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Evaluation of the Qualities of Cookies Produced from Blends of Tigernut and Soybean Flour

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Abstract

This study investigated the physicochemical, functional and protein content of tigernut-soybean flour blends with the protein and sensory properties of cookies from the flour blends. Tigernut (*Cyperus esculentus*) and soybean (*Glycine max*) was mixed in the ratio of 90:10, 80:20, 70:30, 60:40, 50:50, coded as sample B, C, D, E and F respectively, while 100% wheat flour (sample A) served as control. All the analysis was carried out using standard analytical procedures. pH, total titratable acidity (% lactic acid), viscosity and total soluble solids (°Brix) ranged respectively, from 4.21 - 5.37, 0.021 - 0.039, 9.43 - 2.18 and 1.00 - 4.50% sugar. Least gelation capacity, oil absorption capacity, water absorption capacity, bulk density, dispersibility, swelling power, solubility and foaming capacity ranged from 0.10 - 0.50%, 1.64 - 1.81g/g, 1.23 - 2.13g/g, 0.45 - 0.55g/g, 31.00-36.00%, 3.87 - 5.68g/g, 13.59 - 29.32% and 15.00 - 25.00%for There was significant ($p<0.05$) increase in protein content of the flour (8.68 – 14.81%) and cookies (7.81 – 16.94%) with increase in soybean. Cookies produced from 60:40 % tigernut- soybean flour (sample E) had the highest degree of likeness for colour, aroma, appearance and overall acceptability in the range of like slightly to like moderately. The increase in protein and degree of likeness of the tigernut-soybean cookies suggests that the flour blends can substitute for wheat flour at levels of 70:30 and 60:40% in the production of acceptable cookies of nutritional quality.

Keywords: *Cookies, tigernut flour, soybean flour, protein, physicochemical, functional & sensory properties*

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1. Introduction

Cookies are a form of confectionary product which is consumed all over the world as snack food by children, adults on a large scale in developing countries where protein and caloric malnutrition may be prevalent (Chinma *et al*., 2012). They are nutritive snacks made from unpalatable dough that is transformed into appetizing product with the application of heat in an oven (Ikuomola *et al*., 2017). The demand for wheat flour in the production of cookies has significantly increased due to the progressive increase in the consumption of cookies and utilization of wheat flour by households in Nigeria (Ayo-Omogie and Odekunle, 2017). This partly stimulated the use of wheat-based composite flour in cookies production with the aim of improving the nutritional content of the cookies and also enhances crop utilization (Kiin-Kabari and Giami, 2015). Wheat flour is the basic raw material for cookies production; however, in Nigeria, high cost of wheat importation and non-production due to climate variation has affected production of certain snacks due to the depletion of the country's foreign reserve. The use of composite flour is now common so as to decrease the demand for imported wheat and encouraging the production and use of locally grown non-wheat agricultural products. Composite flour is a mixture of flours obtained from protein-rich legumes, roots and tubers which are rich in starch such as cassava, yam, potato, and cereals with wheat flour (Noorfarahzilah *et al*., 2014). Composite flour is desirable as it improves the nutritional value of bakery products. (Arukwe, 2020) reported that composite flours produced from legumes and tubers such as soybean, cassava, potatoes, cocoyam and others have higher protein content and caloric value.

Tigernut (*Cyperus esculentus*) is a root crop which is highly underutilized despite its nutritional quality. In Nigeria, tigernut is known as 'Aya' in Hausa, 'Ofio' in Yoruba, and 'Ahiausa' in Igbo where these varieties (black, brown and yellow) are cultivated. It can be eaten raw as a snack or crushed with the resulting white paste made into porridge or processed into refreshing beverage drinks (Akajiaku *et al*., 2018). Tigernut is an excellent source of dietary fiber, carbohydrate, and antioxidants (Omoba *et al*., 2015; Awolu *et al*., 2016) but has low protein content of 3.28-8.45% (Adel *et al*., 2015) when compared to soybean which have a protein content of 38-55% as reported by Ikuomola *et al*. (2017).

Soybean (*Glycine max*) is also one of the underutilized crops in terms of value addition and yet there is an increased agricultural activity for its production in Nigeria. It is a leguminous crop that belongs to the family (*Fabaceae*) formerly (*Legumesnosae*), which grows in tropical, Sub-tropical and temperate climates (Tafida *et al*., 2022). The seeds are high in protein, and their amino acid makeup is similar to that of animal proteins (Okwunodulu *et al*., 2022), and contain significant quantities of minerals and vitamins (Barber *et al*., 2017). The soybean which is a rich source of nutrients, has also been reported to have medicinal properties (Jing and Wei-Jie, 2016). The utilization of tigernut and soybean in the production of baked product such as cookies will not only improve the nutrient content but serve as a means of value-addition and in the reduction of the demand for the imported wheat. The physicochemical and functional properties of such composite flour is necessary to ascertain the flour behavior and suitability for food production.

Functional properties determine the complex interaction between the composition, structure, and molecular conformation. They determine whether the blends would be useful in bakery products where hydration to improve handling desired and in ground meat, doughnuts, and pancakes where oil absorption property is of prime importance (Mepba *et al*., 2007). Protein is believed to be mostly responsible for functional properties, such as foaming, emulsification, nitrogen solubility, oil, and water absorption. These properties are affected by the intrinsic factors of protein, such as molecular structure and size, and many environmental factors, including the method of protein separation or production (Yu *et al*., 2007). The low protein content and absence of gluten are considered disadvantageous for its exclusive use in food products, especially in those where the elasticity of the dough is essential for product quality (Mepba *et al*., 2007). Physicochemical and functional properties play important role in the flavour development and texture of food products.

The study therefore is aimed at evaluation of the physicochemical, functional, protein content and sensory properties of cookies produced from blends of tigernut and soybean flour with wheat flour as control.

2. Materials and Methods

2.1 Raw Materials, Ingredients and Analytical Chemicals

Fresh tigernut tubers, soybean seeds, wheat flour and all the ingredients used in the cookies production: eggs, baking powder, sugar, salt, baking fat and milk, were purchased at Mile 3 market in Diobu, Port Harcourt, Rivers State, Nigeria. Chemicals used were of analytical grades obtained from the Food Analysis Laboratory, Department of Food Science and Technology, Rivers State University.

2.2 Production of Tigernut flour

Tigernut flour was prepared using the method described by Ade-Omowaye *et al*. (2008) with some modifications. The tubers were sorted to remove unwanted materials like pebbles, stone, and foreign seeds, then washed with water. The cleaned nuts were dried at 60°C for 12 h, milled and sieved through 100 ɥm aperture size sieve and the resultant flour was packaged in ziploc bag and stored for further use.

2.3 Production of Soybean flour

Soybean flour was produced following the method described by Obinna-Echem *et al*., 2018. The seeds were sorted, washed, and soaked in water for 24 h with a change in water every 6 h before blanching at 85ºC for 2 min. The seed coats were removed; the seed was washed and dried in an oven (DHG-9140 A, Shanghai, China) at 30ºC for 24 h. The dried seeds were milled with an attrition mill (Globe P14, Shanghai, China) into flour and sieved with 100µm sieve size to obtain soy flour. The flour was packaged in well-labeled Ziploc bag and stored till needed for analysis.

2.4 Formulation of Tigernut and Soybean flour blends

Tigernut and soybean flour blends were formulated at different ratios of 90:10, 80:20, 70:30, 60:40, and 50:50 while 100% wheat flour was used as control. The flour blends were mixed using a Kenwood mixer (A90IE, Kenwood Haunt Hampshire, England) for 10 min in order to achieve uniform blending.

2.5 Production of Tigernut-Soybean Cookies

The method as described by Barber and Obinna-Echem (2016) was used in the cookie preparation. The flour blends, sugar, baking powder and salt were hand mixed in a bowl. This was followed by addition of the fat and further mixing by hand to obtain a bread crumb-like mixture. The mixture was transferred into food processor (Home luck). The liquid (egg and vanilla flavor) was added to the mixture and mixed at medium speed for 3-5min to obtain the dough. The dough was manually rolled out on a floured board into sheets of uniform thickness of 4 mm and cut with a circular cookie cutter with diameter of 4 cm. The cut dough was transferred to baking trays lined with grease-proof paper and baked at 180°C for 10 -15 min in a domestic oven. The cookies were allowed to cool to room temperature before packaging in air tight Ziploc and stored for further analysis.

2.6 Determination of the Physicochemical Properties of 100% Wheat and Tigernut-Soybean Flour Blends

pH, titratable acidity (as % lactic acid), total soluble solid (ºBrix) and viscosity was determined using AOAC (2012) standard method. The samples (2 g) were homogenized in 20 mL of distilled water and filtered into a beaker. The pH meter (Jenco 6177) after calibration and stabilization with standard buffer of pH 4.0 and 7.0, was used to determine the sample pH. Thereafter, 3 drops of phenolphthalein were added as the indicator and the mixture was titrated against 0.1 M NaOH. Acidity was expressed as % lactic acid with each ml of the 0.1 M NaOH equivalent to 0.0908 of lactic acid. Total soluble solids content was determined at 29±2ºC using Abbe hand refractometer. The sugar content percentage (soluble sugar) was read from the scale of the refractometer when held close to the eye. Viscosity of the 10 g of the flour sample in 100 mL of distilled water was determined using Rotary Viscometer (NDJ-85, China).

2.7 Determination of the Functional properties of 100% Wheat and Tigernut-Soybean flour blends

Water and oil absorption capacity, bulk density, least gelation concentration, dispersibility and foaming capacity were determined according to the method described by Onwuka (2005). Swelling power and solubility were determined according to the method described Aidoo *et a*l. (2022). Briefly, water and oil absorption capacity were determined by centrifugal-gravimetric method after the centrifugation of 1 g of the samples in 10 mL of distilled water and pure gino oil respectively. Loose and packed bulk density was determined gravimetrically before and after gentle tapping of 10 mL graduated cylinder filled with the samples until there was no further diminution of the sample levels. Least gelation concentration was determined as the concentration when the sample heated, cooled and held at 40°C for 2 h could not slip or fall from the inverted test tube. Dispersibility was determined gravimetrically after 5 g of the homogenized samples in 100 mL of distilled water were allowed to stand for 3 h. Swelling power and solubility were determined gravimetrically after heating to 85ºC, holding for 30 min before centrifugation at 1000 rpm for 15 min. Swelling capacity was calculated by dividing the sediment weight with the sample weight. The soluble component in the supernatant after evaporation of water was used in the computation of solubility (%) by dividing the soluble component weight with the sample weight multiplied by 100.

2.8 Determination of the Protein Content of 100% Wheat and Tigernut-Soybean flour and Cookies

Determination of protein was by the Kjeldahl method (AOAC, 2012). The samples after digestion with a catalyst tablet in a digestion unit was distilled with the addition of excess sodium hydroxide (NaOH) for the conversion of ammonium ion to ammonia gas. The amount of ammonia was quantified by back titration with sulphuric acid and total nitrogen was calculated and corrected using the reference acetanilide value and multiplied by a factor of 6.25 to obtain the protein value.

2.9 Sensory Evaluation of 100% Wheat and Tigernut-Soybean Cookies

Cookie samples were subjected to sensory evaluation within 24 hours after production. Colour, taste, aroma, crunchiness, appearance and overall acceptability were assessed on the cookie samples using a 9-point hedonic scale where: 1 = dislike extremely, 2 = dislike very much, 3 = dislike slightly, 4 = dislike moderately, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = liked very much, 9 = liked extremely (Iwe, 2010). Overall acceptability was calculated as mean values of all the other sensory attributes assessed. Twenty assessors from Rivers State University who are familiar with cookies, and are neither sick nor allergic to baked products, were involved in the assessment. The assessors were instructed to rinse their mouth with water after tasting each cookie sample.

2.10 Statistical Analysis

Analyses were carried out in duplicates. Data obtained were subjected to Analysis of Variance (ANOVA). Difference between means were evaluated using Tukey's multiple comparison tests at 95% confidence level using Minitab (Release 18.1) statistical software English (Minitab Ltd. Conventry, UK).

3. Results and Discussion

3.1 Physicochemical Properties of 100% Wheat and Tigernut-Soybean flour blends

The result of the physicochemical properties of 100% wheat flour and tigernut-soybean flour blends is shown in Table 1. pH of the 100% wheat flour (sample A) was 4.21, while the tigernut-soybean flour blends' pH ranged from 4.31 - 5.37 for sample E and D. There was significant difference ($p<0.05$) between the control and the blends, and between the different blends. The pH of flours differed slightly from 5.62-5.92 reported by Akojo and Coker (2018) and 5.60 - 6.23 reported by Obinna-Echem *et al.* (2020). Low pH according to Ogunjobi and Ogunwolu (2010) can help in the development of pleasant taste of the final product. Total titratable acidity (TTA) of the blends ranged from 0.021% (samples B and D) to 0.039% (sample F). The 100% wheat sample had TTA of 0.035%, and were similar ($p<0.05$) to samples E (0.033%) and F (0.039%) with 40 and 50% increase respectively in soybean inclusion. These results were lower than 0.13 - 0.29% reported by Akojo and Cooker (2018). There was significant difference ($p<0.05$) between the control (9.43 Pa.s) and the blends in their viscosity values, which ranged from 1.72 Pa.s (samples C and D) to 2.18 Pa.s (sample F). Viscosity of food is important in food intake and is an important determinant of food acceptability (Ikujenlola, 2008). The Brix value reflects the amount of sugar present in a sample, and expressed in terms of the percentage of the sucrose content. The total soluble solid (⁰Brix) content had the value of 1.00 for the 100% wheat sample, while the blends recorded sugar content of 3.00 (sample D) to 4.50 (sample E). Sugar is important in baked products for taste (sweetness), flavour, structure and texture (Zhou *et al.*, 2014).

Table 1: Physicochemical Properties of 100% Wheat and Tigernut-Soybean flour blends

Sample	pH	TTA (%)	Viscosity (Pa.s)	Total soluble solids (ºBrix)
A	4.21 ± 0.00^{e}	0.035 ± 0.00^{ab}	9.43 ± 0.01^{b}	1.00 ± 0.00^{d}
B	4.88 ± 0.04^{b}	0.021 ± 0.00^{c}	1.73 ± 0.00^{d}	3.55 ± 0.07^{b}
C	4.80 ± 0.01^{b}	0.025 ± 0.00^{bc}	1.72 ± 0.00^{d}	3.10 ± 0.14^{c}
D	5.37 ± 0.00^{a}	0.021 ± 0.00^{c}	1.72 ± 0.00^{d}	3.00 ± 0.00^{c}
E	4.31 ± 0.01^{d}	0.033 ± 0.00^{b}	1.79 ± 0.00^{c}	4.50 ± 0.00^{a}
F	4.57 ± 0.02^{c}	0.039 ± 0.00^{a}	2.18 ± 0.00^{a}	3.70 ± 0.14^{b}

Values are mean ± standard deviation of duplicate determinations. Values with the same superscripts in the same column are not significantly different at ($p<0.05$).
A = 100% Wheat flour
B = 90% Tigernut: 10% Soybean flour blend
C = 80% Tigernut: 20% Soybean flour blend
D = 70% Tigernut: 30% Soybean flour blend
E = 60% Tigernut: 40% Soybean flour blend
F = 50% Tigernut: 50% Soybean flour blend

3.2 Functional Properties of 100% Wheat flour and Tigernut-Soybean Flour Blends

Functional properties of 100% wheat flour and tigernut-soybean flour blends is presented in Table 2. Functional characteristics are required to evaluate and possibly help to predict how new proteins, fat, crude fibre and carbohydrates may behave in specific systems as well as demonstrate if such protein can be used to stimulate or replace conventional protein (Sadiq *et al*., 2009). The functional properties of 100% wheat flour, and flour blends from tigernut and soybean are shown in Table 2.

Least gelation capacity (LGC) of the 100% wheat flour (sample A) was 0.20%, while the tigernut-soybean flour blends recorded LGC ranging from 0.20% (sample B) to 0.50% (sample F). There was no significant difference (p<0.05) between the 100% wheat flour sample, and sample B with 90% tigernut and 10% soybean flour. LGC is used to measure the ability of the protein to form a gel. Abu *et al.* (2005) suggested that a lower LGC indicates a better gelling capacity, hence sample B will have a better gelling capacity than the other flour blends here.

The oil absorption capacity (OAC) of the 100% wheat flour was 1.80 g/g, while the tigernut-soybean flour blends recorded OAC of 1.64 g/g (sample C) to 1.81 g/g (sample D). There was no significant difference (p<0.05) between the 100% wheat flour and the tigernut-soybean flour blends in their OAC. The result here was similar to 1.70 - 1.90 g/g reported by Bello *et al.* (2019) for flour blends of sorghum, African yam bean and soybean. The water absorption capacity (WAC) of the 100% wheat flour (sample A) was 1.23 g/g while the flour from blends of tigernut and soybean recorded WAC ranging from 1.33 g/g (sample B) to 2.13 g/g (sample F). There was significant difference (p<0.05) between the wheat flour and blended flour samples in their WAC. The WAC of the flour blends increased with inclusion of soybean flour. Bello *et al.* (2019) also reported increase in WAC with increase in soybean flour addition. The result of the WAC was similar to the report of 1.00 – 2.90 by Obinna-Echem *et al*. (2020) for cowpea-tigernut flours blends. Water absorption characteristics represent the ability of a product to associate with water under conditions where water is limiting, such as dough and pastes. The results obtained suggest that tigernut-soybean flour blends would be useful in food systems such as bakery product.

There was no significant difference (p>0.05) among samples in their bulk densities. This is advantageous, as all flours can be packaged the same way. The 100% wheat flour recorded bulk density of 0.54 g/ml while the tigernut-soybean flour blends recorded bulk density ranging from 0.45 g/ml (sample F) to 0.55 g/ml (sample B). This result differs from bulk density of 0.59-0.61 g/ml for sorghum, pigeon pea and soybean flour blends reported by Adeola *et al*. (2017). Low bulk density values of the flour samples imply that more of the samples could be prepared using a small amount of water yet give the desired energy nutrient density (Bello *et al.*, 2019).

Dispersibility shows the ability of the flour to reconstitute in water. The dispersibility of the flour blends reduced with increase in soybean flour inclusion. The 100% wheat flour recorded dispersibility of 36.00% while the tigernut-soybean flour blends recorded dispersibility ranging from 31.00% (sample F) to 33.00% (sample B). This is lower than 45 -51% dispersibility reported for different flours by Oluwole *et al*. (2016). The lower dispersibility of the flour blend samples could be an indication of the ability of its flour or powder to aggregate more when dispersed in water with gentle stirring (Sharma *et al.*, 2012).

The swelling power of the 100% wheat flour was 5.62% while the tigernut-soybean flour blends recorded swelling powder ranging from 3.87% (sample F) to 5.68% (sample E). The swelling power was lower than 6.90-7.97% reported by Adeola *et al.* (2017) for sorghum, pigeon pea and soybean flour blends. Solubility of the 100% wheat flour (13.59%) differs significantly (p<0.05) from the tigernut-soybean flour blends which ranged from 15.29% (sample F) to 29.32% (sample E). Low swelling power and solubility may influence the rising of bakery products.

Foaming capacity of 100% wheat flour was 25.00% while the tigernut-soybean flour blends recorded foaming capacity ranging from 20.00% (samples C, D, E and F) to 25.00% (sample B). The foaming capacity of wheat flour in this study (25.00%) differs from 12.92% reported by Nawaza *et al*. (2015). Foaming capacity affects the consistency and appearance of foods. High foaming capacity implies a better continuous cohesion of the flour protein around air bubbles and this is very good for bakery products like cakes (Nawaza *et al.*, 2015).

Table 2: Functional Properties of 100% Wheat and Tigernut-Soybean flour blends

Sample	Least gelation capacity (%)	Oil absorption capacity (g/g)	Water absorption capacity (g/g)	Bulk density (g/ml)	Dispersibility (%)	Swelling power (%)	Solubility (%)	Foaming Capacity (%)
A	$0.20{\pm}0.00^{d}$	$1.80{\pm}0.13^{a}$	$1.23{\pm}0.08^{d}$	$0.54{\pm}0.01^{a}$	$36.00{\pm}0.00^{a}$	$5.62{\pm}0.63^{a}$	$13.59{\pm}0.16^{f}$	$25.00{\pm}0.00^{a}$
B	$0.20{\pm}0.00^{d}$	$1.69{\pm}0.05^{a}$	$1.33{\pm}0.07^{cd}$	$0.55{\pm}0.00^{a}$	$33.00{\pm}0.00^{c}$	$5.17{\pm}0.31^{ab}$	$16.04{\pm}0.79^{d}$	$25.00{\pm}0.00^{a}$
C	$0.30{\pm}0.00^{c}$	$1.64{\pm}0.13^{a}$	$1.47{\pm}0.13^{c}$	$0.52{\pm}0.01^{a}$	$33.10{\pm}0.00^{b}$	$4.94{\pm}0.86^{b}$	$17.75{\pm}0.21^{c}$	$20.00{\pm}0.00^{b}$
D	$0.30{\pm}0.00^{c}$	$1.81{\pm}0.14^{a}$	$1.64{\pm}0.08^{b}$	$0.53{\pm}0.05^{a}$	$33.10{\pm}0.00^{b}$	$5.51{\pm}0.32^{a}$	$21.34{\pm}0.20^{b}$	$20.00{\pm}0.00^{b}$
E	$0.40{\pm}0.00^{b}$	$1.74{\pm}0.23^{a}$	$1.94{\pm}0.10^{ab}$	$0.52{\pm}0.01^{a}$	$33.10{\pm}0.00^{b}$	$5.68{\pm}0.47^{a}$	$29.32{\pm}0.11^{a}$	$20.00{\pm}0.00^{b}$
F	$0.50{\pm}0.00^{a}$	$1.77{\pm}0.16^{a}$	$2.13{\pm}0.02^{a}$	$0.45{\pm}0.07^{a}$	$31.00{\pm}0.00^{b}$	$3.87{\pm}0.30^{c}$	$15.29{\pm}0.01^{e}$	$20.00{\pm}0.00^{b}$

Values are mean ± standard deviation of duplicate determinations. Values with the same superscripts in the same column are not significantly different at (p <0.05). A = 100% Wheat flour
B = 90% Tigernut: 10% Soybean flour blend
C = 80% Tigernut: 20% Soybean flour blend
D = 70% Tigernut: 30% Soybean flour blend
E = 60% Tigernut: 40% Soybean flour blend
F = 50% Tigernut: 50% Soybean flour blend

3.3 Protein Content of 100% Wheat and Tigernut-Soybean flour and Cookies

Shown in Figure 1, is the protein content of the tigernut-soybean flour and their cookies. The protein content of the tigernut-soybean flour blends ranged from 7.81 – 16.94% for sample B and F respectively, while the wheat flour had the value of 5.63%.

The protein content of the tigernut-soybean flour blends was significantly (p<0.05) higher than that of wheat flour. There was significant (p<0.05) increase in the protein content of the tigernut-soybean flour blends with increase in the inclusion of soybean flour. Bello *et al.* (2019) also reported increase in protein content as a result of soybean flour addition to sorghum and African yam bean flour blends. The difference from wheat flour and increase with increase in soybean addition, could be attributed to soybean. Soybean has been reported to contain high amount of protein (40%) (Shurtleff and Aoyagi, 2016) with acceptable amount of essential amino acids that is similar to that of animal proteins and makes for a balanced diet (Messina *et al*, 2017; Okwunodulu *et al*., 2020). The protein content of the cookies produced from 100% wheat flour was 10.50%, and were similar to 10.87% protein content reported by Asomugha *et al*. (2022) for cookies produced from 100% wheat flour. The cookies produced from tigernut-soybean flour blends had protein content ranging from 8.68 - 14.81% for sample B and F respectively. There was significant difference (p<0.05) between the protein content of the flour and those of the cookies. Cookies produced from 100% wheat flour had higher protein content than its flour; and sample B, C and D. The protein content of the tigernut-soybean cookies was also significantly (p<0.05) higher than those of their flours except for sample B. The trend lines showed that the rate of increase in the cookies was higher than in the flour blends. This increase was expected with the addition of other ingredients particularly with egg in the batter preparation. Adelakun *et al.* (2021) also reported increase in the protein content (10.51-17.01%) of cookies with increase in soy flour ratio, which were also similar to the protein content of cookies in this study.

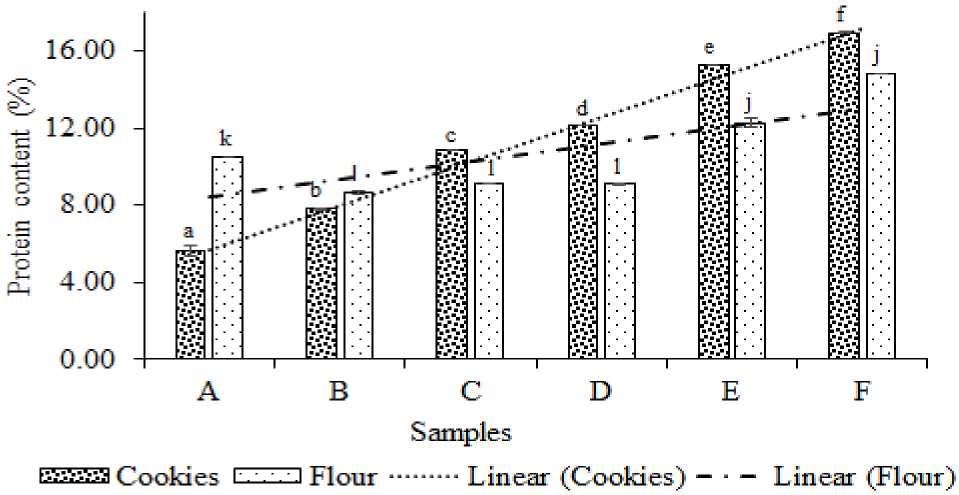

Figure 1: Protein Content of 100% wheat flour and tigernut-soybean flour blends and their Cookies produced

Bars and error bars represent the mean and standard deviation of duplicate determinations. Bars with different alphabets are significantly (p<0.05) different.
A = Cookies produced with 100% Wheat flour
B = Cookies produced with 90% Tigernut: 10% Soybean flour blend
C = Cookies produced with 80% Tigernut: 20% Soybean flour blend
D = Cookies produced with 70% Tigernut: 30% Soybean flour blend
E = Cookies produced with 60% Tigernut: 40% Soybean flour blend
F = Cookies produced with 50% Tigernut: 50% Soybean flour blend

3.4 Sensory Attributes of Cookies produced from 100% wheat flour and tigernut-soybean flour blends

The Assessors' degree of likeness for the sensory attributes of the 100% wheat cookies, and tigernut-soybean cookies is shown in Figure 2. The degree of likeness for colour of the cookies produced from 100% wheat flour was 6.10, while the tigernut-soybean cookies had scores of 4.55 - 6.65 for sample F and E. Degree of likeness of aroma and crunchiness of the 100% wheat cookies was 6.10, while the tigernut-soybean cookies had scores ranging from 4.55 (sample B) to 7.10 (sample E) and 4.35 (sample F) to 6.40 (sample D) for aroma and crunchiness respectively. The taste and appearance score of the cookies produced from 100% wheat flour was 5.85 and 6.35 respectively, while the tigernut-soybean cookies recorded taste and appearance score ranging from 4.20 (sample F) to 7.25 (sample E) and 4.70 (sample F) to 6.95 (sample E) respectively. The overall acceptability score of the 100% wheat cookies (6.10) did not differ much from 6.65 overall acceptability score of 100% wheat cookies reported by Asomugha *et al*. (2022). The tigernut-soybean flour blends cookies had overall acceptability of 4.51 for sample F to 6.82 for sample E. Samples D (6.03) and E (6.82) recorded overall acceptability scores that were not significantly different (p>0.05) from the control (6.10). Sample E had significantly (p<0.05) the highest degree of likeness for colour, aroma, appearance, taste and overall acceptability. The values were in the range of like slightly to like moderately. This suggests that the tigernut-soybean flour blend of up to the ratio of 60:40% can be utilized in cookie production. The flour blends may also be utilized in households for the production of other functional bakery products such as bread, biscuits, and cakes thereby reducing the dependency on wheat flour.

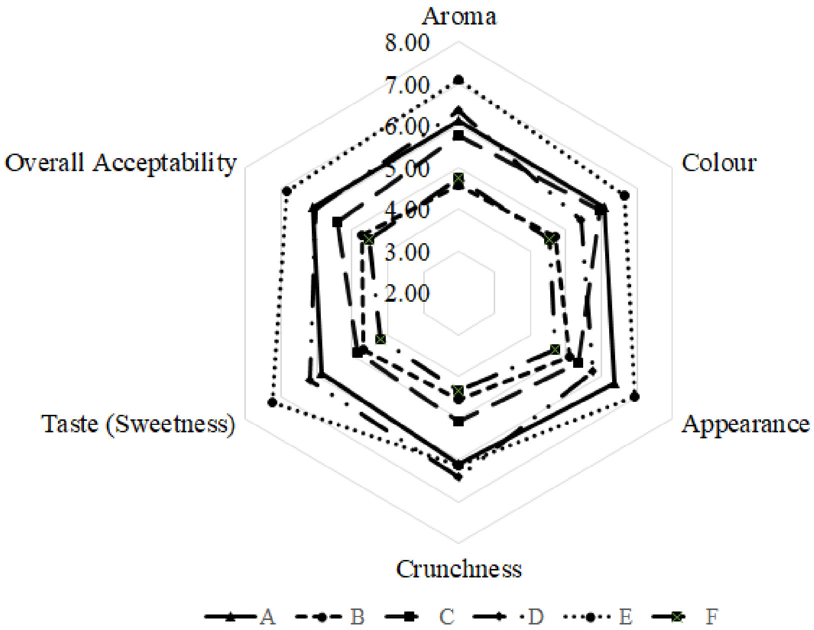

Figure 2: Sensory Attributes of Cookies produced from 100% wheat flour and tigernut-soybean flour blends
A = Cookies produced with 100% Wheat flour
B = Cookies produced with 90% Tigernut: 10% Soybean flour blend
C = Cookies produced with 80% Tigernut: 20% Soybean flour blend
D = Cookies produced with 70% Tigernut: 30% Soybean flour blend
E = Cookies produced with 60% Tigernut: 40% Soybean flour blend
F = Cookies produced with 50% Tigernut: 50% Soybean flour blend
Hedonic scale: 1 = dislike extremely, 2 = dislike very much, 3 = dislike slightly, 4 = dislike moderately, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = liked very much, 9 = liked extremely

4. Conclusion

The study established that it is possible to produce good and acceptable cookies from a combination of tigernut and soybean flours, which will compare and compete favourably with cookies produced from wheat flour. The pH and total titratable acidity of 100% wheat flour was significantly ($p<0.05$) lower than the test samples, the viscosity of the test samples was comparable with the control but the viscosity of the control was significantly higher. The functional properties of the tigernut-soybean flour where comparable with the 100% wheat flour. The sensory assessment revealed that cookies sample E produced with 60% tigernut and 40% soybean flours had the highest scores in terms of color, aroma, appearance and overall acceptability, and were liked better than the 100% wheat flour cookies. Based on the overall scores, the control sample did not differ significantly ($p<0.05$) from the cookie samples from tigernut and substitution with soybean flour at 30% and 40%. This therefore shows that tigernut and soybean flour can be substituted with wheat flour at levels of 30% and 40% for the production of acceptable cookies of nutritional quality

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Competing Interests

Authors declare that there are no competing interests exist.

Consent (Where ever applicable)

Not applicable

Ethical Approval (Where ever applicable)

Not applicable

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