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Nutritional Composition and Sensory Properties of Cookies Made with Sorghum (*Sorghum bicolor*) and Groundnut (*Arachis hypogaea*)

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Abstract

This study evaluated nutrient composition and sensory properties of cookies made with white sorghum and groundnut. Cookies samples were produced with the following: A: 100% wheat flour (control) and five sorghum flour (SF) and Groundnut paste (GP) blend samples were prepared as follows: B(90:10); C(80:20); D(70:30); E(60:40); F(50:50). Proximate and mineral (magnesium, potassium, manganese and iron) composition and sensory properties were analyzed using standard procedures. Mean Analysis of Variance ($p<0.05$) were used for data analysis. Findings show samples were significantly higher than the control in fat, protein, crude fiber and ash content. Fat, protein, crude fiber, ash and carbohydrate content (%) of A(control) was 2.8, 19.17, 0.35, 0.79 and 58.22 respectively while that of the least among the trial samples (B) was 6.33, 21.77, 1.12, 1.76 and 56.41 respectively. Sample F had the highest composition of the minerals containing (in mg/g): 2.15 (magnesium); 11.94 (potassium); 1.082 (manganese) and 1.073 (iron). Sensory attributes evaluation scores ranged between 6.20 and 7.85 (depicts likeness) and this was comparable to that of F with scores ranging from 6.15 and 6.60 (depicts likeness).

Keywords: Sorghum, Groundnut, Cookies, Proximate, Composition, Mineral, Composition, Sensory, Properties.

Introduction

Sorghum is of good nutritional value and health benefits. Sorghum, like other cereals, is an excellent source of B-complex and fat-soluble vitamins. The concentrations of thiamine, riboflavin, and niacin in sorghum are comparable to those found in maize. It contains fat-soluble vitamins such as vitamins E and K. Sorghum is also rich in minerals, with phosphorus being the most abundant. Since minerals and vitamins are concentrated in the pericarp and germ, refined sorghum products may lose a portion of these essential nutrients. These nutrients are vital for maintaining overall health [Hassan, 2023]. Sorghum is one of the best sources of dietary fiber. Unlike some other grains, it does not have an inedible hull, meaning the whole grain can be consumed. This increases its fiber content along with other essential nutrients. The high fiber content of sorghum supports digestion, hormone production, and cardiovascular health. Sorghum contains polyphenolic compounds in its pericarp, which have significant health-protective effects, surpassing those of many commonly consumed grains, fruits, and vegetables. Its antioxidant activity is 3-4 times higher than that of some other whole grains. Black sorghum is particularly rich in antioxidants due to its high anthocyanin content. These antioxidants may help reduce inflammation, lower the risk of cancer, and improve blood sugar regulation [Hassan, 2023]. Studies suggest that a diet rich in sorghum is associated with a lower incidence of esophageal cancer [Sleem *et al.*, 2024]. Diabetes is a condition which occurs due to a higher level of glucose and less sensitivity to insulin in the body. The starch in sorghum grain is more slowly digested as compared to the other cereals owing to tannin content of sorghum bran which has an inhibitory effect on amylase which digests carbohydrates, and it is of low glycemic index, hence, sorghum is suitable for the management of diabetes and increased insulin sensitivity in diabetic patients [Khalid *et al.*, 2022; de Oliveira and de Alencar Figueiredo, 2024]. Sorghum is naturally gluten-free, making it an excellent alternative for individuals with celiac disease and studies have shown that sorghum-based products are safe and non-toxic for people with gluten intolerance [Khalid *et al.*, 2022; Hedge *et al.*, 2023]. Sorghum has the potential for managing blood cholesterol owing to its functional dietary fiber and lipids and studies indicate that sorghum lipids contribute to lowering cholesterol levels, which in turn reduces the risk of stroke, chronic inflammation, and type 2 diabetes [Stefoska-Needham, 2024]. Sorghum is a good source of both calcium and magnesium. Every 100 g of sorghum satisfies 5% of the recommended daily intake of calcium and 40% of the daily recommended intake of magnesium. A diet rich in sorghum can help prevent osteoporosis and arthritis [Stefoska-Needham, 2024]. The vitamin B6 present in Sorghum plays a major role in the production of a neurotransmitter gamma-aminobutyric acid (GABA). GABA is responsible for regulating the nerve impulses in the human body. Increased GABA production improves a person's mood, ability to focus, promoting relaxation and helping to control stress and depression. Vitamin B-complex, particularly niacin (B3), plays a vital role in metabolism by helping the body convert food into usable energy. Sorghum provides 28% of the daily niacin requirement, making it an excellent energy-boosting food. Ingesting sorghum-based food helps to boost the energy level and remain focused on work and is also rich in copper and iron [de Oliveira and de Alencar Figueiredo, 2024].

Despite its health benefits, nutritional potentials and applicability in food industry, sorghum (especially the white variety) is still grossly underutilized [Sadiq *et al.*, 2025]. Nigeria is the largest sorghum producer in West Africa [Charyulu *et al.*, 2024] and the second world's leading producer of this underutilized cereal grain [Khalifa and Eltahir, 2023].

Peanut or groundnut (*Arachis hypogaea*) is a legume of the pea family (*Fabaceae*) which is grown for its edible seeds. The seeds are a nutritionally dense food, rich in protein and fat that help protect against heart diseases, vitamins, minerals and antioxidants (Ciftci and Suna, 2022; Yu, 2025). As with other legumes, the plant adds nitrogen to the soil by means of nitrogen-fixing bacteria and is thus particularly valuable as a soil-enriching crop.

Since wheat, which is highly consumed by Nigerians, is a temperate crop and does not thrive well in Nigerian tropical climate, efforts should be diverted towards sorghum as an alternative in some wheat-based products like cookies with enrichment with peanuut.

Objectives of the study

The general objective of this study was to evaluate the nutrient composition and sensory properties of cookies produced with different ratios of sorghum flour and groundnut paste with the control made with 100 percent wheat flour. Specifically, the study determined:

- proximate composition of the cookies and compared it with that of control (100% wheat flour).
- mineral composition (magnesium, potassium, manganese and iron) of the cookies and compared it with that of control.
- sensory properties of the cookies and compared it with that of the control.

Materials and Method

***Design of the Study*:** This study is an experimental design.

Procurement of Materials: The materials used for this project include sorghum, groundnut, xanthan gum, sugar, salt, margarine, baking powder, eggs, milk flavor and vanilla flavor. The equipment used includes a baking oven, measuring cups and spoons, baking tray, bowl, rolling pin and cookies cutter. White sorghum, groundnut and other materials were purchased from Aguda Market, Lagos State.

Preparation of materials: The following materials were prepared:

Sorghum Flour: This produced using the method of Goubgou *et al.*,2021. A known quantity (2kg) of sorghum grains were manually sorted to remove foreign materials and damaged seeds. The grains were then thoroughly cleaned and dried to reduce moisture content. The grains were milled using a commercial milling machine and sieved with a 0.5 mm sieve to obtain fine sorghum flour.

Groundnut (Peanut): This was produced using the method of Abdulrahman *et al.,* 2014. The Groundnut was first carefully sorted to remove any impurities. The groundnut was roasted using salt for 10 minutes and removed from the flame after 10 minutes of roasting. It was then sieved to remove the salt or any dirt from the groundnut and was cooled and was peeled. It was then blended and grounded into paste form using a grinder.

Formulation of samples

The samples were formulated thus:
Sample A (Control): 100% Wheat flour
Sample B: 90% Sorghum flour: 10% Groundnut paste
Sample C: 80% Sorghum flour: 20% Groundnut paste
Sample D: 70% Sorghum flour: 30% Groundnut paste
Sample E: 60% Sorghum flour: 40% Groundnut paste
Sample F: 50% Sorghum flour: 50% Groundnut paste

Preparation of Cookies

Recipe for cookies: The ingredients used for the cookies preparation were as follows (Audrey, 2015):

Ingredients	**Measurements**
Flour:	500g (wheat flour/ sorghum flour: groundnut paste blend)
Xanthan gum:	5g (not added to control)
Margarine:	13g
Baking powder:	3g
Sugar:	150g
Egg:	3
Milk flavor powder:	15g
Vanilla flavor powder:	10g
Salt:	1g

Procedure for cookies preparation
Cookies were prepared using the method of Audrey, 2015 with slight modification as follows:

- beat eggs, sugar, margarine, and vanilla flavor thoroughly into a creamy, smooth consistency.
- add dry ingredients (including sorghum flour, groundnut paste, xanthan gum, baking soda, and salt) and mix to obtain consistent dough.
- knead dough manually on a clean, smooth surface for about 3–5 minutes.
- roll out to a uniform thickness of approximately 4 mm and cut into desired shapes using a cookie cutter.
- place on a parchment-lined baking tray and bake in a preheated oven at 180°C for approximately 12–15 minutes or until golden brown.
- Allow cookies to cool for 10 minutes and package in clean polyethylene bags, sealed, and stored at room temperature for analysis.

Proximate analysis: This was carried out using the method of A.O.A.C., 2023. All analyses were carried out in triplicates:
Crude protein content was determined by the routine semi-micro Kjeldahl procedure. This consists of digestion, distillation and titration using Kjeldahl apparatus and reagents. Crude protein was calculated using appropriate formular.
Crude fat content was determined using Soxhlet apparatus. After 1g of dried sample was passed through the soxhlet apparatus, the fat content was calculated using appropriate formular.
Ash content was determined by weighing 2.0g of the sample into a porcelain crucible and transferred into a muffle furnace set at 550°C for 4 hours after which these were cooled and weighed. Ash content was calculated using appropriate formular.
Crude fiber was determined by placing 2g of the sample in a fiber flask, apparatus and reagents. Fiber content was calculated using appropriate formular
Carbohydrate was determined by difference of the moisture, protein, crude fat, ash and crude fiber from 100.
***Mineral Analysis*:** Minerals analyzed were: magnesium, potassium, manganese and iron. The ash (2g) of each sample was digested with 5ml of 2M HCL. This was heated to boil and filtered through a Whatman No.1 filter paper into a 100ml volumetric flask. The filterate was made up to mark with distilled water and the concentration reading was done at wavelength required for each mineral using Jenway Digital Flame Photometer (Model-PFP7)
***Sensory Evaluation*:** A total of 20 taste trained panelists from Department of Human Nutrition and Dietetics, Lead City University, Ibadan participated in the sensory evaluation.
A 9-point hedonic scale was used for data collection and the scale was as follows: 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. This was adapted from the method of Lawless and Heymann, 2013). Cookies were presented in identical containers coded to avoid bias. Each panelist was provided potable water for mouth rinsing between tastings. The sensory attributes evaluated by panelists included taste, aroma, color, texture, appearance, and overall acceptability.
***Statistical Analysis*:** All laboratory analyses including proximate composition, mineral content were carried

out in triplicates for each sample. Data analyzed were expressed as mean ± standard deviation. Results of proximate and mineral composition were compared using Analysis of Variance (ANOVA-Least Significant Difference) at $p<0.05$ while Duncan Multiple Range Test was used to compare mean data for the sensory evaluation scores ($p<0.05$).

Results

Table 1: Proximate Composition of the Cookies made from 100% Wheat Flour (Control) and Five Different Ratios of White Sorghum and Groundnut (%)

Samples	Moisture	Fat	Protein	Fiber	Ash	Carbohydrate
A	19.02±0.04	2.80±0.01	19.17±0.11	0.35±0.01	0.79±0.02	58.22±0.14
B(90:10)	12.61*±0.33	6.33**±0.17	21.77**±0.31	1.12**±0.08	1.76**±0.09	56.41*±0.39
C(80:20)	14.58*±0.45	8.09**±0.03	35.36**±0.28	1.01**±0.07	1.52**±0.08	39.44*±0.26
D(70:30)	13.65*±0.32	12.30**±0.17	35.90**±0.25	1.19**±0.04	1.69**±0.24	35.27*±0.23
E(60:40)	8.80*±0.51	17.36**±0.19	36.35**±0.44	0.92**±0.06	1.74**±0.06	34.83*±0.28
F(50:50)	7.26*±0.25	21.00**±0.21	38.00**±0.26	0.92**±0.05	1.76**±0.09	31.06*±0.17

** = Mean data significantly lower than the control (p<0.05); ** = Mean data significantly higher than the control (p<0.05); A=100% wheat (control); B (SF: GP-90:10); C(80:20); D(70:30); E(60:40); F(50:50)*

Table 1 shows proximate composition of the cookies. The moisture content of the cookies ranged from 7.26% in Sample F (50% sorghum flour, 50% groundnut paste) to 19.02% in Sample A (100% wheat flour). All the trial samples were significantly higher than the control in fat, protein, crude fiber and ashes.

Table 2: Mineral Composition of the Cookies made from 100% Wheat Flour (Control) and Five Different Ratios of White Sorghum and Groundnut (mg/g)

Samples	Magnesium	Potassium	Manganese	Iron
A (100% wheat)	0.78±0.02	2.94±0.14	0.042±0.014	0.271±0.024
B(90:10)	0.83**±0.02	2.85*±0.02	0.023*±0.003	0.040*±0.012
C(80:20)	1.43**±0.01	2.97±0.02	0.024*±0.005	0.061*±0.009
D(70:30)	1.52**±0.01	3.56**±0.06	0.029*±0.008	0.074*±0.012
E(60:40)	1.53**±0.01	7.08**±0.05	0.198**±0.004	1.068**±0.015
F(50:50)	2.15**±0.02	11.94**±0.09	1.082**±0.028	1.073**±0.043

** = Mean data significantly lower than the control (p<0.05); ** = Mean data significantly higher than the control (p<0.05); A=100% wheat (control); B (SF: GP-90:10); C(80:20); D(70:30); E(60:40); F(50:50)*

Table 2 shows the mineral content of the formulated samples. All the trial samples were significantly higher than the control in magnesium content. Samples D, E and F were significantly higher than the control in potassium while samples E and F were significantly higher than the control in manganese and iron ($p<0.05$).

Table 3: Sensory Properties of Cookies made from 100% Wheat Flour (Control) and Five Different Ratios of White Sorghum and Groundnut

Sample	Color	Taste	Texture	Aroma	Appearance	Overall Acceptability
A	$6.90^{a}\pm0.79$	$7.35^{a}\pm1.23$	$6.20^{a}\pm1.58$	$7.85^{a}\pm1.04$	$6.95^{a}\pm1.05$	$7.50^{a}\pm1.10$
B(90:10)	$6.25^{a}\pm1.12$	$5.25^{c}\pm1.71$	$5.40^{b}\pm1.54$	$6.15^{b}\pm1.31$	$6.30^{a}\pm0.87$	$5.75^{c}\pm1.62$
C(80:20)	$6.00^{a}\pm1.17$	$5.10^{c}\pm1.80$	$5.45^{b}\pm1.47$	$5.95^{c}\pm1.57$	$6.00^{a}\pm1.26$	$5.55^{c}\pm1.96$
D(70:30)	$5.20^{b}\pm1.99$	$5.55^{c}\pm1.99$	$5.95^{b}\pm1.64$	$5.25^{c}\pm1.68$	$5.05^{c}\pm2.04$	$5.30^{d}\pm2.23$
E(60:40)	$6.00^{a}\pm1.21$	$5.80^{c}\pm1.67$	$6.20^{a}\pm1.28$	$6.05^{b}\pm1.00$	$5.50^{b}\pm1.32$	$5.70^{c}\pm1.66$
F(50:50)	$6.20^{a}\pm1.77$	$6.15^{b}\pm1.81$	$6.45^{a}\pm1.64$	$6.30^{b}\pm1.92$	$6.25^{a}\pm1.86$	$6.60^{b}\pm1.64$

Means with the different superscript along the same column are significantly different (p<0.05).
A=100% wheat (control); B (SF: GP-90:10); C (80:20); D(70:30); E(60:40); F(50:50)

Table 3 shows the sensory scores of the formulated samples. There was a significant difference (p<0.05) in most sensory attributes across the samples, indicating that the formulation influenced panelists' perceptions in terms of color, taste, texture, aroma, appearance, and overall acceptability. The control was the most acceptable sample because it had the highest scores which fell in likeness range (6 to 9) while Sample F was most liked among the trial samples. There is need to improve upon the sensory properties of the trial samples.

Discussion of findings

The compositional and sensory evaluation of cookies formulated from varying proportions of sorghum flour and groundnut paste revealed notable nutritional enhancements and consumer preferences. Sample A, made entirely of wheat flour, served as the control, while Samples B to F replaced wheat with sorghum and groundnut paste in ascending ratios. The results indicated that incorporating groundnut paste significantly influenced the proximate composition, mineral content, and sensory appeal of the cookies. This corroborated the report of Osuji *et al.*, 2022 who observed the influence of peanuts on the nutrient composition and sensory properties of cookies produced from wheat, cocoyam cashew and groundnut.

The proximate analysis (Table 1) demonstrated significant improvements in the nutritional profile of the formulated samples compared to the control. Moisture content decreased progressively from 19.02% in Sample A to 7.26% in Sample F, which is beneficial for shelf stability. The reduction aligns with findings of Ajayi *et al.,* 2012, who noted that oilseeds like groundnuts lower moisture in baked goods due to their high fat content.

Fat content increased substantially, ranging from 2.80% in the control to 21.00% in Sample F, confirming the lipid-rich nature of groundnuts. This trend supports the results of Adebayo *et al.,* 2016 and Ayo *et al.*, 2025, who observed elevated fat levels in groundnut-enriched formulations. Protein content also improved significantly, with Sample F containing 38.00%, double that of the control (19.17%). This agrees with Onwuka and Nnam, 2002 and Ijarotimi, 2022 who reported that legumes, especially groundnuts, enhance the protein density of cereal-based foods, making them nutritionally superior.

Crude fiber and ash contents increased across all formulated samples, with Sample D recording the highest fiber (1.19%) and Samples B & F the highest ash content (1.76%), indicating improved dietary fiber and mineral retention. These results are in line with the report of Onwuka and Anam, 2002 and Ijarotimi, 2022 who observed an enhancement of the fibre and ash contents of cereal-legume based food products. This enhancement is desirable and important since fiber and ash are necessary in maintaining digestive and metabolic health (Bulsiewicz, 2023; Razzaque and Wimalawansa, 2025). Conversely, carbohydrate content decreased, with Sample F showing the lowest (31.06%) due to higher fat and protein proportions replacing carbohydrates, which is consistent with energy-dense food formulation principles as reported by Okoye *et al*.,2010.

As shown in Table 2, the mineral content of the cookies was notably enhanced by groundnut inclusion. Magnesium content increased from 0.78 mg/100g in Sample A to 2.15 mg/100g in Sample F, affirming the mineral-rich nature of legumes. Manganese and iron contents followed the same trend, with Sample F showing the highest values (1.082 and 1.073 mg/100g respectively). These enhancements corroborate the report of Ayo *et al*., 2025 who documented the ability of groundnuts to boost micronutrient levels in composite blends with cereals.

Interestingly, potassium values increased modestly, with Samples D,E, F significantly higher than the control (2.94 mg/100g), aligning with findings of Fasoyiro *et al.,* 2010 on the potassium density of groundnut-based products. The statistical significance across most mineral parameters ($p<0.05$) affirms that replacing wheat with sorghum and groundnut paste significantly improved the micronutrient quality of the cookies.

The sensory evaluation (Table 3) reflected a nuanced but promising consumer response. Sample A received the highest scores for aroma (7.85), taste (7.35), and appearance (6.95), possibly due to the familiar sensory characteristics of wheat-based cookies. Sample F, despite being entirely wheat-free, was most acceptable in sensory parameters among the trial samples with the scores ranging from 6.15 to 6.60 which depicted likeness. This was similar to the report of Osuji et al., 2022 who observed sensory score range of 6.10 to 7.60 in cookies produced with cocoyam, cashew and groundnut.

Sample D, though nutritionally enhanced, had the lowest acceptability (5.30), likely due to imbalances in flavor or mouth feel at intermediate groundnut concentrations. These results are in agreement with the report of Adeyeye and Omolayo, 2014, who observed that product acceptability peaks at specific blend ratios and drops when sensory components are overwhelmed.

The current study supports earlier works by Akubor, 2004 and Abdel-Aal (2024), who found that combining cereals with legumes improves both nutrition and functionality of baked goods. The high protein and fat content, paired with improved mineral composition, presents the formulated cookies—particularly Sample F—as potential alternatives to conventional wheat cookies, and will be useful in regions prone to protein-energy malnutrition.

Furthermore, the study aligns with trends identified by Sridhar *et al*., 2023 on consumer preference for nutrient-dense, plant-based baked products. Despite minor sensory drawbacks in some blends, overall acceptability remained within favorable limits, underscoring the feasibility of these cookies for mainstream consumption, especially in functional food markets.

Conclusion

Production of cookies with sorghum and groundnut is possible, workable and applicable and it enhanced the proximate and mineral composition of the snack. The samples produced with sorghum and groundnut contained higher composition of fat, protein, crude fibre and ash, magnesium and iron compared with the control while cookies samples produced with 60% sorghum flour/40% groundnut paste (Sample E) and that produced with 50% sorghum flour/50% groundnut paste (Sample F) were more enriched than the control in manganese and iron. Also the sensory properties of the trial samples were liked but the sample F was most acceptable in sensory properties evaluated but there is need to improve on the products for better consumer acceptability.

Recommendations

Based on the findings of this study the following recommendations were made:

1. Household and commercial use of white sorghum and groundnut in cookies production and consumption should be encouraged.
2. The higher nutritional value of the cookies produced with sorghum and ground makes it applicable in combating under nutrition.
3. White sorghum is recommended for use as a wheat replacement in the production of cookies.

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