International Journal of Food Science and Nutrition
ISSN: 2455-4898; Impact Factor: RJIF 5.14
Received: 15-01-2021; Accepted: 07-02-2021; Published: 10-03-2021
www.foodsciencejournal.com
Volume 6; Issue 2; 2021; Page No. 38-44

Evaluation of physico-chemical and organoleptic properties of wheat-African yam bean composite flour breads

Egbujie Augustine Eseroghene*, Odion-Owase Emmanuel, Suleiman Mohammed
[1] Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria
[2] Department of Food Technology, Auchi Polytechnic, Auchi, Edo State, Nigeria

Abstract
This study was carried out to evaluate the proximate composition, mineral composition, physical and sensory properties of breads supplemented with African yam bean flour. African yam bean flour was prepared and used at different graded replacement levels (10-50%) for wheat flour in the production of wheat-African yam bean composite flour breads with 100% wheat flour bread loaves as control. The proximate, mineral, physical and sensory properties of the bread samples were determined using standard methods. The crude protein, fat, crude fibre and ash contents of the bread samples were found to increase proportionally with increased in African yam bean flour substitution from 7.92–12.68%, 4.45-6.22%, 3.41-5.62%, 1.45-2.44%, respectively, while the carbohydrate content decreased from 61.54-34.22%. The mineral composition of the breads samples also increased simultaneously with increase substitution of African yam bean flour from 68.32-104.12mg/100g (Calcium), 48.44-92.10mg/100g (Phosphorus), 84.58-122.18mg/100g (Potassium), 1.12-2.22mg/100g (Iron) and 1.48-2.68mg/100g (Zinc), respectively. The physical properties of the bread samples (Loaf volume, loaf height, Loaf weight, oven spring and specific loaf volume) decreased significantly ($p<0.05$) with increase substitution of African yam bean flour from 312.01-120.42cm^3, 6.97-3.72cm, 402.15-381.34g, 458.30–402.00cm and 0.74-0.24cm^3/g, respectively. The result for the sensory attributes shows extremely likeness for the control (100% wheat bread) in colour, texture, taste, flavour and overall acceptability than the wheat-African yam bean composite bread samples as indicated by the reduction in values with gradual increase in substitution of African yam bean flour. However, the study showed that the nutrient content of wheat flour could be improved by substituting it with African yam bean flour at different graded levels in the production of bread loaves and other baked products.

Keywords: bread, supplementation, wheat flour, African yam bean flour, proximate composition, mineral composition, physical properties, sensory properties

Introduction

Although consumption of animal proteins are encouraged because of their balanced amino acid profile, utilization of plant proteins can effectively substitute in regions with limited availability of animal proteins. This provides a good alternative for the use of composite flours or wheat flour substitutes in the production of bread and other bakery products such as biscuits and cakes which are considered important "ready to eat" foods among both rural and urban dwellers (Aklozie and Udofia, 2009) [2]. Diets based on whole grains are gaining increase on daily bases due to various health benefits associated with them as they are good sources of dietary fibre, antioxidants, vitamins, minerals among others (Hegazy and Ibrahim, 2009) [20]. Legumes are consumed worldwide, especially in developing and under developed countries where the consumption of animal protein may be limited as a result of economic, social, religious or cultural factors (Okoye and Obi, 2017) [28]. However, the use of legume as protein source is limited by the presence of anti-nutrients or toxic substances which interfere with digestive processes and prevent efficient utilization of their proteins (Fasoyiro *et al.*, 2006). To improve the nutritional quality and organoleptic acceptability of leguminous seeds as well as making them bio-available to the body for easy utilization, there is therefore the needs to reduce or inactivate the anti-nutrient (Phytates, saponins, protease inhibitors, oxalate, lectins, haemagglutinins and flatulence factors) which are naturally present in them by the use of some simple processing techniques such as roasting, blanching, cooking, soaking, autoclaving, malting, fermentation and dehulling (Aremu *et al.*, 2011; Okorie, 2013) [4, 27].

Bread is a staple food produced by baking dough of flour and water with addition of other ingredients such as sugar, salt, yeast, milk and fat (Okaka, 2005) [26]. Bread is also described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking (Dewettinck *et al.*, 2008) [9]. Bread can also be seen as nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat from the oven (Olaoye *et al.*, 2007) [30]. Bread is a convenient and inexpensive food product containing digestive and dietary principles of vital importance (Kulkarmi and Deshponde, 2007) [21].

Due to high demand and cost of wheat flour which serves as the most important ingredient in bread making, there is need to initiate and develop an alternative source of flour from locally available nutrient dense food crops which will reduce the importation of wheat flour and as well serve as economic advantage. This idea led to the production of composite flour from locally available crops. Composite flour is a mixture of different flours from cereals, legumes, oil seeds, root and tuber crops, fruit or other raw materials that is created to satisfy specific functional characteristics and nutrient composition.

Wheat (*Triticum aestivum*) is one of the dominant crops in temperate countries that is used as human food and livestock feed. The usefulness of wheat depends partly on its adaptability and high yield potentials as well as on the gluten protein fraction which confers the visco-elastic properties that allow dough to be processed into bread, pasta, noodles and other food products (Browns *et al.*, 2011) [7]. The low protein content of wheat flour has gear towards the desire to fortify or supplement bread and other baked products with plant proteins derived from legumes or pulses. This is because legume proteins have low levels of sulphur containing amino acids (methionine and cystine) but are rich in lysine and tryptophan, which are essential limiting amino acids in most cereals (Dewettinck *et al.*, 2008) [9].

African yam bean (*Sphenostylis stenocarpa*) is an underutilized leguminous crop which serves as a good source of relatively cheap plant protein that can be used to improve the nutritional status of people in developing countries, especially the poor and low income earner (Eke, 2002) [12]. African yam bean seeds are relatively high in protein, fat, minerals and vitamins. It is also rich in amino acids such as lysine and tryptophan than most of other leguminous crops (Alozie and Udofia, 2009) [2].

The use of non-conventional flours, such as African yam bean flour to supplement wheat flour in the production of bread and other baked products would increase farmer income by adding value to the specified product, increase the protein intake of their consumers, encourage food security and diversification and as well reduce wheat importation. The objective of this study therefore, was to develop and evaluate the proximate, mineral, and physical and sensory properties of wheat breads supplemented with African yam bean flour.

Materials and Methods

Matured dried African yam bean seeds (*Sphenostylis stenocarpa*) used for the study where purchased from Ogbete Main Market, Enugu, Enugu State, Nigeria. Commercial wheat flour and other ingredients (salt, milk, yeast, fat and sugar {sucrose}) used for the production of bread where equally purchased from the same market.

Preparation of Malted African Yam Bean Flour

The malted African yam bean flour was prepared according to the method of Egbujie and Okoye (2019) [10]. One kilogramme (1kg) of African yam bean seeds were sorted to remove dirt and other extraneous materials. The sorted seeds were thoroughly cleaned and steep in 2.5 liters of potable water in a plastic bowl at room temperature (30±2º C) for 24 h with occasional change of soaked water at intervals of 6 h to prevent microbial fermentation. The soaked seeds were drained, rinsed and spread on wet jute bag and allowed to sprout at ambient temperature for 96 h. During this period, the spread seeds were sprinkled with water at intervals of 6 h to facilitate germination. Non-germinated seeds were handpicked and discarded and the geminated seeds were collected, spread on the trays and dried using a tray dryer (Model EU 850D, UK) at 60º C for 18 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried malted African yam bean seeds were cleaned manually and rubbed in-between palms to remove the sprouts and hulls. The dehulled malted seeds were milled using a hammer mill and sieved through a 500 micron-mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and stored in a refrigerator until needed for further use.

Flour Blend Formulation

Wheat flour (WF) was blended with African yam bean flour (AYBF) in the ratios of 90:10, 80:20, 70:30, 60:40 and 50:50 in a Kenwood mixer (Model NX 908 G Kenwood, Britain, UK) to produce wheat-African yam bean composite flour. The composite flour produced were packaged individually in an airtight plastic container, labeled and stored in a refrigerator until needed for further use.

Preparation of Bread Samples

The bread samples were prepared according to the method of Dewettinck *et al.* (2008) [9]. Recipe used for the preparation of the bread include 100% flour, 15% dried yeast, and 40% sugar (Sucrose), 5% vanilla flavour, 5% salt and 180mL distilled water. During preparation, all the ingredients with the exception of the yeast were thoroughly mixed together in a micro dough mixer (Model KSM 850, USA) to obtain hard consistent dough. After that, the yeast was activated by putting 20g of yeast in a sealed plastic container containing 30mL of warm distilled water, 25g of sugar and 15g of flour and allowed to rest at room temperature (30±2º C) for 25 min to form the yeast-in-water dispersion. The dough produced was transferred into a plastic bowl and pierced carefully at the centre. The yeast-in-water dispersion was poured into the pierced hole and the dough containing the yeast-in-water dispersion was repeatedly kneeded manually for 10 min to introduce oxygen for vigorous fermentation and to encourage the development of gluten. The kneeded dough was carefully divided and moulded manually into uniform shapes of similar sizes. The moulded doughs were placed separately into baking pans smeared with vegetable oil and covered with greased bread wrapper. The bread doughs were allowed to ferment at room temperature (30+2º C) for 1 h. The fermented doughs were proofed at 40º C in a cabinet proofer for 85 min and baked in an electric oven (Salva, USA) at 200º C for 50 min. The bread loaves were removed from the oven, taken out of the baking pans and allowed to cool at ambient temperature for 1 h. The cooled bread loaves were divided into two (2) lots. The first lot was wrapped with aluminum foils and used for sensory evaluation after 2 h. The second lot was packaged in low-density polyethylene bags and kept in a refrigerator until needed for analysis. The bread loaves produced from 100% wheat flour were used as control.

Chemical Analysis

The moisture, protein, fat, crude fibre, ash and carbohydrate contents of standard and composite bread were determined in triplicate using standard analytical methods (AOAC, 2006) [3]. Moisture content was determined by drying 5g of the milled breads at 130º C for 1 h in an air oven (Sanyo Gallenkamp, Weiss Technik, West Midlands, and UK). The ash content was determined gravimetrically after incineration in a muffle furnace at 550º C for 24 h. Crude fibre content was determined by difference after the incineration of the filter paper containing the insoluble materials from the hydrolysis and washing of moisture-free defatted sample (1g). Fat content was determined by exhaustive extraction of 1g of the sample with petroleum ether in soxhlet extraction unit (Gerhardt, Bonn, Germany). Protein content was determined by Kjeldahl method. After distillation and titration, the nitrogen was corrected using a factor of 6.25. Carbohydrate was calculated by difference on dry sample weight by subtracting the summation of the percentage of moisture, protein, and fat, crude fibre and ash contents from 100%. The calcium, phosphorus, potassium, iron and zinc contents of the samples were determined in triplicate using atomic absorption spectrophotometer (Milton Roy Spectronic 601) according to the method of Abiodun and Akinoso (2014) [1].

Physical Analysis

The loaf volume of standard and composite flour breads were determined by the method of Giami *et al.* (2004) [18]. Loaf height was determined by the method of See *et al.* (2007). Loaf weight was determined using electronic balance and the specific loaf volume was calculated as (loaf volume/loaf weight). Oven spring was determined by seed displacement method of Oladunmoye *et al.* (2010) [29]. All determinations were carried out in triplicate.

Sensory Evaluation

The wheat and composite flour bread samples were cooled for 2 h after baking at room temperature (30±2º C). The loaves were then sliced separately into small slices with the aid of a bread knife. The sensory test was conducted by the panel of twenty (20) semi-trained consumer test panelists comprising of staff and students of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The samples were evaluated for the attributes of crust colour, texture, taste, flavour and overall acceptability using a nine-point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively (Okaka, 2010) [24]. The sensory evaluation was carried out in the Food Research Laboratory of the Department of Food Science and Technology, Enugu State University of Science and Technology, Enugu, Nigeria. The panelists were sitted in such a way that they could not see the rating of each other. The samples were randomly coded and served in plain coloured plastic plates and each assessor was provided with a cup of drinking water to rinse his/her mouth after testing each sample to avoid residual effect. The assessors were asked to evaluate and score the bread loaves based on their degree of preference and acceptance of each product.

Statistical Analysis

The data generated in this research work were subjected to one-way analysis of variance (ANOVA) using SSPS, version 20 software. Means were separated by the use of Duncan's New Multiple Range Test (DNMRT) at $p<0.05$ and the results were expressed as means standard deviation of triplicate determinations.

Results and Discussion

Proximate Composition of Wheat-African yam bean Composite Bread Samples.

The proximate composition of the bread samples are presented in Table 1. The moisture content of the bread samples ranged from 6.82-9.02% with the control sample (100% wheat flour bread) and the sample substituted with 50% African yam bean flour having the least and highest moisture contents, respectively. The moisture content of the samples increases steadily with increased substitution of African yam bean flour. High moisture content in foods encourages rapid growth of microorganisms. The low moisture content observed in this study is advantageous owning to the facts that it could lead to the reduction in microbial proliferation and extension of the product shelf life (Elkalifa and Barnhart, 2010). The protein content of the samples varied significantly ($p<0.05$) from 7.92-12.68% with increase substitution of African yam bean flour. The wheat bread substituted with 50% African yam bean flour had the highest value for protein (12.68%) and this is in agreement with the report that African yam bean is a good source of protein (Ekop, 2006) [13]. Protein plays an important role in building and maintenance of body cells and tissue (Okaka, 2006). The fat content of the bread samples ranged from 4.45-6.22. The fat content of the bread samples increased steadily with increase substitution of African yam bean flour in the products. The increase in fat content could be attributed to the addition of high quality African yam bean flour in the blends. Fat is important in the diet because it supplies essential fatty acids and also facilitates the absorption of fat soluble vitamins in humans (Michaelson *et al.*, 2000). The crude fibre content of the sample varied significantly ($p<0.05$) from 3.41-5.62% with increase in the level of African yam bean substitution. The control sample (100% wheat flour bread) had the least crude fibre content (3.41%). The observation is in agreement with the report of Alozie and Udofia (2009) that African yam bean is a good source of crude fibre. The ash content of the bread samples increase steadily with increase substitution of African yam bean flour in the products. The sample substituted with 50% African yam bean flour had the highest ash value (2.44%), while the control sample recorded the least ash value (1.45%).The ash content (1.45-2.44%) reported in this study were higher than the ash content (1.25-1.36%) of wheat-ground bean composite flour bread reported by Chinkwendu *et al.* (2015). The ash content of a food material is used as an index for estimating the amount of minerals present in the food product (Ishiwu and Oyenji, 2004). The carbohydrate content of the bread samples which varied from 61.54-34.22 decreased simultaneously with increase in the levels of African yam bean flour substitution. The inclusion of African yam bean flour generally resulted in total reduction of carbohydrate content of the bread and this is in consonance that the bread flour (wheat flour) is the major source of carbohydrate in bread. This result is in agreement with the report of Oluwalana *et al.* (2012) for wheat-sweet potato composite flour breads. The substitution of wheat flour with African yam bean flour in the production of bread loaves greatly improve the protein, fat, crude fibre and ash contents of the composite flour breads.

Mineral Composition of Wheat-African yam bean Composite Bread Samples

The mineral composition of the bread samples are presented in Table 2. The calcium content of the bread samples which ranged from 68.32-104.12mg/100g increased significantly ($p<0.05$) with increase substitution of African yam bean flour. The control sample (100% wheat flour bread) had the least calcium content (68.32mg/100g), while the sample substituted with 50% African yam bean had that highest calcium content (104.12mg/100g). The increase in calcium content could be attributed to the inclusion of African yam bean flour in the products. Calcium in conjunction with magnesium, phosphorus and protein are important for proper bone development in infants and young children (Okaka *et al.*, 2006) [25]. The phosphorus content of the bread samples varied significantly ($p<0.05$) from 48.44-92.10mg/100g. The sample substitution with 50% African yam bean flour had the highest phosphorus content (92.10mg/100g).The increase in the phosphorus content of the composite flour breads is an indication that African yam bean is a good source of phosphorus (Aremu *et al.*, 2006) [5]. Phosphorus is an important nutrient that plays a significant role in the formation of Adenosine Trisphosphate (ATP) in the human body (Okaka *et al.*, 2006) [25]. The potassium content of the bread samples varied significantly ($p<0.05$) from 84.58-122.18mg/100g with proportional increase of African yam bean flour. The control sample (100% wheat bread flour) had the lowest potassium content (84.58mg/100g). The potassium content (84.58-122.18mg/100g) reported in this study was lower than potassium content (177.56-188.40mg/100g) of breads made from blends of Orarudi (*vigna sp.*) and wheat flour reported by Onoja *et al.* (2014).The iron content of the bread samples increased significantly ($p<0.05$) from 1.12-2.22mg/100g with increase in substitution with African yam bean flour. The control sample (100% wheat bread flour) had the least iron content (1.12mg/100g), while the sample substituted with 50% African yam bean flour had the highest iron content (2.22mg/100g). The observed increase in the iron content could be attributed to the inclusion of African yam bean flour in the products. Iron is a component of myoglobin, a protein that provides oxygen to the muscles and supports metabolism in humans (Wesslsing-Resmick, 2014) [38]. The zinc content of the bread sample varied from 1.48-2.68mg/100g. The sample substituted with 50% African yam bean flour had the highest zinc content (2.68mg/100g). Zinc supports normal growth and development during pregnancy, childhood and adolescence (Ravichandan *et al.*, 2010). The substitution of wheat flour with African yam bean flour in the production of bread loaves immensely enhanced the mineral contents of the products.

Physical properties of Wheat-African yam bean Composite Bread Samples

The physical properties of the bread samples are presented in Table 3. The loaf volume of the samples decreased sequentially with increase substitution of African yam bean flour from 312.01-120.42cm^3. The decrease may be attributed to high level of gluten present in wheat flour compared to composite blends which could not be properly stretched by carbondioxide (Co_2) gas during fermentation and proofing (Elleuch *et al.*, 2011) [14]. The loaf height of the bread samples spontaneously decreased from 6.97-3.72cm with increase in substitution with African yam bean flour. The values obtained in this study (6.97-3.72cm) were higher than the loaf height (5.68-2.54cm) of wheat-sweet potato composite flour breads reported by Hathorn *et al.* (2008). The decrease in the loaf height could be attributed to proportional increase of African yam bean in the products. This report is in consonance with the findings of Malomo *et al.* (2012) [22] who reported similar decrease in loaf height of wheat flour breads substituted with bread fruit and breadnut flours. The loaf weight of the bread samples was observed to decreased significantly ($p<0.05$) from 402.15-381.34g with increase in substitution with African yam bean flour. The increase in loaf weight of the control sample (100% wheat flour bread) was due to the increase in carbondioxide retention capacity of wheat flour compared to the composite flour blends during fermentation and proofing (Shittu *et al.*, 2007) [37].The oven spring of the bread samples decrease gradually from 458.30-402.00cm with the control sample (100% wheat bread flour) having the highest value (458.30cm). The decrease observed in the oven spring of the bread samples could be attributed to the inclusion of African yam bean flour in the products which causes the reduction of the gluten content of wheat flour. This observation is in agreement with the report of Malomo *et al.* (2012) [12] for wheat-breadfurit-breadnut composite flour breads. The specific loaf volume of the bread samples decreased significantly ($p<0.05$) from 0.74-0.4cm^3/g with increase substitution with African yam bean flour. The values obtained in this study (0.74-0.24cm^3/g) was lower than the specific loaf volume (1.20-3.86cm^3/g) of breads produced from blends of Orarudi (*Vigna sp.*) and wheat flour reported by Onaja *et al.* (2011). The substitution of wheat flour with African yam bean flour in the production of bread loaves drastically reduced the physical properties of the products.

Sensory Properties of Wheat-African yam bean Composite Bread Samples

The sensory properties of the bread samples are presented in Table 4. There were significant ($p<0.05$) differences between the control and the composite flour breads in colour, texture, taste, flavour and overall acceptability. The overall acceptability was determined on the basis of quality scores obtained from the evaluation of colour, texture, taste and flavour. The result showed that the control sample (100% wheat flour bread) was the most acceptable to the judges followed by wheat-African yam bean composite flour bread substituted with 10,20,30, 40 and 50% African yam bean flour. The observed change in colour from light-brown in the control sample to darker-brown in the sample substituted with 50% African yam bean flour could be attributed to Mailard browning reaction caused by the reaction between the amino acids of the proteins, added sugar and caramelization which are both influenced by the distribution of water (Fayle and Gerrard, 2002; Onimawo and Akubor, 2005) [17, 32]. Mailard reaction is reported to be related to temperature, time and presence of moisture (Ballolli *et al.*, 2014) [6]. Colour serves as an important consumer appeal factor for the initial acceptability of the baked product. The result of the sensory scores revealed that the panelists showed preference to the colour, texture, taste and flavour of the control sample (100% wheat flour bread) compared to the composite breads as they were significantly ($p<0.05$) different from the control in all the parameters evaluated. However, the substitution of wheat flour with African yam bean flour in the production of bread produced nutritious and acceptable results.

Conclusion

Desirable and acceptable breads were produced from composite flours of wheat and African yam bean. Although, the composite flour bread samples were more nutritious, while the 100% wheat flour bread (control) was organoleptically more acceptable. The supplementation of what flour with African yam bean flour greatly improve the protein, fat, crude fibre and ash contents of the composite bread samples compared to the 100% wheat bread. The exploitation of wheat/African yam bean composite bread samples for the commercial production of bread will be advantageous with the present cost of wheat flour and will equally reduce the cost of bread production since African yam bean is cheap and readily available in different parts of Nigeria and other sub-Saharan African countries.

Table 1: Proximate Composition (%) of Wheat- African Yam Bean Composition Bread Samples.

Sample ID	% Substitution WF:AYBF	Moisture	Protein Nx 6.25	Ash	Fat	Crude fibre	Carbohydrate
A	100:0	6.82^{f}±0.04	7.92^{f}±0.06	1.45^{f}±0.11	4.45^{f}±0.02	3.41^{f}±0.06	61.54^{a}±0.08
B	90:10	7.12^{e}±0.04	8.14^{e}±0.12	2.28^{e}±0.04	4.78^{e}±0.06	3.98^{e}±0.14	56.48^{b}±0.16
C	80:20	7.45^{d}±0.06	9.55^{d}±0.20	2.30^{d}±0.06	4.96^{d}±0.10	4.56^{d}±0.08	50.20^{c}±032
D	70:30	8.74^{c}±0.04	10.76^{c}±0.18	2.33^{c}±0.04	5.48^{c}±0.11	4.94^{c}±0.02	43.72^{d}±0.54
E	60:40	8.10^{b}±0.02	11.42^{b}±0.04	2.38^{b}±0.10	5.68^{b}±014	5.15^{b}±0.01	38.94^{e}±0.24
F	50:50	9.02^{a}±0.18	12.68^{a}±0.14	2.44^{a}±0.08	6.22^{a}±0.18	5.62^{a}±0.06	34.22^{f}±0 32

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly ($p<0.05$).
WF – Wheat Flour, AYBF – African Yam Bean Flour

Table 2: Mineral Composition (mg/100g) of Wheat- African Yam Bean Composite Bread Samples

Sample ID	% Substitution WF:AYBF	Calcium	Phosphorus	Potassium	Iron	Zinc
A	100:0	68.32^{f}±0.01	48.44^{f}±0.03	84.58^{f}±0.08	1.12^{f}±0.02	1.48^{f}±0.06
B	90:10	72.14^{e}±0.12	56.12^{e}±0.02	88.18^{e}±0.02	1.22^{e}±0.12	1.62^{e}±0.02
C	80:20	78.52^{d}±0.08	64.22^{d}±0.01	94.22^{d}±0.04	1.38^{d}±0.06	1.98^{d}±0.10
D	70:30	86.44^{c}±0.18	69.40^{c}±0.04	102.46^{c}±0.14	1.62^{c}±1.20	2.18^{c}±0.20
E	60:40	96.41^{b}±0.16	76.44^{b}±0.11	112.14^{b}±0.02	1.89^{b}±0.14	2.34^{b}±0.16
F	50:50	104.12^{a}±0.03	92.10^{a}±0.22	122.18^{a}±0.11	2.22^{a}±0.09	2.68^{a}±0.04

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly ($p<0.05$).
WF – Wheat Flour, AYBF – African Yam Bean Flour

Table 3: Physical Properties of Wheat-African Yam Bean Composite Bread Samples

Sample ID	% Substitution WF:AYBF	Loaf volume (cm^3)	Loaf Height(cm)	Loaf weight(g)	Oven spring(cm)	Specific loaf volume (cm^3/g)
A	100:0	312.01^{a}±0.03	6.97^{a}±0.11	402.15^{a}±0.00	458.30^{a}±0.04	0.74^{a}±0.08
B	90:10	292.14^{b}±0.15	6.12^{b}±0.04	392.10^{b}±0.01	446.14^{b}±0.02	0.68^{b}±0.02
C	80:20	246.18^{c}±1.04	5.88^{c}±0.10	389.10^{c}±0.06	438.62^{c}±0.06	0.52^{c}±0.01
D	70:30	214.32^{d}±0.18	5.02^{d}±0.01	386.06^{d}±0.01	424.19^{d}±0.08	0.46^{d}±0.03
E	60:40	172.10^{e}±0.11	4.46^{e}±0.00	384.14^{e}±0.18	412.02^{e}±0.00	0.32^{e}±0.04
F	50:50	120.42^{f}±1.02	3.72^{f}±0.24	381.34^{f}±0.16	402.00^{f}±0.02	0.24^{f}±0.00

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly ($p<0.05$).
WF – Wheat Flour, AYBF – African Yam Bean Flour

Table 4: Sensory Properties of Wheat-African Yam Bean Composite Bread Samples

Sample ID	% Substitution WF:AYBF	Colour	Texture	Taste	Flavour	Overall acceptability
A	100:0	7.88^{a}±1.12	7.42^{a}±1.15	7.72^{a}±1.18	7.70^{a}±1.14	7.86^{a}±1.22
B	90:10	7.54^{b}±1.38	7.24^{b}±1.60	7.30^{b}±1.42	7.36^{b}±1.12	7.18^{b}±1.20
C	80:20	7.18^{c}±1.42	6.48^{c}±1.22	6.64^{c}±1.12	6.72^{c}±1.40	6.54^{c}±1.10
D	70:30	6.42^{d}±1.02	6.21^{d}±1.10	6.18^{d}±1.32	6.24^{d}±1.10	6.12^{d}±1.33
E	60:40	5.30^{e}±1.12	5.33^{e}±1.48	5.28^{e}±1.11	5.33^{e}±1.28	5.42^{e}±1.14
F	50:50	4.64^{f}±1.18	4.55^{f}±1.18	4.68^{f}±1.42	4.60^{f}±1.11	4.30^{f}±1.24

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly ($p<0.05$).
WF – Wheat Flour, AYBF – African Yam Bean Flour

References

1. Abiodun OA, Akinoso R. Effect of harvesting periods on the chemical and pasting properties of trifoliate yam flour. Journal of Food Chemistry. 2014; 65:142-159.
2. Alozie YE, Udofia US. Amino-acid composition of seed meals of African yam bean and sensory properties of cake made from wheat and African yam bean flour blends. Journal of Food Technology. 2009; 7(4):115-118.
3. AOAC. Official Methods of Analysis. Association of Analytical Chemists. 18th edn. Washington, D.C. USA. 2006, 614-621.
4. Aremu MO, Osinfade BG, Basu SK, Ablaku BE. "Development and Nutritional Quality Evaluation of kersting's Groundnut-Ogi for African Weaning Diet". American Journal of Food Technology. 2011; 6(12):1021-1033.
5. Aremu OM, Olaofe O, Emmanuel TA. Comparative study on the chemical and amino acid composition of some Nigerian under-utilized legume flours. Pakistan Journal of Nutrition. 2006; 5:34-38.
6. Ballolli U, Malagi U, Yenagi N, Orsat V, Gariepy Y. *et*

al. "Development and Quality Evaluation of Foxtail Millet (*Setaria italic L.*) Incorporated Breads". Karnataka Journal of Agricultural Science; 2014; 27(1):52-55.
7. Browns F, Hemery Y, Price R, Anson NM. Wheat aleurone: separation, composition, health aspects and potential food uses. Critical Reviews in Food Science and Nutrition. 2011; 52:553-568.
8. Chikwendu NJ, Nwamarah JU, Nnebe NU. Determination of Nutrient Composition and Oganoleptic Evaluation of Bread Produced from Composite Flours of Wheat and Beans. African Journal of Agricultural Research. 2015; 10(51):4706-4712.
9. Dewettinck K, Bockstaele FV, Kuhne B, Walle DV. Nutritional value of bread: Influence of Processing, Food interaction and Consumer perception. Journal of Cereal Science. 2008; 48(2):243-257.
10. Egbujie AE, Okoye JI. Quality Characteristics of Complementary Foods Formulated from Sorghum, African yam bean and Crayfish Flours. Science World Journal. 2019; 14(2):16-22.
11. Elkhalifa EO, Bernhart R. Influence of grain germination on functional properties of sorghum flour. ScienceDirect Food Chemistry. 2010; 121:387-392.
12. Eke OS. Effects of malting on the dehulling characteristics of African yam bean seeds and functional properties of the flour. Journal of Food Science and Technology. 2002; 39(4):406-409.
13. Ekop AS. Changes in amino acid composition of African yam bean (*sphenostylis stenocarpa*) and African locust bean (*Parkia bigloboga*) on soaking. Pakistan Journal of Nutrition. 2006; 5(3):254-256.
14. Elleuch M, Badigian D, Roiseux O, Besbes S, Blecker C, Attia H. *et al*. "Dietary Fibre and Fibre-Rich by-Products of Food Processing: Characterization, Technological, Functional and Commercial Applications". Food Chemistry; 2011; 124:411-421.
15. Eneche HE. Production and evaluation of cakes from African yam bean and wheat flour blends. Proceedings of the Nigeria Institute of Food Science and Technology, 2006, 46-47.
16. Fasoyiro SB, Ajibade SR, Omole AJ, Adeniyan ON, Faride EO. "Proximate, minerals and antinutritional factors of some underutilized grain legumes in South-Western Nigeria", Journal of Nutrition and Food Science. 2016; 36(1):18-23.
17. Fayle SE, Gerrard JA. Consequences of Maillard Reaction in Food; Royal Society of Chemistry, Cambridge, UK, 2002, 9-19.
18. Giami SY, Amasisi T, Ekiyor G. Comparison of bread making properties of composite flour from kernel of roasted and boiled African bread fruit (*Treculia africana*) seeds. Journal of Raw Material Research. 2004; 1(1):16-25.
19. Harthorn CS, Biswas MA, Gichuhi PN, Bovell-Benjamin AC. Comparison of Chemical, Physical, Micro-structural and Microbial Properties of Breads Supplemented with Sweet Potato Flour and High Gluten Dough enhancers. LWT-Food Science and Technology. 2008; 41:803-815.
20. Hegazy AI, Ibrahim NI. Evaluation of the Protein Quality of Wheat-BISCUIT supplemented with Funegreek Seed Flour. World Journal of Dairy Food Science. 2009; 4:129-135.
21. Kulkarmi M, Deshpande U. *In-vitro* screening of tomato genotypes for drought resistance using polyethylene glycol. African Journal of Biotechnology. 2007; 6(6):691-696.
22. Malomo O, Ogunmoyelu OAB, Adekoyeni OO, Jimo O, Ogunsina BSIO, Olaoye AO. *Et al*. Nutritional and physical properties of kariya seeds. International Agro-physiology. 2012; 25:97-100.
23. Michaelson KF, Weaver L, Branca F, Robertson A. Feeding and nutrition of infants and young children. Journal of Science and Immunology. 2000; 52(5):483-490.
24. Okaka JC. Teach Yourself Sensory Evaluation and Experimentation. Ocjanco Academic Publishers, Enugu, Nigeria, 2010, 68-70.
25. Okaka JC, Akobundu ENT, Okaka ANC. Food and Human Nutrition: An Integrated Approach, Ocjanco Ac ademic Publishers, Enugu, Nigeria, 2006, 102-144.
26. Okaka JC. Handling, Storage and Processing of Plant Foods. Ocjanco Academic Publishers, Enugu, Nigeria, 2005, 182-190.
27. Okorie SU. Chemical composition of breadfruit (*Artocarpus communis*) seed flour as affected by processing (boiling and roasting). Pakistan Journal of Nutrition, 2013, 9(5):419-421.
28. Okoye JI, Obi CD. "Nutrient Composition and Sensory Properties of Wheat-African Bread Fruit Composite Flour Cookies". Sky Journal of Food Science. 2017; 6(3):021-026.
29. Oladunmoye OO, Akinoso R, Olapade AA. "Evaluation of Some Physico-Chemical Properties of Wheat, Cassava, Maize and Cowpea Flours for Bread Making". Journal of Food Quality. 2010; 33(6):693-703.
30. Olaoye OA, Onilude AA, Oladoye CO. Breadfruit flour in biscuit making. African Journal of Food Science, 2007, 20-23.
31. Oluwalana IB, Malomo SA, Ogbodogbo EO. Quality Assessment of Flour and Bread from Sweetpotato-Wheat Composite Flour Blends. International Journal of Biological and Chemical Sciences. 2012; 6(1):65-76.
32. Onimawo IA, Akubor PI. Food Chemistry: Integrated Approach with Biochemical Background, Ambik Press Ltd., Benin City, Nigeria, 2005, 158-162.
33. Onoja US, Akubor PI, Gernar DI, Chinma CE. Evaluation of complementary foods formulated from local staples and fortified with calcium, iron and zinc. Journal of Nutrition and Food Sciences. 2014; 4(6):01-06.
34. Onoja US, Dibua UME, Eze JI, Odo GE. Physico-Chemical Properties, Energy, Mineral, Vitamin and Sensory Evaluation of Wheat-Based Bread Supplemented with Legume, Root, Tuber and Plantain Flours. Global Journal of Pure and Applied Sciences. 2011; 17(3):319-327.
35. Ravichandran SK, kumaravel G, Rameshkumar, Ajithk umar TT. Antimicrobial peptides from the marine fishes. Reverse Journal of Immunology; 2010; 3:146-156.
36. Ishiwu CN, Onyeji AC. Properties of an instant gruel based on blends of maize(*Zea mays L.*) starch, African yam bean (*Sphenostylis stenocarpa*) flour and soybean (*Glycine max*) flour. Nigerian Journal of Nutritional Sciences. 2004; 25:218-223.
37. Shittu TA, Raji AO, Sanni LO. "Bread from Composite

Cassava-Wheat Flour: Effect of Baking Time and Temperature on Some Physical Properties of Bread Loaf". Food Research International. 2007; 40:280-290.
38. Wesslsing-Resmick. Iron and mechanisms of emotional behavior. Journal of Nutritional Biochemistry. 2014; 25(11):1101-1107.