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Quality attributes of cookies from wheat, lima bean and tigernut composite flour

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Abstract

Cookies are widely consumed throughout the world especially among children. They are ready-to eat, convenient and inexpensive food products, containing digestive and dietary principle of vital importance. This study investigated the quality attributes of cookies from wheat, lima beans and tigernut composite flour. Wheat flour was blended with lima beans and tigernut flour at the ratios of 90:5:5, 85:10:5, 80:15:5, 75:20:5 and 70:25:5, respectively. The flour blends were analysed for proximate, functional and pasting properties while the cookies produced from the blends were analysed for anti-nutritional, colour and sensory properties using standard laboratory procedure. Data obtained were subjected to analysis of variance, and mean values were separated using Duncan's multiple range test. The moisture content, crude fat, crude protein, total ash, crude fibre and total carbohydrate ranged from 8.09%-10.82%, 4.24%-5.58%, 7.04%-8.08%, 1.65%-2.10%, 3.06%-3.48% and 72.68%-73.10%, respectively. Increase in lima bean substitution led to increase in bulk density, water absorption capacity, oil absorption capacity, swelling capacity except solubility index. Significant differences were observed in the pasting properties of the flour blends. Phytate and tannin content of the cookies ranged from 0.574-0.634% and 0.168-0.231% while range of values for lightness, redness and yellowness of cookies were: 38.82-40.04, 6.90-7.96 and 16.26-18.26, respectively. However, cookies prepared from blend of 70% wheat flour, 25% lima bean and 5% tigernut flour were the most preferred in terms of overall acceptability.

Keywords: cookies, wheat, lima bean, tigernut

Introduction

Wheat (Triticum spp.) is the most important staple food crop for more than one third of the world population and contributes more calories and proteins to the world diet than any other cereal crop (Adams et al., 2012). Wheat flour is used to prepare bread, produce biscuits, confectionary products, noodles and vital wheat gluten or seitan (FAO, 2010). Many people like wheat-based products because of the taste and particularly the texture. Wheat is unique among cereals because its flour possesses the ability to form visco-elastic dough when mixed with water. Wheat is nutritious, easy to store and transport and can be processed into various types of food. Virtually all the wheat flour used for baking in confectionery industries in Nigeria is imported. Therefore, a campaign on the use of composite flour is being advocated. With the ban on importation, it is hoped that these local crops should be revived and used as substitutes for imported ones (Nwosu, 2013).

Tigernut (Cyperus esculentus L.) is a root tuber that is a member of the family Cyperaceae. It has other names including "chufa", Zulu nuts and yellow nut sedge (Rubert et al., 2011). It has been planted extensively in Africa, Asia and European countries for centuries because of its food value and commercial importance (Yeboah et al., 2011). Recently, the use and acceptability of tigernut in food formulation has increased tremendously (Omoba et al., 2015). Tigernut contains 50% moisture content, 12% fat, 8% crude fibre, 4% protein, 1.80% ash and 34% carbohydrate. Tiger-nut tuber is also rich in vitamins (C and E) and minerals like zinc, sodium, potassium, magnesium and it contains minute quantities of copper (Bamishaiye and Bamishaiye, 2011). The utilization of tigernut flour in food product has been deemed successful. For example, tigernut flour had been incorporated with wheat flour and date palm fruit flour cookies by Jimoh (2021) for improvement in the quality properties of the cookies.

Lima bean (Phaseolus lunatus) is a legume that originated from Peru. However, lima bean, an underutilized legume, has also been found to be grown in the rural parts of Nigeria. Indigenously, the legume is regarded as "kapala" amongst "Yoruba" and "ukpa" amongst "Igbos" of South-Western and South-Eastern Nigeria, respectively, where it is mostly consumed as part of diets (Seidu et al., 2018). Lima bean is the second most economically important species of Phaseolus and is one of the twelve primary grain legumes known in the world. The dry grains have nutritional value similar to common bean, containing approximately 63% of carbohydrates, 25% of protein and 6% of fibre (Díaz et al., 2010). Grain consumption contributes synergistically to its medicinal properties, such as antioxidant, diuretic, anti-inflammatory, antitumor and antimicrobial, with a positive effect against some chronic diseases (Palupi et al., 2022). Lima beans are a very rich source of B-complex vitamins, especially vitamin B6 (pyridoxine), thiamine (vitamin B1), pantothenic acid, riboflavin and niacin. Lima bean is also one of the excellent sources of minerals like molybdenum, iron, copper, manganese, calcium, magnesium. The utilization of lima bean in composite with wheat flour for biscuit manufacture has been studied by El-Gohery (2021).

Cookies are small, flat, sweet, baked goods typically containing flour, eggs, sugar and either butter or cooking oil (Abayomi et al., 2013; Adeyeye and Akingbala, 2015). In most English-speaking countries, except for the US and Canada, cookies are called biscuits (Abayomi et al., 2013; Adeyeye and Akingbala, 2015). Cookies are made from unleavened dough (Adeleke and Odedeji, 2010; Adeyeye and Akingbala, 2015).

Composite flour from wheat, lima bean and tigernut flour has not been fully exploited in confectioneries and flour-based food formulations. Therefore, cookies from blends of wheat, lima bean and tigernut flour blends will ensure improvement in the nutritional quality of the food product, make available another variety of cookies and overall, promote the health of consumers of the food product. Therefore, the main objective of this study is to evaluate the quality attributes of cookies made from wheat, lima bean and tigernut composite flour.

Materials and methods

Material

Commercially branded wheat flour, lima beans, yellow variety of tigernut and other ingredients such as sugar, butter and nutmeg were obtained from Mile 12 market, Lagos state. Nigeria. The production of sample was done in Food Processing Laboratory and all reagents were obtained from Food Analytical Laboratory, Yaba College of Technology, Lagos, Nigeria

Preparation of lima beans flour

The lima beans were sorted to remove dirt, stones, and the husks before washing with enough quantities of water, and soaked for 12 h at room temperature. The water was decanted and beans placed on jute bags, covered with a damp cloth and allowed to germinate for 24 h, and then transferred on a tray, dried at 60 °C, milled, sieved using 0.5 mm size mesh, packaged and stored for further analysis.

Preparation of tigernut flour

Yellow tigernut (Cyperus esculentus) was sorted to remove unwanted materials like stones, pebbles and other foreign materials before washing with tap water. The cleaned tubers were dried in a cabinet dryer at 60°C for 72 h. Dried tubers were milled using laboratory mill (Fritsch, D-55743, Idar-oberstein-Germany) and the milled sample was sieved (using 250µm screen) to obtain the flour. The tigernut flour was packed and sealed in polyethylene bags at ambient temperature (26±2 oC).

Formulation of wheat-lima beans-tigernut composite flour

Composite flour blends were prepared by substituting the wheat flour with lima bean flour and tigernut flour in the ratio of 90:5:5, 85:10:5, 80:15:5, 75:20:5, 70:25:5, respectively.

Proximate composition of wheat-lima beans-tigernut composite flour

Moisture content, total ash, crude protein and crude fat were determined using the procedure of AOAC (2005) method. AOAC (2005) procedure 925.10 was used for the moisture content determination; AOAC (2005) procedure 923.03 was used for the ash content determination; AOAC (2005) procedure 984.13 was used for the protein content determination; AOAC (2005) procedure 923.03 was used for the crude fat content determination; crude fibre was evaluated by acid and alkali hydrolysis, while total carbohydrate was calculated using difference method

% Carbohydrate = 100 − (moisture % ash + % fat + % protein + % fibre content)

Functional properties of wheat-lima beans-tigernut composite flour

Water absorption and oil absorption capacities were determined as described by Beuchat (1977), swelling power and solubility index were determined as described by Takashi and Siebel (1988), while bulk density was determined according to the method described by Maninder et al. (2007).

Pasting properties of wheat-lima beans-tigernut composite flour

Pasting properties of the composite flour blends samples was determined using Rapid viscosity Analyzer. Three grams (3 g) of the flour samples was mixed with 25 ml of distilled water heated from 50 to 95 oC at a rate of 1.5 oC/minute, and then held at 95 oC for 15 min before cooling back to 50 oC at 1.5 oC/min and finally held at 50 oC for 15 min. The following pasting properties were then determined using the Rapid Visco Analyzer (Newport Scientific, RVA super 3, Switzerland); gelatinization temperature, maximum or peak viscosity, minimum viscosity, final viscosity, breakdown viscosity, and setback viscosity.

Preparation of cookies from wheat-lima beans-tigernut composite flour

The method described by Adeola and Ohizua (2018), with modification, was used in the preparation of cookies. The blended flour samples in percentages (90:5:5, 85:10:5, 80:15:5, 75:20:5, 70:25:5) were measured and poured in a bowl. Using the rubbing method; fat (250 g), sugar (120 g) and salt (1 g) were added and rubbed for 30 min, after which the water was added to the flour-based mixture and kneaded and made into dough. The dough was rolled and flattened into a uniform thickness of about 3.5 mm before cutting out into different shapes using a hand cutter. The cut-out dough was baked at 220 oC for 20 min. After baking, the cookies were cooled to room temperature, and it was packed in an air-tightly container for storage prior to evaluation.

Antinutritional factors of cookies from wheat-lima beans-tigernut composite flour

Tannin was determined as described using the modified vanillin–hydrochloric acid (MV – HCl) method of Price et al. (1978) and phytate content according to the method determined by Adedeji et al. (2013).

Colour properties of cookies from wheat-lima beans-tigernut composite flour

Minolta chroma meter (CR- 410, Japan) was used based on (CIE) L*a*b* scale. After calibrating the instrument by covering a zero-calibration mask followed by white calibration plate. The cookies were analysed by placing them on the petri dish, and then the image was captured on the samples. The colour attributes such as lightness (L*) (0 = black and 100 = white) and chromaticity coordinates (a* corresponds to the colour range from red-green coordinates [- is green, while + is red], b* corresponds to the colour range from blue-yellow coordinates [- is blue with + indicating yellowness]) were recorded.

Sensory evaluation of cookies from wheat-lima beans-tigernut composite flour

The method described by Iwe (2002) was used for the sensory evaluation of cookies. Twenty trained panellists were used for the sensory evaluation. The attributes evaluated were taste, appearance, colour, flavour, texture and overall acceptability. For each cookies sample, panellists scored these characteristics using 9-point hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely).

Statistical Analysis

Data were analysed using Statistical Package for Social Sciences software (SPSS Software Version 20) and means separated with Duncan's multiple range tests. Analysis of variance (ANOVA) was used to compare means at $p \leq 0.05$ level of significance.

Results and discussion

Proximate composition of wheat-lima beans-tigernut composite flour
The proximate composition from composite flour of lima beans, tigernut and wheat flour is presented in Table 1. Significant ($p < 0.05$) differences were observed among the samples. Moisture content of food is important in ascertaining the keeping quality and safety of the food during storage (Gemede, 2020). The moisture content of the composite flour ranged from 8.09 to 10.82% with the flour blends at 75:20:5 having the highest value (10.82%), while the least moisture content (8.09%) was observed in flour blend from 85:10:5. The moisture content of the flour blends is in agreement with the values of 4.23-13.38 reported by Oke et al. (2016) on wheat and tigernut flour blends. According to Akanbi et al. (2011), lower moisture content of foods is an indication of lower susceptibility to microbial proliferation especially when stored in ideal packages; thus, an indication that wheat, lima beans and tigernut flour blends will stay longer on the shelf.
The crude fat content of the composite flour varied from 4.24 to 5.58%; sample 85:10:5 had the highest crude fat content; and sample 75:20: 5 had the least crude fat content. Significant ($p < 0.05$) difference exists in the crude fat contents of the composite flour. Fat imparts taste and flavour to food and serves as a binding agent for other ingredient to form smooth dough.
The crude protein of the composite flour ranged from 7.04 to 8.08%. The high crude protein content obtained in this study could be attributed to high protein content of lima bean. Matured lima bean has been reported to contain protein content of about 20.62% (Farinde et al., 2018). The high protein content in lima bean substituted with wheat and tigernut flour could be of great nutritional importance in developing countries such as Nigeria, where there could be an occurrence of protein malnutrition (Okpala and Okoli, 2011). Proteins are increasingly being utilized to perform functional roles in food formulation; hence, the protein content of the wheat-lima bean-tigernut composite flour obtained in this study suggests that they might be useful in other food formulations where high protein content is desirable.
Total ash content is an indication of mineral content present in food material. The total ash of the composite flour varied between 1.65% and 2.10%. Sample 80:10:5 had the highest total ash content, whereas sample 75:20:5 had the least total ash content. The results of total ash content obtained were in agreement with the value of 1.73-3.90% reported by Olapade et al. (2014) on blends of wheat, cassava and cowpea flours. Sample 80:10:5 had the highest total ash content which implies that the flour will be rich in mineral content.
The crude fibre content of the composite flour ranged from 3.06 to 3.48%. The result of crude fibre obtained was lower than the value of 2.82 to 9.82% reported Oke et al. (2019) on wheat-tigernut flour. This could be due to differences in the variety of tigernut used in this study. However, Adejuyitan et al. (2009) also reported tigernut to be high in fibre. Fibre is essential in human diet as it improves the stool bulk by acting as a vehicle for faecal fluid. It improves the health of the gastro-intestinal system and metabolic system in human (Atobatele et al., 2016).
Carbohydrates are the source of energy which is also important in the functioning of the brain, heart, nervous, digestive, and immune system (WHO, 2011). The carbohydrate contents ranged between 72.68% and 73.11%. The value of carbohydrate content obtained is higher than the value of 23.71-70.45% reported by Ndife et al. (2014) on wheat-soy flour. High carbohydrate content suggests high energy value when the flour blends is used for formulation of food.

Functional properties of wheat-lima beans-tigernut composite flour

Functional properties of the composite flour are shown in Table 2 below. Significant difference ($p < 0.05$) was observed in all the functional properties of the composite flour. The bulk density varied between 0.81 and 1.00 g/ml, with sample 70:25:5 having the highest value while sample 90:5:5 had the lowest value for bulk density. It has been reported that bulk density is influenced by the structure of the starch polymers and loose structure of the starch polymers could result in low bulk density (Malomo et al., 2012). Bulk density is also an important parameter for determining the easy ability of packaging and transportation of particulate or powdery foods. Therefore, low bulk density of the composite flour blends is an indication of less packaging requirement. Nutritionally, low bulk density promotes digestibility of foods especially in children with immature digestive systems while high bulk density decreases the caloric and nutrient intake of children resulting in growth faltering (Olaitan et al., 2014). This suggests the composite flour blend samples will be useful in food product such as baked cookies. The result obtained for the bulk density in this study was higher than the value of 0.67–0.78g/ml reported by Oke et al. (2016) on wheat and tigernut flour blends.
The result obtained for water absorption capacity (WAC) ranged from 206.70 to 234.20%. Water absorption characteristic represents the ability of the product to associate with water under conditions when water is limiting such as dough and pastes. Water absorption capacity is important in the development of ready to eat foods. It has been observed that a high-water absorption capacity assures product cohesiveness (Housson et al., 2002). Niba et al. (2001) also reported that water absorption capacity is important in bulking and consistency. High water absorption capacity in the flour blends indicates its usefulness in bakery products as this could prevent staling by reducing moisture loss according to Okpala and Chinyelu (2011).
The oil absorption capacity (OAC) ranged between 147.83 and 174.38%. Oil absorption capacity is attributed mainly to the physical entrapment

Table 1. Proximate composition of wheat-lima beans-tigernut composite flour

WF:LF:TF	Moisture Content (%)	Crude Fat (%)	Crude Protein (%)	Total Ash (%)	Crude Fibre (%)	Total Carbohydrate (%)
90:5:5	9.64±0.04c	4.86±0.03c	7.57±0.05c	1.84±0.02b	3.06±0.04b	73.03±0.06c
85:10:5	8.09±0.07a	5.58±0.06e	8.08±0.04e	2.10±0.04d	3.48±0.04e	72.68±0.07a
80:15:5	9.23±0.06b	5.11±0.06d	7.77±0.04d	1.85±0.05bc	3.24±0.04d	72.80±0.08b
75:20:5	10.82±0.05e	4.24±0.03a	7.04±0.06a	1.65±0.04a	3.16±0.05c	73.10±0.06c
70:25:5	10.09±0.04d	4.73±0.03b	7.04±0.06a	1.65±0.04a	3.16±0.05c	73.10±0.06c

Mean values with different superscripts within the same column are significantly different ($p < 0.05$);
WF: wheat flour, LF: Lima bean flour, TF: tigernut flour

of oils. It is an indication of the rate at which protein binds to fat in food formulations (Omimawo et al., 2012). Oil absorption capacity is useful in formulation of foods such as sausages and bakery products. Fat acts as a flavour retainer and increases the mouth-feel of foods. Fat increases the leavening power of the baking powder in the batter and improves the texture of the baked products. The result of oil absorption capacity obtained was higher than the value of 130.50-151.60% reported by Oke et al. (2019) on wheat-chia seed flour.

Swelling power ranged between 3.75 and 4.47 g/g, respectively. Swelling power measures hydration capacity. It has also been reported to be part of the criteria for a good food product quality (Omobolanle et al., 2017). The result obtained from the swelling power of wheat, lima beans and tigernut flour was lower than the value of 5.75–7.64 g/g reported by Oke et al. (2016) on wheat and tigernut flour blends. It is clear that the swelling capacity of composite flours is highly affected by the level of lima beans flour supplementation owing to the protein contents 7.04 to 8.08% of the composite flour blends in the current study. The solubility index ranged between 0.05 and 0.33%. The low solubility index of the blends implies that the flour will hold less moisture during preparation and will be nutrient dense (Wang and Copeland, 2013).

Pasting properties of wheat-lima beans-tigernut composite flour

Table 3 shows the pasting properties of wheat-lima beans-tigernut composite flour. The peak viscosity ranged between 2043.50 and 2404.00 RVU. Sample 90:5:5 had the lowest peak viscosity while sample 85:10:5 had the highest peak viscosity. Peak viscosity is the point at which gelatinized starch reaches its maximum viscosity during heating in water. It indicates the water binding capacity of a starch (Shimelis et al., 2006). The peak viscosity obtained from the study is higher than the value of 1382-1708 RVU reported by Sanni et al. (2020) on composite flour from wheat, sorrel seed protein isolates and yellow cassava flours. Trough viscosity values ranged between 1123.00 and 1381.00 RVU. Sample 90:5:5 had the lowest trough viscosity value and sample 85:10:5 had the highest trough viscosity value. Trough viscosity is the lowest viscosity the gruel can attain at a constant temperature range on the rapid visco-analyser and also the indication of how gruel will disintegrate during cooling (Ezeocha and Onwuka, 2010). The trough viscosity obtained from the study is higher than the value of 536- 820 RVU reported by Ocheme et al. (2018) on wheat and groundnut protein concentrate flour blends.

Breakdown viscosity ranged between 868.00 and 1072.00 RVU. Breakdown viscosity was defined as the difference between peak and hold viscosity, breakdown viscosity reflects different susceptibility of starch breakdown upon shearing and heating. Starch granules became increasingly susceptible to shear disintegration when swelled, especially in starches with lower amylose content (Kaur et al., 2007). Sample 85:10:5 had the highest breakdown values and sample 75:20:5 had the lowest breakdown values. The breakdown viscosity obtained from the study is lower than the value of 1043- 4012 RVU reported by Olapade et al. (2014) on blends from wheat, cassava and cowpea flours. Final viscosity value ranged between 2440.50 and 2911.00 RVU. Final viscosity measured the ability of the starch to form viscous paste after cooking and cooling, and also the resistance of a paste to shear force during stirring (Surojanametakul et al., 2006). The final viscosity value obtained is higher than the value of 1810.7- 2188.0 RVU reported by Sanni et al. (2020) on composite flour from wheat, sorrel seed protein isolates and yellow cassava flours. Final viscosity increased with increase wheat flour substitution with lima beans and tigernut flour.

Setback is the viscosity where recrystallization of starch starts again. Setback ranged between 1317.50 and 1530.00 RVU. Setback viscosity is the quality of starch contained in a food material (Tulyathan and Leeharatanaluk, 2007). The setback viscosity obtained from this study was in agreement with the value of 891-1669 RVU reported by Olapade et al. (2014) on blends from wheat, cassava and cowpea flours. Peak time value ranged between 5.53-5.90 min. Sample 90:5:5 had the lowest peak time and sample 70:25:5 had the highest value of peak time. Peak time is the time required to attain peak viscosity, maintained constant in all the structures. Peak time is the time at which the peak viscosity occurred in minutes, and it is a measure of the cooking time of the flour (Oke et al., 2016). Pasting temperature is one of the properties which provide information of estimated minimum cooking time or cooking temperature for a particular food material and the energy costs that may be involved. Pasting temperature ranged from 71.38-86.00 ºC. High pasting temperatures is associated with higher amylose content and high

Table 2. Functional properties of wheat-lima beans-tigernut composite flour

WF:LF:TF	Bulk Density (g/ml)	WAC (%)	OAC (%)	Swelling Power (g/g)	Solubility Index (%)
90:5:5	0.81±0.00a	206.70±0.04a	147.83±0.06a	3.75±0.02a	0.33±0.04d
85:10:5	0.87±0.00b	213.23±0.05b	151.90±0.09b	4.05±0.03b	0.24±0.04c
80:15:5	0.95±0.00d	227.37±0.04d	173.73±0.07d	4.38±0.05d	0.14±0.04b
75:20:5	0.92±0.00c	218.46±0.06c	166.85±0.08c	4.20±0.06c	0.21±0.03c
70:25:5	1.00±0.00e	234.20±0.06e	174.38±0.06e	4.47±0.05e	0.05±0.03a

Mean values with different superscripts within the same column are significantly different ($p < 0.05$);
WF: wheat flour, LF: Lima bean flour, TF: tigernut flour, WAC: Water absorption capacity, OAC: Oil absorption capacity

Table 3. Pasting properties of wheat-lima beans-tigernut composite flour

WF:LF:TF	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak Time (Minutes)	Pasting Temperature (°C)
90:5:5	2043.50±193.04a	1123.00±103.24a	920.50±89.80ab	2440.50±102.53a	1317.50±0.71a	5.90±0.14a	71.38±0.60a
85:10:5	2404.00±87.68b	1332.00±55.15ab	1072.00±32.53b	2793.50±103.94b	1461.50±48.79bc	5.74±0.09a	72.58±1.24a
80:15:5	2324.00±46.67b	1376.00±134.35b	948.00±87.68ab	2807.50±86.97b	1431.50±47.38b	5.84±0.23a	80.00±7.99ab
75:20:5	2203.50±7.78ab	1335.50±65.76ab	868.00±57.98a	2762.50±37.48b	1427.00±28.28b	5.70±0.24a	86.00±0.57b
70:25:5	2304.50±21.92b	1381.00±15.56b	923.50±6.36ab	2911.00±19.80b	1530.00±4.24c	5.53±0.00a	85.65±0.14b

Mean values with different superscripts within the same column are significantly different ($p < 0.05$);
WF: wheat flour, LF: Lima bean flour, TF: tigernut flour

resistance towards swelling (Ikegwu and Okechukwu, 2010).

Anti-nutritional composition of cookies from wheat-lima beans-tigernut composite flour

The anti-nutritional composition of the cookies from blends of wheat, lima beans and tigernut flours is presented in Table 4. Phytate and tannins are considered antinutrients because they interfere with the absorption of essential nutrients in the human body; therefore, it is important to determine their levels for several reasons including nutritional assessment, dietary planning and promoting quality health outcomes. The phytate content of the cookies ranged between 0.574 and 0.634%. Sample 70:25:5 had the highest (0.231%) and sample 75:20:5 had the lowest (0.168%) tannin content. The results are not consistent with 0.12-2.36 % reported for tannin contents of raw and processed pearl millet, wheat, cowpea and groundnut blends studied by Hajjagana et al. (2014). The substitution of lima bean flour with wheat-tigernut flour at 15, 20 and 25%, respectively, significantly increased the phytate contents of the cookies but only increased the tannins content at 15%, respectively. This is attributed to the inherent tannin (5.58 mg/g) and phytate (8.57 mg/g) contents in raw lima bean (El-Gohery, 2021).

Colour properties of cookies from wheat-lima beans-tigernut composite flour

Colour is an important quality parameter in food industries, owing to its direct relationship with the consumers' choice and preferences. Colour is the first contact perceived as a measure of quality and could greatly influence the consumers' acceptability of food products (Pathare et al., 2013). The colour properties of cookies are presented in Table 5. The colour results in terms of lightness (L*), redness (a*), yellowness (b*). Significant ($p < 0.05$) differences existed in lightness (L*), redness (a*) and yellowness (b*) of cookies produced from wheat, lima beans and tigernut composite flour. Increase in lima bean flour supplementation increased the colour properties of the composite flour blends. Lightness, redness and yellowness ranged from 32.82 to 40.04, 6.90-7.96 and 16.26-18.26, respectively. The colour of the cookies changed to dark brown as wheat flour is diluted with lima bean and tigernut flour. However, a change in the colour of the cookies in this current study to dark brown could be attributed to varying factors, including: natural pigments in the ingredient (lima bean contains chlorophyll, while tigernuts have a reddish-brown skin which could have impact on the colour of the cookies); Maillard reactions and caramelization during baking operation of the cookies; interaction of the composite flours with other ingredients, as well as particle size and texture, which could also have been responsible for the changes in colour of the cookies.

Sensory qualities of cookies from wheat-lima beans-tigernut composite flour

The sensory qualities of cookies from wheat, lima beans, and tigernut flour are presented in Table 6. Significant ($p < 0.05$) differences were observed in all the sensory attributes. The taste of the cookies ranged between 7.10 and 7.60. Sample 90:5:5 had the highest value of taste and sample 85:10:5 had the lowest value of the taste. Taste is the extent of sweetness, saltiness and blandness of a food sample (Amin et al., 2016). Colour is the most important sensory attribute of food and as such holds a preeminent position in overall food quality. The colour of the cookies ranged between 7.35 and 7.85. Sample 70:25:5 had the highest colour attribute and sample 85:10:5 had the lowest value of colour attribute. Texture ranged between 6.75 and 7.50. Sample 75:25:5 had the lowest value of texture and sample 90:5:5 had the highest value of texture. Texture is defined as those properties of a food that are sensed by touch in the mouth and with the hands. Texture can be described in terms of soft or hard, mushy or crunchy, or smooth or lumpy. Sample 75:25:5 had the highest value of aroma and sample 90:5:5 had the lowest value of aroma. The consumer perception determines its acceptability. The acceptability ranged from 7.70 and 8.05. Sample 85:10:5 had the lowest value of overall acceptability and sample 70:25:5 had the highest value of overall acceptability. All the cookie samples had similar sensory score; however, sample 70:25:5 had the highest overall acceptability.

Table 4. Anti-nutritional composition of cookies from wheat-lima beans-tigernut composite flour

WF:LF:TF	Tannin (%)	Phytate (%)
90:5:5	0.188±0.006b	0.624±0.003c
85:10:5	0.186±0.004b	0.574±0.003a
80:15:5	0.213±0.002c	0.634±0.006d
75:20:5	0.168±0.004a	0.581±0.005a
70:25:5	0.231±0.008d	0.605±0.005b

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); WF: wheat flour, LF: Lima bean flour, TF: tigernut flour

Table 5. Colour properties of cookies from wheat-lima beans-tigernut composite flour

WF:LF:TF	Lightness (L*)	Redness (a*)	Yellowness (b*)
90:5:5	38.82±0.73a	7.01±0.11a	16.26±0.50a
85:10:5	39.97±0.25b	7.96±0.04c	17.86±0.05cd
80:15:5	39.48±0.84ab	6.90±0.03a	17.76±0.26c
75:20:5	40.04±0.01b	7.56±0.02b	18.26±0.05d
70:25:5	40.03±0.44b	7.56±0.12b	16.94±0.09b

Mean values with different superscripts within the same column are significantly different ($p < 0.05$);
WF: wheat flour, LF: Lima bean flour, TF: tigernut flour

Table 6. Sensory qualities of cookies from wheat-lima beans-tigernut composite flour

WF:LF:TF	Taste	Texture	Colour	Aroma	Overall Acceptability
90:5:5	7.60±1.27a	7.50±1.43a	7.55±1.73a	7.10±1.41a	7.90±1.52a
85:10:5	7.50±1.10a	6.85±1.04a	7.35±1.04a	7.30±1.03a	7.70±1.08a
80:15:5	7.10±1.17a	6.90±0.91a	7.50±1.10a	7.20±1.11a	7.75±0.64a
75:20:5	7.45±1.57a	6.75±1.48a	7.70±0.86a	7.65±0.99a	8.00±0.86a
70:25:5	7.50±1.15a	7.25±1.02a	7.85±0.75a	7.40±0.94a	8.05±0.89a

Mean values with different superscripts within the same column are significantly different ($p < 0.05$);
WF: wheat flour, LF: Lima bean flour, TF: tigernut flour

Conclusions

The study shows that cookies can be produced from wheat, lima beans and tigernut. Supplementation of lima beans-tigernut flour with wheat flour for cookies improved the crude protein, total ash, bulk density, water and oil absorption capacities, swelling capacity, solubility, mineral composition and colour properties. The tannin and phytate contents of the cookies are low; thus, may not impede mineral absorption. The sensory properties of the cookies showed that all cookie samples were of similar ratings; however, sample 70:25:5 had the highest overall acceptability.

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