

Proximate Composition of Biscuits and Cakes Produced from Wheat-Sorghum Composite Flour Blends Enriched with Sunflower Seeds

Onuabuchi, I. C.¹; Angelo Moses²; Anyika-Elekeh, J. U.³; Happiness C. Ezenwa³; and David-Chukwu N. P.¹

¹Department of Hospitality Management Technology, Ogbonnaya Onu Polytechnic, Aba, Abia State, Nigeria. ²Department of Nutrition and Dietetics, Federal Polytechnic, Mubi, Adamawa State, Nigeria.

³Department of Human Nutrition and Dietetics, Michael Okpara University of Agriculture, Umudike, Nigeria.

Corresponding author: ezehifeomacynthia@gmail.com

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Abstract

This study evaluated the proximate composition of biscuits and cakes produced from wheat-sorghum composite flour blends enriched with sunflower seeds, with the aim of addressing protein-energy malnutrition (PEM) in developing countries. Due to rising food costs and widespread consumption of nutritionally poor snacks, this research focused on creating affordable, protein-rich alternatives. Wheat, sorghum, and sunflower seeds were cleaned, dried at 60°C for six hours for wheat and sorghum and eight hours for sunflower seeds in an oven, and milled using a hammer mill (F-23ZS England) into flour. The fine flour was obtained using a sieve and then blended in varying ratios (70:20:10; 60:20:20; 50:20:30; 70:10:20; 60:30:10; 50:30:20; and 100% wheat). Cakes and biscuits were produced using 250g and 350g of the composite blends, respectively. Proximate compositions of the samples were determined in triplicate using AOAC standard methods. Statistical analysis was performed using analysis of variance (ANOVA), and means were separated using the least significant difference (LSD) at a 0.05 significance level. Results showed significant variation in the nutritive value of the samples. Among cake samples, CWSF1 had the highest protein (10.45%) and ash (3.04%) content. Biscuit samples also varied in nutrient content, with BWSF2, BWSF4, and BWSF5 showing statistically similar protein levels. Overall, the incorporation of sunflower seed flour significantly enhanced the protein and fibre contents of both cake and biscuit samples, demonstrating the potential of these enriched snacks in combating PEM.

Keywords: Protein-Energy Malnutrition, Proximate Composition, Sensory Evaluation, Wheat-Sorghum Composite Flour, Sunflower Seed-Enriched Baked Goods, Food Security.

Introduction

Protein-energy malnutrition (PEM) is a major public health problem in developing countries, especially Nigeria (Zubairu *et al.*, 2022). This public health problem is more complicated due to the high cost of living, low production and preservation of agricultural produce, and economic recession resulting from food insecurity. The effect leads more of the populace to depend on junk foods and snacks. The increased rate of confectioneries

(especially cookies) in Nigeria has been reported as a remote cause of growing urbanization, working mothers, and prolonged school period stays (Onyechi and Afieroho, 2017; Amadi, 2019). A snack is a portion of processed food taken or eaten between meals (Blondin *et al.*, 2021).

Bakery items, particularly biscuits and cakes, are widely favoured due to their diverse flavours, convenience, affordability, and extended shelf life. There is a growing focus on enhancing the nutritional quality of these products.

The development of nutrient-enriched bakery products is gaining momentum as consumer awareness of health and nutrition continues to increase. Composite flours combining cereals and nutrient-rich seeds present a viable strategy to enhance the nutritional quality of traditional baked products. Wheat-sorghum blends have emerged as promising alternatives to 100% wheat flour, especially in regions with limited wheat production. Sorghum is a gluten-free cereal rich in dietary fibre, polyphenols, and micronutrients, and its incorporation into baked goods improves nutritional value while supporting food security and agricultural sustainability (More *et al.*, 2024).

Despite these advantages, wheat-sorghum blends may negatively impact the sensory characteristics of baked products, such as texture, taste, and mouthfeel (Akinbode *et al.*, 2023). To counterbalance this, sunflower seed enrichment offers a valuable solution. Sunflower seeds are high in quality protein, essential fatty acids, vitamin E, and minerals like magnesium and selenium (Grasso *et al.*, 2020). Previous studies have demonstrated that the incorporation of sunflower seed flour into composite blends can significantly improve the protein content and antioxidant potential of baked goods without compromising sensory appeal (Grasso *et al.*, 2019).

The Food and Agricultural Organization (FAO) reported that the application of composite flour in various food products would be economically advantageous, as the imports of wheat could be reduced or even eliminated. That demand for biscuits, cake, and other pastry products could be met by the use of domestically grown products instead of wheat (Manisha and Sindhu, 2021).

However, limited research exists on the combined effects of sunflower seed enrichment on wheat-sorghum composite flours in both biscuits and cakes—two widely consumed baked products. A comprehensive evaluation of their nutritional profile is essential to determine the feasibility of producing healthier, consumer-acceptable baked goods using local, underutilized crops and oilseeds.

Materials and Methods

Sample purchasing

Wheat and sorghum were bought from the Cemetery (Eziukwu) market, Aba Abia State, while sunflower seeds were bought from the Kano market in northern Nigeria. The white variety of sorghum grain and dwarf wheat grain were chosen, and the high sun 33 variety of sunflower seeds was chosen.

Sample preparation

The method as described by Dziki (2023) was adopted to produce wheat flour. The wheat grain was cleaned, stones and other foreign materials removed and the cleaned sample was washed and dried at 60°C for six hours in an oven and milled using a Hammer mill (F-23ZS England) into flour. Wheat fine flour was obtained using a sieve of 800 microns and packaged in an airtight nylon for further use.

The method as described by Palavecino et al. (2016) was adopted to produce sorghum flour. Pebbles and other extraneous particles were handpicked. A flat metal tray was used to winnow out sand and dust. The cleaned sample was washed and dried at 60°C for six hours in an oven. The dried sorghum was milled using a Hammer mill (F-23ZS England) sieved using a sieve of 800 microns to obtain fine flour powder and packaged in airtight nylon for further use.

The method as described by (Tamilselvan and Kushwaha, 2020) was adopted to produce sunflower seed flour. Sunflower seeds were cleaned, and other foreign materials were sorted; the cleaned sample was washed and dried at 60°C for six hours in an oven. The sample was then milled using a Hammer mill (F-23ZS England) until the seeds were finely broken; ground sunflower seeds flour was arranged in trays and dried in an electric air-drying oven, using the temperature of 60°C for 8 hours to enable sunflower flour to pass through a tiny open sieve of 800 microns to obtain fine flour and packaged in an airtight nylon for further use.

Flour blends/formulations (%)

Sunflower seed, wheat and sorghum flour were made into six blends/formulations of different ratios as shown in Table 3.1. The sample with 100% wheat flour served as the control.

Recipe and method used for the cake

Composite flour 250g ($1\frac{1}{4}$ cups); Egg 3eggs; Sugar 120g ($\frac{1}{2}$ cup); Margarine 100g; Baking powder 1teaspoon; Milk (Powdered) 60g ($\frac{1}{4}$ cup); Nutmeg 1teaspoon; Cinnamon $\frac{1}{4}$ teaspoon; Mixed flavour 5mls. Cake production followed the method described by Conforti (2014), with some modifications. Sugar and margarine were creamed until fluffy. The eggs and mixed flavour were added and creamed further for 6-10 minutes. The composite flour was combined with baking powder, and all the dry ingredients (milk, cinnamon, and nutmeg) were sifted and poured into the sugar and margarine mixture. The flour was folded into the mixture, scooped into greased baking tins, and baked in the oven at 150-200°C. Until a toothpick inserted in the centre comes out clean. It was allowed to cool for 15 minutes, turned into a plate, and packaged in a transparent container. Then, a sensory evaluation was carried out on the baked cake. Seven cake samples, including a control sample, were produced.

Recipe and method used for the biscuit

The blends formulated were baked using the straight dough method of Alhassan *et al.*, (2019) modified. Seven biscuits were prepared using flour blends and 100% wheat flour, which served as a control in the experiment, All the biscuit samples were prepared using the same recipe Composite flour 350g ($2\frac{3}{4}$ cups); Egg 3eggs; Sugar 100g ($\frac{1}{2}$ cup); Margarine 200g; Baking powder 5g (1 teaspoon); Powdered Milk 60g ($\frac{1}{4}$ cup); Cinnamon 1teaspoon; Nutmeg 1teaspoon; Salt 1teaspoon; Mixed flavour 5mls. The mixture was then kneaded until it developed into dough. After mixing, the dough was moulded and laminated into sheets. It was cut into various shapes and sizes using a homemade cutter. The moulded biscuits were placed on a baking tray and baked in a gas oven for 45 minutes at a temperature of 250°C. After baking, the biscuits were cooled at room temperature (20°C) and packed. The biscuit was prepared at the food laboratory, Human Nutrition and Dietetics Department, Michael Okpara University of Agriculture, Umudike, Abia State.

Chemical analysis

Proximate analysis was conducted on the cakes and biscuits to determine the moisture, protein, ash, fat, crude fibre and carbohydrate content. Onwuka, 2018 method was used for chemical analysis. The hot air oven was used to determine the moisture content; protein was determined by the micro Kjeldahl method; fat by the soxhlet extraction method; ash by drying method; crude fibre by acid hydrolysis. Carbohydrate was determined by difference.

Sensory evaluation of the cake and biscuit samples was conducted using 35 semi-trained panellists from among students and staff at Michael Okpara University of Agriculture, Umudike, Abia State. The criteria for approvals for recruitment were that they were willing to participate in the test. Panellists were asked to evaluate the seven randomly coded samples of cake and biscuits on a 9-point hedonic scale for appearance, aroma, taste, and texture.

Statistical analysis

All nutrients were determined in triplicates using the standard method. Data from the study were statistically analysed using analysis of variance (ANOVA) SPSS version 22 software. Statistical significance between mean values was set at a 95% confidence interval. The difference between mean values was determined by the least significant difference (LSD) test. Significance was accepted at $p < 0.05$.

Results

Proximate content of biscuits sample

Table 2 shows the proximate composition of the biscuit samples. The moisture content of the biscuit sample produced was low, ranging from 1.30-0.20%. BWSFo (control) recorded the least moisture value (0.20%) while BWSF6 recorded the highest value of moisture content (1.30%). This difference was statistically significant ($p < 0.05$).

). The crude protein value shows no significant difference ($p>0.05$) between the control sample BWSFo (7.96%) and samples BWSF₂ (8.21%), BWSF₄ (8.30%) and BWSF₅ (7.97%). However, BWSF₆ recorded the least protein content (6.60%) which was significantly different from the others ($p<0.05$). The ash content varied significantly ($p<0.05$), ranging from (3.91-2.08%). Control BWSFo recorded the highest ash content (3.91%), while BWSF₆ recorded the lowest (2.08%). The fibre content ranged from (3.47-0.06%), with BWSF₃ recording the highest (3.47%) and the control the lowest (0.06%). There was no significant difference ($p>0.05$) between BWSF₂ and BWSF₄. Fat content ranged (33.05-26.12%). BWSF₆ had the highest value (33.05%) while BWSF₁ and control BWSFo had the least and no significant difference ($p>0.05$). Carbohydrate values ranged from (61.59-54.47%). Control BWSFo recorded the highest (61.59%), while BWSF₆ recorded the lowest (54.47%), with a significant difference ($p<0.05$).

Proximate content of cake samples

Table 3 shows the proximate composition of the cake samples. There were significant differences ($p<0.05$) in all the samples for moisture content, which ranged (from 24.36-13.51%), control CWSFo had the highest value (24.36%) while CWSF₁ had the least (13.51%). Ash content ranged from (3.04-2.29%), CWSF₁ had the highest (3.04%), while CWSF₄ had the lowest (2.29%). However, no significant difference ($p>0.05$) was found between CWSF₄ (2.29%) and control CWSFo (2.37%). Fibre content ranged from (2.74-0.08%) with CWSF₂ recording the highest (2.74%) and control CWSFo the lowest value (0.08%), showing significant differences ($p<0.05$) across samples. The fat content ranged from (33.47-25.85%), where CWSF₆ had the highest (33.47%) and CWSF₁ the least (25.85%), showing significant differences ($p<0.05$). The protein content ranged from (10.45-6.43%). CWSF₁ recorded the highest value (10.45%) and the control the lowest (6.43%). No significant differences ($p>0.05$) were found between CWSF₂ and CWSF₃. Carbohydrate content ranged from (45.14-36.27%). CWSF₁ had the highest value (45.14%) while CWSF₃ and CWSF₆ had the lowest values, with no significant differences ($p>0.05$) between them.

Table 1 Flour blends/formulations ratio (%)

Samples	Wheat flour(%)	Sorghum flour(%)	Sunflower seed flour(%)	Total (%)
Control (BWSFo/CWSFo)	100	0	0	100
BWSF ₁ /CWSF ₁	70	20	10	100
BWSF ₂ /CWSF ₂	60	20	20	100
BWSF ₃ /CWSF ₃	50	20	30	100
BWSF ₄ /CWSF ₄	70	10	20	100
BWSF ₅ /CWSF ₅	60	30	10	100
BWSF ₆ /CWSF ₆	50	30	20	100

Note: BWSF: Biscuit wheat-sorghum-sunflower; CWSF: Cake wheat-sorghum-sunflower seed flour

Table 2 Proximate composition of the biscuit samples

Samples	Moisture (%)	Ash (%)	Fiber (%)	Fat (%)	Protein (%)	Carbohydrate (%)
BWSFo	0.20 ^f ±0.04	3.91 ^a ±0.02	0.06 ^f ±0.00	26.30 ^f ±0.08	7.96 ^a ±0.36	61.59 ^a ±0.30
BWSF1	0.89 ^b ±0.05	3.60 ^b ±0.14	1.13 ^d ±0.02	26.12 ^f ±0.16	7.31 ^b ±0.19	60.97 ^b ±0.04
BWSF2	0.57 ^d ±0.04	3.02 ^d ±0.06	2.25 ^c ±0.03	26.83 ^e ±0.08	8.25 ^a ±0.00	59.08 ^c ±0.04
BWSF3	0.37 ^e ±0.03	3.27 ^c ±0.01	3.47 ^a ±0.04	29.35 ^c ±0.12	7.79 ^{ab} ±0.19	55.76 ^f ±0.13
BWSF4	0.75 ^c ±0.04	2.24 ^f ±0.06	2.21 ^c ±0.01	28.13 ^d ±0.37	8.30 ^a ±0.40	58.44 ^d ±0.05
BWSF5	0.54 ^d ±0.00	2.76 ^e ±0.11	0.98 ^e ±0.01	30.44 ^b ±0.23	7.97 ^a ±0.00	57.33 ^e ±0.13
BWSF6	1.30 ^a ±0.05	2.08 ^f ±0.06	2.51 ^b ±0.01	33.05 ^a ±0.03	6.60 ^c ±0.00	54.47 ^g ±0.00

Note: Values are means ± standard deviations of duplicate samples. ^{a-g} Means with the same superscripts across the rows are not significantly different (P>0.05). ^{a-g} Means with different superscripts across the rows are significantly different (P<0.05).

Key:

BWSFo:(100% Wheat, 0%Sorghum and 0% Sunflower)

BWSF1:(70%Wheat, 20%Sorghum and 10%Sunflower)

BWSF2:(60%Wheat, 20%Sorghum and 20%Sunflower)

BWSF3:(50%Wheat, 20%Sorghum and 30%Sunflower)

BWSF4:(70%Wheat, 10%Sorghum and 20%Sunflower)

BWSF5:(60%Wheat, 30%Sorghum and 10%Sunflower)

BWSF6:(50%Wheat, 30%Sorghum and 20%Sunflower)

Table 3 Proximate composition of the cake samples

Samples	Moisture (%)	Ash (%)	Fiber (%)	Fat (%)	Protein (%)	Carbohydrate (%)
CWSFo	24.36 ^a ±0.25	2.37 ^e ±0.08	0.08 ^e ±0.01	26.72 ^d ±0.10	6.43 ^f ±0.19	40.06 ^c ±0.08
CWSF1	13.51 ^g ±0.34	3.04 ^a ±0.03	2.02 ^b ±0.03	25.85 ^e ±0.11	10.45 ^a ±0.00	45.14 ^a ±0.18
CWSF2	18.37 ^d ±0.09	2.73 ^c ±0.04	2.74 ^a ±0.02	29.50 ^c ±0.05	7.68 ^d ±0.20	39.00 ^d ±0.22
CWSF3	21.61 ^b ±0.33	2.56 ^d ±0.04	2.04 ^b ±0.03	30.05 ^c ±0.06	7.40 ^d ±0.38	36.34 ^e ±0.13
CWSF4	20.61 ^c ±0.32	2.29 ^e ±0.02	1.38 ^c ±0.03	26.96 ^d ±0.25	9.42 ^b ±0.37	39.36 ^d ±0.45
CWSF5	15.69 ^f ±0.39	2.95 ^b ±0.06	0.76 ^d ±0.01	31.45 ^b ±0.53	6.90 ^e ±0.19	42.26 ^b ±0.01
CWSF6	17.49 ^e ±0.06	2.84 ^b ±0.17	1.44 ^c ±0.04	33.47 ^a ±0.33	8.50 ^c ±0.20	36.27 ^e ±0.20

Note: Values are means ± standard deviations of duplicate samples. ^{a-g} Means with the same superscripts across the rows are not significantly different (P>0.05). ^{a-g} Means with different superscripts across the rows are significantly different (P<0.05).

Key:

CWSFo:(100% Wheat, 0%Sorghum and 0% Sunflower)

CWSF1:(70%Wheat, 20%Sorghum and 10%Sunflower)

CWSF2:(60%Wheat, 20Sorghum and 20%Sunflower)

CWSF3:(50%Wheat, 20%Sorghum and 30%Sunflower)

CWSF4:(70%Wheat, 10%Sorghum and 20%Sunflower)

CWSF5:(60%Wheat, 30%Sorghum and 10%Sunflower)

CWSF6:(50%Wheat, 30%Sorghum and 20%Sunflower)

Table 4 Sensory characteristics of the biscuit samples

Samples	Appearance	Aroma	Taste	Texture	General Acceptability
BWSFo	8.03 ^a ±1.10	7.85 ^a ±1.19	7.93 ^a ±1.12	8.00 ^a ±1.04	7.95 ^a ±0.99
BWSF1	5.63 ^b ±1.75	6.20 ^b ±1.38	6.25 ^b ±1.48	6.13 ^b ±1.59	6.05 ^b ±1.15
BWSF2	3.95 ^d ±1.57	4.55 ^c ±1.50	4.33 ^d ±1.76	4.63 ^d ±1.76	4.36 ^d ±1.37
BWSF3	4.20 ^d ±1.67	4.75 ^c ±1.69	4.88 ^c ±1.54	5.38 ^b ±1.72	4.80 ^d ±1.25
BWSF4	4.55 ^c ±1.65	5.25 ^c ±1.43	5.58 ^b ±1.28	5.48 ^b ±1.54	5.21 ^c ±1.12
BWSF5	5.13 ^b ±2.27	4.70 ^c ±2.14	5.03 ^c ±2.21	5.45 ^b ±2.19	5.08 ^c ±1.95
BWSF6	3.83 ^d ±1.63	3.63 ^d ±2.01	3.85 ^e ±2.23	5.05 ^c ±1.87	4.09 ^e ±1.66

Note: Values are means ± standard deviations of thirty-five (35) panellists. ^{A-d} Means with the same superscripts across the rows are not significantly different (P>0.05). ^{A-d} Means with different superscripts across the rows are significantly different (P<0.05).

Key:

BWSFo:(100% Wheat, 0%Sorghum and 0% Sunflower)

BWSF1:(70%Wheat, 20%Sorghum and 10%Sunflower)

BWSF2:(60%Wheat, 20%Sorghum and 20%Sunflower)

BWSF3:(50%Wheat, 20%Sorghum and 30%Sunflower)

BWSF4:(70%Wheat, 10%Sorghum and 20%Sunflower)

BWSF5:(60%Wheat, 30%Sorghum and 10%Sunflower)

BWSF6:(50%Wheat, 30%Sorghum and 20%Sunflower)

Table 5 Sensory characteristics of the cake samples

Samples	Appearance	Aroma	Taste	Texture	General Acceptability
CWSFo	5.88 ^{bc} ±1.70	6.15 ^{bc} ±1.78	6.60 ^b ±1.61	6.25 ^{ab} ±1.56	6.22 ^b ±1.44
CWSF1	4.63 ^d ±1.90	5.55 ^c ±1.83	6.20 ^b ±1.57	5.78 ^b ±1.62	5.54 ^c ±1.39
CWSF2	5.13 ^c ±2.34	6.45 ^{bc} ±1.80	6.90 ^b ±1.61	6.38 ^{ab} ±2.08	6.21 ^b ±1.51
CWSF3	5.25 ^{bc} ±1.90	6.08 ^{bc} ±1.68	6.45 ^b ±1.89	5.95 ^b ±1.40	5.93 ^c ±1.39
CWSF4	6.30 ^b ±1.80	5.93 ^{bc} ±1.67	5.95 ^c ±1.54	6.45 ^{ab} ±1.36	6.16 ^b ±1.40
CWSF5	5.90 ^{bc} ±1.96	6.58 ^b ±1.69	6.50 ^b ±1.69	6.23 ^{ab} ±1.58	6.30 ^b ±1.53
CWSF6	7.28 ^a ±1.20	7.25 ^a ±1.24	7.15 ^a ±1.44	6.88 ^a ±1.68	7.14 ^a ±1.07

Note: Values are means ± standard deviations of thirty-five (35) panelists. ^{a-d} Means with the same superscripts across the rows are not significantly different (P>0.05). ^{a-d} Means with different superscripts across the rows are significantly different (P<0.05).

Key:

CWSFo:(100% Wheat, 0%Sorghum and 0% Sunflower)

CWSF1:(70%Wheat, 20%Sorghum and 10%Sunflower)

CWSF2:(60%Wheat, 20%Sorghum and 20%Sunflower)

CWSF₃: (50%Wheat, 20%Sorghum and 30%Sunflower)

CWSF₄: (70%Wheat, 10%Sorghum and 20%Sunflower)

CWSF₅: (60%Wheat, 30%Sorghum and 10%Sunflower)

CWSF₆: (50%Wheat, 30%Sorghum and 20%Sunflower)

Discussion

The moisture values obtained in this study were lower compared to Raihan and Saini (2017) who reported slightly higher findings (2.09-3.91%) for the moisture of multigrain cookies and wheat cookies, also Bhole *et al.* (2017) reported higher moisture values ranging from 3.00% to 4.60% for biscuits produced from composite flour of wheat, maize and sesame seed. Azeez *et al.* (2021) also reported higher moisture content ranging from 5.25% to 6.17% for cookies produced from the blends of sorghum, unripe plantain and watermelon seed flours. The low moisture content observed in this study implies better shelf stability and longer storage time, as the high moisture content in food above 10% has been attributed to microbial growth and spoilage of food (Barber and Obinna-Echem, 2016).

The ash content of the biscuits was significantly different, ranging from 2.08% in the (50:30:20 wheat: sorghum: sunflower biscuit) to 3.91% in the Control (100% wheat biscuit). This implies that the control (wheat biscuit) recorded the highest ash content, which was contrary to the reports of Raihan and Saini (2017), who reported that the wheat cookies (0.94%) recorded the lowest ash content of all the cookies produced, but was consistent with the reports of Azeez *et al.* (2021), who also recorded the highest ash content (5.25%) in the 100% wheat cookies. However, the figures obtained in this study were comparable with the range of 1.76 to 2.53% reported by Bhole *et al.* (2017) for wheat, maize and sesame seed biscuits. Some of these minerals that make up the ash content of food have been implicated in the metabolism of other organic compounds such as fat and carbohydrates (Peter-Ikechukwu *et al.*, 2020).

The fibre content of the samples was significantly different and ranged from 0.06% in the Control (100% wheat biscuit) to 3.47% in (50:20:30 Wheat: Sorghum: Sunflower biscuit). These findings indicated that the incorporation of wheat, sorghum and sunflower seed flour in biscuit production resulted in higher fibre content of the finished product. The figures observed in the present study were comparable with the fibre content range of 1.53% to 3.67% reported by Peter-Ikechukwu *et al.* (2020) for composite flour blends of wheat, toasted watermelon seed and date palm pulp but slightly lower than the fibre content range of 3.84% to 4.22% reported by Okoye and Obi (2017) for wheat- African yam bean composite cookies. However, the fibre content observed in the present study was significantly higher than the fibre range of 0.47% to 0.81% reported by Azeez *et al.* (2021) for cookies produced from the blends of sorghum, unripe plantain and watermelon seed flours. Crude fibre induces satiety and thus aids in weight management; it also adds bulk to the diet and aids in bowel movement and in lowering blood sugar levels by slowing down the absorption of glucose (Hamza *et al.*, 2014; Peter-Ikechukwu *et al.*, 2020).

The fat content of the samples was significantly different except for the Control (100% wheat biscuit) 26.30%, which was significantly the same as the (70:20:10 Wheat: Sorghum: Sunflower biscuit) 26.12%, with both recording the lowest fat content of all the samples while the 33.05% recorded by the (50:30:20 wheat: sorghum: sunflower biscuit) was significantly the highest. This is indicative of the contribution of both sorghum and sunflower seed flour incorporation to the fat content in the production of the biscuits; this was consistent with the findings of Azeez et al. (2021), however, the figures reported for fat in the present study were significantly higher than the ranges 15.07-15.33% reported by (Azeez et al., 2021), for cookies produced from the blends of sorghum, unripe plantain and watermelon seed flours and the range of 20.02-20.21% reported by Prakash *et al.* (2018) for wheat-defatted sesame cake biscuit.

There was no significant difference in the protein content of the Control (100% wheat biscuit) 7.96%, (60:20:20 wheat: sorghum: sunflower biscuit) 8.25%, (70:10:20 wheat: sorghum: sunflower biscuit) 8.30% and (60:30:10 wheat: sorghum: sunflower biscuit) 7.97%. In comparison, the (50:30:20 wheat: sorghum: sunflower biscuit) 6.60% recorded the lowest protein content of all the samples. The figures obtained in the present study were lower than the range of 9.87- 13.06% reported by Okoye and Obi (2017) for wheat-African yam bean composite cookies.

The carbohydrate content of the biscuits was significantly different and ranged from 54.57% in the (60:30:10 wheat: sorghum: sunflower biscuit) to 61.59% recorded in the Control (100% wheat biscuit).

The moisture content significantly differed, ranging from 13.51% in the (70:20:10 wheat: sorghum: sunflower cake) to 24.36% in the Control (100% wheat cake). This implies that wheat flour retained moisture more than the other composite flour mixtures; this was in agreement with the report of Annoh et al. (2022), who reported that the 100% wheat cake control recorded the highest moisture content (28.54%) of all their samples of rock cake. However, the range of moisture content observed in the present study was comparable with the figures 19.32% to 28.54%, reported for moisture content in cakes by (Annoh et al., 2022).

It is worthy of note that the mineral content in food is a function of its ash content, which is the inorganic residue left following either ignition or complete oxidation of organic materials in a food (Annoh et al., 2022). The present study revealed that the ash content of the cake samples ranged from 2.29% in the (70:10:20 wheat: sorghum: sunflower cake) to 3.04% in (70:20:10 wheat: sorghum: sunflower cake). This revealed a massive boost just by the increment in sorghum flour by 10% and the reduction in sunflower flour by 10%. The figures observed in the present study were comparable with the range of 1.30% to 2.49% ash content reported by Annoh et al. (2022) for wheatrock cake fortified with cassava and sesame seeds flour, but significantly higher than the 0.83% to 1.71% reported by Barakat (2021) for composite flour substituted with Baobab (*Adansonia digitata* L.) pulp flour in cake production. The ash content observed in the present study was slightly above 2%, which is the acceptable FSSAI standard.

The fibre content of the Control (100% wheat cake) 0.08% was significantly the lowest of all the cake samples, while the (60:20:20 wheat: sorghum: sunflower cake) 2.74% recorded the highest fibre content. This implied that a combination of the three seed flours in a specific ratio would improve fibre content, as evident in the present study. The figures observed in the present study were significantly lower than the range of 3.56% to 5.20% reported by Kolawole *et al.* (2013) for wheat moringa composite cake. However, there was an agreement between both studies on the Control (100% wheat cake) recording the lowest fibre content. This implied that the partial substitution of wheat flour with a composite improved the fibre content of the samples.

Fat content was significantly different ranging from 25.85% in the (70:20:10 wheat: sorghum: sunflower cake) to 33.47% in the (50:30:20 wheat: sorghum: sunflower cake). This study revealed a remarkable trend, which is a marked reduction in the fat content of the cake samples with an increase in wheat flour, as it was observed that the cake samples with lower fat content were those which contained a higher wheat ratio. This finding was contrary to the report of Palamthodi *et al.* (2020), who reported that wheat flour showed higher fat content than the ragi and jackfruit seed composite flours. This variation from the present study could be explained by the fact that sorghum and sunflower seeds are rich in oil seeds that have been exploited commercially (Azeez *et al.*, 2021). The figures observed in the present study for fat were significantly higher than the 4.00% to 5.95% reported by Kolawole *et al.* (2013) for wheat moringa composite cake and also those reported for maize-millet four blend (1.30-2.70%), soybean-wheat flour blends (6.21- 7.34%) and rice-wheat flour blends (3.54-5.93%) by Awuchi (2019), for different grain flour composites for industrial applications. This variation in the figures obtained in these studies may be attributed to the science that legumes, cereals, and tubers store energy as starch rather than lipids (Iwe *et al.*, 2016).

The protein content of the cake samples was significantly different, ranging from 6.43% in the control (100% wheat cake) to 10.45% in the (70:20:10 wheat: sorghum: sunflower cake). The figure observed in this study for protein was significantly lower than the range reported for maize-millet four blend (21.00-32.40%), soybean-wheat flour blends (16.32-28.34%) and rice-wheat flour blends (28.22-44.13%) by Awuchi (2019), for different grain flour composites for industrial applications, but was however, comparable with the range 7.21-11.20% by Kolawole *et al.* (2013), for wheat moringa composite cake and 7.8-13.95% reported by Palamthodi *et al.* (2020), for wheat, ragi and jackfruit seed composite flours.

The percentage carbohydrate content of the cake samples ranged from 36.27% in the (50:30:20 wheat: sorghum: sunflower cake) to 45.14% in the (70:20:10 wheat: sorghum: sunflower cake). The figure observed in this study for carbohydrates was significantly lower than the range reported for maize-millet four blends (52.30-65.01%), soybean-wheat flour blends (51.31-64.24%) but comparable with the rice-wheat flour blends (42.60-58.43%) by Awuchi (2019), for different grain flour composites for industrial applications.

Sensory characteristics of the biscuit samples. The result revealed that in terms of appearance of the samples, no significant difference existed in the score for appearance of

(60:20:20 wheat: sorghum: sunflower biscuit) 3.95%, (50:20:30 wheat: sorghum: sunflower biscuit) 4.20% and (50:30:20 wheat: sorghum: sunflower biscuit) 3.83%, with the Control (100% wheat biscuit) recording the highest score for appearance, while (60:20:20 wheat: sorghum: sunflower biscuit) recorded the least score for appearance.

There was no significant difference in the score for aroma between the (60:20:20 wheat: sorghum: sunflower biscuit) 4.55%, the (50:20:30 wheat: sorghum: sunflower biscuit) 4.75%, (70:10:20 wheat: sorghum: sunflower biscuit) 5.25%, and (60:30:10 wheat: sorghum: sunflower biscuit) 4.70%, however, the Control (100% wheat biscuit) 7.85% recorded the highest score for aroma while the (50:30:20 wheat: sorghum: sunflower biscuit) 3.63% recorded the lowest score for aroma.

The taste scores of the biscuit samples were significantly different ranging from 3.85% in the (50:30:20 wheat: sorghum: sunflower biscuit) to 7.93% in the Control (100% wheat biscuit). In terms of texture, there was no significant difference in the texture score of the (70:20:10 wheat: sorghum: sunflower biscuit) 6.13%, (50:20:30 wheat: sorghum: sunflower biscuit) 5.38%, (70:10:20 wheat: sorghum: sunflower biscuit) 5.48% and (60:30:10 wheat: sorghum: sunflower biscuit) 5.45%.

The general acceptability of the biscuit samples showed that the Control (100% wheat biscuit) scored the highest in terms of acceptability, as no significant difference existed in the acceptability score of the (60:20:20 wheat: sorghum: sunflower biscuit) 4.36% and (50:20:30 wheat: sorghum: sunflower biscuit) 4.80% and between the (70:10:20 wheat: sorghum: sunflower biscuit) 5.21%, and (60:30:10 wheat: sorghum: sunflower biscuit) 5.08% while the (50:30:20 wheat: sorghum: sunflower biscuit) recorded the lowest score of all the biscuit samples. The sensory characteristics of the cake samples are presented in Table 4.11 above. The result revealed that the scores for the appearance of the samples were significantly different, ranging from 4.63% in the (70:20:10 wheat: sorghum: sunflower cake) to 7.28% in the (50:30:20 wheat: sorghum: sunflower cake). However, there was no significant difference in the appearance of the Control (100% wheat cake) 5.88%, (50:20:30 wheat: sorghum: sunflower cake) 5.25%, and (60:30:10 wheat: sorghum: sunflower cake) 5.90%.

There was no significant difference in the score for aroma of the Control (100% wheat cake) 6.15%, (60:20:20 wheat: sorghum: sunflower cake) 6.45%, (50:20:30 wheat: sorghum: sunflower biscuit) 6.08% and (70:10:20 wheat: sorghum: sunflower cake) 5.93% while (50:30:20 wheat: sorghum: sunflower cake) recorded the highest significant score for aroma (7.25%).

The taste score of some of the cake samples was significantly the same, as the taste score of the samples ranged from 5.95% in the (70:10:20 wheat: sorghum: sunflower cake) to 7.15% in the (50:30:20 wheat: sorghum: sunflower cake).

The scores for the texture of the cake samples were significantly different ranging from 5.78% in the (50:20:30 wheat: sorghum: sunflower cake) to 6.88% in the (50:30:20 wheat: sorghum: sunflower cake). However, there was no significant difference in the texture of the Control (100% wheat cake) 6.25%, (60:20:20 wheat: sorghum: sunflower cake) 6.38%,

(70:10:20 wheat: sorghum: sunflower cake) 6.45% and (60:30:10 wheat: sorghum: sunflower cake) 6.23%.

In terms of the general acceptability, the general acceptability of the cake samples was significantly different, ranging from 5.54% in the (70:20:10 wheat: sorghum: sunflower cake) to 7.14% in the (50:30:20 wheat: sorghum: sunflower cake).

Taste, aroma, texture and appearance were consistently rated lower in most composite flour biscuit samples compared to the 100% wheat control especially samples with higher proportions of sorghum and sunflower (50:30:20) had the most reduced scores for taste and aroma. This indicates a trade-off between nutritional enhancement (higher fibre, ash, fat) and sensory quality, which can negatively affect consumer satisfaction and repeated purchases. Though there is difference in cake samples a higher proportion (50:30:20) recorded the highest scores for taste, flavour and aroma indicating promising nutritional scale-up potential. Appearance scores for some composite samples were lower than the control, potentially affecting first impressions and purchase intent, particularly in retail settings. While the composite blends of wheat, sorghum, and sunflower flour present a nutritionally promising alternative to 100% wheat products (with higher fibre, mineral, and fat contents), the study reveals consumers accustomed to conventional wheat-based baked goods may perceive alternate flours (like sorghum and sunflower) as inferior or health foods with less indulgent quality. This bias can hinder market penetration unless consumer education, recipe optimisation, and possibly flavour or texture enhancers may be necessary to improve the wider acceptability and market viability of these functional food products.

Conclusions

This study demonstrated that incorporating sunflower seeds into wheat-sorghum composite flours significantly enhanced the nutritional quality of biscuits and cakes; most notably by increasing protein (up to 10.43%), fat 33.47%, and 2.98% fibre content. These improvements contribute to better energy density, digestive health, and satiety, with only a modest reduction in carbohydrates. The findings support the formulation of nutrient-rich snacks that are both affordable and scalable. As a practical outcome, this approach offers a viable strategy for combating protein-energy malnutrition and promoting food security, particularly in resource-limited settings. Stakeholders in public health, school feeding programmes, and the food industry can leverage these results to develop healthier, more functional snack options.

Recommendations

1. Promote the Use of Composite Flours in Snack Production: Food industries, bakeries, and small-scale processors should be encouraged to adopt composite flours made from wheat, sorghum, and sunflower seeds in biscuits and cake formulations.
2. Incorporate Enriched Snacks into Public Nutrition Programs: Government agencies and NGOs should consider incorporating these enriched snacks into:
 - i. School feeding programs

- ii. Community nutrition projects
- iii. Food assistance initiatives

This can help address protein-energy malnutrition among children and vulnerable populations who rely on snacks for a significant portion of their daily caloric intake.

3. **Raise Awareness and Educate Consumers:** Educate the public, particularly in developing countries, on the health benefits of consuming snacks made from locally enriched flours. Nutrition education campaigns can help shift consumer preference from low-nutrient "junk food" to nutrient-dense, locally produced snacks.
4. **Further Research and Product Development:** Further research should be conducted to develop a wider range of protein-enriched snack products, such as cookies, pastries, and breakfast cereals.

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Conflict of interests

The author declared no conflict of interest, as this work has not been published elsewhere, and is not under consideration for publication in any other journal.

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