

Chemical Composition, Functional and Sensory Properties of Cookies Produced from a Blend of Oat (*Avena sativa*), Tigernut (*Cyperus esculentus* L.) and Defatted Soybean (*Glycine max*) Flours

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ABSTRACT

Background: Oat has potential to substitute wheat, and benefits gluten intolerant individuals. However, blending oat, tigernut, and defatted soybean could better enhance cookie quality, and address protein-energy malnutrition and micronutrient deficiencies.

Objective: To evaluate chemical composition, functional and sensory properties of cookies made from the blend of oat, tigernut and defatted soybean flours.

Methodology: 100% oat (TO1), oat:soy in 95:5 (TOS1), and oat:tigernut:soy in ratios of 90:5:5 (T11), 70:25:5 (T12), and 50:45:5 (T13) were formulated. Laboratory analyses (water and oil absorptions, and bulk density of blends, proximate and mineral evaluation of cookies), and sensory assessment (involving 40 untrained panelists) were conducted. Statistical analysis was performed using SPSS 21.0 at $p < 0.05$.

Results: Highest bulk density (0.63 g/dm³), water (20.73%) and oil (12.49%) absorptions observed in TOS1, T13 and T11, described significant effects of increasing protein and fibre contents across the samples, respectively. Highest values of protein (12.73%) and calcium (28.65 mg) in TOS1, sodium (32.75 mg) and iron (5.74 mg) in T11, ash (1.80%) in T12, fibre (2.79%), potassium (47.40 mg) and zinc (3.13 mg) in T13 were recorded, $p < 0.05$. Mineral content of potassium, sodium, calcium, and zinc increased with tigernut and soybean inclusion. T12, T13 and T11 were most preferred for flavour, taste, and colour, showing reduced attractiveness but enhanced aroma and taste as inclusion of tigernut and defatted soy flours increased, respectively.

Conclusion: Incorporating tigernut and soybean flours into oat flour produces nutrient-dense cookies with acceptable functional and sensory qualities suitable for addressing protein-energy malnutrition, micronutrient deficiency, and celiac disease.

Keywords: Oat, Tigernut, Defatted Soybean, Composite Flour, Cookies

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INTRODUCTION

Cookies are widely consumed snacks by both children and adults because of their diverse sensory qualities, energy density, extended shelf life, and affordability (1, 2). They play an important role in meeting the dietary needs of many consumers. Though wheat flour (*Triticum aestivum* L.) is commonly used in cookie production due to its gluten content, which imparts elasticity and

extensibility to dough. It has high starch content but contains a relatively low amount of dietary fibre, protein, and essential minerals. The presence of gluten also restricts the consumption of wheat-based products among individuals with celiac disease (3).

Research has demonstrated that enriching cookies with nutrients they inherently lack can enhance

their nutritional, functional, and storage qualities (4, 5). However, the economic feasibility of such fortification strategies remains a key concern, particularly in addressing hidden hunger and food insecurity in low- and middle-income countries. This challenge highlights the need to explore nutrient-dense indigenous crops as alternatives to wheat flour. Such substitutes can improve the nutritional quality of cookies and other baked products, provide gluten-free options for individuals with gluten intolerance, and promote long-term economic sustainability. Based on this premise, oat (*Avena sativa*) has emerged as a promising alternative with nutritional qualities comparable to wheat (6).

Oat flour is especially rich in dietary fibre, notably β -glucan, which has been shown to lower total and low-density lipoprotein cholesterol levels by enhancing bile acid excretion (7). It also contributes to improved glycaemic control and slow gastric emptying. Oats possess relatively high protein content, ranging from 13 to 20%, and are naturally gluten-free when compared with other cereals such as wheat, barley, and rice. These characteristics make oat flour beneficial in reducing the risk of cardiovascular diseases, obesity, type 2 diabetes, celiac disease, and malnutrition (4, 7).

Another indigenous crop with significant nutritional potential is tigernut (*Cyperus esculentus* L.). Tigernut serves as a natural sweetener due to its high sugar content, making it suitable for use in the confectionery industry (8). Incorporating tigernut flour in cookie formulations can reduce the need for refined sugar while enhancing flavour and micronutrient content (9). Its tubers have been successfully utilized as additives in the production of biscuits and ice cream because of these desirable properties (10). Tigernut exists in two main varieties—brown and yellow. Flour from the brown variety is particularly rich in protein, fat, ash, potassium, manganese, magnesium, and iron, whereas the yellow variety contains higher levels of carbohydrates, calcium, sodium, and copper (10, 11).

Soybean (*Glycine max*) is another valuable food ingredient with a biological protein quality comparable to that of animal sources. It is widely consumed by vegetarians and recommended for individuals requiring low-cholesterol diets, high-quality amino acids, and polyunsaturated fatty acids. Defatted soybean flour is especially useful in enhancing the nutritional profile of cereal-based baked products, as it contains 60–70% of the total

soybean protein in a concentrated form. In addition, it supplies bioactive compounds such as isoflavones, dietary fibre, and essential micronutrients (12). Given the nutritional advantages of oat, tigernut, and soybean, as well as the importance of promoting indigenous crops to address food insecurity, this study investigated the chemical composition, functional characteristics, and sensory attributes of cookies produced from blends of oat, tigernut, and soybean flours.

MATERIALS AND METHODS

Materials

The experimental materials used for this study are whole oat grains and yellow tigernut tubers sourced from Mushin Market, Lagos State, Nigeria, and defatted soybean obtained from the Department of Food Science, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. Other ingredients—margarine, sugar, eggs, salt, and sodium bicarbonate—were purchased from Ogele/Iya Laje Market in Ondo town, Nigeria.

Methods

Two controls were used in the study: TO1 (100% oat flour) as the baseline and TOS1 (95:5 oat–soy flour) to assess the effect of soy flour. These controls enabled evaluation of the individual and combined effects of soy and tigernut flours in treatments T11 (90:5:5), T12 (70:25:5), and T13 (50:45:5) on cookie quality.

Preparation of flours

The whole oat grains were first sorted to remove impurities, then dry-milled into a fine powder using a self-regulated (thermostatic) attrition mill at a constant temperature of 65 °C. The resulting flour was spread evenly on clean, sterilized trays and left to cool at room temperature to prevent clumping or moisture buildup (12). Yellow tigernut flour was prepared using a prescribed method with minor adjustments (10). The tigernut tubers were cleaned, sorted, and thoroughly washed before being oven-dried at 65°C. Once dried, the tubers were milled into flour and sieved through a 45 μ m mesh to obtain a fine, uniform consistency. The resulting flour was stored at 4°C until further use. Together with defatted soy flour, the three flours were mixed in different proportions for cookie production (Table 1).

Cookie formulations and preparation

The cookie production adopted method stated in previous research (13) with minor modifications

(Figure 1). Composite flours of oat, tigernut, and soy at different ratios (Table 1) were used, with constant amounts of sugar, fat, and salt (Table 2). The flours were mixed, blended with melted fat and baking powder, and combined with eggs and milk

to form dough. After kneading, the dough was rolled, cut into shapes, and baked at 170°C for 15 minutes. The baked cookies were cooled and stored in HDPE containers for further analyses.

Table 1: Formulation of cookie samples

Composition	Treatment	Proportion
Oat flour (control)	T01	100
Oat flour +soy flour (control)	T0S1	95:5
Oat flour +tigernut flour +soy flour	T1	90:5:5
Oat flour +tigernut flour + soy flour	T12	70:25:5
Oat flour + tigernut flour + soy flour	T13	50:45:5

Table 2: Formulation of flour blends and other ingredients for cookie production

Composition	Treatment	Proportion (%)	Corn starch (g)	Milk (g)	Sugar (g)	Whole egg (g)	Margarine (g)	Water (g)	Baking powder (g)
Oat flour (control)	T01	100	25	13	15	10	7	25	5.0
Oat flour + soy flour (control)	T0S1	95:5	25	13	15	10	7	25	5.0
Oat flour + tigernut flour + soy flour	T11	90:5:5	25	13	15	10	7	25	5.0
Oat flour + tigernut flour + soy flour	T12	70:25:5	25	13	15	10	7	25	5.0
Oat flour + tigernut flour + soy flour	T13	50:45:5	25	13	15	10	7	25	5.0

T01 = 100% oat flour (control); T0S1 = 95% oat flour + 5% soybean flour (control); T11 = 90% oat flour + 5% tigernut flour + 5% soybean flour; T12 = 70% oat flour + 25% tigernut flour + 5% soybean flour; T13 = 50% oat flour + 45% tigernut flour + 5% soybean flour

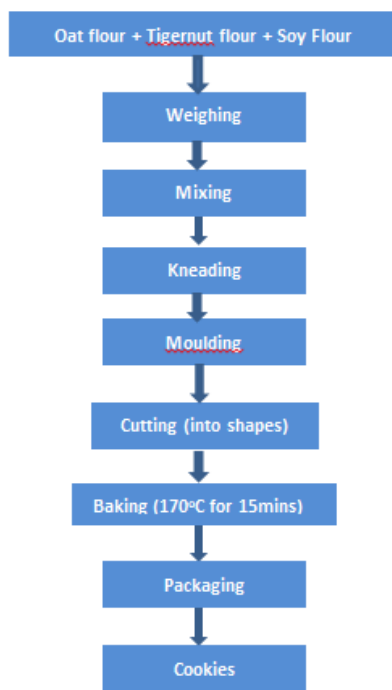


Figure 1: Functional cookies production

Functional properties of the blends

Water absorption capacity (WAC), oil absorption capacity (OAC), and packed bulk density (PBD) of the flour blends were determined. The WAC was measured using Sosulski's method (14), in which 1 g of flour was weighed into a centrifuge tube, mixed with 10 mL of distilled water, and centrifuged at 3500 g for 20 minutes. After decanting the supernatant, the residue was weighed, and WAC was calculated using Equation 3.1.

$$\text{Water absorption capacity (\%)} = \frac{W_3 - W_2}{W_1} \times 100 \quad (3.1)$$

Where:

W_3 = weight of test tube + sample after centrifuging and decanting

W_2 = weight of test tube + sample before water additions and centrifuging

W_1 = weight of sample

Oil absorption capacity (OAC) was determined using Beuchat's method (15). One gram of flour was placed in a centrifuge tube, mixed with 10 mL of Gino oil, and allowed to stand for 5 minutes. The mixture was then centrifuged at 3500 g for 20 minutes, and after decanting the oil, the residue was weighed. OAC was calculated using Equation 3.2.

$$\text{Oil absorption capacity (\%)} = \frac{W_3 - W_2}{W_1} \times 100 \quad (3.2)$$

Where:

W_3 = weight of test tube + sample after centrifuging and decanting

W_2 = weight of test tube + sample before water additions and centrifuging

W_1 = weight of sample

Packed bulk density (PBD) was measured using 10 g of flour placed in a 50 mL graduated cylinder, gently tapped until the volume stabilized, and calculated using Equation 3.3 (16).

$$\text{Bulk density} = \frac{\text{weight of sample (g)}}{\text{volume of sample after tapping (ml)}} \quad (3.3)$$

Proximate analysis of samples

Moisture determination

Moisture content was determined using the AOAC standard method (17). Labeled petri dishes were cleaned, dried in an oven at 100 °C for 30 minutes, cooled in a desiccator containing freshly ignited CaO, and weighed to a constant weight (W_1). Each sample (5 g) was placed in a petri dish, and

the combined weight was recorded (W_2). The dishes with samples were oven-dried at 105 °C for 3 hours (Gallenkamp size 3, London, UK), cooled in a CaO desiccator, and weighed. Drying and weighing were repeated in 1-hour intervals until a constant weight (W_3) was achieved. Analyses were performed in triplicate, and moisture content was calculated using Equation 3.4.

$$\text{Moisture Content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100\% \quad (3.4)$$

Where:

W_1 = weight of empty moisture can

W_2 = weight of empty can + sample before drying

W_3 = weight of can + sample dried to constant weight

Crude fat determination

Crude fat content was determined using a Soxhlet apparatus following AOAC guidelines (17). Samples (0.5 g) were placed in a thimble and extracted continuously with n-hexane for 3.5 hours. After extraction, the thimble was dried in a hot air oven at 50 °C to constant weight. The fat content was calculated from the weight difference before and after extraction and expressed as a percentage on a dry weight basis.

$$\% \text{ Crude fat} = \frac{W_3 - W_2 \times 100}{W_1} \quad (3.5)$$

W_1 = weight of sample

W_2 = weight of empty flask

W_3 = weight of flask + extracted fat (constant weight after drying)

Determination of crude protein content

Protein content was determined using the Kjeldahl method, involving digestion, distillation, and titration (AOAC, 17). For digestion, 1 g of sample was mixed with 3 g hydrated cupric sulfate (catalyst), 20 mL sodium sulfate solution, and 0.1 mL concentrated sulfuric acid in a Kjeldahl flask. Then, the whole solution was heated until it became colorless. During distillation, the digest was cooled, diluted to 100 mL with distilled water, and 10 mL of this was combined with 5 mL of 40% sodium hydroxide and distilled to release ammonia. For titration, the distillate was titrated with 0.1 M hydrochloric acid until the color changed from green to pink. Protein content was calculated using Equation 3.6.

Crude protein (%) = % Nitrogen x 6.25

$$\% \text{ Nitrogen} = \frac{VF \times N \times 0.0014 \times 100}{W} \quad (3.6)$$

Where:

VF = Total volume of the digest = 100ml
W = Weight of the sample digested
T = Titre value
6.25 = Conversion factor
N = Normality of HCL in moles per 100ml (0.1N)

Determination of total ash content

Total ash content was determined following AOAC procedures (17). Crucibles were cleaned, dried, cooled in a desiccator, and weighed. One gram of sample was added, then ashed in a muffle furnace at 550 °C until a uniform white-grey ash was obtained. The crucibles were cooled in a desiccator and weighed, and ash content was calculated using Equation 3.7.

$$\% \text{ Total Ash} = \frac{(W_3 - W_2) - (W_2 - W_1)}{W_2} \times 100 \quad (3.7)$$

W₁ = weight of sample
W₂ = weight of sample + crucible
W₃ = weight of sample + crucible (constant weight after drying)

Determination of crude fibre content

Total ash content was determined following AOAC procedures (17). Crucibles were cleaned, dried, cooled in a desiccator, and weighed. One gram of sample was added, then ashed in a muffle furnace at 550 °C until a uniform white-grey ash was obtained. The crucibles were cooled in a desiccator and weighed, and ash content was calculated using Equation 3.7.

$$\% \text{ Crude fibre} = \frac{W_3 - W_2}{W_1} \times 100 \quad (3.8)$$

Where:

W₁ = Initial weight of sample
W₂ = Weight of sample + crucible before ashing
W₃ = Weight of sample + crucible after ashing (constant weight after drying)

Determination of carbohydrate content

The total carbohydrate content was calculated by subtracting the sum of moisture, crude protein, crude fat, ash, and crude fibre from 100%.

$$\text{Carbohydrate} = 100 - (\text{crude fibre} + \text{crude protein} + \text{crude fat} + \text{total ash}) \quad (3.9)$$

Mineral analysis

Mineral content (Ca, Na, Fe, Zn, and K) was determined following AOAC methods (17). Two grams of each sample were ashed in a muffle furnace at 550 °C for 6–8 hours, and the resulting

ash was dissolved in HCl. Minerals were analyzed using a Buck Model 210 VGP atomic absorption spectrometer (USA) with an air-acetylene flame and hollow cathode lamps as the resonance source. Calibration curves were prepared from standards, and digested samples were measured in duplicate. Mineral concentrations were reported in parts per million (ppm) based on the standard curves.

Sensory evaluation and physical properties of the cookies

Sensory evaluation of the cookies was conducted within 24 hours of preparation, assessing appearance, aroma, taste, texture, thickness, and overall acceptability using a 5-point hedonic scale (1 = dislike extremely, 5 = like extremely). Forty panelists familiar with cookies, and without allergies or illness, participated in the testing at the sensory laboratory of Wesley University, Ondo, Nigeria. Panelists were instructed to rinse their mouths with water between samples to maintain consistent taste evaluation.

Statistical analysis

Data analysis was performed using SPSS version 21.0, applying analysis of variance (ANOVA) and Duncan's multiple range test at a 5% significance level ($p < 0.05$).

Ethical consideration

The study protocol was approved by the Institutional Research Committee of Wesley University, Ondo, Nigeria (Ref. No. NUD/18/013). Informed consent was obtained from all panelists, and a single-blind design was used to keep them unaware of the ingredient composition of the samples to prevent bias.

RESULTS

Functional properties of the flour blends

The functional properties of the flour blends are shown in Table 3. Significant differences were observed in PBD, WAC, and OAC ($p < 0.05$). TOS1 had the highest bulk density (0.63 g/cm³), while TO1 and T11 had lower, similar values (0.58 g/cm³). Water absorption capacity was highest in T13 (20.73%). Oil absorption capacity was highest in T11 (12.49%).

Proximate composition of the cookies

The proximate composition of the cookies is shown in Table 4, with significant differences ($p < 0.05$) observed in fat, fibre, moisture, protein, and carbohydrate contents. T12 had the highest fat (43.36%) and ash (1.80%), reflecting the lipid and mineral contribution of tigernut flour, while T13

showed the highest fibre (2.79%) and moisture (25.10%).

Table 3: Functional properties of the blends

Samples	Parameters		
	Bulk density (g/dm ³)	Water absorption (%)	Oil absorption (%)
TO1	0.58±0.001 ^a	11.67±0.289 ^a	11.86±0.556 ^c
TOS1	0.63±0.002 ^d	13.59±0.002 ^b	10.58±0.002 ^a
T11	0.58±0.002 ^a	18.41±0.019 ^c	12.49±0.115 ^d
T12	0.59±0.012 ^b	19.73±0.566 ^c	11.31±0.115 ^b
T13	0.62±0.012 ^c	20.98±0.177 ^d	12.38±0.001 ^d
F	729.429**	675.710**	30.621**

**Significant at $p < 0.01$. TO1 = 100% oat flour (control); TOS1 = 95% oat flour + 5% soybean flour (control); T11 = 90% oat flour + 5% tigernut flour + 5% soybean flour; T12 = 70% oat flour + 25% tigernut flour + 5% soybean flour; T13 = 50% oat flour + 45% tigernut flour + 5% soybean flour, F-value of significant differences between the group means.

Table 4: Proximate composition of the cookies

Samples	Parameters					
	Crude fat	Crude fibre	Ash	Moisture	Crude protein	Carbohydrate
TO1	27.39±1.39 ^a	0.39±0.00 ^b	1.49±0.00 ^a	7.49±0.00 ^a	7.35±0.17 ^b	61.83±1.23 ^e
TOS1	39.84±0.19 ^c	0.19±0.00 ^a	1.49±0.01 ^a	10.85±0.02 ^b	12.73±0.15 ^e	28.83±1.09 ^c
T11	33.07±0.61 ^b	1.59±0.00 ^c	1.52±0.00 ^a	12.31±0.14 ^c	6.33±0.11 ^a	55.20±0.66 ^d
T12	42.36±0.78 ^d	1.99±0.00 ^d	1.56±0.45 ^a	18.79±0.14 ^d	10.55±0.19 ^c	23.51±1.17 ^b
T13	43.76±0.08 ^d	2.79±0.00 ^e	1.80±0.04 ^a	25.10±0.71 ^e	11.53±0.29 ^d	16.71±0.89 ^a
F	157.970**	1139257.021**	1.242	3026.330**	609.240**	1103.089**

**Significant at $p < 0.01$, 0.05. TO1 = 100% oat flour (control); TOS1 = 95% oat flour + 5% soybean flour (control); T11 = 90% oat flour + 5% tigernut flour + 5% soybean flour; T12 = 70% oat flour + 25% tigernut flour + 5% soybean flour; T13 = 50% oat flour + 45% tigernut flour + 5% soybean flour. F-value of significant differences between the group means.

Mineral composition of the cookies

Table 5 presents the mineral composition of cookies made from oat, tigernut, and defatted soybean flour blends. Significant differences ($p < 0.05$) were observed for sodium (Na), potassium (K), calcium (Ca), and iron (Fe), while

zinc (Zn) did not vary significantly ($p > 0.05$). T11 had the highest sodium (32.75 mg) and iron (5.74 mg), T13 had the highest potassium (47.40 mg) and zinc (3.13 mg), and TOS1 had the highest calcium (28.65 mg).

Table 5: Mineral composition of the cookies

Samples	Parameters				
	Na	K	Ca	Fe	Zn
TO1	31.10±0.566 ^d	42.55±0.919 ^d	25.00±0.424 ^c	5.33±0.002 ^d	2.05±0.001 ^a
TOS1	27.65±0.354 ^b	36.65±0.212 ^c	28.65±0.212 ^d	3.99±0.002 ^a	2.75±0.002 ^{ab}
T11	32.75±0.354 ^e	28.75±0.354 ^a	19.00±0.141 ^a	5.74±0.002 ^e	2.09±0.706 ^{ab}
T12	15.70±0.000 ^a	33.25±0.212 ^b	23.95±0.495 ^b	4.08±0.002 ^b	2.63±0.004 ^a
T13	30.10±0.424 ^c	47.40±0.849 ^e	24.00±0.566 ^{bc}	4.71±0.002 ^c	3.13±0.004 ^b
F	621.790**	307.048**	123.312**	258796.22**	4.219

**Significant at $p < 0.01$, 0.05. TO1 = 100% oat flour (control); TOS1 = 95% oat flour + 5% soybean flour (control); T11 = 90% oat flour + 5% tigernut flour + 5% soybean flour; T12 = 70% oat flour + 25% tigernut flour + 5% soybean flour; T13 = 50% oat flour + 45% tigernut flour + 5% soybean flour. F-value of significant differences between the group means.

Sensory evaluation of the cookies

The cookie samples were found to be significantly different for all sensory attributes, including appearance, colour, texture, flavour, taste, and overall acceptability (Table 6). T12 was preferred

for appearance (4.18 ± 0.791) and flavour (4.15 ± 0.975), T11 scored highest for colour (4.20 ± 0.758), and taste was equally liked in T12 and T13 (4.08 ± 1.047 and 4.08 ± 0.944).

Overall acceptability was highest for T11 (4.23 ± 0.733).

Table 6: Sensory evaluation of the cookies

Samples	Parameters					
	Appearance	Colour	Texture	Flavor	Taste	Overall acceptability
TO1	3.75±0.707 ^a	3.58±0.747 ^a	3.15±1.001 ^a	3.30±1.018 ^a	3.20±1.224 ^a	3.65±0.949 ^a
TOS1	3.83±0.844 ^{abc}	3.83±0.747 ^a	3.65±0.921 ^b	3.93±0.917 ^b	4.00±0.961 ^b	4.05±0.749 ^b
T11	4.13±0.686 ^{bc}	4.20±0.758 ^b	3.98±0.800 ^b	3.70±0.911 ^{ab}	4.03±0.800 ^b	4.23±0.733 ^b
T12	4.18±0.791 ^c	3.90±0.744 ^{ab}	3.78±0.947 ^b	4.15±0.975 ^b	4.08±1.047 ^b	4.20±0.723 ^b
T13	3.80±0.791 ^{ab}	3.75±0.742 ^a	3.65±0.834 ^b	4.05±0.904 ^b	4.08±0.944 ^b	3.93±0.944 ^{ab}
F	2.619*	0.006**	0.002**	0.001*	0.000*	0.013*

**Significant at $p < 0.01$, * Significant at $p < 0.05$. TO1 = 100% oat flour (control); TOS1 = 95% oat flour + 5% soybean flour (control); T11 = 90% oat flour + 5% tigernut flour + 5% soybean flour; T12 = 70% oat flour + 25% tigernut flour + 5% soybean flour; T13 = 50% oat flour + 45% tigernut flour + 5% soybean flour. F-value of significant differences between the group means.

DISCUSSION

The findings of this study establish the chemical composition, functional characteristics, and sensory attributes of cookies produced from a blend of oat, tigernut, and soybean flours. Bulkiness of the samples increases with the inclusion of soy flour. This could likely be due to the higher protein content of soy flour, which has been earlier reported by other studies to influence blend compactness (18). Overall, the values of bulk density in the blends prepared in this study were generally lower than the 0.67–0.78 g/cm³ earlier reported for wheat–tigernut composites (18). Though cookies with low bulk density seem to be lighter, and have low calories, they are usually known to be nutrient dense, signifying the considerable amount of protein, fibre, and micronutrients that cookies produced from the blend demonstrate (19).

Water absorption capacity was highest in the blend containing the largest amount of tigernut flour. This attribute can be related to high dietary fibre in tigernut and soybean. This is consistent with the report that fibre-rich flours enhance water retention (20). On the other hand, oil absorption capacity was highest in T11 (12.49%), reflecting the flour's ability to bind oil, likely through interactions within the tigernut fibre matrix (14). These functional properties are important as they affect dough handling, baking performance, and cookie texture. Intake of food with dietary fibre is essential for increasing satiety, preventing constipation, and improving positive postprandial effects by slowing gastric emptying (7). Thus, the cookie produced from this blend could be suitable for improving digestive health and lowering blood glucose control, making it suitable for individuals

suffering from constipation, diabetes, and colon cancer (21).

Furthermore, the proximate assessment of the blend shows that TOS1 recorded the highest protein content, which can be related to soybean flour's high-quality protein. Having TO1 containing the highest carbohydrate content is typical of pure oat flour cookies. However, this finding correspond report by other researchers. Incorporating tigernut and soybean flours increases moisture, fat, protein, and fibre but decreases carbohydrates (22). However, a previous study has shown that composite flours made with tigernut improve nutritional profiles while altering macronutrient distribution (23). Though the moisture levels of the products in this study were found to exceed the recommended 10%. The products will benefit from air-free packaging material and preservatives in order to extend their shelf life and prevent the risk of microbial growth (23). Overall, tigernut and soybean flour enrich cookies by increasing protein, fibre, and fat content while lowering carbohydrates, highlighting their potential for producing more nutritionally dense baked products.

Furthermore, adding tigernut flour in varying amounts, alongside 5% soybean flour, enhanced the mineral content, particularly K, Na, Ca, and Zn. This is potentially due to a high amount of natural minerals present in the blended flours, as previously reported (18, 24). Differences in iron content may reflect variations in processing methods such as drying and milling. Thus, enriching oat cookies with tigernut and soybean flours improves both nutritional value and mineral

balance, carrying the health benefits for the consumers (25, 26).

However, it was observed that the inclusion of tigernut and soybean flours affected the appearance, with higher levels producing a darker colour. This might likely be due to Maillard reactions as earlier reported by other scholars (25, 27). Notwithstanding, the taste of the cookies remained largely unaffected, showing that moderate incorporation of tigernut and 5% soybean flour does not reduce palatability but sustains sensory appeal. Texture decreased slightly with more tigernut flour, but composite cookies still outperformed the control. These results agree with previous studies reporting that partial substitution with oat and tigernut flours can enhance aroma, colour, and overall sensory quality (28, 29). Largely, moderate levels of tigernut combined with soybean flour produced cookies that were well accepted by panelists, indicating an optimal balance between nutritional improvement and consumer preference.

CONCLUSION

The study demonstrated that incorporating tigernut and defatted soybean flours into oat flour significantly increases nutrient density with a considerable amount of protein, essential minerals, and sensory qualities of cookies. This enrichment increased levels of potassium, calcium, and zinc, and influence iron content, appearance, and texture of the cookies. This provides an opportunity for using indigenous foods in producing snacks that are nutrient-dense and can be used to address protein-energy malnutrition, micronutrient deficiencies, constipation, and metabolic diseases. Future research should aim at optimizing the flour blend ratios and processing techniques, and assess functional and antinutritional properties to further improve cookie quality without compromising their nutritional benefits. Examining the effects of cookies produced from the blend of oat, defatted soybean, and tigernut on postprandial response and satiety will also be important to establish the health claim of the products.

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CONFLICT OF INTEREST

Authors declare no conflict of interest

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