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CHEMICAL COMPOSITION AND FUNCTIONAL CHARACTERISTICS OF WHEAT/AFRICAN OIL BEAN FLOUR BLENDS AND SENSORY ATTRIBUTES OF THEIR COOKIES

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ABSTRACT

Wheat flour (WF) was substituted with African oil bean seed flour (AOBF) at 0, 5, 10, 15 and 20% in cookies. The chemical and functional properties of the flours and their blends as well as the physical and sensory attributes of the cookies were determined. The flour blends had higher fat, ash and protein than the 100% wheat flour. The level of these nutrients improved as the amount of AOBF in the blend increased. Gross energy also increased as AOBF increased in the blend, WF having 398.91 and AOBF 676.01 kcal/100 g. The WF, AOBF and the blends were all rich in macro-elements (K, Na, Ca, Mg and P), and low in Fe and Zn. Phytate content was highest in WF, and generally reduced as the level of AOBF increased in the blends. Water absorption increased while the oil absorption generally decreased with increasing substitution levels. Wheat flour exhibited the highest foaming capacity and stability followed by the 5% AOBF substitution and then the 100% AOBF. AOBF had the highest bulk density of 0.87 g cm^{-3} while that of WF was 0.78 g cm^{-3}. There were no significant differences ($P>0.05$) in the weight and height of the cookies. Also, no significant difference ($P>0.05$) existed for taste, aroma and texture of wheat cookies and the composite cookies but significant difference ($P<0.05$) existed for colour. All the composite cookies were as acceptable as the 100% wheat cookie, with the 5% AOBF substitution being rated better than the 100% wheat cookie.

Keywords: *Wheat cookies, Wheat/African oil bean composite flour, Chemical composition, Sensory attributes*

1. INTRODUCTION

A cookie is a flat, round-shaped, ready-to-eat wheat- based snack. It is a popular snack because it is readily available, has fairly long shelf life, handy and easy to carry about. Cookies are soft-type biscuits with surface cracking pattern as an important characteristics and this is greatly affected by their fat content. For most baked food products, fat content affects flavour and mouth feel, and is also connected to appearance, texture, palatability and lubricity (Zoulias et al., 2002). Though wheat has a high level of protein when compared with most cereals, it is still classified as a poor protein source, coupled with the fact that its protein is deficient in lysine, an essential amino acid. This has led to studies on fortifying wheat protein with other plant sources high in protein. Such plant sources include legumes and oil seeds. These are also deficient in methionine and the blending of the two (wheat and legumes/oilseeds) will bring about a mutual balancing of each other's amino acids and this is known as 'protein complementation' (Potter, 1987). The resulting blend of flour produces cookies with better nutritional characteristics. Cookies with good sensory attributes and high protein contents have been produced from blends of wheat/cottonseed (Fugy and Tunklun, 1972); wheat/soy flour (Tsen et al., 1973); wheat/sesame seed (Hoojsat and Zabik, 1984); Wheat/cowpea (Okaka and Isieh, 1990; McWatters et al, 2003); wheat/chickpea (Singh et al., 1991); wheat/safflower (Ordorica-Falomir and Parades-Lopez, 1991); wheat/pigeon pea (Harrinder et al., 1999) and wheat/soybean and kinema (Shrestha and Noomhorm, 2002). Dreuiter (1978) reported that the maximum level of wheat substitution that would make an acceptable baked product is 30%.

However, corn germ flour can replace up to 48% of wheat flour in chocolate chips and oatmeal cookies without detrimental effects on texture and flavour Tsen and Weber, 1977). Dough prepared with different levels of peanut flour (10, 20 and 30%) showed close resemblance to the 100% wheat flour in consistency and handling characteristics, and peanut flour can replace at least 30% of wheat flour in a sugar recipe formula without adversely affecting baking performance, physical characteristics and acceptability (McWatters, 1978). Wheat flour substituted with fluted pumpkin flour (FPF) contained higher contents of crude protein and minerals such as calcium, sodium, potassium, iron and phosphorus. The protein content of the cookies of the composite was higher than the protein levels reported for conventional cookies (Egan et al., 1981; Shrestha and Noomhorm, 2002). All the cookies prepared from the composite of wheat and FPF were nutritious as the consumption of 100 g of each of the product formulation would provide more than half of the recommended daily requirement for protein (25-30 g dayΓ^{1}) and about a sixth of the requirement for energy (1790-2500 kcal dayΓ^{1}) as recommended by FAO/WHO [16] for children aged between 5 and 19 years. The values of energy and protein obtained for cookies supplemented with FPF compared favourably with the composition of cookies produced for use in food aid programmes which ranged from 15.1 to 20.0% and 422-497 kcal (100 g)Γ^{1} [17]. This makes it useful for food supplements for the alleviation of protein-energy malnutrition in developing countries (Giami et al., 2005). Cookies prepared from the blend of wheat flour and African breadfruit kernel flour also showed good source of protein, the quality of which was found to be better than that of wheat cookies because of the complementation between the two sources of protein (Akubor and Badifu, 2004). The cookies showed no significant difference in weight, diameter and height when compared to wheat cookies. The protein contents of cookies prepared from blends of wheat flour and peanut flour, soybean flour and field pea flour was better than that of wheat-flour cookies. Cookies prepared from 30% soybean flour contained as much as twice the protein in wheat (McWatters, 1978). Sensory evaluation results showed that most organoleptic attributes of soybean flour cookies were not affected adversely until 20 or 30% soybean flour levels were used. The use of African oil bean seed flour in cookie formulation has not been explored, but it is expected to give excellent protein-rich products because of the high protein quality of the seed. The present study examined the effect of different levels of African oil bean seed substitution on the physico-chemical and sensory qualities of wheat flour and wheat cookies.

2. MATERIALS AND METHODS

2.1. Preparation of African Oil Bean Seed Flour

The African oil bean seeds with the shells in place were washed and boiled in an aluminum pot for 90 min. The water was drained and the seeds dehulled manually and oven dried at 60 °C for 24 h after slicing the cotyledons into smaller sizes to aid drying (hot-air oven Model PBS 118SF, Genlab Widnes, England). Dried dehulled seeds were ground using a laboratory mill and screened through a size 40 mesh (British standard).

2.2. Blend Formation and Cookie Preparation

Blends of 0, 5, 10, 15 and 20% African oil bean flour, (AOBF) replacing wheat flour (WF) were prepared by gradual mixing of the AOBF and WF in an Electric food mixer, kil unit 111 at top speed for 5 min. A modified sugar cookie recipe and procedure described by McWatters *et al.* (2003) was used for cookie formulation. The basic ingredients used were 300 g of flour blend, 150 g margarine, 175 g granulated sugar, 25 g of beaten whole egg, 3.75 g of salt, and 1.8 g of baking powder. The dry ingredients (flour, sugar, salt and baking powder) were first thoroughly mixed in a bowl by hand for 3-5 min. Margarine was added and incorporated well into the dry ingredients until the mixture was uniform. Egg was then added and the mixture kneaded in a mixer (Kenwood mixer, model 28434) for 3.5 min to get slightly firm dough. The dough was manually rolled on a pastry board into sheets of uniform thickness of 0.4 cm and cut into circular shapes of 4.9 cm diameter with a circular scone cutter. The cut dough pieces were placed on lightly greased pans and baked at 160 °C for 15 min in an air oven (PBS 118SF, Genlab Widnes, England). The cookies were cooled at room temperature (30±2 °C) and packed in polyethylene bags. Sensory evaluation was carried out 24 h after baking

2.3. Proximate Analysis

Proximate analysis of the various blends of flour was carried out using the standard procedures of AOAC (1990) and values for each sample were mean of three replicates.

2.4. Functional Properties

The functional properties that were analyzed included water and oil absorption capacities, foaming capacity and foam stability, and the bulk density of wheat flour, African oil bean seed flour and their blends. Water absorption capacity was determined as described by Sosulski *et al.* (1976). One gram (1 g) of flour sample was mixed with 10 ml. of distilled water in a centrifuge tube and was allowed to stand at 30±2°C for 1 h. It was then centrifuged (3,500R, 30 minutes) and water absorption capacity was expressed as g cm^{-3} of water absorbed by 1 g flour. Oil absorption capacity was determined as described by Sosulski *et al.* (1976). A gram (1 g) of flour sample was mixed with 10 ml of oil in a centrifuge tube and was allowed to stand for one 1 h at 30±2 °C. It was then centrifuged (3,500R, 30 min) and oil absorption capacity (OAC) was expressed as g cm of oil absorbed by 1 g of flour.

Foaming capacity (FC) and foam stability (FS) were determined by the method of Narayana and Narasinga Rao (1982). Two grams (2 g) of flour sample was weighted into a foaming capacity cylinder and 50 ml of distilled water was added at 30±2°C. The suspension was mixed properly shaken to foam and the volume of the foam after 30 seconds was recorded. The foaming capacity was expressed as a percentage increase in volume. The foam volume was recorded 1 h after whipping to determine the foam stability (FS) as a percentage of the initial volume.

Bulk density was determined as outlined by Okaka and Potter (1979). A 50 g flour sample was put into a 100 ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The bulk density (gm^{-3}) was calculated as weight of flour (g) divided by flour volume (cm^{3}).

2.5. Mineral Analysis

The preserved ashed samples were used to make solutions that were used to determine the mineral constituents of the sample. This was done by dissolving the ash with 10 ml of 10% HCl and then filtering to remove particles. This was then made up to 100 mls in a measuring cylinder and the solution poured into sample bottles. The analysis of sodium and potassium were carried out using flame photometer. Mineral elements like calcium, magnesium, iron, and zinc were analyzed using the Perkin Elmer atomic absorption spectrophotometer (AAS) while phosphorus was determined by the phosphor-vanado molybdate method (AOAC, 1990).

2.6. Determination of anti- nutritional factors

The anti-nutrients that were determined included oxalates, phytates and tannins. Tannin determination used was that of Makkar and Goodchild (1996). Approximately 200 mg of finely milled raw samples was mixed with 10 ml of 70% aqueous acetone for the extraction process which lasted for 2 h at 30°C in water bath. Pigments and fats were first removed from the samples by extracting with diethyl ether containing 1% acetic acid. The total polyphenols (tannic equivalent) was then determined in 0.05 ml aliquot in test tubes by the addition of distilled water to make up to 1.0 ml which was followed by the addition of 0.5 ml of the Folin ciocalteau reagent (Sigma Chemicals, St. Louis, MO). and then 2.5 ml of sodium carbonate solution. The tubes were vortexed and absorbance recorded at 725nm after 40 minutes. The amount of total polyphenols was then calculated from the standard curve.

The method used for determining phytate was that of Young and Greaves (1940). Exactly 8 g of each finely ground raw sample (wheat, African oil bean, and composite blends) were soaked in 200 ml of 2% hydrochloric acid for 3 h. The extract was then filtered through a 2-layered hardened filter paper. The filtrate (50 ml) was pipetted in triplicates into a 400 ml capacity beaker and 10 ml of 0.3% ammonium thiocyanate (NH_4 SCN) solution was then added as indicator. About 107 ml of distilled water was also added to give it the proper acidity (pH 4.5). The resulting solution was then titrated with a standard iron chloride ($FeCl_3$) solution containing 0.00195 g Fe/ml of $FeCl_3$ used until a brownish yellow colour persists for 5 minutes. Phytin phosphorus was determined by multiplying the factor 1.19 and the amount of phytin present was calculated by multiplying the value of phytin-phosphorus by 3.55 (each mg of iron is equivalent to 1.19 mg of phytin-phosphorus).

Oxalate was determined by the method of Day and Underwood (1986). One gram each of finely ground samples was mixed with 7.5 ml of 1.5N sulphuric acid and the solution carefully stirred intermittently with a magnetic stirrer for about 1 h after which the solution was filtered using a Whatman number 1 filter paper. Exactly 25 ml of the filtrate was then collected and titrated hot (80-90 °C) against 0.1N potassium permanganate solution to a point where a faint pink colour appeared and persisted for about 30 minutes.

2.7. Pasting Characteristics Evaluation

The pasting characteristics of the flours were determined using a Brabender visco-amylograph. Flour slurry containing 10% solids (w/w, dry basis), was heated from 30 to 95 °C at a rate of 1.5 °C /min, held at 95 °C for 15 minutes, and cooled at the same rate to 50 °C (Shuey and Tipples). The pasting performance was automatically recorded on the graduated sheet of the amylogram. The pasting temperatures, peak viscosities, viscosity at 95 °C, stability, cooking times and setback viscosities were read off the amylograph.

2.8. Sensory Evaluation

Sensory evaluation of cookies was conducted by a 20- member trained panel. The sensory characteristics examined were taste, colour, aroma, texture (mouth feel) and overall acceptability (a combination of all other characteristics). All the five sensory attributes were rated on a 9-point hedonic scale with 1= dislike extremely, 5= neither like nor dislike and 9 = like extremely (Larmond, 1977). The coded cookies were randomized and presented to the judges in the mid- morning (in white plates). The judges were provided with water to rinse their mouths in between samples.

2.9. Statistical Analysis

Mean ± standard deviation (SD) values were calculated and the data was subjected to statistical analysis of variance as described previously (Enujiugha, 2006).

3. RESULTS AND DISCUSSION

The chemical composition of wheat flour (WF), African oil bean seed flour (AOBF) and their blends are shown in Table 2. The AOBF contained higher amounts of fat, ash and protein than WF and this reflected in the blends as every increase in the level of AOBF resulted in a direct increase of fat, ash and protein in the blends. This was probably as a result of addition effect (Akubor and Badifu, 2004) as AOBF was higher in these nutrients than WF. Only traces of crude fibre were detected in the WF, AOBF and their blends. This was probably as a result of the milling process that the WF, AOBF and the blends were subjected to. However, the moisture and nitrogen free extract levels of the WF, AOBF and the blends decreased with increase in WF substitution. WF contained 10.56% moisture and 71.85% NFE While AOBF contained 3.66% moisture and 12.20% NFE. WF (398.91 kcal/100 g) contained an adequate amount of energy while AOBF (676.01 k cal/100 g) contained an even higher amount, which is within the recommended dietary allowance. The energy values of the blends increased with increased amounts of AOBF which was probably because of the higher fat content of AOBF compared to WF. The energy value of a food is much more related to the fat content (Ihekoronye and Ngoddy, 1985). The mean caloric value of the blends was 424.69 kcal/100 g. The AOBF contained a fairly large amount of protein which reflected in the blends to cause an increase in protein level with every increase in WF substitution. Cookies made from these blends will therefore be good sources of protein which are better than all wheat cookies.

Table 1: Recipe Formulation with different proportions of ingredients

Ingredients (g)	0	5	10	15	20
Wheat flour	300.00	285.00	270.00	255.00	240.00
Pentaclethra flour	-	15.00	30.00	45.00	60.00
Margarine	150.00	150.00	150.00	150.00	150.00
Sugar	175.00	175.00	175.00	175.00	175.00
Egg	25.00	25.00	25.00	25.00	25.00
Salt	3.75	3.75	3.75	3.75	3.75
Baking powder	1.80	1.80	1.80	1.80	1.80

Table 2: Chemical composition (%) of wheat flour (WF), African oil bean seed flour (AOBF) and their blends

WF:AOBF ratios (%)	Moisture	Fat	Ash	Protein	NFE	energy (kcal/100 g)
100% WF	10.56±0.21a	8.47±0.37a	0.30±0.14a	8.82±0.12a	71.85a	398.91a
95 : 5	10.34±0.71a	10.50±0.29b	1.00±0.28b	11.44±0.09b	66.72b	407.14b
90 : 10	10.30±0.25a	13.69±0.38c	1.20±0.00c	12.43±0.25c	62.39c	422.59b
85 : 15	9.97±1.07b	14.65±0.52c	1.25±0.07c	13.54±0.05d	60.59c	428.37b
80 : 20	9.15±0.99b	16.49±0.46d	1.30±0.13c	13.95±0.22d	59.11d	444.65c
100% AOBF	3.66±1.01c	59.41±0.65e	1.60±0.13d	23.13±0.47e	12.20e	676.01d

*Mean±SD of three replicates. *Mean values within a column with the same letter were not significantly different ($p>0.05$)*

Table 3: Mineral Composition (mg/100g) of wheat flour (WF), African oil bean seed flour (AOBF) and their blends.

WF:AOBF ratios (%)	K	Ca	Mg	P	Fe	Zn	Na
100% WF	111.44a	52.14a	70.62a	392.0a	25.58a	13.08a	57.50a
95 : 5	105.35a	60.78b	79.13b	370.0b	46.31b	14.10a	67.61b
90 : 10	122.32b	49.63c	71.83b	342.0c	34.52c	10.02b	56.61a
85 : 15	105.57a	0.96d	73.27c	230.0d	ND	1.28c	85.55c
80 : 20	95.02c	1.68e	71.13b	219.0d	ND	0.77d	73.45d
100% AOBF	83.92d	18.30f	64.03d	200.6e	ND	2.05e	80.02e

*ND = not detected. *Mean values within a column with the same letter were not significantly different (p>0.05)*

Table 4: Levels of some anti-nutritional factors in wheat flour (WF), African oil bean seed flour (AOBF) and their Blends.

WF : AOBF ratios (%)	Oxalate (mg/g)	Phytate (mg/100 g)	Tannin (g/100 g)
100% WF	0.57±0.03a	204.54±8.05a	0.014a
95 : 5	0.84±0.02b	178.45±8.13b	0.015a
90 : 10	1.02±0.05c	166.49±0.02c	0.016a
85 : 15	0.990±0.01c	121.37±8.08d	0.017a
80 : 20	0.87±0.05b	149.09±8.07e	0.017a
100% AOBF	4.23±0.12d	267.82±0.03f	0.020b

*Mean±SD of three replicates. *Mean values within a column with the same letter were not significantly different (p>0.05)*

Table 5: Functional properties of wheat flour (WF), African oil bean seed flour (AOBF) and their blends.

WF : AOBF ratios (%)	Water absorption (g cm^{-3})	Oil absorption (g cm^{-3})	Foaming capacity (%)	Foam stability (%)	Bulk density (g cm^{-3})
100% WF	1.27±0.05a	0.92±0.04a	31.0±1.41a	54.79±2.05a	0.78±0.02a
95 : 5	1.30±0.14a	1.02±0.07b	12.0±0.90b	41.67±11.7b	0.73±0.02b
90 : 10	1.46±0.06b	0.77±0.03c	12.0±0.40b	33.33±0.52c	0.69±0.01c
85 : 15	1.56±0.12b	0.74±0.16c	10.0±0.20c	30.00±1.14c	0.67±0.01c
80 : 20	1.76±0.06c	0.74±0.05c	9.0±1.02d	30.00±4.01c	0.65±0.03c
100% AOBF	1.80±0.10c	0.73±0.03c	12.0±0.50b	41.67±11.7b	0.87±0.01d

*Mean values within a column with the same letter were not significantly different (p>0.05)

Table 3 shows the mineral composition of wheat flour (WF), African oil bean seed flour (AOBF) and their blends. The level of phosphorus in WF is highest and decreases with increase in WF replacement with AOBF which is contrary to that observed for cookies supplemented with fluted pumpkin seed four (FPF) (Giami et al., 2005). All the samples had a high content of potassium, magnesium, phosphorus and sodium. Potassium contents ranged between 95.02 mg/100 g and 101.35 mg/100 g, 71.13-79.13 mg/100 g for magnesium and 56.61-73.45 mg/100 g for sodium for the blends.

Oxalates were lowest in WF (0.57 mg/g) and highest in AOBF (4.23 mg/g), the mean of the blends was 0.93 mg/g Table 4). Tannins had the lowest content in the samples considered of all the anti-nutrients determined. It was lowest in WF and increased with each increase in the level of wheat flour substitution. This was probably due to the addition AOBF to the WF. AOBF and the blends were significantly different (P<0.05) from WF. Phytates in WF was at a level of 204.54 g/100 g. This value decreased as the level of WF substitution increased up to sample 4 (121.37 g/100 g) but on reaching sample 5, the phytate content increased again. The reason for the increase in the latter samples is not understood but the decrease which occurred from the WF up to the 10% substitution level is of great advantage. Since phytates are known to chelate some divalent metals like calcium, magnesium, zinc and manganese, it is calming to know that this decrease will lower this chelating effect making more of these minerals available for use in the body (Enujiugha and Akanbi, 2005).

Table 5 shows the functional properties of the wheat flour, African oil bean seed flour and their blends. The bulk density of WF and AOBF were 0.78 and 0.87 g cm^{-3} respectively and varied from 0.73 to 0.65 for the blends.

The foam capacity recorded for wheat flour was 31.0% and AOBF 12.0%. This conforms to a previous work where WF, African breadfruit kernel flour and their blends were analyzed (Akubor and Badifu, 2004).

Foaming capacity of the blends ranged between 9 and 12%, reducing as the level of AOBF increase in the blends. This shows that the foaming capacity was affected by the level of fat in the samples. The high foaming capacity of WF shows that its protein is able to form a large interfacial area (Damodaran, 1996); the lower values of the AOBF (foaming capacity) could be attributed to its high fat content and lipids have been shown to be foam depressants (Poole, 1989). Lipids especially phospholipids have been shown to impair foaming properties of proteins when present at a concentration greater than 0.5% (Damodaran, 1996). This is because lipids are more surface-active than proteins and therefore readily adsorb at the air-water interface and inhibit adsorption of protein during foam formation. Kinsella (1976) had demonstrated that foaming capacity is not dependent on the amount of lipid alone but also on the type of lipid present.

The highest foam stability recorded (54.79%) which decreased with increase in WF substitution with AOBF up till 15% substitution and then finally to AOBF where it showed great stability again. Proteins that possess good foaming power do not have the ability to stabilize the foam. Foam ability and stability seems to be influenced by two different sets of molecular properties of proteins that are often antagonistic (Damodaran, 1996). This could account for the high foam stability of the AOBF and even the blends. Stability is said to depend on the rheological properties of the protein film.

The water and oil absorption properties exhibited by WF and AOBF are 1.27 and 1.80 g cm^{-3}, 0.92 and 0.73 g cm^{-3} for the water and oil respectively. The property increased in the blends with increase in AOBF, it has been suggested that the high water and oil absorption capacities of the blends compared to WF displays the presence of high amount of polar amino acids and hydrophilic carbohydrates in the blends (Shanmugasundaram and Venketaraman, 1989). The mechanism of fat absorption has been attributed mainly to the physical entrapment of oil and the binding of fats to the apolar chain of protein (Kinsella, 1976). The oil and water entrapment of AOBF was low probably as a result of the level of saturation of its particles (because of high fat content) which prevents oil and water entrapment.

The physical characteristics of cookies prepared from WF, AOBF and their blends are shown in Table 6. The diameter of wheat cookie was 6.07cm and varied between 6.04 and 6.27 cm for the blends. There was no significant difference in the height of the wheat cookies and those prepared from the blends (P>0.05). The average weight of cookies from the blend was 11.51 g as compared with 12.74 g obtained for the cookies prepared from only wheat. This result was similar to those reported for cookies prepared from wheat-fluted pumpkin flour blends (Giami et al., 2005). No significant difference (P>0.05) existed in the weight of the all wheat cookies and blends.

There was no particular trend followed in the weight of the cookies and this could be attributed to inconsistent rolling thickness of the dough which was exhibited as a result of the high fat content. This made the dough softer on every increase in WF substitution and made rolling more difficult. The dough on every increase in WF substitution has a reduced viscosity which encouraged breakage during rolling. The average spread ratio of the blends was 12.81. There was no significant difference (P>0.05) in the spread ratio of the wheat flour and the blends.

Table 7 shows that cookies prepared from 10% and 20% wheat substitution was rated lowest for all the sensory attributes evaluated. The cookies were darker in colour, were softer especially for the 20% substitution due to the high level of oil and also possessed rough surfaces as a result of oil accumulation. The sensory scores for all the samples do not differ for taste, aroma and texture. The 5% substitution level gave the highest scores for all the sensory attributes which compared favourably with the wheat flour. This shows that the 5% substitution level gave the optimum level of substitution. For all the sensory attributes, the 5% substitution level was not significantly different from the wheat cookies except for overall acceptability where it was significantly different (P<0.05). This showed that the 5% substitution level was more acceptable than the wheat cookie. The cookie prepared at this level of substitution was golden in colour and possess quality diameter. Cookies prepared from all the other blends (10%, 15%, 20%) were as acceptable as the wheat cookie with no significant difference. The pasting characteristics of the different flours and their blends are presented in Table 7. The Brabender viscosities of the blends were generally lower than the control (wheat flour). This is suggestive of the presence and interaction of components such as fats and proteins (from the substituted African oil bean seed flours) with starch, which must have lowered the viscosities of the blends (Oluwamukomi et al., 2006). The apparent gelatinization temperature (T_a) of the 100% wheat flour (control) was very low (56°C), while those of the blends ranged from 77-81 °C. These higher values obtained for the blends could be a result of the buffering effect of fat (from African oil bean seed flour) on the gelling properties of the starch component of the blended flours. The implication is that the blends would require more energy consumption to cook, and the dough strength would be weak and undesirable (Enujiugha, 2006).

Table 6: Some physical characteristics of cookies prepared form wheat flour (WF) and the blends of wheat flour and African oil bean seed flour (AOBF)

WF : AOBF ratios (%) in the cookies	Weight (g)	Diameter (D)	Height (H) (cm)	Spread ration (D/H)
100% WF	12.74±0.26b	6.07±0.01a	0.52±0.03a	11.67±0.63a
95 : 5	11.94±0.64b	6.27±0.05a	0.47±0.06a	13.34±1.73a
90 : 10	11.04±0.44b	6.09±0.08a	049±0.03a	12.43±0.63a
85 : 15	11.32±0.20b	6.04±0.04a	0.47±0.06a	12.85±1.69a
80 : 20	11.73±1.51b	6.16±0.11a	0.53±0.06a	12.62±1.04a

*Mean±SD of five replicates. *Mean values within a column with the same letter were not significantly different (p>0.05)*

*Table 7: *Sensory scores of cookies prepared from wheat flour (WF), and the blends of wheat flour and African oil bean seed flour (AOBF)*

WF : AOBF ratios (%) in the cookies	Colour	Aroma	Taste	Texture	Overall acceptability
100% WF	6.75b	6.85a	6.80a	6.05a	6.85b
95 : 5	7.35a	7.10a	7.50a	7.35a	7.75a
90 : 10	5.30d	5.95a	6.85a	6.35a	6.75b
85 : 15	6.05c	6.50a	6.70a	6.55a	7.10b
80 : 20	5.65d	6.00a	6.75a	6.20a	6.15b

**Mean values within a column with the same letter were not significantly different (p>0.05)*

*Table 8: Pasting characteristics of the flours used in baking**

WF:AOBF ratios (%)	T_a	V_p	V_a	V_b	V_c	V_p -V_b	V_c -V_p	V_c -V_a	V_c -V_b
100% WF	56	700	510	470	960	230	260	450	490
95 : 5	81	350	260	300	480	50	130	220	180
90 : 10	79.5	440	260	180	660	260	220	400	480
85 : 15	77	580	340	360	940	220	360	600	580
80 : 20	64.5	430	310	480	920	-50	490	610	440

** V_p -V_b = Stability during cooking; V_c -V_p = Set-back value; V_c -V_a = Consistency; V_c -V_b = Gelatinization index; T_a = Gel temperature; V_p = Peak viscosity; V_a = Viscosity at 95°C; V_b = Viscosity after 15 min at 95°C; V_c = Viscosity at 50 °C. All viscosity values are expressed in BU, Brabender units.*

4. CONCLUSION

Cookies prepared from wheat- African oil bean seed flour blends have been shown to be nutritious. The cookie could serve as a rich source of protein, minerals and energy. Except for the 'sleeping oil' appearance exhibited by wheat flour substitution levels of 15 and 20%, all levels of substitution produced cookies of acceptable quality. This study has shown that cookies fortified with African oil bean flour at the 5% substitution level gave a product that compared well and above the all-wheat cookies, thus making this ratio (95% WF: 5% AOBF) the best of all the substitution levels.

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