Original Research Article

Chemical Composition and Sensory Properties of Wheat, African Yam Bean and Tiger Nut Residue Composite Flour Cookies

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ABSTRACT

This study looked into the use of a blend of Wheat, African yam bean and tigernut residue flours for the production of cookies and assessment of its chemical, and sensory properties. The experiment used a completely randomized design, a total of 5 samples of the composite flour and one control (100% wheat flour) were obtained and used to bake the cookies. Proximate composition, mineral and sensory properties of the cookies were evaluated. The result obtained indicates that there were statistically significant differences in the output ($p < 0.05$). The moisture content of the cookies ranged from 5.43 % to 6.91 %, ash content ranged from 1.33 % to 2.10 %, fat contents ranged from 6.70 % to 12.20 %, crude fibre content ranged from 3.85 % to 7.65 %, crude protein contents ranged from 11.20% to 15.08% while carbohydrate content ranged from 57.33 % to 71.48 %. The result for the mineral showed that magnesium, calcium, iron, phosphorus, and sodium ranged from 67.33 to 79.50, 29.00 to 43.03, 2.30 to 3.26, 117.00 to 139.66, 117.00 to 139.66 mg/100g respectively. The sensory attributes of the cookies samples varied significantly ($p < 0.05$) in terms of colour, crispiness, taste, texture and overall acceptability. All of the composite flour cookies except for sample 3 differed significantly from the control in terms of acceptability. The study shows that supplementation of wheat flours with 15% African yambean and 15% tigernut residue produced well accepted cookies. It is anticipated thatthese products can lessen food insecurity. Furthermore, all the samples scored above average in terms of colour, crispiness, taste, texture and overall acceptability indicating that the incorporation of African yambean flour and tigernut residue did not adversely affect these attributes.

Keywords: African Yam bean, Tiger nut residue,cookies, Chemical composition, sensory properties.

1. INTRODUCTION

Cookies is described as a form of confectionary product dried to a low moisture content [1]. It is a nutritive snacks obtained from single or composite dough which has been transformed into digestible and more appetizing products through the action of heat in the oven [2]. When compared to other types of biscuits, they tend to be larger with a softer, acceptable texture and usually contain flour, sugar and some type of oil or fat [3]. Cookies are characterized by a formula high in sugar and shortening and low in water [4]. They differ from other baked foods like bread and cakes because they have low moisture content making them comparatively free from microbial spoilage and having long shelf [5]. The main ingredients of cookies are wheat flour, fat (margarine) and sugar and water, while other ingredients such as salt, milk, aerating, emulsifier agent, flavor and colour can be included.

They can also be enriched or fortified with other ingredients in order to meet specific nutritional or therapeutic needs of consumers [4]. They are consumed all over the world as snacks and on a large scale in the developing countries where protein-energy malnutrition is prevalent especially among children and adolescents [6].

Present day cookies are traditionally made from soft wheat, a cereal which is cultivated in many parts of the world but imported by countries including Nigeria with unfavourable climatic conditions for its cultivation [7]. Wheat (Triticumaestivum L.), though scarcely cultivated in Nigeria is a rich source of carbohydrate and also contains protein, fat, ash, fiber, and vitamins as well as mineral such as sodium, potassium, calcium, magnesium, iron, phosphorus, copper, zinc and manganese [8]. Wheat importation leads to competition and depletion of scarce foreign exchange. Hence the need to source local substitute for wheat in baked products. To this end, the use of composite flour has been encouraged since it will reduce the importation of wheat. Utilization of locally available, inexpensive materials like African yam bean and tiger nut that can partially substitute wheat flour without adversely affecting the acceptability of the product will be a good product development. This will increase the overall nutrients, encourage agricultural sector, increase cookies variety, reduce dependence on wheat flour for the production of cookies at lower cost of production.

African yam bean is mainly grown in the Southern parts of Nigeria, The Ibo people of South Eastern Nigeria call it “Okpodudu, Ijiriji, Azama”. The seeds may be boiled and eaten with original seasoning, roots, tubers and fruit or converted to paste for the product of a type of “ moimoi [9]. It is one of the lesser known and underutilized legumes that is very rich in protein, carbohydrate, vitamins and minerals [10].The protein of African yam bean is made up of over 32 percent essential amino acids, with lysine and leucine being predominant [11]. African yam bean seeds can be roasted and eaten with palm kernel as snacks or boiled and eaten with local seasoning, starchy root crops and fruits [12. [11] reported that African yam bean seeds can be also processed into flour which can be used for the production of bakery and confectionary products such as breads, biscuits, cookies, doughnuts, pie crust and cakes.

Tiger nut (Cyperusesculentusvar sativa) is a lesser known and underutilized crops, many of which are potentially valuable as human and animal food and is very widely grown in Northern Nigeria [13]. It is known in Nigeria as “Aya” in Hausa,”Ofio” in Yoruba and “Akiausa” in Igbo [14]. Tigernut has high calcium, sodium and phosphorus and low magnesium, manganese, iron, zinc and copper mineral contents[15]. The high values of calcium found in tigernut are adequate for bone and teeth development in infants[15]. The presence of other minerals such as iron is highly important because of its requirement for blood formation [16].

Previous research reports have shown the production of cookies from composite flours such as wheat, fiofio, and cowpea [17], lima bean, sorghum and wheat [18], wheat, cocoyam and pigeon pea [19] among others but reports of composite flours made of wheat, African yam bean (Sphenostylisstenocarpa) and Tiger nut (Cyperusesculentusvar sativa) residue in cookies production are not common, Therefore the objective of this study was to produce an acceptable cookies from a blend of african yambean, tiger nut residue and wheat flour.

2. MATERIAL AND METHODS

2.1 Materials Procurement

Wheat flour, Tiger nut, African yam bean and other ingredients was purchased from Eke-Awka market, Anambra state, Nigeria.

2.2 Preparation of African yam bean flour

The African yam bean was processed into flour using the method described by [20] with a slight modification. The beans were sorted to remove defective portions and then soaked in clean water for 24h after which they were dehulled manually by rubbing rigorously between the palms. The dehulled beans were then dried at 72^{o}C for 4h. The dried dehulled beans were milled using the hammer mill machine (tigerextruda 6.5 hp, UK) into fine particle size of about 250 micron. The flour were packaged in polyvinyl chloride bag and stored at room temperature until use

2.3 Preparation of Tigernut residue Flour

Tigernut residue was prepared as described in by [21]. Tigernut tubers were sorted, carefully washed, crushed, blended and sieved to extract milk, leaving the residue that was dried in a cabinet dryer at 60^{o}C for 24h. The residue was then milled into flour, sieved using 212 μm sieve size to obtain flour of uniform particle size and stored in a plastic air-tight container with a lid at room temperature for further usage

2.3Research Design

The design is completely randomized design;three different flours will be mixed at various ratios to give 100g composite

Table 1:Ratios of blends of wheat, African yam beans and Tiger nutresidue in Cookies production

No	Wheat flour(g)	African Yam Bean flour (g)	Tigernut Residue flour (g)
1	70	15	15
2	70	20	10
3	70	10	20
4	80	10	10
5	90	05	05
6	100	00	00

2.4 Production of cookies

Production of cookies were prepared according to the method previously describedby [22] with slight modificationby the authors. The recipes used were flour (100g), fat (40g), sugar (20g), eggs (1) and baking powder (2g) salt (2g) milk powder (30g). The ingredients were properly weighed with a weighing balance (Mettler, PC 400, Switzerland). Then creaming of fat and sugar was done followed by addition of eggs and then the flour and baking powder, salt, and milk powder were added to the creamy mass and mixed to a homogenous mass using Kenwood electronic mixer for 30min. The batter was then rolled out with a rolling pin to a thickness of 3 inches and 1inch diameter using a biscuit cutter. The cut cookies were placed on a o baking tray and baked at 175^{o}c in an oven for 10-15min. The cookies were then brought out from the oven and left to cool at room temperature before packaging in polyethylene bag for subsequent proximate and sensory analyses.

2.5 Chemical Analysis

The moisture, crude protein, fat, ash and crude fibre contents of the cookies were determined in triplicate according to standard analytical methods [23]. Carbohydrate was obtained by difference of moisture, protein, fat and ash from 100% [24]. The potassium and iron contents of the cookies were determined after ashing by the use of a flame photometer (Model 405, Corning, UK) according to the method of Ndieet *al.*[25]. The calcium and magnesium contents of the samples were determined using atomic absorption spectrophotometer (Perkin-Elmer, Model 1033, Norwalk, CT, USA) according to the method of [23]. Phosphorus was determined by the vanadomolybdate colorimetric method of Giami[26].

2.6 Sensory Evaluation

A semi-trained 15 panelist made up of male and female staff and students of the department of Food Science and Technology, NnamdiAzikiwe University, Awka were used. The panelists were educated on the respective descriptive terms of the sensory scales and requested to evaluate the various cookies samples for taste, appearance, texture, aroma and overall acceptability using a 7-point hedonic scale, where 7 was equivalent to like very much and 1 equivalent to dislike very much. Presentation of coded samples was done randomly and portable water was provided for rinsing of mouth in between the respective evaluations [27].

2.7Statistical Analysis

The mean of all parameters were evaluated for significance ($P\leq 0.05$) by analysis of variance (ANOVA) and the mean separation and the significant effect tested by Duncan's multiple range of test using SPSS version 23.0(IBM, USA)

3. RESULTS AND DISCUSSION

3.1 Proximate composition (%) of cookies produced from composite flours

The proximate composition of the cookies samples was presented in table 2, The result showed that the proximate composition of the cookies varied with the proportion of the three flours in the formulated blends. The variations could be attributed to differences in the chemical constituents of individual flours used in composite flour formulation. As observed, incorporation of African yam bean and tigernut residue in the cookies samples slightly increased their moisture, ash, fibre, fat and protein content while the carbohydrate content of the cookies samples decreased slightly.

The moisture content ranged from 5.43 to 6.91%, the moisture content of the control (100% wheat flour) was significantly the lowest. The influence of incorporation of African yam bean and tigernut residue on the moisture content of the cookies samples was clear as all the composite samples had higher moisture compared to the control sample. Smaller values ranging from 3.70 – 4.60% was reported as the moisture content of cookies produced from blends of maize and tigernut flours [28]. However, [29] reported higher moisture content ranging from 7.10 -10.89% for biscuit produced from composite flours of wheat, sorghum and defatted coconut flour. The variation in moisture content can be attributed to differences in the raw materials used as well as environmental and experimental factors [30]. The low moisture content obtained in this study is desirable for the prevention of microbial activities and extension of the shelf-life of the cookies if protected from absorbing moisture through proper packaging.

The ash content of a food material could be used as an indicator of mineral constituents of the food because ash is the inorganic residue remaining, after the water and organic matter have been removed by heating in the presence of an oxidizing agent [31]. The ash contents of the supplemented cookies are higher than that of the control cookies produced, Sample 2 (WH-70: AYB-20: TNR-10) had a highest value of 2.10% while sample 6 (100% wheat flour) had lowest value of 1.33%. The result showed that incorporation of African yambean and tigernut residue flour slightly increased the ash content of the product, this might be due to that African yambean are rich in ash content [32;33].

There was significant increase in the fibre content of the cookies samples. The values increased from 3.85% in sample 6 (100% wheat flour) to 7.65% in sample 3(Cookies made with 70% wheat flour, 10% African yam bean flour and 20% Tiger nut residue). This is in agreement with the study of [34] and [11] who reported an increase in fibre content of cookies produced from wheat-tigernut residue composite flour and wheat-african yambean composite flour respectively. [35] also reported increase in fibre content (0.48 to 1.03%) of wheat cookies fortified with pineapple peel flour although their values are lower than the ones obtained in this study. crude fibre composition is a measure of the quality of indigestible cellulose, pentose, lignin and other components of this type present in food [36]. Crude fibre has little food value but it plays a role in the increased utilization of nitrogen and absorption of some other micronutrients and provides bulk necessary for peristaltic action in the intestinal tract [37].

All the samples differed significantly ($p < 0.05$) in fat content, the fat content of the fortified cookies increased greatly when compared to the control sample. The percentage fat content of the cookies samples ranged from 6.70 % in control sample 6 (100% wheat flour) to 12.20% in sample 3 (Cookies made with 70% wheat flour, 10% African yam bean flour and 20% Tiger nut residue) The percentage fat content obtained in this study fell below the range (9.95-20.45%) reported by [38] for cookies produced from wheat, defatted peanut and avocado flour blends but higher than 3.84 -4.63% reported by [11] for Wheat-African yambean composite cookies . The varied results could be attributed to the differences in the raw materials used. It could also be as a result of the function of the butter used in the cookies formulation [37]. High-fat content in food especially baked products can create the challenge of rancidity during storage, although fat facilitates absorption of fat-soluble vitamins, provides essential fatty acids and important volatile compounds for flavor and sensory qualities[39].

The protein content of control sample 6(100% wheat flour) was the lowest (11.20%), while those with African yam bean flour and tigernut residue substitutions had higher protein contents. This showed that the addition of African yam bean flour and tigernut residue resulted in increase in the protein content of the cookies, sample 2(WH-70: AYB-20: TNR-10) was the highest (15.08%).. This observation is not in doubt because African yam bean had been reported to be a good source of protein [40; 41; 42]. There has been similar report on the increase in protein content of bakery products substituted with pigeon pea flour [12].

The carbohydrate content of cookies was within the range of 57.33 to 71.48%. There was a significant difference($p < 0.05$) between sample 6 (100% wheat flour) and other blended samples while sample 1(WH-70: AYB-15 : TNR- 15), 2(WH-70: AYB-20 : TNR- 10) and 3(

WH-70: AYB-10 : TNR- 20) has no a significant (p > 0.05) difference among them. The carbohydrate content of the cookies samples incorporated with African yam bean and tigernut residue were lower than the control sample. This may be as a result of the substitution which led to the reduction or changes in the carbohydrate content of the blended sample. [43] and [11] reported similar decrease in carbohydrate content of cookies produced from blends of wheat and African yam bean and wheat and bambara groundnut respectively. According to [44], carbohydrate content contributes energy value of food formulations. The high carbohydrate in these cookies makes them ideal for all age groups most especially infants since they require energy for their rapid growth.

Table 2: Proximate composition (%) of cookies produced from composite flour

NO	WH:AYB:TR	Moisture	Ash	Fibre	Fat	Protein	Carbohydrate
1	70 : 15 : 15	$6.86^{a}\pm0.53$	$1.80^{b}\pm0.13$	$6.90^{b}\pm0.05$	$12.10^{b}\pm0.05$	$14.30^{ab}\pm0.61$	$57.70^{d}\pm0.70$
2	70 : 20 : 10	$6.60^{ab}\pm0.91$	$2.10^{a}\pm0.19$	$5.73^{c}\pm0.03$	$11.06^{c}\pm0.06$	$15.08^{a}\pm0.88$	$58.46^{d}\pm1.40$
3	70 : 10 : 20	$6.91^{a}\pm0.82$	$1.77^{bc}\pm0.12$	$7.65^{a}\pm0.05$	$12.20^{a}\pm0.00$	$14.14^{ab}\pm0.93$	$57.33^{d}\pm0.90$
4	80 : 10 : 10	$6.39^{ab}\pm0.64$	$1.58^{cd}\pm0.08$	$5.70^{c}\pm0.05$	$10.46^{d}\pm0.05$	$13.01^{bc}\pm0.01$	$62.86^{c}\pm0.12$
5	90 : 05 : 05	$5.81^{ab}\pm0.45$	$1.41^{de}\pm0.00$	$5.50^{d}\pm0.00$	$7.50^{e}\pm0.05$	$11.80^{cd}\pm1.00$	$67.97^{b}\pm0.52$
6	100:00:00	$5.43^{b}\pm0.45$	$1.33^{e}\pm0.00$	$3.85^{e}\pm0.05$	$6.70^{f}\pm0.05$	$11.20^{d}\pm1.00$	$71.48^{a}\pm0.48$

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p≤0.05).

Key: WH – Wheat flour, AYB – African yam bean flour, TNR – Tigernut residue

3.2 Mineral composition (mg/100g) of cookies produced from the composite flours

The mineral composition of cookies produced from composite flours of wheat, African yam bean and tigernut residue is shown in table 3, The magnesium content ranged from 67.33 to 79.50mg/100g with sample 6 (!00% wheat flour) as the least and sample 2 (WH-70: AYB-20 : TNR- 10) as the highest, It was observed that inclusion of African yambean and tigernut residue flour in the cookies formulation generally improved the magnesium content of all the composite samples. The values obtained for magnesium in this study is lesser than range of values (78.55 – 98.88 mg/100 g) reported for wheat-defatted peanut-avocado biscuit [38],The varied results may be attributed to differences in the raw materials used. Magnesium has been reported by [45] to be an activator of many enzyme systems and maintains the electrical potential in the nerves. Magnesium works with calcium to assist in muscle contraction, blood clotting and the regulation of blood pressure and lung function [45].

The calcium content of sample ranged from 29.00mg/100g in sample 6 (100% wheat flour) to 43.03mg/100g in sample 2(WH-70: AYB-20 : TNR- 20) the inclusion of African yambean and tigernut residue flour increased the calcium content of the sample, [42] also reported an improvement in calcium content wheat-African yam bean cookies. Calcium is essential in maintaining total body health. Apart from keeping bones and teeth strong, it ensures proper functioning of muscles and nerves [16]. It is important in regulation of the tone and contractility of heart and acts as an antidote to the depressant action of potassium [46].

There was also an improvement in the iron content of cookies as all the supplemented samples had values higher than the control and ranged from 2.30 mg/100 g to 3.26 mg/100g. [11] also reported improvement in iron content of cookies produced from wheat and African yam bean flours. Iron content is important in contributing to the overall daily dietary intake of essential elements especially the micronutrients [47].

The phosphorus content of the cookies samples ranged from 117 to 139.00 mg/100 g. The highest value was observed in sample 2(WH-70: AYB-20: TNR- 10) while the least value was observed in sample 6 (100% Wheat flour). The results obtained were less than the values (176.37-221.36 mg/100 g) recorded for biscuits made from blends of wheat, defatted peanut and avocado composite flour [38]. The varied results could be attributed to the differences in the raw materials used. . Phosphorus is required to maintain osmotic balance of body fluids, body pH, muscle regulation and nerve irritability, glucose absorption control and enhanced normal retention of protein during growth [48]. It is also an important component of cell and body fluids that helps control heart rate and blood pressure by countering negative effects of sodium [48].

There were significant difference ($p < 0.05$) in the sodium content in all the samples. The sodium content ranged from 25.26 to 33.26mg/100 g .These values do not meet the United State Department of Agriculture (USDA) recommendation for sodium (1500 mg/g) [49]. The values were however; higher than 14.11 – 16.08 mg/100 g reported by [31] for sodium content of cookies produced from flour blends of wheat, walnut and carrots, differences in the raw materials used could be the reason for the varied result. Sodium helps in maintenance of water balance, transmission of nerve impulses, absorption and transportation of some nutrients; it has been recommended to be taken in reduced quantity. High sodium intake may contribute to high blood pressure in salt sensitive individuals [50].

Table 3: Mineral composition (mg/100g) of cookies produced from the composite flours

NO	WH:AYB:TR	Magnesium	Calcium	Iron	Phosphorus	Sodium
1	70 : 15 : 15	78.50^{b}±0.10	39.01^{b}±0.02	3.10^{a}±0.10	135.33^{b}±1.52	29.80^{b}±0.10
2	70 : 20 : 10	79.50^{a}±0.10	43.03^{a}±0.50	3.26^{a}±0.05	139.66^{a}±1.52	33.26^{a}±0.15
3	70 : 10 : 20	74.56^{c}±0.05	36.31^{c}±0.54	2.86^{b}±0.05	129.66^{c}±1.52	28.56^{c}±0.20
4	80 : 10 : 10	73.30^{d}±0.05	36.00^{c}±1.00	2.80^{b}±0.10	123.00^{d}±1.00	28.53^{d}±0.14
5	90 : 05 : 05	70.43^{e}±0.51	32.00^{d}±1.00	2.56^{c}±0.15	120.00^{e}±1.00	28.14^{e}±0.22
6	100 :00 :00	67.33^{f}±0.57	29.00^{e}±1.00	2.30^{d}±0.10	117.00^{e}±1.00	25.26^{f}±0.15

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different (p≤0.05).

Key: WH – Wheat flour, AYB – African yam bean flour, TNR – Tigernut residue

3.3 Sensory properties of the cookies

The mean scores for the sensory evaluation of cookies produced from composite flours of wheat, African yambean and tigernut residue is shown in table 4. The cookies samples had mean scores ranging from 5.00 – 6.00 for colour with sample 1(WH-70: AYB-15 : TNR- 15) having the highest scores while sample 3(WH-70: AYB-10 : TNR- 20) had the least scores. All the samples scored above average in terms of colour indicating that incorporation of African yam-bean and tigernut residue flour did not adversely affect these attributes. The panelists liked the brown colour of the cookies samples which may have resulted from Millard resulting from the presence of reducing sugars, proteins and amino acids and caramelization due to the effect of severe heating during processing [38]

Taste is the sensation of flavor perceived in the mouth and throat on contact with a substance and it is one of the most important attributes watched out for in a food product [51]. It could be affected by the types and quality of ingredients and could also depend on the formulation of the food material [52].Means scores of taste of the cookies samples range between 4.40 and 6.33, Sample 6(100% Wheat flour) has the highest score while sample 2(WH-70: AYB-20 : TNR- 10)has the lowest score, all the samples scored above average in terms of taste indicating that incorporation of African yambean and tigernut residue flour did not adversely affect these attributes, [11] reported that the taste of cookies fortified with African yam bean were accepted. These observations are in line with the one obtained in the present study.

Mouthfeel shows the response of sense organs in the mouth to the roughness, smoothness, chew ability, stickiness of food in the mouth [44]. The control sample 6 (100% wheat flour) had the highest mean value of 5.93, sample 3 (WH-70: AYB-10 : TNR- 20) had the least score of 4.60. All the samples scored above average in terms of mouthfeel indicating that incorporation of African yambean and tigernut residue flour did not adversely affect these attributes.

Crispiness is a textural characteristic of cookies which shows how soft or hard a cookie is and its ability to be munched easily [53]. The results in Table 4 revealed that some significant differences ($p<0.05$) existed in the crispiness of the cookies samples with least scores of 4.86 in Sample 3(WH-70: AYB-10 : TNR- 20) and highest score of 6.06 in sample 6 (100% wheat flour).

The mean scores for the overall acceptability of the cookies were above the average, indicating high acceptability of the samples. There was no significant ($p > 0.05$) difference between sample 6 (100% wheat flour) which has the highest value (6.20) and sample 1 (70% wheat flour, 15% African yam bean flour and 15% Tiger nut residue) but they differed significant ($p < 0.05$) with the other samples. According to [38], the baking conditions (temperature and time variables); the state of the cookies constituents, such as fibre, starch, protein (gluten) whether damaged or undamaged and the amounts of absorbed water during dough mixing, all contribute to the final outcome of the overall acceptability

Table 4: Sensory properties of the cookies

NO	WH:AYB:TR	Colour	Taste	Mouth feel	Aroma	Cripsiness	Overall Acceptability
1	70 : 15 : 15	$6.00^{a}\pm0.75$	$5.60^{ab}\pm1.35$	$5.66^{ab}\pm0.81$	$5.26^{a}\pm1.22$	$6.06^{a}\pm0.88$	$6.13^{a}\pm0.91$
2	70 : 20 : 10	$5.66^{ab}\pm0.81$	$4.40^{c}\pm1.35$	$5.00^{bc}\pm1.30$	$4.20^{b}\pm1.82$	$4.93^{c}\pm1.16$	$5.06^{b}\pm 0.96$
3	70 : 10 : 20	$5.00^{b}\pm1.36$	$4.73^{bc}\pm1.03$	$4.60^{c}\pm0.91$	$4.40^{b}\pm0.88$	$4.86^{c}\pm0.83$	$4.93^{b}\pm0.96$
4	80 : 10 : 10	$5.66^{ab}\pm0.89$	$5.46^{ab}\pm1.40$	$5.80^{a}\pm1.01$	$5.26^{a}\pm0.89$	$5.60^{abc}\pm1.18$	$5.40^{b}\pm1.21$
5	90 : 05 : 05	$5.80^{a}\pm0.86$	$5.00^{bc}\pm1.13$	$5.26^{ab}c\pm1.09$	$5.13^{a}\pm0.89$	$5.66^{a}\pm1.20$	$5.53^{b}\pm1.17$
6	100:00: 00	$5.86^{a}\pm0.74$	$5.93^{a}\pm0.79$	$5.93^{a}\pm0.79$	$5.66^{a}\pm0.89$	$6.00^{ab}\pm1.06$	$6.20^{a}\pm0.67$

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p\leq0.05$).

Key: WH – Wheat flour, AYB – African yam bean flour, TNR – Tigernut residue

4. CONCLUSION

Cookies were produced from a partial substitution of wheat with African yam bean and tiger nut residue flour. The samples with African yam bean and tiger nut residue substitution had higher values of protein, fat , ash and fibre contents than the control sample (100% wheat).Sample 2 (cookies substituted with 20% African yam bean and 10% tiger nut residue flour) had the highest value of Magnesium, Calcium, Iron, Phosphorus and Sodium contents. The control sample was most accepted in terms of general acceptability. Among the blended samples, sample 1 (cookies substituted with 15% African yam bean and 15% tiger nut residue flour) was the most acceptable in terms of general acceptability. Acceptable cookies of improved nutritional quality and high dietary fibre content could be produced from blends of wheat, African yam bean and tiger nut residue flour.

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