 minutes, moulded, proofed for 30 min and baked at 180 ^{0}C for 25 minutes.

Table 1: Flour Formulation table

	Pigeon pea (%)	Tigernut (%)	Guava Leaves (%)	Sent leaves (%)	Wheat (%)
Control	0	0	0	0	100
PTN1	30	65	3	2	0
PTN2	30	65	5	0	0
PTN3	30	65	0	5	0

Keywords*: PTN1: 30, 65, 3, and 2% pigeon pea, tigernut, guava and scent leaf powder; PTN2: 30, 65, 5% pigeon pea, tigernut, guava leaf powder and PTN3: 30, 65, 5% pigeon pea, tigernut, and scent leaf powder.*

Table 2: Bread Ingredient Formulation table

	Control	PTN1	PTN2	PTN3
Wheat flour	550	-	-	-
Pigeon pea flour	-	225	225	225
Tigernut flour	-	490	490	490
Guava leaf powder	-	30	50	-
Scent leaf powder	-	20	-	50
Psyllium husk	30	30	30	30
Corn starch	50	50	50	50
Baking powder	20	20	20	20
Apple cider vinegar	10	10	10	10
Coconut oil	40	40	40	40
Date syrup	20	20	20	20
Egg	100	100	100	100
Tigernut milk	180	165	165	165

Keywords*: PTN1: 30, 65, 3, and 2% pigeon pea, tigernut, guava and scent leaf powder; PTN2: 30, 65, 5% pigeon pea, tigernut, guava leaf powder and PTN3: 30, 65, 5% pigeon pea, tigernut, and scent leaf powder.*

2.3 Functional Properties of Flour

The flour yield (%) was calculated as the ratio of the weight of dried flour obtained to the initial wet weight of raw material, expressed as a percentage. Water absorption capacity (WAC) was determined where 1 g of flour was suspended in 10 mL of distilled water, stirred for 30 minutes, centrifuged at 3,500 rpm for 30 min and calculated as water absorbed per gram of dry flour (g/g) (Chinma et al., 2015). Oil absorption capacity (OAC) was measured as water absorption capacity using vegetable oil in place of water. Bulk density was determined by the tapping method using a 25-mL graduated cylinder, expressed in g/mL.

2.4 Proximate Composition

The proximate analysis of the bread samples was conducted using AOAC (2016) standard methods. Moisture content was determined using the oven drying at 105 ^{0}C until constant weight. Crude protein was estimated using the Kjeldahl method (N×6.25). Crude fat was extracted using petroleum ether in a Soxhlet apparatus. Crude fiber was determined by acid-alkali digestion. Ash content was obtained by incineration at 500 ^{0}C for 6 h in a muffle furnace. Carbohydrate was estimated by difference: 100 - (moisture+protein+fat+fiber+ash).

2.5 Mineral Analysis

Mineral content (iron, chromium, copper and zinc) was determined using Atomic Absorption Spectrophotometry (AAS, Model AA-7000, Shimadzu, Japan). This was followed by dry ashing of the bread samples and dissolution of the ash in dilute nitric acid (AOAC, 2016). The results were expressed as mg per 100g dry weight.

2.6 Sensory Evaluation

Sensory evaluation was conducted with a 9-point hedonic scale (1= dislike extremely; 9= like extremely) by 20 semi-trained assessors drawn from the staff and students of the Department of Food Science and Technology, Chukwuemeka Odumegwu Ojukwu University, Igbariam Campus. The panelists evaluated the colour, crustiness, flavour, crumbliness, aroma, taste, texture and acceptability. Samples were presented in random order using a three-digit code and, and water was provided for rinsing between samples.

2.7 Statistical Analysis

All experiments were conducted in triplicates and data were expressed as mean ± standard deviation (SD). Data were subjected to one-way analysis of variance (ANOVA) using SPSS version 26.0 (IBM Corp, Armonk, NY). The mean was separated using Duncan's multiple range test at 5% significant level ($p<0.05$).

3. Results

3.1 Flour Yield and Functional Properties

The flour yield and functional properties of the raw flours are presented in Table 3. Pigeon pea flour had the highest flour yield (80.06%), followed by tigernut flour (67.19%), scent leaf powder (25.08 %) and guava leaf powder (23.17 %) as the least. The significantly higher flour yield of pigeon pea relative to the other flours is consistent with the reported moisture content and starch-to-fiber ratio of the crop (Adel and Prakash, 2015). Scent leaf and guava leaf powders would have been affected by relative low density of leaf cell solids usually observed after drying (Abubakar et al., 2018).

Significant differences ($p<0.05$) were observed among all flours for flour bulk density. Bulk density was in the order of pigeon pea (0.70 g/ml) > tigernut (0.62 g/mL) > guava leaf (0.42 g/mL) > scent leaf (0.36 g/mL). The decreasing bulk density from pigeon pea to scent leaf indicates progressively more porous particle structures in the latter flours. This is functionally relevant for dough aeration and crumb formation (Ogunlakin et al., 2012).

Pigeon pea exhibited the highest water absorption capacity (3.81 g/g), followed by tigernut flour (3.49 g/g), while the least was scent leaf powder (1.12 g/g). The superior higher absorption of the pigeon pea reflects its high protein content and hydrophilic polysaccharides (Ijeh and Ejike, 2011). High water absorption capacity in bread flour can improve dough handling and increase product moistness. However, it may reduce shelf life if moisture migration is not controlled (Okpalanma et al., 2025).

Tigernut flour recorded the highest oil absorption capacity (3.29 g/g), significantly ($p < 0.05$) exceeding the other flours. The high oil absorption of the tigernut flour reflects its oleic acid and unsaturated fatty acid profiles. These properties improve flavour retention and mouthfeel in baked products (Benitez et al., 2011).

Table 3: Flour Yield and Functional Properties of Tigernut and Pigeon pea flour and guava and scent leaf powders.

Functional Properties	Pigeon pea flour	Tigernut flour	Guava leaf powder	Scent leaf powder
Flour Yield	80.06^{a}±0.08	67.19^{b}±0.11	23.17^{d}±0.07	25.08^{c}±0.11
Water absorption Capacity (g/g)	3.81^{a}±0.07	3.49^{b}±0.07	1.73^{c}±0.10	1.12^{d}±0.01
Oil absorption Capacity (g/g)	1.51^{c}±0.00	3.29^{a}±0.08	2.08^{b}±1.00	1.57^{a}±0.01
Bulk density (g/mL)	0.70^{a}±0.02	0.62^{b}±0.01	0.42^{c}±0.01	0.36^{d}±0.03

Mean±SD across the same row having the same superscript are not significantly different.

***Keywords**: PTN1: 30, 65, 3, and 2% pigeon pea, tigernut, guava and scent leaf powder; PTN2: 30, 65, 5% pigeon pea, tigernut, guava leaf powder and PTN3: 30, 65, 5% pigeon pea, tigernut, and scent leaf powder.*

3.2 Proximate Composition of Composite Bread

Table 4 presents the proximate composition of the four bread formulations. PTN1 formulation recorded the highest moisture content (38.34 mg/100g), significantly ($p < 0.05$) different from the control (29.70 mg/100g) and PTNS2 (37.26 mg/100g). The markedly elevated moisture content of the PTN1 (38.34 mg/100g) could be explained by the combined hydrophilic polysaccharide contributions of both pigeon pea and tigernut flours, which increase water retention in the bread matrix. While this may enhance product freshness immediately after baking, it also implies a shorter shelf life and greater susceptibility to microbial spoilage. This should be given critical consideration for product development and packaging (Chinma et al., 2015). PTNS1 had the highest protein content (9.73 mg/100g), while the control had the lowest protein content compared to the formulated samples. The increase in protein content in the formulated samples was expected given the protein richness of pigeon pea (Adeola and Ohazurike, 2016).

Crude fat increased in all the composites, with PTN3 having the highest value (4.98 %) compared to 2.95 % in the control. Crude fiber was significantly elevated in all composite formulations (4.92-5.94 mg/100g) relative to the control (1.64 mg/100g). The significant increase in crude fibre across all composite formulations (4.92–5.94 vs. 1.64 mg/100g in control) is nutritionally the most consequential finding of this study. Dietary fibre intakes are critically inadequate in Nigeria and across Sub-Saharan Africa, where ultra-processed, low-fibre foods dominate urban diets (WHO, 2023). The composite breads produced in this study could bridge this fibre gap, especially with the WHO-recommended minimum intake of 25 g of dietary fibre per day for adults (Nwagbo et al., 2025). The PTN1 formulation had the highest ash content (2.64 mg/100g). Increased ash content in PTN1 (2.64 mg/100g) reflects the higher mineral load introduced by the leaf powders. There was, however, no statistically significant difference in individual mineral concentrations at the levels measured. Carbohydrate content was highest in the control (57.50 mg/100g) and lowest in PTN1 (39.24.24 mg/100g). The reduction in carbohydrate from 57.50 mg/100g (control) to 39.24 mg/100g (PTN1) is nutritionally advantageous for the management of hyperglycaemia and obesity. This is consistent with current dietary recommendations for reduced glycaemic load foods (Okpalanma et al., 2025).

Table 4: Proximate Composition of Tigernut-Pigeon Pea Bread Enriched with Guava and Scent leaf Powders

Proximate Composition (mg/100g)	**Control**	**PTN1**	**PTN2**	**PTN3**
Moisture	29.70^{d}±0.08	38.34^{a}±0.06	37.26^{c}±0.39	38.08^{b}±0.12
Protein	6.98^{c}±0.51	9.95^{a}±0.30	9.13^{b}±1.00	9.73^{b}±0.00
Crude fat	2.59^{d}±0.00	3.89^{c}±0.29	4.53^{b}±0.06	4.98^{a}±0.02
Crude fiber	1.64^{b}±0.35	5.94^{a}±0.07	5.33^{a}±0.07	4.92^{a}±0.64
Ash	1.59^{b}±0.28	2.64^{a}±0.21	1.84^{b}±0.35	2.19^{ab}±0.00
Carbohydrate	57.50^{a}±0.21	39.24^{d}±0.45	41.91^{b}±0.59	40.10^{c}±0.55

Mean±SD across the same row having the same superscript are not significantly different.

***Keywords**: PTN1: 30, 65, 3, and 2% pigeon pea, tigernut, guava and scent leaf powder; PTN2: 30, 65, 5% pigeon pea, tigernut, guava leaf powder and PTN3: 30, 65, 5% pigeon pea, tigernut, and scent leaf powder.*

3.3 The Mineral Composition

The mineral composition of the bread samples in Table 5 shows the comparative values of the control and formulated samples. Iron content ranged from 1.76 mg/100g in the control to 1.47 mg/100g. Chromium was uniformly low (0.1 mg/100g) across all samples. Copper showed a numerical increase in the composites (0.20 – 0.28 mg/100g) without any statistical difference. Zinc values were also comparable across groups (1.05 – 1.08 mg/100g). This indicated no significant effect of the leaf powder enrichment on bread mineral content. There was an absence of statistically significant differences in iron, zinc, chromium, and copper concentrations across formulations. This suggests that the leaf powder enrichment did not substantially alter the mineral bioavailability or total content at the blend proportions used. It is possible that the level of leaf powder incorporation was insufficient to produce detectable changes in mineral density. It is also possible that mineral-phytate interactions reduced net mineral availability uniformly across samples (Chude et al., 2021; Okpalanma et al., 2025). Pigeon pea is known to contain phytic acid and polyphenols that chelate divalent minerals such as iron and zinc. This could have potentially masked any additive mineral effect of the leaf powders (Nwosu et al., 2014). Future studies should consider fermentation or soaking pre-treatments to reduce antinutritional factors and improve mineral bioavailability in these composite systems (Chude et al., 2021).

Table 5: Mineral Composition of Tigernut-Pigeon Pea Bread Enriched with Guava and Scent leaf Powders

Mineral Composition (mg/100g)	**Control**	**PTN1**	**PTN2**	**PTN3**
Iron	1.76^{a}±0.10	1.87^{a}±0.09	1.86^{a}±0.01	1.81^{a}±0.01
Chromium	0.1±0.00	0.1±0.00	0.1±0.00	0.1±0.00
Copper	0.20±0.00	0.24±0.00	0.28±0.00	0.24±0.00
Zinc	1.05^{a}±0.04	1.06^{a}±0.01	1.05^{a}±0.04	1.08^{a}±0.04

Mean±SD across the same row having the same superscript are not significantly different.

***Keywords**: PTN1: 30, 65, 3, and 2% pigeon pea, tigernut, guava and scent leaf powder; PTN2: 30, 65, 5% pigeon pea, tigernut, guava leaf powder and PTN3: 30, 65, 5% pigeon pea, tigernut, and scent leaf powder.*

3.4 Sensory Attributes

The results of the sensory evaluation are presented in Table 6. The control sample scored significantly higher ($p < 0.05$) in all sensory attributes compared to all composite formulations. The control bread had the highest score for color (7.62), crustiness (7.00), flavour (7.38), crumbliness (7.23), aroma (7.54), taste (7.23), texture (7.46) and overall acceptability (7.62). Among the composite bread samples, PTN1 had marginally higher scores across most attributes, while PTN2 had the lowest scores for aroma (3.23) and taste (3.23). All composite formulations scored between 3.23 and 4.54. This indicates a range from ‘dislike moderately’ to ‘neither like nor dislike’ on the hedonic scale. The significantly lower sensory scores of all composite breads relative to the control bread across all attributes is a common finding in composite bread research (Chinma et al., 2015; Ogunlakin et al., 2012). This is evidence of consumer habituation to the colour, texture, and flavour profile of 100% wheat bread. These are attributable to the darkened crust and crumb coloration produced by the Maillard reaction with leaf-derived phenolic compounds (Aniemena et al., 2024). The herbal and somewhat astringent aroma imparted by scent leaf essential oils could have impacted on the sensory acceptance. Again, the denser crumb structure from absence of gluten network formation in the non-wheat composites could explain the lower hedonic scores. Notably, the PTN1 formulation, despite containing both leaf powders, achieved marginally better scores than PTN2 and PTN3 for most attributes. This suggests a degree of flavour balance between the two leaf types. The overall acceptability scores for composite breads (3.69–4.54) indicated moderate to marginal consumer acceptance. Though below the control, the moderately low overall acceptability of the formulated samples is consistent with sensory outcomes reported for novel functional foods. This could be attributed to consumers’ unfamiliarity with the ingredient profile (Abubakar et al., 2018). Sensory optimization strategies such as flavour masking, spice blending, or gradual consumer familiarization programmes could improve acceptance in future product iterations (Aniemena et al., 2024).

Table 6: Sensory Attributes of Tigernut-Pigeon Pea Bread Enriched with Guava and Scent leaf Powders

Sensory Attributes	Control	PTN1	PTN2	PTN3
Colour	7.62^{a}±1.50	4.46^{b}±2.03	3.46^{b}±1.51	3.54^{b}±1.94
Crustiness	7.00^{a}±1.15	4.23^{b}±1.88	3.93^{b}±1.12	4.00^{b}±1.68
Flavor	7.38^{a}±1.56	3.85^{b}±2.19	3.62^{b}±1.39	3.92^{b}±1.89
Crumbliness	7.23^{a}±1.54	4.31^{b}±2.62	3.92^{b}±1.80	3.77^{b}±1.83
Aroma	7.54^{a}±1.27	4.41^{b}±1.94	3.85^{b}±2.19	3.23^{b}±1.64
Taste	7.23^{a}±2.05	4.38^{b}±1.89	3.31^{b}±1.70	3.23^{b}±2.01
Texture	7.46^{a}±1.27	4.00^{b}±1.87	3.38^{b}±1.39	3.23^{b}±1.83
Overall acceptability	7.62^{a}±1.33	4.54^{b}±2.43	3.85^{b}±1.14	3.69^{b}±1.60

Mean±SD across the same row having the same superscript are not significantly different.

***Keywords**: PTN1: 30, 65, 3, and 2% pigeon pea, tigernut, guava and scent leaf powder; PTN2: 30, 65, 5% pigeon pea, tigernut, guava leaf powder and PTN3: 30, 65, 5% pigeon pea, tigernut, and scent leaf powder.*

4. Conclusion

This study provides, for the first time, a comprehensive quality evaluation of tigernut–pigeon pea composite bread enriched with guava and scent leaf powders. The composite formulations demonstrated substantially improved crude fibre, fat, and ash contents relative to 100% wheat bread, while maintaining comparable mineral profiles. Sensory scores, though significantly lower than the control, fell within a range amenable to improvement through product reformulation and consumer education. The findings establish a novel, evidence-based foundation for the development of nutritionally enhanced, locally sourced composite breads suited to the dietary needs of Nigerian and West African populations. Future research should investigate the bioavailability of nutrients, shelf-life stability, antinutritional factor reduction strategies, and optimal blend ratios to maximize both nutritional value and sensory acceptability.

References

Abubakar, M. S., Musa, A. M., Ahmed, A., & Hussaini, I. M. (2018). Medicinal plants used in the treatment of diabetes mellitus and selected food enrichment: A systematic review. Journal of Pharmacognosy and Phytotherapy, 10(3), 45–58. https://doi.org/10.5897/JPP2018.001

Adel, A. M., & Prakash, J. (2015). Chemical composition and antioxidant properties of tigernut (Cyperus esculentus) flour. Journal of Food Science and Technology, 52(4), 2156–2164. https://doi.org/10.1007/s13197-013-1205-1

Adeola, A. A., & Ohazurike, C. O. (2016). Nutritional and antinutritional composition of pigeon pea and its products. African Journal of Food Science, 10(6), 102–112. https://doi.org/10.5897/AJFS2015.0425

Akuru, E. A., Katata-Seru, L., Mabelebele, M., & Tshilande, N. (2024). A comprehensive review on guava: Nutritional profile, bioactive potential, and health-promoting properties of its pulp, peel, seeds, pomace and leaves. *Food Research International*, *196*, 114944. https://doi.org/10.1016/j.foodres.2024.114944

Aniemena, C.C., Emojorho, E.E., Onuoha, L.N., Okoronkwo C.N., Nwagbo, C.C. and Ugwu, I.O. (2024). Quality Assessment of Cupcake produced from Wheat-Garri Flour Blends, Asian Journal of Advanced Research and Reports, 18(7): 159-166.

Association of Official Analytical Chemists (AOAC). (2016). Official Methods of Analysis (20th ed.). AOAC International.

Benitez, V., Cantera, S., Aguilera, Y., Molla, E., Esteban, R. M., Diaz, M. F., & Martin-Cabrejas, M. A. (2011). Impact of germination on starch, dietary fibre and physicochemical properties in non-conventional legumes. Food Research International, 44(5), 1373–1379. https://doi.org/10.1016/j.foodres.2011.01.011

Chinma, C. E., Anuonye, J. C., Simon, O. C., Ohiare, R. O., & Danbaba, N. (2015). Effect of germination on the physicochemical and antioxidant characteristics of tigernut (Cyperus esculentus) flour. Food Chemistry, 185, 208–214. https://doi.org/10.1016/j.foodchem.2015.03.117

Chude,C.O., Nwagbo, C.C., Okpalanma, E.F. And Uba, B.O. (2021). Functional And Rheological Profile Of LAB-Fermented Bambara Groundnut (Vigna Subterranean (L) Flour). Journal Of Advances In Microbiology, 10: 1-9

Food and Agriculture Organization (FAO). (2022). FAOSTAT: Crops and Livestock Products Database. Retrieved from https://www.fao.org/faostat/en/#data

Ijeh, I. I., & Ejike, C. E. C. C. (2011). Current perspectives on the medicinal potentials of Ocimum gratissimum Linn. Journal of Medicinal Plants Research, 5(5), 794–819.

Luo, Y., Peng, B., Wei, W., Tian, X., & Wu, Z. (2019). Antioxidant and anti-diabetic activities of polysaccharides from guava leaves. *Molecules*, *24*(7), 1343. https://doi.org/10.3390/molecules24071343

Nwosu, J. N., Udeozor, L. O., Owuamanam, C. I., & Ojukwu, M. (2014). Substituting wheat flour with pigeon pea flour in bread production: Nutritional and sensory qualities. American Journal of Food and Nutrition, 4(2), 35–43. https://doi.org/10.5251/ajfn.2014.4.2.35.43

Nwagbo, C.C., Ugwu, I.A., Anyadioha, J.I., Okeke, M.N., and Nwafor, P.M. (2025). Cultivating and Promoting Functional Foods to Address Micro-Nutrient Deficiencies in Nigeria: A Review of Agricultural and Dietary Strategies. African Journal of Education, Science and Technology (AJEST), 8 (2): 1-10.

Ochieng, C. O., Ishola, I. O., & Bekele, T. (2024). Health and therapeutic potentials of *Ocimum* essential oils: A review on isolation, phytochemistry, biological activities, and future directions. *Journal of Essential Oil Research*, *36*(4), 378–401. https://doi.org/10.1080/10412905.2024.2338117

Ogunlakin, G. O., Oke, M. O., Babarinde, G. O., & Olapade, D. G. (2012). Effect of drying methods on proximate composition and physico-chemical properties of cocoyam flour. American Journal of Food Technology, 7(4), 245–250. https://doi.org/10.3923/ajft.2012.245.250

Okpalanma, E.F, Ukpong, E.S, Ezegbe, C.C., Chude, C.O, And Nwagbo, C.C. (2025). Effect Of Modified Traditional Cooking Methods On Nutritional Quality Of African Yam Beans (Sphenostylis Stenocarpa. Nigerian Journal Of Nutritional Sciences. 46 (2)

Santos, C. M. P., Ribeiro, A. B., & Ferreira, F. A. (2023). Fishing the targets of bioactive compounds from *Psidium guajava* L. leaves in the context of diabetes. *International Journal of Molecular Sciences*, *24*(6), 5761. https://doi.org/10.3390/ijms24065761

World Health Organization (WHO). (2023). Nutrition: Global targets for 2025. Retrieved from https://www.who.int/teams/nutrition-and-food-safety/global-targets-2025