Original Research Article

QUALITY CHARACTERISTICS AND SENSORY PROPERTIES OF BREAD ELLABORATED WITH FLOUR BLENDS OF WHEAT AND AFRICAN YAM BEAN`

Abstract

This study evaluated quality characteristics and sensory properties of bread elaborated with flour blends of wheat and African yam bean. The wheat flour was procured, while the purchased African yam bean seeds were cleaned, sorted, washed and steeped in 2.5 litres of clean water for 12h with intermittent changing of soaking water at 3h intervals, drained, sprayed on moistened jute bag spread on malting table and covered with moistened jute bag. The seeds were germinated for 72 h with occasional sprinkling of water. Thereafter, harvested imbibed seeds were dried in a hot air oven at 60 ºC for 12h and converted into flour with attrition mill. Wheat flour and African Yam Bean flour were sieved individually with500 mm mesh size sieve. The flours were blended in the percentage ratios (W: W) of 100:0, 90:10, 80:20 and 70:30 for samples A, B, C and D, respectively. Three grams of yeast (Sacharomyces cerevisiae, Foshan Ceng Goa Food Co. Ltd, De Rich Instant Dry) were dissolved in clean bowl with 30 ml of water and 10 g sugar of the stipulated receipe and left for 1 h to activate at ambient temperature ($29 \pm 1^{O}C$). The flour blends were evaluated for proximate composition, functional properties and consumer acceptability. Preference ranking tests were conducted to describe and evaluate the acceptability of the bread loaves according to hedonic scale on texture, flavour, colour and overall acceptability using a 9-point, where1 = dislike extremely and 9 = extremely like. The data generated were analysed statisticaly using one way analysis of variance and means separated by Tukey test at 5 % level of Significance. The results showed that sample D – 30 % substituted African yam bean flour had higher swelling index (1.81g/g), water absorption capacity (160.00 %), protein content (14.89 %), fat content (2.80 %), panelists textural scores (6.55) and the least flavour scores (4.05),colour scores (5.70) and overall acceptability scores (3.85) compared to other samples. There were no statistically significant differences ($p < 0.05$) in overall acceptability scores of samples B, C and D. The overall acceptability scores showed that samples acceptance decreased with increased levels of substitution with African yam bean seed flour.
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Keywords:

Flour

Blending

fermentation

bread loaves

sensory properties

1. Introduction

Many household especially those with children prefer their breakfast to be bread which is a fermented product. Bread is made mostly from wheat flour an imported product (Okoye and Okaka, 2009) and it is important staple whose consumption has increased greatly in both developed and developing Countries. Bread is the most consumed cereal based product and the second widely consumed non–indigenous food after rice. During bread production many ingredients are added to wheat flour to increase its palability and improves its flavour development.

Hence, bread could serve as vehicle for supply of important nutrients which emanate from the subsidiary products. An addition of water to flour results to paste or dough. Water not only dissolve soluble protein groups in flour (albumin, globulin and proteoses) but also leave the undissolved glutenin and gliadin to form bread structure. The quantity of liquid added to flour affects the texture and crumb of bread, hence good loaves are made by adopting percentage recipe of dry ingredients to the stated quantity of liquid (Edema, 2004). Calcium propionate is also an essential ingredients, which are added to retard growth of moulds and extend the shelf-life of the bread. Bread may lack good volume probably due to insufficient kneading to enable good gluten stretch. The rising of dough during fermentation is as a result of network of reaction complexes taking place in which the gluten retains CO_2, binding water temporarily, activating the gelatinization of starch and the formation of foam – raising structures of the bread (Lagrain *et al.*, 2013). Bread is known to undergoes high economic loss caused by staling and microbial spoilage (mould and rope spoilage) as reported Gobbetti et al. (2019) and Ripari et al. (2016). Wheat flour is an ideal flour for bread production, but its costly nature and non availability resulted in application of composite flour in production of baked products.

Composite flour has been defined by Seibel (2006) as a mixture of flours obtained from tubers rich in starch (cassava, potatoes or yam), legume flours rich in protein (cowpea. Soybean and Bamabara Groundnut) and cereals (maize, rice , millet and sorghum) with or without wheat flour. Starches are mostly biodegrable polymer that play active roles in raising action and different sources of starches give an enhanced interaction due to association of starch and glutein. Association of starch and glutein provides a more malleable and stable network with adequate CO_2 retention that makes structure of the bread to resist collapse during fermentation and cooling (Delcour & Hoseney, 2009). Makowska *et al.* (2023) stated that bread consumption increases the incidence of civilization diseases, therefore the application of raw materials with proven anti-diabetic and hypertension- lowering properties will increase its attractiveness and desirability.

African yam bean (*Sphenostylis stenocarpa*) has been reported by Nzelu (2008) to be an important indigenous legume in Nigeria with high level of protein among other great potentials and it is consumed in many African countries. It is nutritionally superior to most other legumes in terms of digestible proteins and minerals contents. It is also one of the less-known and under-utilized legumes readily available in the country. A substitution of wheat flour with African yam bean flour in bread production enhances quality of produced bread, increases the nutritional value, and also reduces the huge amount of money spent in wheat importation as well as reducing the unit price of bread. African yam bean has different range of colours from pale white to spotted black, cream and brown in between (Okoye *et al*., 2015). It is grown abundantly in the Northern part of Nigeria for its seed. It has a lot of medicinal and health benefits as it is associated with treatment of chronic and severe wounds. It contains toxic elements which may negatively affect or impair protein digestibility and mineral availability. However, these toxic substances in African yam bean are heat labile and inactivated during heat processing into bread. Bread production involves a series of steps such as mixing of ingredients, fermentation of the dough, dividing and moulding (rounding off) of the dough, proofing, baking in pre-heated oven of a stipulated temperature, cooling, slicing and packaging.

A lot of research is focused on use of wheat for bread production but there is paucity of information on production of bread from germinated African yam bean seed which is a local crop with high levels of protein. Therefore, this work becomes apt and aimed at partial percentage replacement of wheat with African Yam bean flour in production of bread to enhance its nutritional quality while increasing utilization as well as prevent extinction of African yam bean seeds

2. MATERIALS AND METHODS

2.1. Procurement of Raw Materials.

The raw materials used in this study were African Yam Bean seeds (Sphenostylis stenocarpa) wheat flour, sugar, skim milk powder, salt, margarine and yeast (Sacharomyces cerevisiae) which were purchased from Ogbete Main Market in Enugu State, Nigeria and transported to the Food Process Laboratory of the Department of Food Science and Technology, Enugu State University of Science and Technology, Agbani.

2.1.1. Preparation of African Yam bean Seeds for flour production.

One kilogram of African Yam Bean seeds were sorted to remove dirts as well as other extraneous materials, thoroughly cleaned with tap water and steeped in 2.5 litres of portable water in a plastic bowl and left at room temperature for 12 hours. The steeping water was changed at intervals of 3 hours to prevent fermentation, cross contamination and for activation of the seeds' enzymes. The water was drained while wet bean seeds were spread on a moistened jute bag on a malting table for 3days to germinate. The sprouted seeds were harvested and dried in a preheated oven with hot air at 60 ^{o}C for 12 hours. The rootlets on the dried seeds were rubbed in between palms, broken to remove hulls and winnowed. The malted, dried and dehulled beans were ground into fine flour with an attrition mill (locally fabricated Asiko All double griding mill), sieved with 500 mm mesh size cheese cloth, packaged in Ziploc bag as African Yam Bean flour and stored in freezer for further analysis as shown in Fig.1.

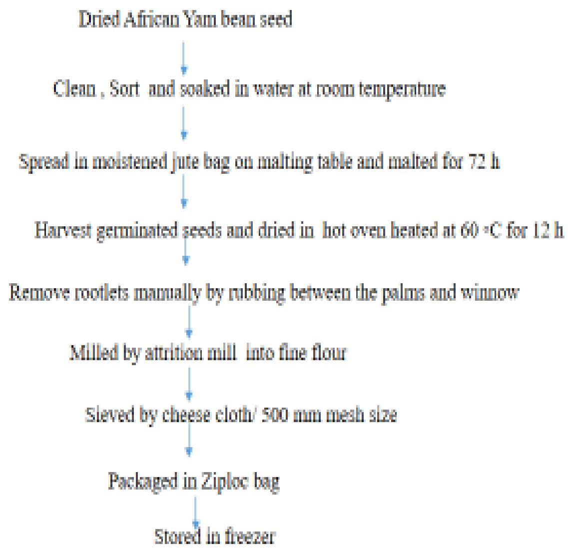

Fig. 1: Preparation flow chart for African yam bean flour

2.2 Composition of the flour blends

The wheat and African yam bean flour were mixed in percentage ratios of 100: 0, 90:10, 80:20 and 70:30 as samples A, B, C and D, respectively. The blends were thoroughly seived to obtain homogenized finer particle-size of standard formulation as shown in Table1. Thereafter, these samples were packaged in a Ziploc bag and stored in freezer until required for analysis and bread production.

Table 1: Composition of Wheat – African Yam Bean seed Flour blends

Flour	A	B	C	D
Wheat	100	90	80	70
Arica Yam Bean	0	10	20	30

Table 2: Bread Recipe Composition

Ingredients	Quantity (g)
Flour	500.0
Fat	20.0
Sugar	140.0
Skim milk (powder)	25.0
Salt	7.5
Yeast	3.0
Water	450.0 – 485.0 mL

2.3 **Wheat- African Yam Bean Bread Production produres**

A modified straight dough method of bread production process as described by Okaka *et al*. (2005); Okoye and Okaka (2009) was adopted. The ingredients were measurd and weighed as shown in Table 2. The yeast was dissolved in clean bowl with 30 ml of water and 140g of sugar. The recipe used in the production was therefore, 500 g of flour, 7.5 g of salt, 140 g of sugar, 25 g of skim milk (powder), 20 g of margarine, 3 g of yeast, and 450 ml of water. Both the dry and wet ingredients flour (wheat & African yam bean) blends were thoroughly mixed using dough mixer stiring for 5 min. The mixed dough was allowed to prove in a bowel enclosed with clean damp cloth for about 1 h at ambient temperature (28 ^{o}C) before kneading and tightening with margarine to improve the texture, smoothness and for proper elasticity.

Thereafter, the proofed dough samples were cut, moulded to shape and sized to 100 g, placed in previously cleaned-greased-baking pans and covered with damp cloth to prevent skin dehydration at the surface at ambient temperature for 1 h until it has increased to 2–3 times its size for final proofing. Then moulded sized dough was baked in a preheated oven at 200 ^{o}C for 45 min, and the bread later depanned, cooled and packaged as shown in Fig.2.

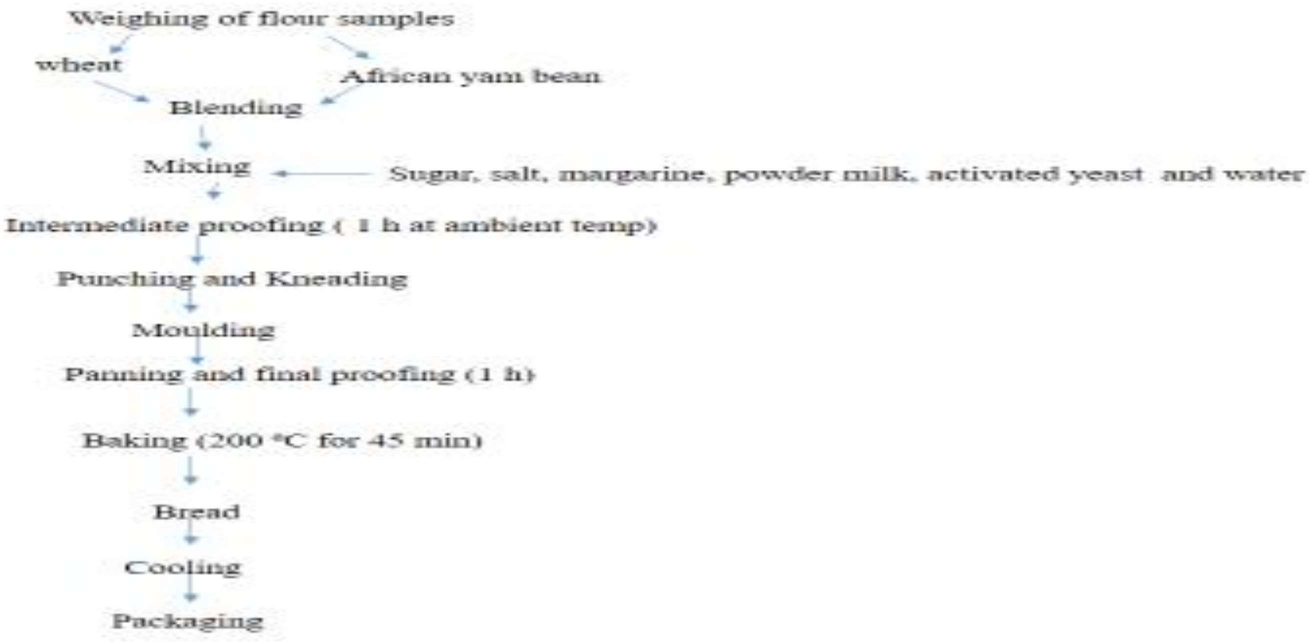

Fig. 2. Flow diagram for bread production

2.4. Analysis of the flour samples

2. 4.1. Proximate Composition of flour samples

2. 4.1.1. Determination of Moisture content

Moisture content of the samples was determined as described by standard methods of AOAC (2010) using hot air oven method. The Moisture dish was cleaned and weighed (W_1). A three gram of the samples was weighed into tarred moisture dishes (W_2). These samples were dried in a hot -air oven at 105 ^{o}C for 2 h. The moisture dish was removed from the oven and cooled in a desiccator to a constant weight (W_3). The dishes were re-weighed, and percentage moisture content calculated as shown in eqn.1.

$$\text{Moisture Content } (\%) = \frac{W2-W3}{W2-W1} \text{ X } 100 \qquad \text{Eqn.1}$$

Where: w_1 =weight of empty moisture dish

w_2 = weight of moisture dish with sample prior to hot-air oven drying

w_3 = weight of moisture dish with sample after hot-air oven drying

2. 4.1.1.2. Determination of Protein Content

The crude protein content of each of the samples was determined by the Micro Kjeldahl technique as described by AOAC (2010). A 2 g of each sample was placed in three different

Kjeldahl flasks. Three grams of anhydrous sodium sulphate and 2g of hydrated copper sulphate (catalyst) were added to each flask. Then 20 ml of concentrated tetraoxosulphate (IV) acid (H_2SO_4) was added to digest each of the samples. The flask with the samples was placed on an electric heater in a fume chamber and heated gently in an inclined position until blacking occurred. Increased heating contimued until a clear solution was obtained and allowed to cool. The contents of the digestion flask were diluted to 100 ml with distilled water and transferred into a 200 mL volumetric flask.

The flasks were placed in a Kjeldahl distillation unit, neutralized with 10 ml of 40 % sodium hydroxide (added through the funnel) and two pieces of zinc metal; then the liberated ammonia was collected in 100 ml of 4 % boric acid with 2 – 4 drops of screened methyl red. The distillates were titrated with 0.01N hydrochloric acid (HCI), until the titre value of the end point changed from green to pink. The quantity of nitrogen was calculated using eqn. 2.

$$\text{Nitrogen (\%)} = \frac{(\text{Titre} - \text{Blank}) \times 14.008 \times \text{Normality} \times 100}{W} \qquad \text{Eqn.2}$$

Where: Titre value

Blank value

W - Weight of sample dried

% crude protein content = % Nitrogen x 6.25.

2. 4.1.1.3. Determination of Fat Content

The fat content of the samples was determined as described by standards methods of AOAC (2010) using solvent extraction method.The extraction flask was washed with distilled water, dried and cooled in a desiccator. A 2 g of the sample was weighed (W_1) into the extraction thimble previously weighed. Thereafter, placed in the Soxhlet apparatus. The washed Soxhlet flask was weighed (W_2) and filled to about three quarter of its volume with petroleum ether (that has the boiling point range of 40-60 ^oC).

The apparatus was then set-up and extraction was carried out for 4 refluxed or 1 h. The process was stopped at end of the process time, thimble removed and petroleum ether distilled off the flask, dried and cooled in a desiccator and reweighed (W_3). The fat content was expressed as a weight of raw sample. The fat content was calculated as shown in eqn. 3:

$$\text{\% Fat Content} = \frac{W3 - W2}{W1} \times 100 \qquad \text{Eqn. 3}$$

Where; W_1 = Weight of sample

W_2 = Weight of empty flask

W_3 = Weight of empty flask + weight of oil

2. 4.1.1.4. Determination of Ash Content

The ash contents of each sample was measured as described by AOAC (2010) using Muffle furnace. A two gram of the sample (W_2) was weighed into a previously cleaned, washed, dried, cooled crucible, weighed (W_1) and transferred to the pre-heated furnace. The temperature of the furnace was then allowed to reach about 550 °C after placing the dish in it. The temperature was maintained until whitish-grey colour was obtained which was an indication that all the organic matter of the sample had been destroyed.

The crucible was then brought out from the furnace, cooled in a desiccator and re-weighed (W_3).The percentage ash content was calculated as shown in eqn.4:

$$\% \text{ Ash Content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \qquad \text{Eqn.4}$$

Where: W1 = Weight of empty crucible

W2 = Weight of empty crucible + sample before ashing

W3 = Weight crucible + ash

2. 4.1.1.5. Determination of Crude Fiber Content

The crude fibre content of each of the sample was determined by the method of AOAC (2010). The Erlenmeyer flask was cleaned, washed, dried in oven and cooled in a desiccator. A five gram (W_1) of each sample was weighed into a specific different 500 mL Erlenmeyer flask and 40 mL of 0.3N sulphuric acid and 0.2 N sodium hydroxide solution were added to the flask. The mixture was heated and refluxed for exactly 1 h counting from the start of boiling (using air condenser).

The flask was removed from heater, cooled a little and filtered through a 150 cm number 4 Whatman paper. The residue was continuously washed with distilled water and transferred to a crucible. The crucible containing the residue was placed in an oven and dried overnight at 105 ^{o}C. Thereafter drying, transferred to a desiccator to cool and weighed (W_2). Finally, the residue was transferred to a previously weighed crucible and placed in a muffle furnace heated at 500 ^{o}C for 6 hours until light gray ash was obtained, removed from the muffle furnace, cooled in a desiccator and reweighed (W_3). The crude fibre was calculated as shown in eqn.5.

$$\% \text{ Crude Fibre Content} = \frac{W_2 - W_3}{W_1} \times \frac{100}{1} \qquad \text{Eqn.5}$$

Where W_3 = Weight of Crucible + sample before ignition
W_2 = Weight of crucible + ash alter ignition

W_1 = Weight of sample

2. 4.1.1.6. Determination of Carbohydrate Content

The carbohydrate content was determind as described by the standard methods of AOAC (2010) by difference as show in eqn.6.

% Carbohydrate content = 100 % - %(Moisture + Protein +Fat + Ash + Crude fibre) Eqn.6

2. 5. Determination of Functional Properties

2.5.1. Determination of Bulk Density

The bulk density was determined as described by Ayo *et al*. (2016). A five gram of flour blends was poured into 5 ml dry measuring cylinder and the volume recorded for loose bulk density. The bottom of the measuring cylinder was gently tapped on a Laboratory bench until no samples was dissolved by the weight of equal volume of distilled water at the same temperature. The bulk density was estimated as mass per unit volume of the sample as shown in eqn.7.

$$Bulk\ density = \frac{Mass\ of\ sample\ (g)}{Volume\ of\ sample\ after\ tapped\ (mL)} \quad \text{Eqn.7}$$

2.5.2. Determination of Swelling Capacity

This was determined as described by Onwuka (2005). A twenty five gram of the flour sample was measured into 100 mL measuring cylinder. The measuring cylinder was thereafter filled with water to 100 mL bench mark.

The mixture was shaken several times and allowed to settle. The volume of the flour was recorded after 15 min as B before swelling and C after swelling. The swelling in the volume was determined by the difference in volume divided by the initial volume as shown in eqn.8 .

$$\text{Swelling index} = \frac{C-B}{A} \quad \text{Eqn.8}$$

Where A = initial volume of 25 g of flour samples
B = volume before swelling
C = volume after swelling

2.4.3. Determination of Water Absorption Capacity (WAC)

This was determined as described by by Onwuka (2005). One gram of the sample was weighed into a dry centrifuge tube and mixed with distilled water to make up 10 mL dispersion. It was centrifuge at 3500 rpm for 15 min.

The supernants were decanted while the tube with the content was reweighed. The gain in mass was calculated as the water absorption capacity of the flour sample as shown in eqn.9.

$$WAC = \frac{Volume\ of\ water\ absorbed}{Weight\ of\ sample} x100 \qquad \text{Eqn.9}$$

2.6. Sensory Evaluation

The sensory evaluation of the samples was carried out as described by Ihekoronye and Ngoddy (1985) and Iwe (2002) on the baked dough. The bread loaves were produced and prepared a day ahead of sensory evaluation and stored at room temperature. The breads were presented in coded forms to 100 semi trained panelists comprising postgraduate and undergraduate students from Departments of Agricultural Education, University of Nigeria and Food Science and Technology, Enugu State University of Science and Technology, Agbani.

The panelists were provided with sachets of water for oral rinsing of mouth in between testing samples and were asked to evaluate each loaf for crust and crumb organoleptic quality attributes of colour, flavour, texture and overall acceptability.using a 9-point hedonic scale, where1 = dislike extremely and 9 = extremely like and the panelists were instructed to rate according to their degree of likeness.

2.7. Statistical Analysis

Data obtained were analysed by one way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPPSS Version 25.0) software.The means of the samples were separated by Turkey Test at 5 % probability level. The results of the research were presented in means and standard deviations.

3. **results and Discussion**

3.1 **Proximate Composition of flour samples.**

The results on proximate composition of the samples are shown in Table 3. The Table showed that moisture content of the samples decreaed significantly ($p < 0.05$) with levels of substitution of African Yam bean flour, but increased among the percent substitution of African yam bean flour. Sample B had the least moisture content of 9.64 %, while sample A (control) had the highest moisture content of 12.68 %.

The moisture content of the samples increased as the proportion of the African yam bean increases.`The moisture content of flour blends had influence on the flour shelf life and above 10

% are likely to cause spoilage of the products through increased microbial action (Okpala *et al.* , 2013; Barber and Obinna- Echem, 2016). The moisture content of food is a measure of stability and susceptibility to microbial contamination. These values except in sample 'A' were lower than 10.32 % reported by Odedeji *et al*. (2014) who found out that low moisture content conferred longer shelf life to bread composite flour. Moreover, moisture content is an important parameter in composite flour because it has an influence on the organoleptic, physical and microbial properties of bread. An ideal moisture content increase positively loaf volume of bread. Flours with moisture content above 14% are not stable at room temperature and as such organisms present in them would start to grow, thus producing off odours (Iwe *et al*.,2016).

The results on changes in protein content in Table 3 indicated that flour bend values ranged from 12.62 – 14.89 %. . Based on the result, the protein content of sample 'A' had least value (12.62%) while sample 'D' had the highest value (14.89%). Table 3 further showed that protein content increased significantly ($p < 0.05$) with increased substitution of African yam bean flour. The formulated flour blends had higher protein content and quality.The flour protein quantity and quality of bread depend on variety and extraction rate for flour. The protein values obtained in the study were similar to reported value of 11.00 % by Oluwafemi and Seidu (2017).

Table 3 also showed that the fat content values of flour samples ranged from 1.68 to 2.80%.The fat content of the samples increased significantly ($p < 0.05$) with increased percentage substitution of African yam bean flour in the flour blends. The low fat content of the flour blends may be attributed to ability of cereals and legumes to stores energy in form of starch rather than lipids. The low fat levels also ensures longer shelf-life for the flour because fats containing products contain unsaturated fatty acids which are susceptible to oxidative rancidity. This finding is in line with reported findings by Onwuka *et al*. (2009) and Nwosu (2013) who found out that African yam bean has high oil content.

The results of ash content of flour blends as shown in Table 3 indicated that ash content increase significantly ($p < 0.05$) with increased supplementation of African yam bean flour. Sample 'D' had the highest ash content of 3.27 %, while sample 'A' had the least ash content of 2.46 %. The Table showed that increased substitution of African yam bean flour increased ash content in flour blends. This finding is in line with reported findings of Ojukwu *et al*. (2012) who stated that African yam bean is a rich source of ash and Millicent (2022) who stated that ash content increase from 0.78 % to 1.45 % as the cocoyam and Bambara groundunts flour substitution levels increased in wheat partially substituted with cocoyam and Bambara groundnuts flour. The ash content of a food sample gives an idea of the mineral elements present in the food. It indicates the composition of inorganic constituent after organic materials (fats, proteins and carbohydrates) and moisture have been removed by incineration. Minerals are essential and ought to be sufficiently available in the composite flour samples. Minerals are a group of essential nutrients which serve a variety of important metabolic functions and are parts of molecules such as haemoglobin, adenosine triphosphate (ATP) and deoxyribonucleic acid (DNA) (Iwe *et al*.,2016).

The results of the fibre content of the samples as shown in Table 3 indicated that sample' A' had the least value of 1.23 %, while sample 'D' had the highest value of 1.42 %. The Table showed that fibre content increased significantly ($p < 0.05$) with increased percent substitution of African yam bean flour in the flour blends. This may be attributed to high crude fibre content of legumes. Crude fibre also slows down release of glucose into the blood stream and decreases intercolonic pressure hence reducing risk of colon cancer as reported by Gibney (1989). Moreover, it has been reported by Ojukwu *et al.* (2012) that fibre content in food products aids in digestion of food and functioning of gasro-intestinal tract.

The results of carbohydrate content of flour blends are shown in Table 3 indicated that carbohydrate contents ranged from 67.63 to 71.54 %. Sample 'D' had the least carbohydrate content of 67.63 %, while sample 'B' had the highest content of 71.54 %. Sample 'B' had higher carbohydrate content than the control. The carbohydrate content of the samples decreased with increased percentage substitution of African yam bean flour in the blends with an exception of sample B. Bread is one of the most important sources of carbohydrate and it occurred abundantly in the form of starch. This decreases in carbohydrate content with increasing substitution of brown bean flour was reported by Okaka (2009). Carbohydrate content of sample A decreased from 69.33 % with addition of African yam bean flour to 67.63 % following 30 % substitution.

The carbohydrate contents of this study were similar to reported carbohydrate content of 60.32 % by Odedeji *et al.* (2014). The carbohydrate contents of the flour blends are high and good indicators that the products made from them will be good sources of energy.

Table 3: Changes in Proximate composition of flour blends

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)
A	$12.68^{a} \pm 0.01$	$12.62^{e} \pm 0.01$	$1.68^{e} \pm 0.01$	$2.46^{e} \pm 0.01$	$1.23^{e} \pm 0.02$	$69.33^{b} \pm 0.02$
B	$9.64^{e} \pm 0.04$	$12.67^{d} \pm 0.04$	$2.12^{d} \pm 0.01$	$2.71^{d} \pm 0.01$	$1.32^{d} \pm 0.01$	$71.54^{a} \pm 0.02$
C	$9.92^{d} \pm 0.06$	$13.93^{c} \pm 0.05$	$2.67^{c} \pm 0.04$	$3.16^{c} \pm 0.03$	$1.37^{c} \pm 0.03$	$68.95^{c} \pm 0.03$
D	$9.99^{c} \pm 0.03$	$14.89^{b} \pm 0.03$	$2.80^{b} \pm 0.05$	$3.27^{b} \pm 0.04$	$1.42^{b} \pm 0.01$	$67.63^{d} \pm 0.05$

Values are mean ± standard deviation from triplicate samples.
Values with different superscripts in the same column are significantly different ($p < 0.05$)
A - 100% wheat flour
B - 90 % wheat flour + 10 % African Yam Bean flour
C - 80 % wheat flour + 20 % African Yam Bean flour
D -70 % wheat flour + 30 % African Yam Bean flour

3.2 **Functional Properties of flour samples**

3.2.1 Changes in water absorption capacity of the flour samples

The water absorption capacity of the flour samples ranged from 60.00 to 140.00 %. Sample A had the least value of 60.00 %, while sample D had the highest value of 140.00 %. Water absorption capacity increased significantly ($p < 0.05$) with increasing levels of African yam bean substitution in the composite flour blends.The difference in water absorption could be attributed to the quantity of damaged and undamaged starch present in the flour sample (Asiedu 1989). It is an indication of the extent to which protein can be incorporated into food formulation. The values obtained in wheat –AfricanYam bean flour blends were higher that reported values of 10.93 % by Suresh *et al.* (2015) in composite flour.

The ability to absorb water is very important property of the flours used in food formulations. The lower water absorption capacity of the wheat and other flours could be attributed to the presence of lower amount of hydrophilic constituents in wheat (Akubor and Badifu 2001). The increase in water absorption capacity of the composite flours could be attributed to the presence of high hydrophobic amino acids with interferes with the ability of these flours to absorb water. A low water absorption capacity is attributed to tight association, while flour with high water absorption capacity is attributed to loose association of amylose and amylopectin in the native granules and the weak binding forces to maintain the starch granules structure (Adebowale *et al.*, 2008). An increase in water absorption capacity is associated with increase in the amylose leaching and solubility as well as loss of starch crystalline ine structure.

The blends with high water absorption may have more hydrophilic constituents. Protein has both hydrophilic and hydrophobic nature and therefore interact with water in foods. Water absorption capacity is a measure of starch digestibility as well as represents the ability of a product to associate with water under a water limiting condition to improve its handling characteristics and dough making potentials (Iwe and Onalope 2001). Flour blends with high water absorption capacity is good in formulation of foods like sausage, dough, processed cheese and other bakery products. Water absorption capacity is important functional property required in formulating food involving dough handling, bulking, consistency of products and baking applications. Thus, the flour blends with the highest water absorption capacity is best accepted in baking applications.

3.2.2. Changes in Bulk density of the flour samples

The results of the changes in bulk density as shown in Table 4 ranged from 0.28 to 0.30 g/mL. The results showed that bulk density of the flour decreased significantly ($p < 0.05$) with increasing levels of African Yam bean flour substitution. Sample A had the highest value of 0.37 g/mL, while Sample D had the least value of 0.30 g/mL.There were no significant difference ($p < 0.05$) in samples B and C. The bulk density values of wheat – African Yam bean flour blends were low than reported value of 0.79 g/mL by Awolu *et al*.(2017) on wheat composite flour.

However, the results were similar to reported values of 0.22 – 0.42 by Yusuf et al (2013) for complementary foods formulated from sorghum, African yam bean and mango pulp mesocarp flour blends. Bulk density is function of particle size, particle size being inversely proportional to bulk density as reported by Onimawo and Akubor (2012) and composite flour with low bulk density is desirable for ease of packaging and transportation. Bulk density depends on the particle size and initial moisture content of the composite flours. An increase in bulk density is an indication of the suitability of the composite flour in food formulations. However, composite flour with low bulk density would be suitable in the formulation of complementary foods as reported by Akapata and Akubor (1999). This could lend to consumption of more food products resulting in high energy and nutritional density. Composite flour with high bulk density would be suitable for use as thickener in food products as well as use in food preparation as it could reduce paste thickness that is essential in convalescent and child feeding.

3.2.3 Changes in Swelling Index of the flour samples

The results of swelling index of the samples are shown in Table 4. The swelling index values ranged from 1.63 to 1.76 g/g. Sample D had significantly ($p < 0.05$) the highest swelling index value of 1.76 g/g. Whereas sample A had the least value of 1.63 g/g. The table showed that swelling index increased significantly ($p < 0.05$) with increasing levels of African Yam bean flour substitution. Swelling index has been reported by Ajatta *et al*. (2016) to depend on the variety of flour and processing method employed. The difference may be attributed to variety of the sample and the processing method employed. It is also a good quality measure in formulation of bakery products. It is an evidence of non –covalent bonding between molecules within the starch granules. It is also a means of ascertaining the ratio of amylose and amylopectin ratios as reported by Iwe *et al*. (2016) in flours. The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations (Igbabul *et al.*, 2014).

High starch content increased the swelling index of flours especially those starchy food compositions with high quantity of amylopectin. Swelling index has been known to cause changes in the hydrodynamic properties of foods and impact desirable characteristics in the body mass as well as increase in thickness and viscosity of such products as reported by Calzetta *et al*. (2000).

Table 4: Functional properties of flour blends

Samples	Water absorption capacity (%)	Bulk density (g/mL)	Swelling-index (g/g)
A	$60.00^{d}\pm0.01$	$0.37^{a}\pm0.01$	$1.63^{d}\pm0.01$
B	$80.00^{c}\pm 0.02$	$0.35^{b}\pm0.00$	$1.64^{c}\pm0.00$
C	$120.00^{b} \pm 0.01$	$0.34^{b}\pm0.00$	$1.71^{b}\pm0.00$
D	$140.00^{a} \pm 0.03$	$0.30^{c}\pm0.00$	$1.76^{a}\pm0.01$

Values are mean ± standard deviation from triplicate samples.
Values with different superscripts in the same column are significantly different ($p < 0.05$)
A - 100% wheat flour
B - 90 % wheat flour + 10 % African Yam Bean flour
C - 80 % wheat flour + 20 % African Yam Bean flour
D -70 % wheat flour + 30 % African Yam Bean flour

3.3 **Sensory Properties of the Bread Loaves**

The results of the sensory properties of the bread loaves are shown in Table 5. The texture of the samples ranged from 3.90 to 6.55. Sample D had the highest texture scores of 6.55, while sample A had the least texture scores compared to other samples. There were no significant different ($p > 0.05$) in texture scores of samples B and C but these samples differed significantly

($p < 0.05$) from other samples. Sample D was moderately like by the panelists compared to other samples. The texture scores of this study were in line with reported values of 5.20 and 8.10 by Chikwendu *et al*. (2015) in wheat and soy composite bread.

The results of scores for flavour of the samples are shown in Table 5. The scores ranged from 4.05 to7.30. Sample A had the highest flavour scores, while sample D had the least flavour scores. The results showed that flavour scores decreased with increasing levels of AfricanYam flour substitution. There were no statistically significant differences ($p > 0.05$) in flavour scores of samples B, C and D. Samples B, C and D were rated neither liked nor dislike, slightly dislike and slightly dislike, respectively.The decreases in flavour with increased substitution of AfricanYam bean flour blends could be attributed to beany flavour of African Yam beans flour.

The flavour scores of this study were in line with 5.80 to 8.40 reported by Chikwendu *et al* . (2015) in wheat and soy composite bread and 8.60 to 8.90 reported by Kazakos et al. (2022) in Novel Sourdough bread made from wheat bran and traditional flour/ sour milk food. Flavour is the sensorial pointer of the sweetness and taste of food. Moreover, the taste of flour blends was influenced by the caramelization reaction between sugar and heat**.**

The changes in colour of the samples are shown in Table 5. The colour scores of the samples ranged from 5.70 to 7.60. Sample A had the highest colour scores of 7.60, while sample D had the least colour scores of 5.70. There were no statistically significant difference ($p > 0.05$) in colour scores of samples A, B and C, which were rated like moderately and like moderately, respectively. There was no significant difference ($p > 0.05$) in colour scores of samples C and D. The colour scores obtained in the study were similar with the values of 5.10 to 8.60 reported values by Onoja *et al*.(2014) in breads produced from Orarudi (Viga sp) and wheat flour blends. colour is also a special sensory attribute that determines the acceptance of products.

The results of overall acceptability scores of the samples are shown in Table 5. The overall acceptability scores ranged from 3.85 to 7.05. Samples A and E were rated moderately desirable and moderately undesirable, respectively. There were no statistically significant differences ($p < 0.05$) in overall acceptability scores of samples B, C and D. Bread with higher amounts of African yam bean flour were darker in colour and less acceptable to the panelists, confirming the need to use African yam bean flour in lower amounts in foods to enhance acceptability. The overall acceptability scores showed that samples acceptance decreased with increased levels of substitution with AfricanYam Bean flour. This ugly trend could be caused by the beany flavour arising from the African Yam Bean flour. Hence I suggest use of an alternative processing method like roasting to disguise the beany flavour and improved highly the acceptance of the bread loaves by every consumer. The overall result of this research was in line with similar research by Oluwafemi and Seidu (2017) who had values of 5.80 to 7.87 in bread formulated from wheat and soybean flour blends.

Table 5: Sensory properties of bread loaves formulated from wheat- African Yam flour blends

Samples	Texture	Flavour	Colour	Overall acceptability
A	$3.90^{c} \pm 1.12$	$7.30^{a} \pm 0.86$	$7.60^{a} \pm 1.60$	$7.05^{a} \pm 0.94$
B	$4.60^{b} \pm 1.70$	$4.80^{bc} \pm 1.64$	$6.90^{a} \pm 1.37$	$4.85^{b} \pm 1.85$
C	$5.50^{b} \pm 1.54$	$4.25^{b} \pm 1.62$	$6.75^{ab} \pm 1.62$	$4.40^{b} \pm 1.60$
D	$6.55^{a} \pm 1.70$	$4.05^{bc} \pm 1.90$	$5.70^{b} \pm 2.05$	$3.85^{bc} \pm 2.06$

Values are mean ± standard deviation from triplicate samples.
Values with different superscripts in the same column are significantly different ($p < 0.05$)
A - 100% wheat flour
B - 90 % wheat flour + 10 % African Yam Bean flour
C - 80 % wheat flour + 20 % African Yam Bean flour
D -70 % wheat flour + 30 % African Yam Bean flour

4. Conclusion

The flour blends of sample D had higher swelling index and higher water absorption capacity than other samples. It also had higher protein, Fat, ash and fiber contents, but had least carbohydrate content compared to other samples. Bread loaves made from the control (sample A) had significantly ($p < 0.05$) higher flavour scores and colour scores as indicated by the panelists. There were no statistically significant differences ($p > 0.05$) in colour scores between samples A, B and C.

Whereas bread loaves from sample D had the least colour scores; bread loaves of sample D had the highest sesory texture scores. There were statistically significant differences ($p > 0.05$) in the texture scores of the samples.The texture, flavour and colour of African Yam bean seed flour substituted samples were appealing to the panelists, but their beany flavours decreased their overall acceptance scores. Though application of African yam bean flour in baked products will reduce food loss and waste along food value chain, but bread with higher amounts of African yam bean seed flour were darker in colour and less acceptable to the panelists. Therefore, African yam bean seed flour substitution in wheat bread should be in lower amounts to enhance acceptability

Hence, alternative methods of roasting or fermentation can be adopted to mask the beany flavour and improved its overall acceptability score.

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