Influence of sweet potato puree and soybean addition on the quality characteristics of gluten-free biscuits

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Abstract

Introduction. This study aims to investigate the effects of sweet potato puree and soybean addition on the quality characteristics of gluten-free biscuits.

Materials and methods. Blends of wheat, sweet potato puree and soybeans flour at varying ratios were used to produce biscuit through D-optimal mixture design. The produced biscuits were subjected to proximate, minerals, physical, textural and sensory analysis.

Results and discussion. The weight, diameter, and spread ratio of the biscuits increased with the addition of sweet potato puree and soybean flour in the blends. The observed ranges were 9.52–15.22 g for weight, 7.21–10.17 mm for thickness, 41.89–47.85 mm for diameter, 45.42–51.16 for lightness (L*), 2.83–5.03 for redness (a*), 17.73–22.34 for yellowness (b*), 10.44–13.99 for energy value, and corresponding increases in spread ratio. The changes in colour parameters indicate enhanced browning reactions and pigment contribution from sweet potato puree.

Moisture content, crude protein, and crude fat increased with increasing levels of sweet potato puree and soybean flour in the formulation. The ranges obtained were 9.08–18.87% for moisture, 12.85–17.08% for crude protein, 17.11–19.63% for crude fat, 1.47–1.92% for ash, 4.85–6.85% for crude fibre, and 44.08–46.44% for carbohydrates. The increase in dietary fibre and protein suggests an improvement in the nutritional quality of the gluten-free biscuits compared to conventional formulations.

The incorporation of soybean flour and sweet potato puree had a significant ($p < 0.05$) positive effect on the mineral content of the biscuits. Calcium, potassium, magnesium, iron, and zinc contents ranged from 23.66–28.77 mg/100 g, 110.90–128.90 mg/100 g, 12.74–16.12 mg/100 g, 0.28–0.34 mg/100 g, and 0.39–0.43 mg/100 g, respectively.

Textural properties, including peak force, adhesiveness, gumminess, springiness, and cohesiveness, varied within the ranges of 2572–6555 N, 5.46–16.68 N·s, 3403–6477.5 N, 0.13–1.07, and 0.05–1.11, respectively.

Conclusion. Despite variations among formulations, all biscuit samples achieved acceptable sensory scores. However, the biscuit produced with 72.5% wheat flour, 20.0% sweet potato puree, and 7.5% soybean flour was the most preferred by the panellists.

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Introduction

Biscuits are small, thin, low-moisture, crispy baked products made from unleavened dough, packaged and sold as ready-to-eat foods, and consumed by individuals of all ages worldwide (Ariyo et al., 2022). Biscuit production requires key ingredients such as water, sugar, fat, and wheat flour; additional ingredients may include milk, salt, aerating agents, flavouring substances, and other food additives (Zuljevic and Akagic, 2021). The classification of biscuits is based on their ingredient composition and the processing methods employed during manufacture.

Wheat is one of the most important cereal crops and is heavily relied upon by a large proportion of the world's population (Erenstein et al., 2022). Wheat flour (*Triticum aestivum* L.) is the primary ingredient used in the production of baked products such as biscuits and contributes nearly half of the global caloric intake (Masood, 2021). However, wheat is deficient in essential amino acids such as lysine and threonine and is also implicated in coeliac disease due to the presence of gluten in wheat grains (Oke et al., 2023; Serwaa et al., 2021). Consequently, several efforts have been made to partially substitute wheat flour with non-wheat flours to improve nutritional quality, promote the utilization of indigenous crops in Nigeria, and help reduce the production costs of bakery products (Olagunju et al., 2020). Regarding the common plant foods that constitute the main source of the world population in their diets, soybeans are highest in terms of nutrition because they contain considerable amounts of the known hematinic minerals and vitamins, which play vital roles in the formations of red blood cells (Mile et al., 2024). In addition to its nutritional composition, soybean possesses notable medicinal and therapeutic properties (Maske, 2020). As a functional food, soybeans have been reported to lower triglyceride and blood cholesterol levels, both of which are major risk factors of cardiovascular diseases. Furthermore, research has shown that soybean consumption alleviates malnutrition and contributes to the regulation of blood glucose and body weight (Ijarotimi et al., 2021). Soybeans are also characterized by low cholesterol content and are rich sources of protein and dietary fibre (Ali et al., 2020)

Sweet potato (*Ipomoea batatas*) is another critical staple crop in Nigeria and many other developing countries and is recognized as one of the most important food crops globally (Onyiba et al., 2023). It belongs to the family *Convolvulaceae* and is classified as a dicotyledonous root crop among major staple foods. Sweet potato roots are rich in starch, sugars, vitamin C, β-carotene, iron, and other essential minerals (Hossain et al., 2022). Sweet potatoes can be processed into a wide range of liquid and semi-solid food products, including milk analogues, soups, baked goods, breakfast cereals, snacks, and dessert formulations (Laveriano-Santos et al., 2022). To ensure year-round availability, the tubers are often converted into purées in the food industry, which may subsequently be aseptically packaged, frozen, or canned to enhance storage stability.

Nevertheless, the use of composite flour blends comprising wheat, soybean flour, and sweet potato purée in biscuit production offers a viable approach to enhancing the nutritional value of biscuits. This strategy may also promote increased utilization and consumer acceptance of biscuits produced from wheat–soybean–sweet potato composite formulations. Therefore, this study aimed to evaluate the quality attributes of biscuits produced from composite flours of wheat, soybean, and sweet potato purée.

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Materials and methods

Materials

All of the ingredients namely: wheat flour (Honey well brand), sweet potato of white fleshed, soybeans and the rest of the ingredients like: sugar, margarine, baking powder, salt, egg, vanilla flavour were purchased in a retail supermarket at Eleweran, Abeokuta, Nigeria

Methods

Preparation of Soybean flour

Soybean flour was produced following the method of Alabi and Anuonye (2007) with slight modifications. One thousand grams (1000 g) of soybean seeds were sorted to remove defective seeds, stones, and other foreign materials. The seeds were thoroughly washed with tap water and boiled in 1250 mL of water for 30 min to soften the hulls and facilitate dehulling. The soybeans were then dehulled, washed, and blanched in water for 10 min. After draining, the seeds were oven-dried at 80 °C for 6 h using a hot air oven (Gallenkamp SG3-08-169, UK). The dried soybeans were subsequently roasted in a steel frying pan at low temperature for 20 min until a light golden-brown colour was obtained. The roasted seeds were dry-milled using a laboratory hammer mill (Fritsch, D-55743, Idar-Oberstein, Germany), sieved through a 100 µm mesh, and packed in airtight containers until further use.

Preparation of sweet potato puree

Sweet potato purée was prepared following the method of Chilungo et al. (2019). The sweet potato roots were thoroughly washed, peeled, and cut into cubes. The cubes were steamed in boiling water for 1 h, allowed to cool, and then mashed using a Kenwood food processor to obtain a smooth purée.

Blend formulation

The formulation of the flour blends is presented in Table 1 and was developed using a D-optimal mixture design. A total of fourteen experimental runs were prepared, with 100% wheat flour serving as the control. The flour blends were packaged and stored until required for biscuit production.

Production of biscuits

Biscuits were prepared using the fourteen flour blends with slight modifications to the procedure described by Ifeh and Chioke (2024). The ingredients were accurately weighed. The measured flour blends, sugar, milk powder, and baking powder were mixed using a Kenwood hand mixer until homogeneous. Eggs were then incorporated to form a cohesive dough, which was rolled into sheets of uniform thickness. A cutter was used to shape the biscuits to the desired size, and they were baked in a preheated oven at 220 °C for 15 minutes. The baked biscuits were allowed to cool for 30 minutes at room temperature and subsequently stored in polythene bags. The formulation for biscuit production (per batch) was as follows: sugar, 150 g; margarine, 150 g; baking powder, 2.84 g; salt, 1.42 g; egg, 1.00 g; and vanilla flavour, 2.84 g.

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Table 1

Composite flour from wheat, soybean and sweet potato purée using D-optimal mixture design

Experiment	Wheat flour (%)	Sweetpotato puree (%)	Soybean flour (%)
1	72.50	22.50	5.00
2	70.83	20.83	8.34
3	75.00	20.00	5.00
4	70.00	20.00	10.00
5	72.50	22.50	5.00
6	70.83	23.33	5.83
7	73.33	20.83	5.83
8	71.67	21.67	6.67
9	72.50	20.00	7.50
10	75.00	20.00	5.00
11	70.00	22.50	5.00
12	72.50	22.50	5.00
13	70.00	20.00	10.000
14	100	0	0

Proximate composition of biscuits

Moisture content was determined using a hot air oven method. Crude fat was measured by Soxhlet extraction, while total ash was determined gravimetrically by ashing the samples in a preheated muffle furnace at 600 °C for 6 h until a constant weight was achieved. Crude fibre was analyzed following extraction with petroleum ether. Crude protein content was determined using the Kjeldahl method (AOAC, 2016), and total carbohydrate was calculated by difference.

Mineral composition of biscuits

The mineral content of the biscuit samples was determined following the AOAC (2006) method. Briefly, 0.5 g of each biscuit sample was digested with a mixture of perchloric, nitric, and sulphuric acids on a hot plate until white fumes appeared. After cooling, the digest was diluted with distilled water, filtered, and made up to volume in a volumetric flask. The concentrations of calcium, potassium, iron, magnesium, and zinc were then determined using an Atomic Absorption Spectrophotometer (AAS).

Physical properties of biscuits

Biscuit physical attributes were evaluated following the approach of Adeola and Ohizua (2018). Four biscuits from each sample were placed side by side, and their diameter (width, W) and thickness (T) were measured using a digital vernier caliper (0.01 mm, Cappera Precision, China). The spread ratio (SR) was calculated as the ratio of diameter to thickness. The weight of the baked biscuits was determined using a digital weighing balance (AD, EK-4100i, Japan) after cooling, and the values for each sample were recorded (Oke et al., 2017).

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Colour properties of biscuits

The colour of the biscuits was determined following the method of Oke et al. (2019). A Minolta Chroma Meter (CR-410, Japan) was used for the analysis. Prior to measurement, the instrument was calibrated using a white calibration plate and a zero calibration mask. Biscuit samples were placed on a Petri dish, and readings were taken to obtain the colour parameters: lightness (L*), redness (a*), and yellowness (b*).

Textural properties of biscuits

The texture of the biscuits was evaluated using a three-point bending test following the method of Da Silva and Moreira (2008). Each biscuit sample was placed on two parallel supports, and a central load was applied. Measurements were performed using a Texture Analyzer (Model TA-XT2i, Stable Micro Systems, Haslemere, UK) equipped with a 2.5 mm thick flat-edged steel blade and a support span of 90.00 mm. The test was conducted at a constant crosshead speed of 30.00 mm/min until fracture occurred. The maximum force (N) at the point of fracture, corresponding to the peak value on the force–deflection (N vs. mm) curve, was recorded as an indicator of the sample's resistance to breakage.

Sensory evaluation of biscuits

Ethical approval for the sensory evaluation was obtained from the Ethical Committee of the Department of Food Science and Technology, Federal University of Agriculture, Abeokuta. Participation was entirely voluntary and panellists were provided with comprehensive information regarding the study objectives, requirements and potential risks prior to participation. Participant's retained the right to withdraw from the sensory evaluation at any stage without penalty. Sixty Panellists from Federal University of Agriculture Abeokuta including staff and student evaluated the biscuit samples through sensory testing. The test panellist's evaluated product attributes including colour, texture, taste and aroma and overall acceptability through their hedonic ratings which ranged from 1 to 9 (extremely dislike to extremely like).

Statistical analysis

All analyses were performed in triplicate and results were expressed as mean values. The data were subjected to statistical analysis using analysis of variance (ANOVA). The means were separated using the Duncan multiple range test at $p \leq 0.05$ probability level (SPSS version 23.0).

Result and discussion

Proximate composition of biscuit from wheat, soybean and sweetpotato puree composite flour

The proximate composition of biscuit using wheat, soybean and sweetpotato puree composite flour (Table 2) indicated that the addition of wheat, soybeans and sweetpotato puree had a significant ($p<0.05$) influenced the proximate composition of the biscuits. Based on the results, it was seen that moisture contents varied between 9.08 and 18.87 % whereby the sample consisting of (75:20:5) was reported to have lowest moisture content amongst samples whereas sample (70.83:20.83:8.34) had the highest moisture content. When the percentage levels of sweet potato puree and soybeans flour blend were added together, the moisture content of the sample, had shown an increase. Moisture content of the food is one of the critical and most popular indices when it comes to defining the quality of processed goods that are dried (Bakare et al., 2020).

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Depending on the thermal characteristics of the ingredients, the rate of moisture loss during baking is determined. Both sweet potatoes and soybeans have ingredients that can hinder the rate of water evaporation much faster than when using wheat flour on its own. It implies that the less moisture can be lost in the course of baking, the higher the amount of moisture contained in it in the end will be provided that the inclusion level of these ingredients is high. The values of the moisture content of the biscuit measured in this study were differed significantly ($p<0.05$) with one another and resemble values obtained by Passos et al. (2013) on biscuits brand of different kinds.

The biscuits had crude fat content between 17.11 and 19.63%. Fat serves multiple critical physiological functions: it acts as a solvent for lipophilic hormones and is essential for steroid hormone synthesis and cellular signaling (Agu et al., 2021). Additionally, it provides essential fatty acids that serve as precursors for eicosanoid synthesis and acts as the carrier vehicle for fat-soluble vitamins A, D, E and K. From an energetic perspective, lipids provide 9 kcal/g, representing the highest caloric density among the macronutrients, surpassing both proteins and carbohydrates which yield 4 kcal/g (Roth, 2011). The relatively narrow variation in fat content across formulations can be explained by the similar quantities of added fats (margarine) in the recipe, as shown in Table 2. However, soybean flour as a legume-based ingredient contributes substantial endogenous lipids to the biscuit formulation, containing approximately 18-22% oil by dry weight (Ali et al., 2020). The lipid fraction in soybean flour is predominantly composed of polyunsaturated fatty acids, particularly linoleic acid (omega-6) and linolenic acid (omega-3), which contribute to the nutritional quality of the final product. This explains why formulations with higher soybean flour content, such as the 10% SF formulation (which recorded the highest fat content of 19.63%), demonstrate elevated total lipid levels. The fat content is further concentrated during baking as moisture evaporates, leading to a relative increase in the proportion of all other constituents, including lipids, on a dry weight basis. This concentration effect explains why samples with lower moisture content often exhibit higher fat percentages. The fat content of the biscuits falls within the standard range of 15-20% characteristic of soft dough biscuits (Hama-Ba et al., 2018). These findings are consistent with other researchers such as Asif-Ul-Alam et al. (2014) and Silky and Tiwari (2014), who reported similar values of 15.10%-18.10% in biscuits prepared using composite flours with varying blend proportions.

The total ash values ranged from 1.47-1.92%. Ash content serves as a reliable proxy indicator of the total mineral constituents present in food materials. During ash determination, the sample is subjected to high-temperature combustion in the presence of atmospheric oxygen, resulting in the complete oxidation and volatilization of organic components (water, proteins, lipids, and carbohydrates), leaving behind the inorganic mineral residue (Sanni et al., 2008). From a nutritional standpoint, these minerals function as essential cofactors and activators for numerous enzymatic reactions involved in the catabolism of macronutrients, including lipid oxidation and carbohydrate metabolism.

The significant increase in ash content observed with higher inclusion levels of soybean and sweet potato puree can be attributed to their superior mineral profiles compared to wheat flour. Soybeans are particularly rich in minerals such as calcium, magnesium, iron, and potassium (Ali et al., 2020), while sweet potato contains substantial amounts of potassium, manganese, and copper (Hossain et al., 2022). The observation of this study aligns with the reporting of Guyih et al. (2020) who documented increased ash contents in biscuits produced from composites of wheat, almond seeds and carrot flour. However, this observation contradicts the report by Bello et al. (2008) who observed reduction in total ash content of biscuits made using blends of wheat, yellow yam, unripe plantain and pumpkin flour. These contradictory findings can be explained by variations in the inherent mineral composition of the raw materials used in the flour blend formulations, as well as potential differences in processing methods that may affect mineral retention.

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Crude fibre content ranged from 4.85-6.85%. Fibre comprises primarily indigestible polysaccharides including hemicelluloses, cellulose, and lignin, along with resistant starch and oligosaccharides. These components exert profound physiological effects on gastrointestinal health and metabolic regulation in humans (Atobatele and Afolabi, 2016). Fibre increases fecal bulk, reduces gastrointestinal transit time, modulates glucose absorption kinetics, reduces postprandial glycemic response, lowers serum cholesterol levels through bile acid sequestration, and promotes beneficial gut microbiota proliferation.

The addition of soybean and SPP flour to wheat flour had significant ($p<0.05$) effects on the fibre content of biscuit samples. This enhancement can be mechanistically explained by the high fiber content of both soybean (containing approximately 15-20% total dietary fiber) and sweet potato (containing 3-5% fibre in fresh weight, concentrated in puree form), which substantially exceeds that of refined wheat flour (typically 2-3% fibre). Similar findings were reported by Eke et al. (2019) who observed increased fiber content in cookies formulated with sweetpotato and cashew nut flour blended with wheat. Guyih et al. (2020) documented comparable results in wheat, almond seed and carrot flour blend cookies. The fibre content obtained in this research indicates that biscuits produced from wheat, soybean and sweetpotato puree blends would provide meaningful dietary fiber contributions when consumed, potentially aiding in meeting recommended daily fiber intake of 25-30 g/day.

The values of crude protein were 12.85-17.08%. The protein contents of the biscuits prepared with different flour blends varied significantly ($p<0.05$). These findings align closely with those provided by Passos et al. (2013). The results indicated that sample (75:20:5) contained the highest percentage of protein. This can be attributed to the superior protein content of both soybean (approximately 35-40% protein) and wheat (10-14% protein) compared to sweet potato (1-2% protein on fresh weight basis).

The biological value of the protein is also enhanced through complementary protein effects: wheat protein is limiting in lysine but adequate in methionine, while soybean protein is rich in lysine but limiting in methionine, thus creating a more complete amino acid profile when combined (Ijarotimi et al., 2021). Beyond their primary role as structural and functional proteins, these macromolecules serve as transport vehicles for micronutrients, facilitating the absorption and distribution of lipids, vitamin A (via retinol-binding protein), iron (via transferrin), sodium and potassium (through various carrier proteins) throughout the body (Mahan and Escott-Stump, 2008).

The total carbohydrate content was found to be 44.08- 46.44%. The carbohydrate content decreased significantly ($p<0.05$) with the incorporation of soybeans and SPP flour in the blends. This reduction can be explained by the displacement of high-carbohydrate wheat flour (which contains approximately 70-75% carbohydrate) with lower-carbohydrate ingredients. Soybean flour contains only 30-35% carbohydrate due to its high protein and fat content, while sweet potato puree, though containing significant carbohydrates, has lower carbohydrate concentration on a dry weight basis compared to wheat flour due to its moisture content and fiber composition. The carbohydrate values in the present study (44.08-46.44%) were considerably lower than the 77.11-81.18% described by Guyih et al. (2020), which can be attributed to the low carbohydrate content of soybean flour and the high level of reducing sugars rather than complex carbohydrates in sweetpotato flour used in this study (Adeola and Ohizua, 2020; Ayo-Omogie and Ogunsakin, 2013). Similar trends of carbohydrate reduction were reported by Ndife et al. (2020) when almond seed and carrot flour were added as partial substitutes for wheat in biscuit formulations.

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Table 2

Proximate composition of biscuit from wheat, soybean and sweet potato puree

WF %	SPP %	SF %	Moisture Content %	Crude Fat %	Total Ash %	Crude Fibre %	Crude Protein %	Total CHO %
72.50	22.50	5.00	12.93±0.04^{e}	18.63±0.03^{d}	1.63±0.01^{c}	6.08±0.04^{cd}	14.91±0.02^{d}	45.83±0.00^{d}
70.83	20.83	8.34	18.87±0.04^{g}	17.11±0.02^{a}	1.47±0.02^{a}	4.85±0.02^{a}	12.85±0.02^{a}	44.88±0.12^{b}
75.00	20.00	5.00	9.08±0.03^{a}	19.63±0.03^{h}	1.92±0.02^{f}	6.85±0.03^{g}	17.08±0.03^{g}	45.59±0.18^{c}
70.00	20.00	10.00	11.22±0.02^{b}	18.89±0.04^{f}	1.92±0.02^{e}	6.59±0.01^{f}	16.68±0.01^{f}	44.85±0.03^{b}
72.50	22.50	5.00	12.75±0.02^{d}	18.14±0.02^{c}	1.83±0.02^{e}	6.04±0.03^{c}	14.91±0.02^{d}	46.35±0.07^{e}
70.83	23.33	5.83	12.20±0.04^{c}	19.08±0.03^{g}	1.64±0.02^{c}	6.24±0.02^{e}	16.14±0.02^{e}	44.72±0.09^{b}
73.33	20.83	5.83	18.67±0.03^{f}	17.64±0.02^{a}	1.54±0.04^{b}	5.08±0.03^{b}	13.00±0.03^{b}	44.08±0.01^{a}
71.67	21.67	6.67	11.93±0.04^{d}	18.11±0.02^{c}	1.74±0.01^{d}	5.04±0.03^{b}	13.91±0.03^{cd}	44.32±0.02^{a}
72.50	20.00	7.50	11.74±0.02^{c}	17.14±0.04^{ab}	1.73±0.02^{c}	6.65±0.02^{f}	13.85±0.02^{c}	45.47±0.01^{bc}
75.00	20.00	5.00	10.08±0.03^{b}	18.63±0.03^{d}	1.82±0.04^{e}	6.49±0.01^{f}	15.78±0.01^{de}	44.90±0.09^{b}
70.00	25.00	5.00	13.30±0.04^{d}	17.89±0.02^{b}	1.80±0.02^{e}	5.24±0.03^{bc}	15.91±0.01^{e}	45.78±0.08^{c}
70.00	20.00	10.00	10.22±0.02^{b}	17.90±0.01^{c}	1.82±0.03^{e}	6.35±0.03^{cd}	15.14±0.03^{de}	46.20±0.02^{e}
72.50	22.50	5.00	13.93±0.03^{d}	19.14±0.02^{f}	1.53±0.02^{b}	5.08±0.02^{b}	14.73±0.02^{d}	45.47±0.12^{c}
100	0.00	0.00	12.75±0.04^{d}	18.31±0.01^{c}	1.72±0.02^{d}	6.14±0.02^{d}	14.66±0.03^{c}	46.44±0.12^{e}

Means in same column with different superscripts are significantly ($p<0.05$) different.
WF = Wheat flour, SF = Soybean flour, SPP = Sweetpotato puree.

Mineral content of the biscuit from wheat, soybean and sweetpotato puree

Table 3 revealed mineral composition of the biscuit using wheat, soybean and sweetpotato puree flour mixes.

Table 3

Mineral content of biscuit from wheat, soybean and sweet potato puree

No	Potassium mg/100 g	Calcium mg/100 g	Magnesium mg/100 g	Iron mg/100 g	Zinc mg/100 g
1	118.71±0.02^{c}	24.86±0.01^{c}	14.65±0.01^{e}	0.33±0.00^{de}	0.42±0.01^{de}
2	120.69±0.01^{d}	27.10±0.01^{g}	16.12±0.01^{h}	0.30±0.01^{ab}	0.40±0.01^{bc}
3	114.70±0.01^{b}	25.12±0.01^{d}	14.91±0.00^{f}	0.31±0.00^{cd}	0.43±0.01^{e}
4	123.72±0.01^{f}	23.66±0.00^{a}	12.74±0.01^{a}	0.31±0.01^{bc}	0.39±0.01^{ab}
5	128.90±0.01^{h}	28.77±0.01^{h}	16.05±0.00^{g}	0.28±0.01^{a}	0.41±0.01^{cd}
6	125.10±0.01^{g}	26.91±0.00^{f}	13.79±0.00^{c}	0.29±0.01^{a}	0.43±0.00^{e}
7	110.90±0.01^{a}	24.09±0.01^{b}	14.19±0.00^{d}	0.34±0.01^{e}	0.39±0.01^{a}
8	119.49±0.01^{c}	25.09±0.00^{d}	13.74±0.01^{c}	0.30±0.01^{ab}	0.41±0.01^{cd}
9	124.57±0.02^{g}	24.95±0.01^{c}	15.00±0.01^{fg}	0.29±0.01^{a}	0.40±0.00^{c}
10	115.80±0.01^{b}	27.30±0.00^{h}	15.05±0.00^{g}	0.32±0.00^{d}	0.39±0.00^{bc}
11	121.70±0.01^{fg}	24.66±0.01^{c}	15.12±0.00g	0.34±0.01^{e}	0.42±0.01^{e}
12	120.72±0.02^{f}	23.86±0.01^{b}	13.98±0.01^{c}	0.32±0.01^{de}	0.43±0.01^{de}
13	119.71±0.02^{e}	24.83±0.01^{c}	14.50±0.01^{d}	0.34±0.00^{e}	0.42±0.01^{d}
14	122.66±0.01^{e}	26.19±0.01^{e}	12.98±0.00^{b}	0.29±0.01^{a}	0.42±0.01^{de}

Means in same column with different superscripts are significantly ($p<0.05$) different.
WF = Wheat flour, SF = Soybean flour, SPP = Sweetpotato pure

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The findings indicated that, potassium, whose value was between 110.90 and 128.90 mg/100 g, showing a significant ($p<0.05$) increase with higher inclusion levels of soybeans and SPP flour. Sample (72.5:20:7.5) exhibited the highest potassium content while sample (73.33:20.83:5.83) showed the lowest. Potassium functions as the primary intracellular cat-ion, playing crucial roles in maintaining cellular osmotic pressure, regulating acid-base balance, facilitating nerve impulse transmission, enabling muscle contraction (including cardiac muscle), and modulating blood pressure through antagonistic effects on sodium (Bolarinwa et al., 2016). The elevated potassium levels can be attributed to the inherently high potassium content of sweet potato puree; Badila et al. (2009) reported potassium concentrations of 243 mg/100 g in sweetpotato. This finding is consistent with the value of 110.9-128.9 mg/100 g reported by Roger et al. (2022) in biscuits prepared using wheat and sweet potato flour blends. Guyih et al. (2020) similarly documented enhancement of potassium content in cookies formulated from wheat, almond seed and carrot flour blends. The potassium levels in both control and composite flour biscuits remained substantially below the Recommended Daily Allowance (RDA) of 3500 mg/day (USDA, 2018). The amounts of calcium measured was between 23.66 to 28.77mg/100 g. The content of calcium in the samples of the biscuit was significantly ($p < 0.05$) different. There was a progressive increase in calcium content with the addition of soybeans and SPP flour to the blends. Calcium serves multiple critical physiological functions including skeletal mineralization, blood coagulation, neurotransmitter release, muscle contraction, enzyme activation, and cellular signaling as a secondary messenger (Bakare et al., 2020). The gradual increase in calcium content can be attributed to the relatively high calcium levels in both soybean flour (approximately 200-280 mg/100 g) and sweet potato puree (30-50 mg/100 g), which substantially exceed the calcium content of refined wheat flour (15-20 mg/100 g). This finding aligns with observations by Bakare et al. (2020), who documented increased calcium content in biscuits formulated from breadfruit and wheat flour enriched with edible fish meal. In contrast, Adegbanke et al. (2020) reported markedly lower calcium contents (2.12-4.45 mg/100 g) in wheat and Bambara nut flour biscuits, suggesting variability based on ingredient selection and processing methods. The calcium content of all biscuit samples remained considerably below the US Department of Agriculture's recommended dietary allowance (RDA) of 800 mg/day, indicating that these biscuits would provide only modest contributions to daily calcium requirements.

Magnesium was within 12.74-16.12 mg/100 g respectively. Magnesium functions as an essential cofactor in over 300 enzymatic reactions, including those involved in ATP synthesis, DNA and RNA synthesis, protein synthesis, muscle contraction and relaxation, neurological function regulation, cardiac rhythm stabilization, blood glucose homeostasis, and blood pressure regulation (Bolarinwa et al., 2016). The incorporation of soybeans and SPP flour significantly ($p<0.05$) increased the magnesium content of the biscuits. This enhancement can be attributed to the high magnesium content of both soybean flour (approximately 280 mg/100 g) and sweet potato (25-30 mg/100 g fresh weight basis), compared to wheat flour (20-25 mg/100 g). The results contrast with the higher values of 32-49 mg/100 g reported by Roger et al. (2022) in wheat and sweet potato flour blend biscuits, and 58.96-56.12 mg/100 g documented by Guyih et al. (2020) in biscuits prepared from wheat, almond seed and carrot flour blends. These discrepancies may be attributed to variations in raw material varieties, processing methods, and analytical techniques employed.

The outcomes have also indicated that the level of iron within the range between 0.28 and 0.34 mg/100 g. Iron plays indispensable roles in oxygen transport (as a component of hemoglobin and myoglobin), electron transport chain reactions within mitochondria, and numerous enzymatic reactions including those involved in energy metabolism and DNA synthesis (Elinge et al., 2012). The results indicated a progressive increase in iron content with higher inclusion levels of soybean and SPP flour in the biscuit formulations. This enhancement can be attributed to the addition of

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soybeans and SPP flour, which are micronutrient-dense ingredients. Soybeans contain approximately 6-8 mg iron/100 g, while sweet potato contains 0.6-1.0 mg/100 g, both exceeding the iron content of refined wheat flour (1.0-1.5 mg/100 g). The bioavailability of iron in these products is further influenced by the presence of phytic acid (which inhibits iron absorption) and ascorbic acid in sweet potato (which enhances non-heme iron absorption). This finding is consistent with Adegbanke et al. (2020) who reported iron contents of 0.97-1.21 mg/100 g in biscuits composed of wheat and Bambara nut flour. However, the iron content of all biscuit samples remained substantially below the RDA of 18 mg/day (USDA, 2018), indicating that these products would provide only minor contributions to daily iron requirements.

The range of value of zinc is 0.39-0.43 mg/100 g. Zinc functions as a cofactor for over 300 metalloenzymes, playing crucial roles in protein synthesis, nucleic acid metabolism, immune function, wound healing, taste perception, and antioxidant defense through superoxide dismutase activity (Elinge et al., 2012). The zinc content increased progressively with higher incorporation of soybeans and SPP flour in the biscuits. Sample (75:20:5) exhibited the highest zinc level compared to sample (100:0:0) and other flour blend formulations. This can be explained by the significantly higher zinc content in soybeans (3-5 mg/100 g) compared to wheat flour (0.7-1.2 mg/100 g), which leads to elevated zinc levels with increasing soybean inclusion. The bioavailability of zinc in these products may be limited by the presence of phytic acid, particularly from soybean flour, which can form insoluble complexes with zinc in the intestinal lumen. The findings contrast with those of Adegbanke et al. (2020), who observed that adding Bambara nut protein isolate to wheat-based biscuits resulted in decreased zinc content. The zinc content of all biscuit samples remained substantially below the RDA of 11 mg/day (USDA, 2020), suggesting these products would provide only modest contributions to daily zinc requirements.

Physical properties of biscuit from wheat, soybean and sweetpotato puree

Table 4 shows the data of the results of physical properties of biscuit. The physical properties of biscuit showed a significant difference ($p < 0.05$). The lightness, the redness and yellowness have ranges of L* (45.42 and 51.16), a* (2.83 and 5.03) and b* (17.73 and 22.34), respectively. One of the notable characteristics of colour is its potential to stimulate appetite in an individual (Adeola and Ohizua, 2018). In baking and roasting, one of the factors applied when it comes to the process control is colour, since the pigments in brown tend to become visible as the browning and caramelization chemical reactions occur (Oke et al., 2021; Pereira et al., 2013).

The lower lightness (L*) values in biscuits with higher concentrations of soybean flour and sweetpotato puree can be attributed to enhanced browning during baking, resulting from the increased availability of both reducing sugars (particularly in sweetpotato) and proteins rich in amino acids (particularly in soybean), which serve as Maillard reaction substrates. The positive values of redness (a*) and yellowness (b*) indicate predominance of these hues in the biscuit samples. Sweet potatoes contain substantial concentrations of carotenoid pigments, including beta-carotene, which impart characteristic orange-red coloration (Hossain et al., 2022). The redness (a*) values increased with higher sweetpotato puree inclusion due to the contribution of these thermostable natural pigments. Similarly, beta-carotene is the primary carotenoid responsible for the yellow-orange pigmentation of sweet potatoes. As the percentage of sweetpotato puree in the formulation increases, yellowness (b*) values rise due to the concentration of these pigments. Soy flour additionally contributes to yellowness through its content of lutein, zeaxanthin, and other minor carotenoids.

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Table 4

Physical properties of biscuit from wheat, soybean and sweet potato puree

WF %	SPP %	SF %	Lightness L*	Redness a*	Yellowness b*	Weight g	Diameter mm	Thickness mm	Spread Ratio
72.50	22.50	5.00	47.04 ±0.04[c]	4.39 ±0.02[b]	17.73 ±0.42[a]	9.52 ±0.02[a]	41.89 ±0.04[a]	7.21 ±0.01[a]	5.81 ±0.01[e]
70.83	20.83	8.34	45.42 ±0.01[a]	4.83 ±0.01[d]	20.58 ±0.01[f]	15.22 ±0.03[h]	46.22 ±0.03[b]	9.84 ±0.01[g]	4.70 ±0.00[a]
75.00	20.00	5.00	48.54 ±0.02[d]	4.54 ±0.02[c]	19.16 ±0.03[c]	14.72 ±0.02[g]	46.57 ±0.03[c]	10.17 ±0.02[h]	4.58 ±0.01[a]
70.00	20.00	10.00	46.63 ±0.01[b]	5.03 ±0.01[e]	19.99 ±0.01[e]	13.61 ±0.01[d]	47.43 ±0.03[d]	8.68 ±0.02[e]	5.47 ±0.01[c]
72.50	22.50	5.00	50.08 ±0.01[f]	4.54 ±0.01[c]	18.51 ±0.01[b]	13.14 ±0.01[b]	47.57 ±0.04[e]	7.76 ±0.02[b]	6.14 ±0.02[f]
70.83	23.33	5.83	48.63 ±0.01[e]	4.36 ±0.01[b]	19.52 ±0.01[d]	13.40 ±0.00[c]	47.85 ±0.01[f]	8.46 ±0.02[c]	5.66 ±0.01[d]
73.33	20.83	5.83	47.06 ±0.01[c]	4.53 ±0.01[c]	20.40 ±0.01[f]	14.58 ±0.01[f]	46.25 ±0.03[b]	9.73 ±0.02[f]	4.87 ±0.18[b]
71.67	21.67	6.67	46.05 ±0.04[b]	4.46 ±0.01[c]	18.83 ±0.02[b]	11.52 ±0.01[a]	42.89 ±0.02[b]	8.21 ±0.02[e]	4.81 ±0.01[b]
72.50	20.00	7.50	46.42 ±0.01[b]	4.43 ±0.01[b]	21.58 ±0.04[g]	14.22 ±0.03[de]	45.22 ±0.03[b]	8.84 ±0.01[f]	5.70 ±0.01[d]
75.00	20.00	5.00	49.54 ±0.02[f]	4.64 ±0.01[b]	20.16 ±0.03[f]	13.72 ±0.02[d]	47.57 ±0.04[b]	9.17 ±0.01[g]	5.58 ±0.00[d]
70.00	25.00	5.00	45.63 ±0.01[a]	4.03 ±0.02[b]	20.99 ±0.01[g]	14.61 ±0.01[g]	46.43 ±0.03[cd]	9.68 ±0.01[g]	4.60 ±0.02[c]
70.00	20.00	10.00	51.08 ±0.00[g]	5.03 ±0.02[e]	19.51 ±0.02[e]	14.14 ±0.02[fg]	46.57 ±0.03[c]	8.76 ±0.02[e]	5.14 ±0.18[cd]
72.50	22.50	5.00	48.06 ±0.01[d]	4.39 ±0.01[b]	20.52 ±0.01[f]	14.40 ±0.01[g]	45.25 ±0.01[b]	9.46 ±0.02[g]	4.66 ±0.01[b]
100	0.00	0.00	51.16 ±0.00[g]	2.83 ±0.01[a]	22.34 ±0.01[g]	14.32 ±0.01[e]	47.51 ±0.02[e]	8.62 ±0.02[d]	5.52 ±0.01[cd]

Means in same column with different superscripts are significantly ($p<0.05$) different.
WF = Wheat flour, S = Soybean flour, SPP = Sweetpotato puree.

The biscuits weighed between 9.52 -15.22 g, with significant ($p<0.05$) increases observed with higher inclusion levels of soybeans and SPP flour. According to Bello et al. (2008), variations in biscuit weight can be explained by differential water-holding capacities of the flours, which influence moisture retention during baking and consequently affect final product weight. The water-holding capacity is determined by the protein composition, fibre content, and starch characteristics of each flour component. This finding contrasts with Uboor et al. (2022), who reported cookies weight increases from 14.33 g to 16.13 g when cassava and pumpkin were incorporated into wheat flour blends. Eke et al. (2019) similarly observed weight increases in biscuit samples with the addition of sweet potato and African yam bean flour to wheat flour blends. Biscuit diameter was 41.89 - 47.85 mm, increasing significantly with the addition of soybeans and SPP flour. Sample (72.5:22.5:5) exhibited greater diameter than both flour blend and control biscuits. This finding aligns with Bello et al. (2008), who

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noted diameter increases upon addition of 10% yellow yam and unripe plantain flour to wheat flour biscuits. The increase in diameter can be explained by the dilution of wheat gluten. Soyflour is gluten-free and contains high protein levels, but these proteins do not form the viscoelastic gluten network characteristic of wheat proteins. Consequently, soyflour addition weakens the gluten structure, resulting in reduced dough elasticity and increased extensibility. During baking, this leads to greater lateral spreading before the structure sets, producing biscuits with larger diameters.

The spread ratios were within 4.58 -5.81, with values increasing as soybeans and SPP flour were incorporated. According to Eke et al. (2019), spread ratio is influenced by dough viscosity, with lower viscosity dough exhibiting more rapid spreading in the oven before structure fixation occurs. The increased spreading with soybean and SPP flour addition can be attributed to alterations in the dough's viscoelastic properties. These findings are consistent with Jothi et al. (2014), who reported elevated spread ratios (3.31 - 4.43) in blends incorporating soybeans and orange-fleshed sweet potato (OFSP) flour. The highest spread ratio was observed in sample (72.5:22.0:5). The optimal spread ratio was recorded in the sample containing 20.83% SPP and 8.34% soybeans flour. Lower spread ratios are generally associated with enhanced crispness and improved overall acceptability in baked products, as they indicate a more compact structure with better texture development. Accordingly, biscuits formulated with 20.83% soybean and 8.34% SPP flour are expected to exhibit superior consumer acceptability characteristics.

Textural properties of biscuit from wheat, soybean and sweet potato puree flour

Table 5 shows a difference in the peak force values of 2572-6555 N. Sample 71.67:21.67:6.67 had the lowest value compared to sample 71.67:21.67:6.67 which had the highest value but the difference was not significant ($p>0.05$). During baking starch swells by the absorption of water and the result is a change in texture to a tender product. Due to the high content of starch found in sweetpotato, its addition into the dough would denote low gelatinization, subsequently, destabilizing the entire integrity of the biscuit and leading to low peak force. The chewiness value was found to be between 2174.50 and 5635.50N. Sample 75:20:5 and 73.33:20.83:5.83 indicated the lowest value whereas sample ratio 75.00:20.00:5.00 had the highest value, and there was a significant difference ($p<0.05$) among the samples in terms of chewiness. Chewiness-requires sufficient energy to chew solid food until it is ready to swallow. It is at times approximated as multiplication of the hardness, cohesiveness and elasticity (Guo, 2021). The hydration of the dough is known to affect chewiness. The elevated moisture level leads to the decrease in the level of stiffness and the decrease of chewiness since the dough is less strong and easy to dissolve during the chewing process. Soyflour and sweetpotato purees have very high water absorption capacities. Incorporated into the dough, they will be less dry and therefore biscuits will be less chewy.

The adhesiveness value was 5.46 to 16.68 N·s. Sample (72.50:22.50:5.00) exhibited the lowest value while sample (71.67:21.67:6.67) showed the highest, with significant differences ($p<0.05$) among samples. Adhesiveness quantifies the degree of stickiness, representing the work required to overcome attractive forces between the probe surface and the sample surface during texture analysis (Trinh and Glasgow, 2012).

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Table 5

Textural properties of biscuit from wheat, soybean and sweet potato puree

WF	SPP	SF	Peak Force N	Chewiness N	Adhesiveness N·s	Gumminess N	Springiness	Cohesiveness
72.50	22.50	5.00	6456.00 ±4.24^{b}	5635.50 ±4.94^{g}	5.46 ±0.04^{a}	6477.50 ±10.61^{f}	0.89 ±0.03^{cd}	1.11 ±0.15^{f}
70.83	20.83	8.34	3595.00 ±5.66^{ab}	3677.50 ±1.26^{f}	14.04 ±0.04^{cd}	3684.50 ±6.36^{ab}	0.95 ±0.08^{d}	1.02 ±0.01^{f}
75.00	20.00	5.00	3588.50 ±3.53^{ab}	2311.50 ±1.15^{c}	10.85 ±0.06^{bc}	5326.00 ±4.24^{e}	0.48 ±0.04^{b}	0.40 ±0.08^{b}
70.00	20.00	10.00	4068.50 ±1.92^{ab}	2283.00 ±2.83^{bc}	6.65 ±0.05^{ab}	3858.50 ±4.95^{abc}	0.58 ±0.01^{b}	0.90 ±0.03^{f}
72.50	22.50	5.00	6555.00 ±4.24^{b}	2444.00 ±4.24^{d}	15.36 ±0.05^{cd}	6448.50 ±10.61^{f}	1.07 ±0.10^{d}	0.83 ±0.05^{e}
70.83	23.33	5.83	5483.50 ±7.77^{ab}	2804.50 ±6.36^{e}	14.54 ±0.04^{cd}	4683.00 ±2.83^{cde}	1.06 ±0.04^{d}	0.65 ±0.05^{c}
73.33	20.83	5.83	3546.50 ±2.12^{ab}	2174.50 ±0.71^{a}	15.18 ±0.01^{cd}	3511.50 ±2.12^{ab}	0.91 ±0.01^{d}	1.07 ±0.02^{f}
71.67	21.67	6.67	2572.00 ±1.79^{a}	2223.50 ±3.54^{ab}	16.68 ±0.05^{d}	3403.00 ±4.24^{a}	0.13 ±0.18^{a}	0.05 ±0.07^{a}
72.50	20.00	7.50	3837.50 ±4.66^{ab}	2223.50 ±3.54^{ab}	15.15 ±0.01^{cd}	4189.00 ±5.44^{abcd}	0.53 ±0.04^{b}	1.02 ±0.03^{f}
75.00	20.00	5.00	4766.00 ±4.00^{ab}	2174.50 ±0.71^{a}	16.02 ±0.95^{d}	4904.00 ±4.49^{de}	1.00 ±0.01^{d}	0.48 ±0.04^{b}
70.00	25.00	5.00	4554.50 ±5.46^{ab}	2806.00 ±4.24^{e}	11.00 ±0.17^{bc}	4607.00 ±3.96^{cde}	0.89 ±0.19^{cd}	0.68 ±0.04^{cd}
70.00	20.00	10.00	5050.00 ±3.54^{ab}	2444.00 ±4.24^{d}	14.30 ±0.35^{cd}	4260.50 ±3.86^{bcd}	1.03 ±0.23^{d}	0.47 ±0.05^{b}
72.50	22.50	5.00	5000.50 ±5.44^{ab}	2282.00 ±1.41^{bc}	6.07 ±0.86^{a}	4949.00 ±3.25^{de}	0.85 ±0.13^{cd}	0.78 ±0.04^{cde}
100	0.00	0.00	4439.00 ±4.35^{ab}	2261.50 ±5.45^{bc}	13.77 ±4.12^{cd}	4541.00 ±6.94^{cde}	0.65 ±0.01^{bc}	0·78 ±0.01^{de}

Means in same column with different superscripts are significantly ($p<0.05$) different.
WF = Wheat flour, S = Soybean flour, SPP = Sweetpotato puree.

At higher moisture contents, biscuit dough becomes increasingly cohesive and adhesive as water acts as a plasticizer, increasing molecular mobility and promoting intermolecular interactions. Enhanced moisture retention associated with higher percentages of sweetpotato puree or soyflour increases adhesiveness by facilitating greater contact between ingredients and promoting sticky characteristics. Excessively adhesive biscuits require more extensive jaw movements during oral processing and increased masticatory effort, even when compressive hardness remains constant (Cakir et al., 2012).

The gumminess value ranged between 3403 and 6477.50 N where the sample 71.67:21.67:6.67 had the least value and there was significant different ($p<0.05$) when compared to the sample 72.50:22.50:5.00 which had the highest value. Gumminess represents the energy required to disintegrate a semi-solid food product to a state ready for swallowing (Trinh and Glasgow, 2012). Higher wheat flour percentages, which contribute gluten proteins, generally increase gumminess due to the elastic and cohesive nature of the gluten network formed by glutenin and gliadin proteins through disulfide bonds and hydrogen bonding. Conversely, sweetpotato puree and soyflour are

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gluten-free ingredients that dilute the gluten network, resulting in softer, less cohesive structures with reduced gumminess.

The springiness was within the range of 0.13 to 1.07, with sample (71.67:21.67:6.67) exhibiting the lowest value and sample (72.50:22.50:5.00) the highest, showing significant differences ($p<0.05$). Springiness represents the rate and extent of recovery when compressive force is removed, indicating the elastic properties of the sample. The springiness values obtained in this work exceed those reported in other cookie studies (Pereira et al., 2013), suggesting enhanced elastic recovery properties. Cohesiveness values ranged from 0.05 to 1.11, with sample (71.67:21.67:6.67) showing the lowest and sample (72.50:22.50:5.00) the highest value, with significant differences ($p<0.05$). Cohesiveness quantifies the strength of internal bonds holding the structure together, measuring the material's ability to withstand a second deformation relative to its resistance during initial deformation. Higher cohesiveness values indicate stronger intermolecular forces and more integrated structural networks within the biscuit matrix.

Sensory properties of biscuit from wheat, soybean and sweet potato puree flour

Sensory properties like colour, texture, flavour, aroma and overall acceptability can be applicable in the identification of food products. Table 7 indicated that colour varied between 7.02 and 7.64. The colour had the least value in sample 72.50:22.50:5.00 and highest in sample 72.5:22.5:5 with no significant difference ($p >0.05$). Makanjuola and Adebowale (2020) also noted that the colour of biscuit samples reduced with addition of water yam flour in blends. The result of this study is not similar to the report of Afari, (2023) that the addition of tigernut flour and pineapple puree in blends reduced the colour rating. All the samples had colour rating within the limit of acceptability. The texture was measured as 6.22-7.22. There was no significant difference ($p>0.05$) among the samples in terms of the texture, sample 72.5:22.5:5 had the least value and sample 75:20:5 and 100:0:0 had the highest value. The taste values were between 7.00 and 7.66. Sample 70.83:20.83:8.34 had the lowest value whereas sample 70.83:23.33:5.83 had the highest value, and there were significant differences ($p<0.05$) among the samples in the taste. The resultant effects of the high concentration of soybean and SPP flour in the blends might be that it influenced the flavor of the biscuit sample. The result does not concur with the report by Makanjuola and Adebowale, (2020) and Afari (2023) on wheat-water yam and wheat-tigernut cookies supplemented with pineapple purée respectively because they did not report high acceptability ratings. This could be due to the high level of taste rating of samples containing high level of wheat since consumers could be used to bake products that contain wheat. The aroma value was recorded in the range of 6.04 and 7.98. The sample 72.5:22.5:5 had the lowest score and the sample 72.5:20:7.5 had the highest score, there was a significant different ($p<0.05$) among the samples regarding the aroma. The Aroma and overall acceptability score of flour blends biscuit samples also slightly decreased as soybeans and SPP flour was added in the blends. This might be as a result of the incorporation of soybeans and incorporation of SPP flour in the mix. This corroborates the findings of Iweh et al. (2017) who found out that aroma and overall acceptability rating of the biscuits sample decreased with the addition of almond seed and carrot flour in the blends. The overall acceptability was between 7.14 and 7.56. The overall acceptability of sample 72.5:22.5:5 was the least in value compared with the high value of the overall acceptability of the sample 72.5:20.00:7.50 and there was no significant difference ($p>0.05$) among the samples. These differences in the overall acceptability of different composite cookies may be explained by the variation in the likeness with regards to taste, colour, aroma and texture. The overall acceptability rating of the control biscuit and biscuit made using wheat, soybean and sweet potato puree flour blends samples was however within the acceptable score rating. The study revealed that it is possible to obtain biscuit of acceptable quality by using blends of wheat, soybeans and SPP flour.

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Table 6

Sensory properties of biscuit from wheat, soybean and sweet potato puree

WF	SPP	SF	Colour	Texture	Aroma	Taste	OA
72.50	22.50	5.00	7.02 ± 1.41^a	6.84 ± 1.97^a	6.88 ± 1.51^a	7.34 ± 1.45^a	7.14 ± 1.63^a
70.83	20.83	8.34	7.26 ± 1.58^a	6.72 ± 2.38^a	6.98 ± 1.62^a	7.00 ± 1.84^a	7.18 ± 1.87^a
75.00	20.00	5.00	7.12 ± 1.12^a	7.02 ± 1.41^a	6.90 ± 1.17^a	7.48 ± 1.04^a	7.30 ± 1.06^a
70.00	20.00	10.00	7.10 ± 1.56^a	6.82 ± 2.18^a	6.96 ± 1.73^a	7.32 ± 1.60^a	7.18 ± 1.77^a
72.50	22.50	5.00	7.54 ± 1.07^a	7.06 ± 1.89^a	7.26 ± 1.28^a	7.32 ± 1.50^a	7.14 ± 1.34^a
70.83	23.33	5.83	7.24 ± 1.17^a	7.06 ± 1.53^a	7.04 ± 1.29^a	7.66 ± 0.98^a	7.36 ± 1.06^a
73.33	20.83	5.83	7.44 ± 1.51^a	6.86 ± 2.32^a	7.04 ± 1.81^a	7.14 ± 1.87^a	7.26 ± 1.89^a
71.67	21.67	6.67	7.06 ± 1.36^a	6.94 ± 1.44^a	7.98 ± 1.71^a	7.23 ± 1.50^a	7.24 ± 1.53^a
72.50	20.00	7.50	7.16 ± 1.27^a	6.52 ± 1.55^a	7.78 ± 1.29^a	7.08 ± 1.74^a	7.38 ± 1.78^a
75.00	20.00	5.00	7.22 ± 1.26^a	7.22 ± 1.63^a	6.70 ± 1.43^a	7.46 ± 1.34^a	7.25 ± 1.45^a
70.00	25.00	5.00	7.20 ± 1.32^a	7.36 ± 1.79^a	6.76 ± 1.27^a	7.38 ± 1.35^a	7.19 ± 1.47^a
70.00	20.00	10.00	7.34 ± 1.48^a	7.16 ± 2.28^a	6.26 ± 1.52^a	7.24 ± 0.99^a	7.22 ± 1.07^a
72.50	22.50	5.00	7.64 ± 1.61^a	6.22 ± 1.87^a	6.04 ± 1.41^a	7.37 ± 1.32^a	7.14 ± 1.99^a
100	0.00	0.00	7.47 ± 1.16^a	7.22 ± 1.65^a	7.30 ± 1.22^a	7.58 ± 1.42^a	7.30 ± 1.28^a

Means in same column with different superscripts are significantly ($p<0.05$) different; OA = Overall Acceptability, W = Wheat, S = Soybeans, SPP = Sweet Potato Puree

Conclusions

The quality attribute of biscuit formulated from composite flours of wheat, soybeans, and sweet potato puree were evaluated. Moisture content of the biscuits showed significant variation, indicating that inclusion of soybean flour and sweetpotato puree enhanced moisture retention during baking, a key factor for product quality. Crude protein content increased significantly with the addition of soybean and sweetpotato puree, while total carbohydrate content decreased. The incorporation of these flours also improved the mineral composition of the biscuits, particularly potassium, magnesium and zinc. Colour properties revealed that higher levels of soybean flour and sweetpotato enhanced redness and yellowness. Biscuit weight and diameter increased with higher substitution levels. Sensory evaluation indicated that all samples were acceptable with the formulation containing wheat: soybean: sweet potato puree at 72.5:20.0:7.5 demonstrating the highest overall acceptability. These findings suggest that partial substitution of wheat with soybean flour and sweetpotato puree can improve the nutritional profile and sensory properties of biscuits without compromising product quality.

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