

Functional Properties and Nutrients Composition of Composite Flour from Wheat and fermented Sesame Seed and Baking cum Sensory Properties of its Bread**¹Oladeji, Babatunde Stephen and ²Nwabuiké, Onyinyechi Fortunatè**¹ Department of Food Science and Technology, University of Calabar, Calabar, Nigeria² Department of Human Nutrition and Dietetics, University of Calabar, Calabar, Nigeria**Correspondence Author's e-mail address:** oladejistephen35@yahoo.com**Abstract**

This study investigated the functional and nutrients composition of composite flours of wheat (*Triticum aestivum* L.) and fermented sesame seed (*Sesamum indicum* L.) with baking and sensory properties of the bread produced from the flour samples. Wheat flour was substituted with fermented sesame seed flour (FSSF) at 10%, 20%, and 30% levels, with 100% wheat flour serving as control and the samples were tagged as A, B, C and D, respectively. The functional and nutrients and anti-nutrient composition of the composite flour samples were determined. The baking and sensory properties of the bread produced from the flour samples were determined. The protein (14.65-16.53%) and fat (11.00 -11.75%) contents were significantly higher compared to control (protein: 12.68%, fat: 2.25%). Also, increased ash and crude fibre but reduced carbohydrate contents was observed. Water absorption capacity (WAC) ranged from 3.84 to 4.17 g/ml, and oil absorption capacity (OAC) from 3.67 to 3.80 g/ml. The composite flours maintain desirable baking qualities. Mineral composition indicated higher copper (up to 1.258 mg/kg) and iron (up to 2.892 mg/kg) levels in composite samples compared to control. Sensory evaluation demonstrated that bread with 10% FSSF (sample C) achieved the highest scores for colour (5.30), taste (5.58), texture (4.42), and overall acceptability (5.17), followed by the 20% blend (sample B), while 100% wheat bread had the lowest sensory ratings. Based on the findings revealed, the study concludes that fermented sesame-wheat composite bread offers a viable, nutrient-enriched alternative to conventional wheat bread, with potential applications in enhancing dietary diversity and combating micronutrient deficiencies and reduce wheat dependent.

Key words: Composite flour, sesame seed, bread, fermentation, hidden hunger**Introduction**

Composite flours are blends of flours from different plant or animal sources formulated to improve the nutritional, functional, and economic value of food products (Akinwotu *et al.*, 2025) The concept has gained prominence in developing countries as a strategy to reduce reliance on imported wheat and promote the utilization of locally available crops. Beyond the nutritional benefits, composite flours can improve functional properties like water absorption, dough stability, and texture, while also reducing production costs and encouraging agricultural biodiversity (Michel *et al.*, 2024).

Cereals such as wheat (*Triticum aestivum* L.) are typically deficient in lysine but adequate in sulfur-containing amino acids like methionine and cysteine, while legumes and oilseeds such as sesame (*Sesamum indicum* L.) are rich in lysine but lower in methionine (Sharma *et al.*, 2021). Malnutrition and micronutrient deficiencies remain pressing public health challenges in many parts of the developing world, particularly in sub-Saharan Africa (Bhutta *et al.*, 2013; Adeyeye *et al.*, 2023). Diets in these regions are often heavily reliant on starchy staples that are energy-dense but lack adequate levels of essential nutrients such as vitamins, minerals, and antioxidants. In response to the need for more nutrient-rich food sources, research attention has increasingly focused on developing affordable, functional food formulations using local raw materials (Michel *et al.*, 2024). One such promising innovation is the use of composite flours which are

blends of cereal, legume, and oilseed flours designed to enhance the nutritional and functional quality of food products.

Additionally, wheat is not widely cultivated in many developing countries, leading to dependency on imports (Erenstein *et al.*, 2022). Sesame seed (*Sesamum indicum* L.), also known as sesame seed in parts of West Africa, offers an excellent complementary profile (Sharma *et al.*, 2021). It is rich in oil, high-quality protein, essential fatty acids, vitamin E, and bioactive lignans such as sesamin and sesamol, which possess antioxidant and cholesterol-lowering properties (Wei *et al.*, 2022; Subrahmaniyan *et al.*, 2024). A major limitation to the nutritional potential of both wheat and beni seed, however, is the presence of anti-nutritional factors such as phytates, tannins, oxalates, and saponins (Soni *et al.*, 2022; Pandey *et al.*, 2023). These compounds hinder the bioavailability of essential nutrients and reduce digestibility (Soni *et al.*, 2022). Fortunately, fermentation, a traditional and cost-effective bioprocessing method, has been shown to reduce these antinutrients significantly while enhancing the vitamin content and antioxidant activity of plant-based foods (Abbaspour, 2024). Through microbial metabolism, fermentation can improve protein digestibility, increase the synthesis of B-complex vitamins, and enhance the release of bound phenolic compounds, leading to improved nutritional quality (Sawant *et al.*, 2025).

While both wheat and sesame seed are individually known for their nutritional properties, limited research has been conducted on the combined effect of fermentation on wheat–sesame seed composite flour, especially with regard to their application in bread production. Previous studies such as Nwamaka (2016) evaluated the quality of bread fortified with sesame full fat and defatted sesame seed meals, Iombol *et al* (2016) evaluated the Nutritional quality and consumer acceptability of Wheat-Sesame composite bread blends. While, Ogundele and Mohamed (2024) explored sesame seed composite flour in biscuit production. But the effect of replacing part of wheat flour in bread making with fermented sesame seed has not been explored. Bread remains a popular, affordable, and convenient vehicle for nutrient delivery. So, this study aimed at evaluating the physico-chemical properties of wheat/ fermented sesame seed composite flour and baking and sensory properties of bread produced from composite flour. The specific objectives of the study were to develop composite flour from blends of wheat and fermented sesame seed flour, determine the nutrient and functional properties of the flour blends and evaluate the baking and sensory properties of the bread produced from the blends.

Materials and Methods

Raw material procurement

Sesame seed was purchased from Bogobiri Market, Calabar, Nigeria. Wheat flour and other ingredients for bread making such as instant baking yeast, salt, egg, granulated sugar and butter were also purchased from Watt Market, Calabar, Nigeria.

Sample preparation

Preparation of sesame seed flour

Sesame seed were sorted to remove dirt and stones, washed, and soaked in water at room temperature for 72 hours to facilitate natural fermentation. After fermentation, the seeds were wet milled using a laboratory hammer mill and sieved through a 0.5 mm mesh to obtain, drained and dried in a hot-air oven at 60 °C for 6 hours to obtain fermented sesame seed flour (FBSF). The flour was stored in airtight containers at room temperature.

Formulation of Composite Flours

Composite flours were formulated by blending wheat flour with fermented sesame seed flour in ratios of 90:10, 80:20, 70:30 and 100:0 for sample A, B, C, and D (control sample), respectively as shown in Table.1

Bread Making

Bread was produced using the straight dough method as described by Akintayo *et al.* (2020). Each flour blend was used to prepare dough with the following fixed ingredient composition (per 100 g flour): Yeast (1%), Sugar (10%), Salt (1%), Vegetable oil (3%), and Water (50% depending on flour absorption

capacity). The ingredients were mixed to for 15 minutes in a kitchen mixer to obtain uniform dough. The dough was molded into loaf pans, allowed to proof for 2 hours and baked at 180 °C for 30 minutes in a preheated oven. Baked loaves were cooled at room temperature and analyzed within 24 hours.

Table 1: Sample formulation

Sample	Wheat flour (%)	Fermented sesame seed flour (%)
A	70	30
B	80	20
C	90	10
D (Control)	100	0

Proximate Compositions Determination

Moisture content, total ash, crude fibre and crude fat, crude protein using Kjeldal apparatus and carbohydrate content were determined by difference for all the flour samples (AOAC, 2005).

Functional Properties Determination

The water absorption capacity (WAC) and oil absorption capacity of the composite flour sample and the control were determined according to the method of Onwuka (2005).

Mineral content analysis of composite flour

The method of Association of Official Analytical Chemists (AOAC, 2005) was used for mineral analysis. Two grammes (2g) of each flour samples were digested with concentrated nitric acid and hydrogen peroxide. Then the solutions were filtered in a 5ml volumetric flask and the filtrate was loaded to Atomic Absorption Spectrophotometer (Model No: novAA-400P, Germany). Zinc (Zn), iron (Fe), copper (Cu), calcium (Ca), and magnesium (Mg) were determined at wavelengths 324.7nm, 248.3 nm, 213.9 nm, 422.7 nm and 285.2 nm respectively. All values were expressed in mg/100 g.

Sensory analysis

The method of Ruston *et al.*, (1996) was used for sensory evaluation of the samples. Bread produced from the formulated blends and the control (wheat flour only) was allowed to cool at room temperature (25 ±2°C). The samples were coded and presented to 20 untrained panelists (students) that were familiar with bread. The panel members were assigned individually to well illuminate laboratory booths and the bread samples coded with random three digits. The panelists were instructed to rank the bread samples on the basis of appearance (color), taste, odour, texture (mouth feel), aftertaste and overall acceptability using a nine-point hedonic scale as described by Ihekoronye and Ngoddy (1985) (where, 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5= neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely).

Statistical analysis

Experimental data were subjected to analysis of variance (ANOVA) Using SPSS Version 21 (SPSS Inc., Chicago, IL, USA). Statistical analyses were carried out with Fisher's least significant difference test with a significance level of 5%. All measurements were performed at least in triplicate.

Results and Discussion

Proximate composition of composite flour

Table 2: Proximate Composition of Composite Flour (%)

Samples	A	B	C	D
Protein	14.65 ± 0.22b	15.66 ± 0.09c	16.53 ± 0.09d	12.68 ± 0.44a
Fat	11.00 ± 0.50b	11.25 ± 0.25b	11.75 ± 0.25b	2.25 ± 0.25a

Ash	2.26 ± 0.01b	2.51 ± 0.04c	2.75 ± 0.25d	0.85 ± 0.05a
Crude Fibre	1.51 ± 0.07b	1.53 ± 0.05b	1.58 ± 0.03b	0.82 ± 0.03a
Moisture	6.21 ± 0.72b	5.00 ± 1.00a	4.79 ± 0.71a	8.29 ± 0.01c
Carbohydrate	64.37 ± 1.05b	64.05 ± 0.58b	62.60 ± 0.77a	75.11 ± 0.75c

Values are expressed as Mean ± SD (n=3). Means with different superscripts (a,b,c) are significantly different at P<0.05

KEYS

A = 70% Wheat Flour, 30% sesame seed Flour B = 80% Wheat Flour, 20% sesame seed Flour

C = 90% Wheat Flour, 10% sesame seed Flour D = 100% Wheat Flour, 0% sesame seed Flour

The proximate composition of the composite flour samples is presented in Table 2. Protein content ranged from 12.68 ± 0.44% in 100% wheat flour (sample D) to 16.53 ± 0.09% in the formulation containing 90% wheat and 10% sesame seed flour (sample C). Fat content was significantly higher ($p < 0.05$) in composite flours containing sesame seed (11.00–11.75%) compared to 100% wheat flour (2.25%). Ash content increased with the level of sesame seed incorporation, ranging from 0.85 ± 0.05% in sample D to 2.75 ± 0.25% in sample C. Crude fibre content followed a similar trend, with composite flours showing higher values (1.51–1.58%) than the control (0.82%). Moisture content varied from 4.79 ± 0.71% in sample C to 8.29 ± 0.01% in sample D. Carbohydrate content was highest in 100% wheat flour (75.11 ± 0.75%) and lowest in sample C (62.60 ± 0.77%).

The proximate composition of the composite flours showed clear nutritional improvements with the incorporation of fermented sesame seed flour. Protein content increased from 12.68% in 100% wheat flour (sample D) to 16.53% in the formulation containing 90% wheat and 10% sesame seed flour (sample C). This enhancement can be attributed to the high protein content of sesame seed, which has been reported to range between 18–25% (Sharma *et al.*, 2021). Similar protein enhancement in composite flours containing sesame has been documented by Igbabul *et al.* (2014) and Mohamed *et al.* (2020), indicating its potential in improving the amino acid profile of cereal-based products, especially lysine content, which is typically low in wheat (Rawat & Indrani, 2015).

Fat content was markedly higher in all composite flours containing sesame seed (11.00–11.75%) compared to 100% wheat flour (2.25%). This is consistent with the findings of Adebisi *et al.* (2017), who reported that sesame seeds contain up to 50% oil, predominantly unsaturated fatty acids. The higher lipid content in the composite flour may contribute positively to the energy density of bakery products and improve palatability.

Ash content, an indicator of total mineral content, also increased with sesame seed incorporation, ranging from 0.85% in the control to 2.75% in sample C. Similar increases in ash content in wheat–sesame blends have been observed by Igbabul *et al.* (2014) and Abdualrahman *et al.* (2019), reflecting the mineral richness of sesame seeds, particularly in calcium, magnesium, and iron.

Functional properties of composite flour

Table 3: Functional Properties of Composite Flour

Sample	WAC (g/g)	OAC (g/g)
A	3.84 ± 0.29a	3.67 ± 0.15a
B	4.01 ± 0.01b	3.73 ± 0.15ab
C	4.10 ± 0.10b	3.80 ± 0.10b
D	4.17 ± 0.15c	3.80 ± 0.10b

Tables 3 show the some functional properties of the composite flour. The water absorption capacity (WAC) of the composite flours ranged from 3.84 ± 0.29 g/g in sample A to 4.17 ± 0.15 g/g in sample D, with significant differences ($p < 0.05$) among samples. Oil absorption capacity (OAC) values were between 3.67 ± 0.15 g/g (sample A) and 3.80 ± 0.10 g/g (samples C and D), with sample A showing the lowest value.

Oil absorption capacity (OAC) ranged from 3.67 g/g in sample A to 3.80 g/g in samples C and D. OAC reflects the ability of flour to bind oil through non-polar side chains of proteins and is important for flavour retention and mouthfeel in baked products (Adebowale *et al.*, 2005). The slightly higher OAC in wheat-dominant formulations (samples C and D) compared to higher sesame seed blends could be related to differences in protein composition and hydrophobicity.

Overall, the functional property results indicate that while sesame seed incorporation slightly reduces WAC, it does not compromise the functional suitability of the flour for bread making. The OAC values also suggest potential for good flavour retention in composite flour-based bread.

Mineral content of composite flour

Table 4: Mineral Content of Composite Flour

Sample	Cu (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Mg (mg/kg)	Ca (mg/kg)
A	$1.258 \pm 0.00a$	$0.987 \pm 0.00a$	$2.892 \pm 0.00a$	$8.234 \pm 0.00ab$	$4.246 \pm 0.00a$
B	$1.095 \pm 0.00b$	$1.036 \pm 0.00a$	$2.758 \pm 0.00ab$	$8.186 \pm 0.00a$	$4.262 \pm 0.00a$
C	$0.315 \pm 0.00c$	$1.036 \pm 0.00a$	$2.497 \pm 0.00b$	$7.944 \pm 0.00a$	$4.254 \pm 0.00a$
D	$0.379 \pm 0.00c$	$1.379 \pm 0.00b$	$2.490 \pm 0.00b$	$8.306 \pm 0.00b$	$4.284 \pm 0.00a$

The mineral composition of the composite flours is shown in Table 4. Copper content was highest in sample A (1.258 mg/kg) and lowest in sample C (0.315 mg/kg). Zinc levels ranged from 0.987 mg/kg in sample A to 1.379 mg/kg in sample D. Iron content varied from 2.490 mg/kg in sample D to 2.892 mg/kg in sample A. Magnesium values were between 7.944 mg/kg (sample C) and 8.306 mg/kg (sample D), while calcium content showed minimal variation, ranging from 4.246 to 4.284 mg/kg across samples. The mineral composition of the composite flours revealed significant differences among formulations, reflecting the contribution of fermented sesame seed flour. Copper (Cu) content was highest in sample A (1.258 mg/kg) and lowest in sample C (0.315 mg/kg), with the control wheat flour (D) recording 0.379 mg/kg. Variations among blends may be attributed to differences in the proportion of sesame seed and the effect of fermentation on mineral solubility.

Zinc (Zn) values ranged from 0.987 mg/kg (sample A) to 1.379 mg/kg (control, D). Interestingly, Zn was not markedly higher in sesame seed blends despite sesame being a good source of the mineral (Abdualrahman *et al.*, 2019). This may be due to the dilution effect from blending with wheat flour or potential losses during fermentation. However, all values fell within the range reported for wheat–sesame composites in similar studies (Igbabul *et al.*, 2014).

Baking Properties of the composite flour

Table 5: Baking Properties of the Composite Flour

Sample	Loaf weight (g)	Loaf Volume (cm ³)	Density (g/cm ³)	Crust colour	Crumb colour
A	364	612	0.59	Dark brown	Lighter brown

B	318	459	0.69	Deep brown	Light brown
C	358	661	0.54	Darker brown	Grayish brown
D	301	573	0.53	Golden brown	White

The baking properties of the bread samples are shown in Table 5. Sample A had a loaf weight of 364 g with a loaf volume of 612 cm³, its crust colour was dark brown, while the crumb appeared lighter brown. Sample B recorded a loaf weight of 318 g, a smaller loaf volume of 459 cm³ and the highest density of 0.69 g/cm³, with a deep brown crust and light brown crumb. Sample C produced a loaf weighing 358 g, with the highest loaf volume of 661 cm³ and a relatively low density of 0.54 g/cm³; its crust colour was darker brown and the crumb was grayish brown. Sample D had the lowest loaf weight of 301 g, a loaf volume of 573 cm³ and the least density of 0.53 g/cm³ with a golden brown crust and a white crumb.

Sensory quality of bread produced from composite flour

Table 6: Sensory Quality of Bread Produced From Composite Flour

Sample	Colour	Aroma	Taste	Texture	Overall acceptability
A	4.42	3.75	4.00	3.75	3.92
B	4.75	4.75	4.75	3.91	4.5
C	5.30	4.50	5.58	4.42	5.17
D	1.30	2.92	2.5	2.17	1.83

KEYS

A = 70% Wheat Flour, 30% sesame seed Flour B = 80% Wheat Flour, 20% sesame seed Flour
 C = 90% Wheat Flour, 10% sesame seed Flour D = 100% Wheat Flour, 0% sesame seed Flour

Sensory evaluation scores for bread samples are presented in Table 6. Colour scores ranged from 1.30 in sample D to 5.30 in sample C. Aroma ratings were lowest in sample D (2.92) and highest in sample B (4.75). Taste scores varied from 2.50 (sample D) to 5.58 (sample C). Texture ratings ranged from 2.17 in sample D to 4.42 in sample C. Overall acceptability was highest for sample C (5.17) and lowest for sample D (1.83). The sensory evaluation results showed clear differences in consumer perception of bread samples formulated with varying proportions of wheat and fermented sesame seed flour. Colour scores ranged from 1.30 in the 100% wheat control (sample D) to 5.30 in sample C (90% wheat, 10% sesame seed), indicating that the inclusion of fermented sesame seed flour markedly enhanced crust and crumb colour. Similar improvements in bread colour due to oilseed flour incorporation have been observed in wheat–flaxseed blends (Mentes *et al.*, 2008).

Aroma scores followed a similar trend, with the highest score recorded in sample B (80% wheat, 20% sesame seed) at 4.75, and the lowest in the control (2.92). The improved aroma in composite breads may be linked to the presence of volatile compounds generated from sesame seed during fermentation and baking, particularly sesame-derived pyrazines and furans known to impart nutty notes (Yoshida & Takagi, 1997).

Taste scores peaked at 5.58 for sample C, indicating strong consumer preference for moderate sesame seed inclusion. This aligns with earlier findings by Igbabul *et al.* (2014), who noted that partial replacement of wheat with sesame flour enhanced flavour complexity without imparting bitterness or off-notes. In contrast, the control sample scored lowest (2.50), suggesting that wheat-only bread in this study was less appealing in flavour compared to composite breads.

4.0 Conclusion

These findings of this study suggest that incorporating fermented sesame seed flour into wheat-based bread formulations is a viable approach for producing nutritionally improved, consumer-acceptable bakery products, with optimal substitution levels likely between 10% and 20%. These findings further suggest that

fermented sesame seed flour not only improves the nutritional and functional attributes of bread but also enhances sensory acceptance, particularly at lower substitution levels where flavour, colour, and texture improvements are maximized without compromising baking performance.

Recommendations

It is recommended that further studies should examine the effect of different fermentation times, drying conditions, and particle sizes on the functional and sensory qualities of fermented sesame seed flour in bread production. Also, additional research should assess the storage stability, microbial safety, and shelf-life of breads made with fermented beniseed flour to ensure quality retention during commercial distribution.

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