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Quality assessment of flour and cookies from wheat, African yam bean and acha flours

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Abstract

In this study, the suitability of wheat, acha and African yam bean composite flour in the development of cookies was investigated. Wheat, acha and African yam bean were blended into various proportions of flour mixes and used to produce cookies. The flour mixes were analyzed for the proximate, minerals composition, functional properties and anti-nutrients, while the cookies were evaluated for its sensory and physical properties. The proximate composition of the flours varied from 7.85-9.71%, 12.34-14.01%, 1.15-1.86%, 1.21-1.49%, 1.65-1.92% and 70.01-76.11% for moisture, protein, fat, crude fiber, ash and carbohydrate content of the flour, respectively. The mineral content ranged from 10.11-13.12 mg/100 g, 52.65-61.76 mg/100 g, 130.71-211.76 mg/100 g, 111.97-130.84 mg/100 g and 14.81-20.43 mg/100 g for calcium, magnesium, potassium, phosphorus and sodium, respectively. The functional properties ranged from 0.76-0.80 g/cm^3; 86.65-188.11 g/g; 94.30-197.23 g/g; 569.23-699.54%; 5.68-6.44%; 61.50-125.50 sec, 73.75-75.25% for bulk density, water absorption capacity, oil absorption capacity, swelling capacity, solubility, wettability and dispersiblity respectively. The anti-nutritional properties ranged from 37.67 to 46.73 mg/100 g, 5.27 to 5.57 mg/100 g and 32.91 to 35.10 mg/100 g for oxalate, phytate and tannin, respectively. The physical properties values ranged from 6.11-8.20 mm, 38.46-39.30 mm, 37.83-38.23 mm, 4.79-5.85, 5.35-7.49 g and 1.72-1.90 kg for thickness, diameter, height, spread ratio, weight and break strength respectively. Cookies from composite flours were not significantly (p>0.05) different from the control in overall acceptability. This shows the possibility of producing nutritious cookies with desirable organoleptic qualities from wheat, acha and African yam bean flour.

1. Introduction

Biscuits or cookies are one of the popular cereal foods, consumed in Nigeria. They are instant, fast and economical food products, with great dietary and digestive principles (Kulkarni, 1997). They are snacks containing high nutrients prepared through the application of heat in the oven where it is transformed into appealing products from rough or unappetizing dough (Olaoye *et al.*, 2007). Majority of these foods products are however poor sources of protein and such contribute to poor nutritional quality (Akpapunam and Darbe, 1994). Being an instant and fast food product, it is important to be enriched with other protein sources such as legumes and oilseeds and fortified with vitamins and minerals (Eltayeb *et al.*, 2011).

Wheat (*Triticum aestivum*) is one of the most useful and valuable crops grown around the world and it is considered as almost first among cereal largely due to the fact that its grain contains protein with unique chemical and physical properties, and other vital nutrients (Ikhtiar and Alam, 2007). Studies have shown that blending of legume with root crops or cereals could help to improve the overall nutrition in the diet. Wheat flour is the major nutritious plant foods available, offering an array of minerals and critical nutrients. Wheat flour is a powder made from the grinding of wheat used for human consumption.

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Acha (*Digitaria exilis*) is a cereal crop grown in some areas of Plateau, Kaduna and Bauchi States. Acha is of great nutritional content and this makes it a popular crop with high demand, especially in urban areas where its nutritional importance is known and valued. It contains methionine and cysteine, two amino acids that are important to human survival. These two amino acids, however, are lacking in wheat, rice, maize, and other cereal crops (Adoukonou-Sagbadja *et al.,* 2007). Moving from the amino acid level to the macromolecule level, *D. exilis,* compared to other cereal crops, has greater protein, carbohydrate, and fiber content (Barikmo *et al.,* 2004). However, the production and supply of acha remains low and falls short of its demand. Acha production is unpopular because of the drudgery involved in its harvest and processing. In the traditional way of processing, the acha grains are dehulled by beating, trampling or in a mortar. Acha seeds are additionally very small in size, which makes its winnowing hard to do as sand tends to remain with the seeds, leading to gritty finished/cooked products.

African yam bean (*Sphenostylis stenocarpa*), an important legume in Africa with duo food product (seeds and tubers) and it is a lesser-known legume of the tropical and sub-tropical areas of the world which has attracted research in recent times (Azeke *et al*., 2005). African yam bean is rich in carbohydrate, protein, vitamins and minerals (Iwuoha and Eke, 1996). African yam bean consists of protein that is made up of over 32% essential amino acids, with leucine and lysine being preponderant (Onyenekwe *et al*., 2000). Therefore, substituting it with wheat in the production of cookies would supply the lysine absent in wheat. This legume has also been reported to be of importance in the management of chronic diseases like hypertension, diabetes, and cardiovascular diseases because of its high dietary fibre content (Enwere, 1998).

In spite of all this, African yam bean is underutilized and hardly consumed in urban areas which are attributed to its complex preparation method. The use of African yam bean in composite flour for cookies production will make it readily available for consumption by all persons. It is a good source of protein, carbohydrate, minerals and vitamins with its protein content, twice that of sweet or Irish potatoes and very much higher than those in yam and cassava (Day, 2013). The utilization of wheat, acha and African yam bean in the production of baked goods are not well known in Nigeria and there is scanty information on the utilization of acha and African yam bean in Nigerian foods since they are both underutilized cereals and legumes respectively. Hence, this study looks into the quality attributes of cookies produced from composite flour from wheat, acha and African yam bean flour.

2. Materials and methods

2.1 Procurement of materials

African yam bean (AYB) and wheat were purchased from a local market (Bodija) in Ibadan, Oyo State while acha was purchased in Jos, Plateau State. Other ingredients such as sugar, yeast, fat, margarine, egg and baking powder were purchased from Sabo market in Ogbomoso.

2.2. Preparation of African yam bean and acha flour

African yam bean flour was prepared according to the methods described by Enwere (1998). The African yam bean (AYB) was cleaned to remove all contaminants such as stones, pods, fragments, immature beans, soaked in water for 12 hrs and blanched for 15 mins to reduce the anti-nutritional factors and beany flavour that might be present. The blanched AYB will then be dehulled and oven-dried at 55°C for 12 hrs, milled into flour, sieved at 450 μm aperture sieve to obtain fine African yam bean flour. Acha flour was prepared according to the methods described by Adegoke (2004) about 2 kg of acha was washed and then dried on clean sack. The dried acha was milled using a hammer mill, sieved (300-400 μm) and then the flour was obtained.

2.3 Formulation and production of cookies

Blends with different proportions of wheat flour (WF), acha flour (AF) and African yam bean (AYBF) were prepared with 100% WF as control. Cookies were prepared using the method described by Ceserani and Kinton (2008). Fat and sugar were creamed together until fluffy. The flour, baking powder, whole egg and salt were added and manually mixed in a bowl to form a dough. The dough was rolled to a uniform thickness and baked in an oven at 170°C for 20 min. The cookies were removed and allowed to cool on a rack, after which they were packaged in low-density polyethylene bags and kept in a plastic container before further analyses.

2.4 Analyses

The flour samples were analyzed according to the method described by AOAC (2005) for moisture, ash, crude fibre, protein, crude fat and carbohydrate was determined by difference. Calcium, magnesium, potassium, phosphorus and sodium were analyzed using the dry-ash techniques according to AOAC (2005). The method described by Mpotokwane *et al*. (2008) was adopted for the determination of bulk density with slight

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modification. Water and oil absorption capacity of the flour was determined as described by Oyeyinka *et al.* (2013). The swelling power and solubility index of the composite flour was determined according to the method described by Sanni *et al.* (2008). The tannin content of the cookies was determined by AOAC (2005) using Folin Denis Reagents. Phytate content was determined using AOAC (2005). Oxalate was determined by the titration method of Nwinuka *et al*. (2005) and Saponins determination was carried out by Fenwick and Oakenfull (1983).

2.5 Physical attributes of cookies

The weight and diameter of the cookie samples were determined by weighing on a weighing balance (Santual Electronic Weighing Balance) and measuring with a calibrated ruler, respectively (AOAC, 2005). Cookies spread ratio was determined according to the method of Giami *et al.* (2004). The thickness of the cookies was determined using the method of Mcwatters *et al.* (2003). Break strength was determined according to the method described by Okaka and ISieh (1990).

2.6 Sensory evaluation

The sensory evaluation was carried out by fifty untrained sensory panelists of undergraduate students of Ladoke Akintola University of Technology, Nigeria. Each panelist was served with cookies made from the composite flour. Water was provided for rinsing between the samples. The organoleptic attributes assessed include colour, taste, aroma, crispiness and overall acceptance of the cookies using the 9-point hedonic scale with 1 dislike extremely and 9 like extremely.

2.7 Statistical analysis

The results of the experiment were subjected to analysis of variance (ANOVA) and the mean was separated with the use of Duncan's multiple range test to determine the significant difference ($p<0.05$) among the sample.

3. Results and discussion

3.1 Results of the proximate composition of the composite flour

The proximate composition of composite flour is shown in Table 1. The moisture content of the composite flour ranged from 7.85 to 9.71% with the control sample (100% wheat flour) having the lowest and sample 50/30/20 wheat, acha and African yam bean having the highest value. The result of the moisture content of the flour varies as acha and African yam bean flour is added. The moisture content of the flour is within an acceptable limit for stable shelf life as reported by Kayisu *et al.* (1981). Moisture content is very essential for life maintenance and analysis of it is one of the most widely used instruments which determine the way the food was processed and its shelf life (Akinsanmi *et al.,* 2015). It has also been used as a measure of stability and susceptibility to microbial contamination. Flours with lower moisture have greater shelf stability since spoilage is often caused by microbial activities and related chemical reactions that require higher moisture levels.

The protein content of the flour ranged from 12.34 to 14.01%. Sample 50% wheat flour, 30% acha flour and 20% African yam bean flour had the highest value. The highest protein content of composite flour could be attributed to the ratio of African yam bean percentage (20/100 g) in the flour component (Iwuoha and Eke, 1996; Onyenekwe *et al.,* 2000) and high protein wheat and acha flour (Jideani and Akingbala, 1993; NRC, 1996). The fat content of the composite flour ranged from 1.15 to 1.86% with 100% wheat flour having the lowest value while 50/30/20 (wheat flour, acha flour and African yam bean flour) had the highest value. The fat content of the flour blends in this study is similar to those reported by Egbebi and Bademosi (2011) and Odenigbo *et al.* (2013). The lower fat gave a higher probability of a longer shelf-life in terms of the onset of rancidity (Ihekoronye and Ngoddy, 1985).

The crude fibre of the flour mixes ranged from 1.21 to 1.49%. Sample with 100% acha flour having the lowest value whereas sample 50% wheat flour, 30% acha

Table 1. Proximate composition of wheat, acha and African yam bean flour blends

Sample (WF/AF/AYBF %)	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrate (%)
100/0/0	7.85±0.16^{a}	12.76±0.03^{a}	1.28±0.04^{a}	1.36±0.00^{a}	1.73±0.01^{b}	75.02±0.25^{c}
80/15/5	9.58±0.01^{c}	13.48±0.01^{b}	1.33±0.11^{b}	1.41±0.02^{b}	1.65±0.01^{a}	71.55±0.08^{b}
70/20/10	9.25±0.13^{c}	13.76±0.06^{b}	1.66±0.02^{b}	1.45±0.03^{b}	1.86±0.02^{c}	71.02±0.15^{b}
50/30/20	9.71±0.12^{c}	14.01±0.06^{c}	1.86±0.03^{c}	1.49±0.02^{b}	1.92±0.02^{c}	70.01±0.04^{a}

Values are expressed as mean±standard deviation. Values with different superscript within the column are significantly different ($p<0.05$).
100/0/0 = 100% wheat flour; 80/15/5 = 80% wheat flour, 15% acha flour, 5% African yam bean flour; 70/20/10 = 70% wheat flour, 20% acha flour, 10% African yam bean flour; 50/30/20 = 50% wheat flour, 30% acha flour, 20% African yam bean flour

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flour and 20% African yam bean flour had the highest value. Fibre content the flour blends of increased with increase in the addition of Africa yam bean and acha flour. The fiber content of the samples was higher than what Oladele *et al.* (2009) reported in their findings. It is well known that soluble fibre generally increases transit time through the gut, slow emptying of the stomach and slow glucose absorption (Chukwuma *et al.,* 2010).

The ash content of the flour ranged from 1.65 to 1.92%, the highest value was observed in the 50/30/20 wheat, acha and African yam bean flour whilst the 100 wheat flour were the lowest. Ash contents are an indication of minerals that are contained in the flours. Flours reported in this study are comparable with the work of Odenigbo *et al.* (2013). The carbohydrate content of the flour ranged from 70.01 to 76.11% with acha flour having the highest and 50/30/20 wheat, acha and African yam bean having the lowest value. The carbohydrate contents of these samples are an indication that the products are good sources of energy. Carbohydrates are good sources of energy and that a high concentration of it is desirable in breakfast meals and weaning formulas. In this regard, therefore, the high carbohydrates content of the wheat flour would make it provide required energy in breakfast formulations (Butt *et al.,* 2010).

3.2 Mineral composition of the composite flour

The mineral content of the composite flour is shown in Table 2. The value ranged from 10.11-13.12 mg/100 g, 52.65-61.76 mg/100 g, 130.71-211.76 mg/100 g, 111.97-130.84 mg/100 g and 14.81-20.43 mg/100 g for calcium, magnesium, potassium, phosphorus and sodium, respectively. The samples were significantly different from one another. Minerals are important in food with high nutritional components and they are classified as essential or non-essential elements. Minerals are essential for health and as such are part of all aspect of cellular function and they are required for building structural components of human beings. Some mineral elements form an integral part of an enzyme or protein structure. They are vital for normal growth, maintenance, effective immune system and prevention of cell damage (Kassa and Hailay, 2014). The results from the mineral analysis showed that the composite flour would contribute substantially to the recommended dietary requirement for minerals.

3.3 Functional properties of the flour

The functional properties of the composite flour are as shown in Table 3. The bulk density of flour is the density measured without the influence of any compression. The bulk density of flour blends ranged from 0.769 to 0.805 g/cm^3. It is clear that decreased in the proportion of wheat flour leads to an increase in bulk density of composite flours. The high bulk density makes the flour suitable for use in food preparations. Therefore, this study shows that high bulk density of composite flour indicates its ability to be used as a thickener in food products and for use in food preparation since it helps to reduce paste thickness which is an important factor in convalescent and child feeding. Bulk density of composite flours increased significantly as acha and African yam bean flour incorporated with wheat flour increases. Similar findings were reported by Eltayeb *et*

Table 2. Mineral composition of flour blends from wheat, acha and African yam bean

Sample (WF/AF/AYBF %)	Calcium mg/100g	Magnesium mg/100g	Potassium mg/100g	Phosphorus mg/100g	Sodium mg/100g
100/0/0	13.12±0.01^d	54.71±0.92^b	141.05±0.02^c	116.91±1.10^c	16.42±0.12^c
80/15/5	11.37±0.12^b	61.76±0.15^d	211.76±0.15^e	111.97±2.68^a	19.79±0.10^d
70/20/10	10.11±0.03^a	59.50±0.07^c	182.66±0.28^d	130.84±0.35^e	20.43±0.10^e
50/30/20	11.86±0.30^b	52.65±0.59^a	130.71±0.21^a	124.65±0.31^d	14.81±0.22^a

Values are expressed as mean±standard deviation. Values with different superscript within the column are significantly different ($p<0.05$).
100/0/0 = 100% wheat flour; 80/15/5 = 80% wheat flour, 15% acha flour, 5% African yam bean flour; 70/20/10 = 70% wheat flour, 20% acha flour, 10% African yam bean flour; 50/30/20 = 50% wheat flour, 30% acha flour, 20% African yam bean flour

Table 3. Functional properties of wheat, acha and African yam bean flour blends

Sample (WF/AF/AYBF %)	Bulk density (g/cm^3)	WAC (g/g)	OAC (g/g)	Swelling capacity (%)	Solubility index (%)	Wettability (s)	Dispersibility (%)
100/0/0	0.769^a	188.115^d	197.230^d	699.540^d	6.440^b	125.500^d	75.250^c
80/15/5	0.774^b	89.372^c	99.090^c	593.410^c	5.680^a	85.500^b	73.750^a
70/20/10	0.781^b	88.565^b	96.461^b	591.264^b	5.713^a	87.351^c	74.950^b
50/30/20	0.805^c	86.650^a	94.305^a	569.230^a	6.245^b	61.500^a	75.000^c

Values with different superscript within the column are significantly different ($p<0.05$).
100/0/0 = 100% wheat flour; 80/15/5 = 80% wheat flour, 15% acha flour, 5% African yam bean flour; 70/20/10 = 70% wheat flour, 20% acha flour, 10% African yam bean flour; 50/30/20 = 50% wheat flour, 30% acha flour, 20% African yam bean flour

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al. (2011) on chemical composition and functional properties of flour and protein isolate extracted from Bambara groundnut.

The water absorption capacity (WAC) for composite flour is given in Table 3. The WAC ranged between 86.65 to 188.11 g/g for the flour blends. The WAC was observed to be highest in the sample with 100% wheat flour and lowest in 50/30/20 wheat, acha, African yam bean flour. The result shows that the addition of acha and African yam bean flour to wheat flour has effects on the amount of water absorption. This could be as a result of the molecular structure of the starch of the grain which prevented water absorption, as could be seen from the lower values of WAC, with the increase in proportions of other flours compared to wheat flours. A similar observation was reported by Kaushal *et al*. (2012). High WAC of composite flours shows that the flours can be used in the preparation of some foods such as sausage, dough, processed cheese and bakery products.

The oil absorption capacity (OAC) of composite flour ranged from 94.31 to 197.23 g/g (Table 3). The highest OAC has observed in 100% wheat flour whilst the lowest value in 50/30/20 wheat, acha, African yam bean flour. The OAC of composite flour differed significantly ($p<0.05$). The presence of high-fat content in flours might have affected adversely the OAC of the composite flours. However, the flours in this study are potentially useful in the interaction of structural components in food most especially in flavour retention, improvement of palatability and extension of shelf life particularly in bakery or meat products where fat absorption is desired (Aremu *et al*., 2007).

The swelling capacity of flour blends ranged between 569.23 and 699.54% with sample 100/0/0 wheat, acha, African yam bean flour having the highest and 50/30/20 wheat, acha, African yam bean flour the lowest. The swelling capacity of flours depends on types of variety, size of particles and types of processing methods or unit operations. The swelling capacity of composite flours decreased as the level of incorporation ratio of acha and African yam bean increased.

The solubility index (SI) of the flour mixes ranged from 5.68 to 6.44%. It was observed that there was a significant decrease in SI as the percentage of inclusion in acha and African yam bean flour increased in the composite flour and this may be due to the large quantity of polysaccharides from the flours. Solubility index (SI) according to Spinello *et al*. (2014) serves as an indicator to measure the degradation of molecular components (starch). It determines the amount of free polysaccharide or polysaccharide released from the granules after the addition of excess of water. Spinello *et al.* (2014) also reported that SI depends on the intensity, type of reaction that occurs and the temperature of the extruder during extrusion which may have influenced the amount of soluble molecules.

The wettability of the flour blends ranged between 61.50 and 125.50 s. There were significant ($p<0.05$) differences among the blends. Wettability reduced as percentage inclusion of acha and African yam bean flour increased. From the results obtained, less than 60 s is required by the flour blends to be fully wet.

The dispersibility of flour blends ranged from 73.75 to 75.25%. There was no significant ($p<0.05$) difference among the blends. Dispersibility is an index that measures how well flour or flour blends can be rehydrated with water. The higher the dispersibility values the better and easier the reconstitution of flour (Kulkani *et al.,* 1991; Adebowale *et al.,* 2008). Since the dispersibility value for all the flour blends is relatively high, it implies that they will reconstitute easily to fine consistent dough during mixing.

3.4 Anti-nutritional factors of the flour

The result of the anti-nutrient composition of flour blends is shown in Table 4. The presence of anti-nutrients in foods could hinder the efficient utilization, absorption or digestion of some nutrients and thus, reduce their bioavailability (Adeniji *et al.,* 2007). Oxalate content ranged from 37.67 to 46.73 mg/100 g. The study had shown that oxalates in large amounts bind with calcium forming calcium oxalate, which is insoluble and not absorbed by the body (Taiwo *et al.,* 2017). Oxalates are considered poisonous at high concentration, but harmless when present in small amounts (Chai and Liebman, 2004). The phytate content varied from 5.27 to 5.57 mg/100 g also increased as the addition of African yam bean and acha flour increased. Phytic acid is the main phosphorus store in mature seeds with a strong binding capacity. Agte *et al*. (1997) described that cereal processing such as soaking of cereal flour prior to heating helps to activate phytases and therefore help zinc availability due to the processing techniques used which required heat. Ojo and Akande (2013) reported that various food processing techniques such as cooking, soaking and autoclaving helps in reducing the anti-nutritional factor of foods. This could mean that the reduction in phytate content will provide a great impact on the availability of zinc. The tannin values ranged from 32.91 to 35.10 mg/100 g increased as a percentage of the addition of African yam bean and acha flour increased. Tannins are polyhydric phenols majorly founds in all parts of plants and are known to lower the activities chymotrypsin, trypsin, lipase and amylase (Inyang and Ekop, 2015). The observed presence and quantity of

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tannins in all the samples can be of great medical importance since tannins serve as good antioxidant.

Table 4. Anti-nutritional factors of wheat, acha and African yam bean flour

Sample (WF/AF/AYBF %)	Oxalate (mg/100g)	Phytate (mg/100g)	Tannin (mg/100g)
100/0/0	37.675^{a}	5.546^{b}	32.915^{a}
80/15/5	41.950^{b}	5.272^{a}	33.790^{b}
70/20/10	43.550^{c}	5.316^{a}	34.450^{c}
50/30/20	46.730^{d}	5.573^{b}	35.100^{d}

Values with different superscript within the column are significantly different ($p<0.05$).
100/0/0 = 100% wheat flour; 80/15/5 = 80% wheat flour, 15% acha flour, 5% African yam bean flour; 70/20/10 = 70% wheat flour, 20% acha flour, 10% African yam bean flour; 50/30/20 = 50% wheat flour, 30% acha flour, 20% African yam bean flour

3.5 Physical properties of cookies

The physical properties values ranged from 6.11 - 6.85 mm, 38.46 - 39.55 mm, 37.65 - 38.23 mm, 4.79 - 5.85 mm, 5.35 - 6.49 mm and 1.72 – 1.90 mm for thickness, diameter, height, spread ratio, weight and break strength respectively (Table 5). There was a significant ($p<0.05$) difference in the physical properties of the cookie samples. The thickness of the cookies increased with the increase of addition of acha and African yam bean flour in the cookie formulation. Values for height increased with increase in the level of composite flour, while the weight of the cookies decreased with increase in the level of acha and African yam bean flour in the formulation. This may be owing to the rise in the protein content from the incorporation of the flours. Spread ratio or diameter is used to determine the quality of flour used in preparing cookies and the ability of the cookies to rise (Bala *et al.,* 2015). The higher the spread ratio of cookies the more desirable it is (Chauhan *et al.,* 2016). Hence, cookies prepared from 80% wheat flour, 15% acha flour and 5% African yam bean flour may be the most preferred based on spread ratio. Similar findings with respect to the weight, diameter, and spread ratio were reported by other researchers (Mridula *et al.,* 2007; Oluwamukomi *et al.,* 2011).

The weight of cookies produced from different flour blends differs significantly from the sample with 100% wheat flour. Their weights decreased with increased substitution of wheat flour with acha and African yam bean flours. This decrease in weight may be owing to the increase in the fat content of the samples as indicated in the fat content of the samples and/ or a decrease in the moisture content. These results are in line with Ayo *et al.* (2007). The break strength of the cookies decreased from 1.90 to 1.72 kg as the percentage of acha and African yam beans were increased. The sample 100% wheat flour had the highest break strength and sample with 50% wheat flour, 30% acha flour, 20% African yam bean flour was the most fragile. This may be due to the inclusion of acha and African yam bean flour.

3.6 Sensory properties of cookies

The mean sensory results for all the quality attributes evaluated are shown in Table 6. All the sensory attributes

Table 5. Physical properties of cookies prepared from flour blends of wheat, acha, and African yam bean

Sample (WF/AF/AYBF %)	Thickness (mm)	Diameter (mm)	Height (mm)	Spread ratio	Weight (g)	Break strength (kg)
100/0/0	6.11^{a}	38.46^{a}	37.83^{a}	5.74^{c}	6.49^{b}	1.90^{b}
80/15/5	6.43^{a}	38.74^{a}	37.92^{a}	5.85^{c}	5.35^{a}	1.80^{b}
70/20/10	6.63^{a}	39.55^{b}	37.65^{a}	5.36^{b}	5.40^{a}	1.75^{a}
50/30/20	6.85^{b}	39.30^{b}	38.23^{b}	4.79^{a}	5.42^{a}	1.72^{a}

Values are expressed as mean±standard deviation. Values with different superscript within the column are significantly different ($p<0.05$).
100/0/0 = 100% wheat flour; 80/15/5 = 80% wheat flour, 15% acha flour, 5% African yam bean flour; 70/20/10 = 70% wheat flour, 20% acha flour, 10% African yam bean flour; 50/30/20 = 50% wheat flour, 30% acha flour, 20% African yam bean flour

Table 6. Mean sensory scores of cookie samples

Sample (WF/AF/AYBF %)	Colour	Taste	Aroma	Crispness	Overall Acceptability
100/0/0	6.891^{b}	6.978^{b}	6.804^{b}	6.935^{b}	7.261^{b}
80/15/5	6.521^{a}	6.742^{b}	6.546^{a}	6.174^{a}	6.717^{a}
70/20/10	6.304^{a}	6.587^{a}	6.304^{a}	6.355^{a}	6.825^{a}
50/30/20	6.717^{b}	6.543^{a}	6.435^{a}	6.478^{a}	6.913^{a}

Values with different superscript within the column are significantly different ($p<0.05$).
100/0/0 = 100% wheat flour; 80/15/5 = 80% wheat flour, 15% acha flour, 5% African yam bean flour; 70/20/10 = 70% wheat flour, 20% acha flour, 10% African yam bean flour; 50/30/20 = 50% wheat flour, 30% acha flour, 20% African yam bean flour

of the cookies decreased with increased substitution of wheat flour with acha and African yam beans. The cookies made with composite flours with a higher percentage of African yam beans had beany flavour which resulted to lower flavour ratings compared to cookies from 100% wheat. The colour of cookies became darker with increased substitution of the wheat flour with acha and African yam beans; from creamy to dark brown. All the cookies were however accepted with respect to all the parameters assessed using the nine-point Hedonic scale.

4. Conclusion

This study determined the proximate, minerals, functional and anti-nutritional properties of flour with the physical and sensory attributes of cookies. Cookies of acceptable quality were produced from composite flours of wheat, acha and African yam beans. The cookies produced have increased nutrient contents which are all desirable for good health and wellbeing. The study shows that supplementation of wheat with 30% acha and 20% African yam beans produced well accepted cookies. The use of acha and African yam beans in cookies will go a long way in enhancing nutrition, health and wellbeing of the consumers and reduce the dependence on wheat flour, thereby saving the huge foreign exchange used in importing wheat, for other projects. It will also reduce food insecurity and diversify the use of acha and African yam bean.

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