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PHYSICO-CHEMICAL AND TEXTURAL PROPERTIES OF GLUTEN-FREE BREAD FORMULATED WITH CASSAVA, DEFATTED SOYBEAN AND MALTED SORGHUM FLOUR BLENDS

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***Abstract*: The proximate, physical and textural properties of gluten-free bread produced from formulated blends of cassava, defatted soybean and malted sorghum were studied. The cassava tuber was processed to get high-quality cassava flow (HQCF). The malted sorghum and defatted soybean were processed using standard methods and sixteen samples were formulated from the blends of cassava defatted soybean and malted sorghum flour in the different ratios. A preliminary investigation was carried out on the raw materials used for the production of the gluten-free bread. Proximate composition of the composite flour blends revealed, that the moisture ranged from 5.25 to 6.79%, protein (6.14 to 9.61%), ash (0.86 to 4.79%), fat (0.68 to 1.12%), fibre (3.10 to 6.82%), carbohydrate (72.38 to 83.84%) and energy content (332.48 to 366.55 kcal); the physical properties of bread and dough showed that the loaf volume, loaf weight, specific loaf, firmness, viscosity and torque were investigated. The values ranged from 200 to 276cm^3, 110 to 182g, 1.57 to 2.19 cm^3/g, 8.44 to 12 to 0.93 Nm, respectively. Textural properties of the finished product were as followed: Hardness (0.46 to 18.20N), springiness (0.69 to 0.93 mm), cohesiveness (0.83 to 0.85 mm), chewiness (6.41 to 8.65 kg/mm), and resilience (0.35 to 0.78m). The results clearly showed that the blends of cassava, defatted soybean, and malted sorghum can be used as replacement in bread production.**

***Keywords:* Bread, Gluten-free, Malted Sorghum, Textural, Defatted soybean.**

1. INTRODUCTION

The market of gluten-free (GF) bakery products has considerably grown; prompted not only by the people suffering coeliac disease and other gluten-related disorders; but also by a new segment of consumers who have chosen to consume GF foods as a lifestyle choice or for health reasons (Foschia *et al.*, 2016). Among the bakery products, bread is a major food consumed daily all over the world (Foschia *et al.*, 2016). However, eliminating gluten seems technological challenge as it gives rise to products with compromised quality (Naqash *et al.*, 2017). To overcome this, a number of hydrocolloids have been studied as gluten replacers. Whose major components are Beta-D-glucoses, Alpha-D-mannose and alpha-D-glucoronic. Xanthan gum is a heteropoly saccharide obtained from soybean. Its solutions are highly viscous at a low concentrations and useful in thickening binding, stabilization and water binding applications (Ghodke, 2009). Starch from the cassava flour is used to improve mixing and recipe; to extend the shelf life of products through moisture retention and to improve quality of baked products such as volume, texture and colour (Conte *et al.*, 2018). Optimizing physical, textural and sensory attributes; researchers have recommended doses of starch from cassava in GF bread, which in general, range between 0.25 % and 3.0 % linked to bread formulation and water content (Moreira *et al.*, 2013).

Bread is a staple food prepared by cooking dough of flour and water and possible more ingredient. Bread is a product of high nutritional value and is consumed in most part of the world (Mridula *et al.*, 2007). Providing energy, iron, calcium, vitamins and protein. It is a perishable product and its production involves the cooking or baking of dough obtained by mixing wheat flour, edible salt (table salt) and potable water, fermented by species of budding yeast used in baking such as *Saccharomyces cerevisiae* and with or without the inclusion of any special component (Moore *et al.*, 2006).

Cassava (*Manihot esculenta* Crantz) is perhaps one of the most widely grown important food and cash crops (Dziedzozve *et al.*, 2006). Its importance is increasing in Africa because of its diverse uses, low cost and its tolerance to environmental stresses such as drought, fire, low soil fertility and its high productivity where other crops fail (Asoedu, 1989). There is increasing interest in the utilization of cassava flour in contemporary baked goods especially for bread making, variety of pastries and convenience foods at household level and for the manufacture of industrial products (Iwe *et al.*, 2014). Consequently, it has increase the demand for the production of high quality cassava flour (HQCF), a flour produced from wholesome freshly harvested and rapidly processed cassava roots. High quality cassava flour is simply unfermented cassava flour, usually characterized as whitish or creamy in colour odourless, bland or sweet in taste and free from adulterants, insect infestation, sand, peel fragments, dust and any other impurities. It has been identified as a local alternative for use as a partial replacement of wheat flour in composite flours for bread making (Olaoye *et al.*, 2006).

Sorghum (*Sorghum bicolor)* is a gluten-free cereal grown in many African countries primarily as food crop with less than 5 % of the annual production commercially processed by the industry (Okoli *et al.*, 2010). Sorghum grain ranks third among the domesticated cereals for human consumption and forms a major staple in many African countries, India and China (Elemo *et al.*, 2011). It is the grain of choice in brewing African traditional beers. Sorghum is composed of anti-nutrients which can inhibit the absorption of essential minerals and protein in the body (Opeyemi *et al.*, 2016). Processing treatments such as soaking, malting and fermentation have been reported to inhibit anti-nutrients in cereals, legumes, roots and tubers (Khattab and Arntfield, 2009). Sorghum is a rich source of various phytochemicals including tannins, phenolic acids, anthocyanins, phytosterols and policosanos (Awika and Rooney, 2004). The physic-chemical properties of sorghum flour are similar to those of wheat flour (Taylor *et al.*, 2006). However, sorghum possesses low starch digestibility that has been shown to cause higher loss of energy in humans (Onesmo, 2011). Factors affecting the digestibility of sorghum starch include cultivars, the extent of starch protein interaction, and the physical form of the starch granules, presence of inhibitors such as tannins, and the type of starch. Starch granules of the sorghum endosperm are embedded in a dense protein matrix with high levels of prolamin-containing protein bodies that surround starch granules thus acting as barrier to starch gelatinization and starch protein interactions (Onesmo, 2011). These factors contribute to the lowering starch digestibility of sorghum.

Soybean (*Glycine max)* belongs to the family leguminosae and sub-family papillionoideae. It is a remarkable cheap source of plant protein for both animals and man and a leading source of edible oils and fats (Alabi and Oluwatosin, 2001). Soybean is nutritionally dense and rich in phytochemicals, copper, zinc and manganese (Ampofo, 2009). Daily consumption of soybean (30 and 50 g) can substitute for an equal amount of animal-based proteins, resulting in a considerable reduction in harmful low density cholesterol with an increase in the beneficial (Pamplona, 2005). According to Hugo et al (2000), mixing of legumes with cereals can improve overall nutrition. Soybean is rich in calcium, iron, phosphorus and vitamins, and also the only source of all the essential amino acids. Soybean proteins are rich in lysine but deficient in sulphur containing amino acids, whereas cereal proteins are deficient in lysine, but have adequate amounts of sulphur amino acids (Tharise *et al.*, 2014).

2. MATERIALS AND METHODS

Sources of Raw Materials

The raw materials used in this study were defatted soybean flour, cassava flour and sorghum flour. High-yielding, low cyanide cassava root of improved cultivar TMS 30572 was obtained from Eke Awka market Anambra State. The soybean and sorghum purchased from the same market. Other ingredients like sugar (Dangote), vegetable oil, egg, dry instant yeast, baking powder, lecithin, xanthan gum were purchased from Aria market in Awka, Anambra State.

Experimental Design

The study was a mixture design a simplex lattice design was used. A Design Expert Software version 12 was adopted. The experimental space generated a total of 16 runs.

Production of HQCF

High-quality cassava flour was produced using the method described by IITA (2006). The fresh root cassava was weighed with Avery Birmingham weighing balance and then peeled manually using stain less knife. The peeled cassava samples were then washed with portable water and weighed to determined percentage yield after peeling. The cleaned tubers were later transferred to a grating machine which grated the cassava roots to slurry/mash. The mash was dewatered using a hydraulic press to about 40 % moisture. The cake was pulverized and subjected to drying in an oven (Uniscope SM9023) set at temperature of 100^oC and dried to 10% moisture level for 13hours. After drying, the cake was milled using hammer mill (powder crusher F-23ZS111). The final High Quality Cassava Flour (HQCF) thus obtained was packed in high density polyethylene bags.

Production of malted sorghum flour

Malting was carried out according to the method described by Ochems (2007) with some modifications. One kilogram of cleaned grains were washed with tap water and then soaked in 2.5 Litre of tap water for 12 hours. The soak water was changed every four hours. At the end of soaking, the water was drained off and the grains were evenly spread on jute bags and covered with the same material in a secluded dark area which was allowed to germinate for 72 hours. Water was sprinkled on the germinating grains at 24 hours intervals to prevent drying out. At the end of each germinating period, the grams were dried in a hot air oven at 60 ^oC for 1½ hour. The rootlets were removed by rubbing the grains between palms. It was then winnowed, milled, sieved with 0.25mm mesh and packaged in high-density polyethylene,

Production of defatted soybean flour

The defatted soybean flour was produced according to the method described by Opeyemi *et al.* (2016). Exactly one kilogram for soybean grains were cleaned to remove foreign matter, soaked in water for half an hour, dehulled and cooked for 45 min. Soybean grains were drained and dried in hot air oven (Laboratory oven, DHG 9101.ISA) at 65 ^oC for 24 hr. The dried grains were milled in an attrition mill (Atlas exclusive, Alzico Ltd. Mill) and defatted using soxhlet apparatus. The defatted flour was sieved through 250mm mesh sieve and packaged.

Bread making procedure

The bread was prepared following the international Cereal Corporation standard No. 131 with slight modification based on Kieffer et al. (1993). The bread formula consists of composite flour (100 g on 10 % moisture basis), water (based on farinograph optimal water absorption), baker's yeast (2.55 g), sugar (1.4 g), vegetable oil (4.7 g), Xanthan gum plus lecithis (3 g), egg (10.5 g), baking powder (20 g) on the basis of flour weight. The dough was kneaded with a farinograph (Farinograph-E, Brabender, GmbH & Co-KG, Disburg, Germany) to optimum consistency based on the farinograph dough development time for each experimental run. The dough was fermented for 20 min at 30 ^oC and 75 % relative humidity (RH) in a proofer (model UNOXXL T 133, cadonegbe, Italy). The fermented dough was portioned into pieces (50 g), rounded by hand and kept for 3 min under room condition. After relaxation, the dough was rolled once using a pan and folded to a shape similar to a croissant. This was followed by proofing for 35 min at 30 ^oC and 75 % RH after which the dough pieces were baked in an oven at 250 ^oC for 1 hour. The baked bread was allowed to cool for 1 hr 30 min at room temperature after which the bread quality parameters were measured and then packaged.

Proximate Analysis

Moisture Content

A Sartorius moisture analyzer MA-300000V3 (Gottingen, Germany) was used to determine the moisture content of the raw material, flours, and blends following the procedure of the instruction manual. The moisture analyzer was warmed up for at least 30 minutes; approximately 2 gram of sample was evenly spread on the tarred aluminum pan. Analysis was performed in the fully automated mode at 105^oC.

Total Ash

Ash determination was carried out according to AOAC (2011) procedure. Two grams of sample was placed in silica dish had been ignited for 6 h, cooled in a desicator and weighed. The dish and sample was ignited first gently and then at 550 ^oC in a muffle furnace (Thermotec TIC-400) for 3 h, until a white or grey ash was obtained, the dish and content was cooled in a desiccator and weighed.

Fat content

The fat content was determined according to AOAC (2011) using Soxhlet extraction method. A 500 mL capacity round bottom flask was filled with 250 mL n-hexane and fixed to the Soxhlet extractor. Five grams of sample was placed in a labeled thimble. The extractor thimble was sealed with cotton wool. Heat was applied to reflux the apparatus for three hours. The thimble was removed with care. The n-hexane was recovered for reuse through distillation. The flask was dried at 70 ^{o}C for 15 minutes in a heating mantle, cooled in a desiccator and weighed.

Crude protein

Crude protein was determined using the Kjeldahl method (AOAC, 2011). One gram of sample was digested in a 50 mL micro Kjeldahl flask containing 10 grams of anhydrous sodium sulphate (Na_2SO_4), one gram of copper sulphate, and 20 mL of concentrated sulphuric acid in a fume chamber until a bluish green clear solution was obtained. The digested sample was allowed to cool at room temperature and then transferred into 250 mL volumetric flask and made up to volume with distilled water. The distillation apparatus was set up and 100 mL of 4% boric acid solution with few drops of methyl red indicator was introduced into a distillate collector. The conical flask was placed under the condenser. Then 5 mL of the sample digested was pipetted into the apparatus and washed down with distilled water. 40 mL of 60% NaOH solution was added to the digest. The sample was heated until 200 mL of distillate was collected in the receiving flask. The content of the flask was titrated with 0.1N H_2SO_4 to a pink colored end point. A blank with filter paper was subjected to the same procedure.

Crude fiber

Crude fiber was determined using the method of AOAC (2011). One (1) gram of the defatted sample was weighed into a 250 mL conical flask. Then 200 mL of 1.25% sulphuric acid and few drops of anti-foaming agent was added to the flask. The flask was placed on digestion apparatus with readjusted hot plate and boiled for 30 minutes, rotating flask periodically to keep solid from adhering on the sides of the flask. At the end of 30 minutes period, the mixture was allowed to stand for one minute and then filtered through a Buchner funnel. Without breaking suction, the insoluble matter was washed with boiling water until it was free of the acid. The residue was washed back into the original flask with 200 mL of 1.25% sodium hydroxide solution. It was boiled again briskly for 30 minutes with similar precautions as before. After boiling for 30 minutes, it was allowed to stand for one minute and then filtered immediately under suction. The residue was washed with boiling water, followed by 1% hydrochloric acid and finally with boiling water until it was free of acid. It was washed twice with alcohol and then with ether three times. The residue was transferred into ashing dish and dried at 100 ^{o}C to a constant weight. Ashing was done at 600 ^{o}C for 6 h, cooled in a desiccator and weighed. The difference between oven dry weight and the weight after incineration was taken as the fiber content of the sample. This was expressed as a percentage mass of the original sample taken for analysis.

Physical and Textural Properties

The physical and textural properties of the GF bread product was determined using a modified standard rapeseed displacement method described by AACC (2000).

3. RESULTS

The result in Table 1 shows the proximate composition of defatted soybean, cassava, malted sorghum and wheat (control) flours (%).

Table 1: Proximate composition of defatted soybean, cassava, malted sorghum and wheat flours (%)

Sample	Moisture	Protein	Fiber	Fats	Ash	Carbohydrate
Soybean flour	8.65±0.07^{b}	34.52±0.03^{a}	3.82±0.02^{a}	0.79±0.03^{c}	6.47±0.03^{a}	41.74±0.04^{d}
Sorghum flour	11.02±0.02^{a}	9.17±0.03^{c}	2.27±0.03^{c}	3.17±0.03^{b}	1.38±0.07^{c}	72.97±0.00^{b}
Cassava flour	6.25±0.35^{d}	1.70±0.00^{d}	1.97±0.03^{c}	0.64±0.05^{d}	3.25±0.35^{b}	86.18±0.09^{a}
Wheat flour	6.97±0.03^{c}	13.92±0.10^{b}	4.75±0.35^{b}	3.60±0.00^{a}	1.50±0.00^{c}	69.25±0.28^{c}

Values are means ± std. values across the column with different superscripts are insignificantly different ($p>0.05$).

The proximate composition of the formulated composite flour blends is shown in Table 2.

Table 2: Proximate Composition of composite flour blends

Sample code	Moisture (%)	Protein (%)	Ash (%)	Fats (%)	fibre (%)	Carbohydrate (%)	Energy (k/cal)
DCM	6.45±0.02^{d}	8.15±0.00^{e}	1.79±0.00^{k}	1.07±0.02^{a}	4.27±0.02^{h}	78.21±0.14^{c}	355.13±0.034^{c}
CMD	5.50±0.00^{j}	7.64±0.02^{h}	3.68±0.07^{g}	0.83±0.00^{cd}	6.82±0.02^{a}	74.16±1.87^{e}	334.75±7.64^{g}
SCM	6.70±0.02^{b}	9.43±0.00^{b}	4.11±0.02^{d}	0.74±0.03^{f}	6.70±0.00^{b}	72.07±0.53^{f}	332.48±1.85^{g}
MCD	5.93±0.00^{f}	6.39±0.07^{k}	4.35±0.02^{c}	0.65±0.04^{h}	3.51±0.04^{l}	77.66±2.26^{cd}	348.05±0.12^{de}
ABC	5.57±0.03^{i}	7.70±0.03^{g}	2.68±0.02^{i}	0.86±0.03^{c}	6.83±0.02^{a}	76.34±0.08^{d}	343.96±0.16^{ef}
DEF	5.25±0.02^{l}	6.14±0.07^{m}	1.85±0.07^{jk}	0.78±0.00^{def}	3.10±0.00^{n}	82.86±0.04^{ab}	363.08±0.07^{ab}
GHI	6.62±0.00^{c}	9.48±0.01^{b}	3.87±0.02^{f}	0.76±0.04^{ef}	6.26±0.03^{d}	73.00±0.03^{ef}	336.78±0.18^{g}
JKL	5.30±0.00^{l}	8.85±0.02^{d}	1.85±0.03^{j}	0.86±0.02^{c}	3.93±0.00^{j}	79.20±0.09^{c}	359.94±0.02^{bl}
MNO	5.64±0.00^{h}	7.78±0.01^{f}	2.82±0.02^{h}	0.94±0.05^{b}	6.75±0.04^{b}	76.06±0.13^{d}	343.84±0.02^{ef}
PQR	6.05±0.00^{e}	6.35±0.07^{k}	0.95±0.01^{l}	0.82±0.02^{cde}	4.05±0.07^{i}	81.77±0.07^{b}	359.88±0.00^{b}
STU	6.68±0.02^{b}	9.61±0.07^{a}	3.95±0.02^{e}	0.74±0.02^{f}	6.62±0.00^{c}	72.38±0.05^{f}	344.65±0.00^{ef}
VWX	6.79±0.03^{a}	8.96±0.02^{c}	4.79±0.07^{a}	0.83±0.01^{cd}	6.03±0.00^{g}	72.59±0.04^{ef}	333.69±0.04^{g}
YZ*	5.40±0.00^{k}	6.24±0.07^{l}	4.59±0.04^{b}	0.81±0.00^{cde}	3.59±0.07^{k}	79.34±0.06^{c}	349.67±0.26^{d}
CSM	5.25±0.04^{l}	6.14±0.04^{m}	0.86±0.00^{m}	0.73±0.00^{fg}	3.16±0.03^{m}	83.84±0.05^{a}	366.55±0.09^{a}
DMC	5.71±0.07^{g}	6.71±0.02^{j}	1.83±0.04^{jk}	1.12±0.02^{a}	6.15±0.02^{e}	78.47±0.04^{c}	350.86±0.10^{d}
CIH	5.60±0.00^{hi}	7.53±0.00^{i}	3.65±0.07^{g}	0.68±0.07^{gh}	6.09±0.00^{f}	76.40±0.00^{d}	341.88±0.12^{f}

Values are means ± std. values across the column with different superscripts are insignificantly different ($p>0.05$).

The physical properties gluten free of bread products from composite flour blends is revealed in Table 3.

Table 3: Physical properties of bread from composite flour blends

Sample code	Loaf volume (cm^3)	Loaf Weight (g)	Loaf specific (cm^3/g)	firmness (N)	Viscosity (mm)	Torque (N/m
DCM	270.31±0.08^{d}	180.29±0.000^{c}	2.04±0.00^{b}	10.92±0.07^{c}	43.02±0.03^{c}	0.74±0.05^{b}
CMD	276.44±0.05^{d}	182.08±0.06^{a}	2.17±0.00^{a}	9.17±0.01^{g}	49.00±0.03^{a}	0.61±0.01^{c}
SCM	241.61±0.02^{l}	162.09±0.02^{c}	1.95±0.01^{c}	10.49±0.00^{d}	25.00±0.00^{h}	0.23±0.00^{g}
MCD	245.13±0.03^{j}	167.50±0.00^{g}	2.03±0.00^{b}	8.49±0.07^{h}	26.00±0.00^{g}	0.29±0.00^{f}
ABC	276.41±0.02^{a}	182.14±0.04^{a}	2.19±0.00^{a}	9.19±0.07^{g}	49.00±0.00^{a}	0.61±0.02^{c}
DEF	270.52±0.00^{c}	180.41±0.07^{b}	1.96±0.02^{c}	10.95±0.07^{c}	42.86±0.00^{d}	0.93±0.04^{a}
GHI	248.16±0.00^{i}	167.32±0.03^{h}	2.06±0.10^{b}	10.53±0.03^{d}	26.00±0.00^{g}	0.20±0.00^{g}
JKL	205.19±0.00^{m}	119.72±0.02^{l}	1.58±0.07^{e}	12.30±0.00^{b}	24.44±0.05^{l}	0.12±0.00^{h}
MNO	260.75±0.02^{g}	174.65±0.02^{e}	2.17±0.00^{a}	9.34±0.00^{f}	45.00±0.00^{b}	0.36±0.00^{e}
PQR	270.67±0.02^{b}	180.13±0.03^{d}	1.57±0.00^{e}	12.52±0.03^{d}	26.10±0.14^{f}	0.62±0.00^{c}
STU	242.00±0.00^{k}	162.06±0.06^{i}	1.94±0.00^{c}	10.49±0.00^{d}	25.00±0.00^{h}	0.24±0.00^{g}
VWX	200.94±0.00^{n}	110.76±0.02^{m}	1.83±0.00^{d}	9.21±0.07^{g}	40.00±0.00^{e}	0.60±0.00^{c}
YZ	248.62±0.01^{h}	140.16±0.00^{k}	2.03±0.00^{b}	8.44±0.002^{i}	26.00±0.00^{g}	0.33±0.00^{ef}
CSM	276.44±0.02^{a}	182.14±0.06^{a}	2.19±0.07^{a}	9.20±0.00^{g}	49.00±0.00^{a}	0.61±0.02^{c}
DCM	262.91±0.02^{f}	173.41±0.01^{f}	2.07±0.02^{b}	9.38±0.02^{e}	43.00±0.00^{c}	0.35±0.00^{e}
CIH	267.03±0.00^{e}	160.14±0.00^{j}	1.61±0.00^{e}	10.49±0.00^{d}	25.00±0.00^{h}	0.46±0.00

Values are means ± std. values across the column with different superscripts are insignificantly different ($p>0.05$).

Textural properties gluten free from composite flour blends of defatted soybean, cassava, and malted sorghum is presented in Table 4.

Table 4: Textural properties of gluten-free bread from composite flour blends.

Sample code	Hardness (N)	Springiness (mm)	Cohesiveness (mm)	Chewiness (kg/mm)	Resilience (m)
DCM	18.20 ± 0.03^{a}	0.93 ± 0.00^{a}	0.95 ± 0.01^{a}	8.65 ± 0.02^{a}	0.73 ± 0.00^{abc}
CMD	16.43 ± 0.04^{d}	0.87 ± 0.02^{ab}	0.84 ± 0.00^{de}	6.95 ± 0.02^{e}	0.70 ± 0.03^{bcd}
SCM	10.49 ± 0.01^{i}	0.74 ± 0.02^{def}	0.87 ± 0.02^{cde}	6.42 ± 0.02^{h}	0.64 ± 0.06^{de}
MCD	10.73 ± 0.01^{h}	0.86 ± 0.03^{b}	0.92 ± 0.02^{abc}	6.67 ± 0.07^{f}	0.39 ± 0.07^{fg}
ABC	16.46 ± 0.02^{b}	0.85 ± 0.03^{bc}	0.85 ± 0.01^{de}	6.94 ± 0.02^{e}	0.76 ± 0.00^{a}
DEF	18.19 ± 0.04^{a}	0.86 ± 0.02^{bc}	0.85 ± 0.02^{de}	8.35 ± 0.02^{a}	0.75 ± 0.01^{ab}
GHI	10.49 ± 0.02^{i}	0.73 ± 0.05^{ef}	0.86 ± 0.03^{cde}	6.41 ± 0.03^{h}	0.35 ± 0.02^{g}
JKL	10.46 ± 0.02^{i}	0.69 ± 0.01^{f}	0.84 ± 0.00^{de}	6.49 ± 0.07^{g}	0.39 ± 0.00^{fg}
MNO	12.77 ± 0.01^{e}	0.87 ± 0.02^{a}	0.84 ± 0.02^{de}	7.20 ± 0.00^{c}	0.68 ± 0.02^{cd}
PQR	15.13 ± 0.03^{c}	0.86 ± 0.02^{bc}	0.91 ± 0.00^{abc}	8.36 ± 0.00^{a}	0.78 ± 0.04^{abc}
STU	10.49 ± 0.00^{i}	0.70 ± 0.02^{f}	0.88 ± 0.02^{bcde}	6.44 ± 0.05^{gh}	0.37 ± 0.02^{fg}
VWX	10.51 ± 0.00^{i}	0.76 ± 0.00^{de}	0.83 ± 0.00^{e}	6.42 ± 0.02^{h}	0.72 ± 0.02^{abc}
YZ	10.85 ± 0.01^{g}	0.88 ± 0.00^{ab}	0.93 ± 0.03^{ab}	6.70 ± 0.00^{f}	0.41 ± 0.02^{f}
CSM	18.17 ± 0.02^{a}	0.87 ± 0.04^{b}	0.85 ± 0.04^{de}	8.35 ± 0.01^{a}	0.75 ± 0.07^{ab}
DMC	11.20 ± 0.00^{f}	0.80 ± 0.01^{cd}	0.86 ± 0.03^{cde}	7.17 ± 0.01^{c}	0.59 ± 0.00^{e}
CIH	14.23 ± 0.04^{d}	0.91 ± 0.01^{ab}	0.90 ± 0.02^{bcd}	7.08 ± 0.02^{d}	0.64 ± 0.00^{de}

Values are means ± std. values across the column with different superscripts are insignificantly different ($p>0.05$).

4. DISCUSSION

The results of Table 1 represented the preliminary investigation on each of the flour used in the preparation of the gluten-free bread products plus the control (wheat) even though it was not used in the process production chain. The moisture content of the different component ranged from 6.25 to 11.02 %. The values for all the flours were significantly ($p<0.05$) different from each other. The moisture content range obtained in this study was below 15.5% maximum specified for flour by CAC (1985). The low moisture content reported in this study is favourable for storability.

The protein content of the components ranged from 1.70 to 34.52% with the defatted soybean flour recording the highest values while cassava flour had the lowest protein content. The protein content of defatted soyflour is higher than that of conventional wheat (100%) flour. This could be due to significant quantity of protein in soybean (Ejiofor and William, 2016).

The crude fibre of each component ranged from 1.97 to 4.75%. The highest and least crude fibre was recorded in wheat and cassava flour, respectively. The fibre of malted sorghum could be due to the hydrolysis of fibre during malting process. Malted sorghum has been reported to contain low levels of crude fibre (Gernah *et al.*, 2011). The results obtained in this study are in agreement with the reported values by (Milkesa, 2020). High fibre foods are reported to enhance gastro-intestinal tract functions (Schneeman, 2002).

The fat content of the components differs significantly ($p<0.05$). The values ranged from 0.64 to 3.60% with the wheat flour having the highest values while the least was observed in cassava flour. The relatively high fat content of wheat flour could be due to the high distribution of this component across the major parts (germ, bran and endosperm). However, grains contain relatively small quantities of lipids. The results obtained in this study are in consonance with the reported values 0.15 to 0.60% by Chisenga *et al.* (2019) for different cassava flours from cassava varieties. High fat flours are good for flavor enhancers and useful in improving palatability of foods in which it is incorporated (Oppong *et al.*, 2015).

The ash content of the components ranged from 1.38 to 6.47%. The highest and least values were recorded in defatted soybean and malted sorghum, respectively. The results obtained in this study are higher compared to the reported values 2.81% 2.28% by Milkesa (2020) for cereal and legume based composite flour. Minerals are essential substance for the musculoskeletal system as well as for numerous biological functions Yanakoulia *et al.*, (2004).

The carbohydrate content of the components differs with the cassava flour having the highest value while defatted soybean flour possessed the least. The values ranged from 41.74 to 86.18%. Cassava flour sample recorded highest carbohydrate scores compared to other flours. This is an indication that cassava tubers are good sources of carbohydrates (Iwe *et al.*, 2017). The results obtained in this study are similar to the reported values (47.08 to 75.22%) by Milkesa (2020) for cereal and legume flours.

The proximate composition of the formulated composite flour blends revealed in Table 2 above. The moisture content of flour samples ranged from 5.25 to 6.79 %; the increased moisture content value is due to increasing proportion of malted sorghum flour substitution. The highest and lowest values of the moisture content was observed in sample VWX and DEF, respectively. There was significant difference ($p<0.05$) among the samples across all the composite flour blends. The results obtained in this study are lower compared to the reported values 11.02 to 11.31 % by Aluge *et al.* (2016) for wheat sorghum-soybean flour blends. High moisture is undesirable in flours. High moisture in foods could enhance the activities of spoilage microorganism which in turns reduces quality and shelf life of food products (Aluge *et al.* 2016). According to the report by Iwe *et al.* (2017), similar values of 7.147 to 8.45 % were observed in high-quality cassava and wheat flour blends. This result is also an indication that the flour samples will keep well if properly stored under good conditions in other to discourage moisture absorption from the atmosphere which may eventually lead to caking (kent, 1984).

The protein content of the composite flour blends ranged from 6.14 to 9.61 % with sample STU having the highest values while DEF and CSM had the least protein content. Protein content increased with a slight increase in malted sorghum substitution. This finding corroborates the observed values 11.78 to 11.98 % by Aluge *et al.* (2016). These results are also in line with the reported values 6.35 to 11.38 % by Iwe *et al.* (2017) for high-quality cassava and wheat flour blends. Malting leads to the degradation of higher molecular weight storage protein which may contribute to slight increase in protein content in malted products (WU, 1983).

The ash content ranged from 0.86 to 4.79 % with VWX and CSM having the highest and least values, respectively. Substitution with malted sorghum flour influences the crude ash content of VWX compared to other samples. As the substitution increased, there was significant increase in the ash content of composite flours developed. The ash content obtained in this study was higher than that reported by Osundahunsi and Aworh, (2003) for complementary foods enriched with soya bean and cowpea tempeh. Increased ash content implies that samples are rich sources of inorganic minerals (Ndife, 2013).

Fat content of the composite flour blends ranged from 0.68 to 1.12 %. The highest and lowest fat content was observed for sample DMC and CIH, respectively. The results obtained in this study is not at par with the reported values 3.01 to 3.96 % by Aluge *et al.* (2016) for wheat-malted sorghum-soybean flour blends. The values obtained here is in consonance with the reported values 0.60 to 0.70 % by Abu *et al.* (2021) for cassava and soybean flour blends. Most foods with high fat content contribute essentially to the energy and vitamin requirement for humans and animal. High fat flours are also good for flavor enhancers and useful in improving palatability of foods in which is incorporated (Oppong *et al.*, 2015). However, the low fat content observed in the samples because the soyabeans has been defatted. The low fat values are beneficial as it gives longer shelf life for the bread to prevent the incidence of rancidity. Also, the low level of fat and oil (lipid) is an indication that such flours would be good source of flour for people with cardiovascular diseases (Abu *et al.*, 2021).

The crude fibre content of the composite flour blends ranged from 3.10 to 6.82 % crude fibre content was highest and lowest in CMD and DEF respectively. There were significant differences ($p>0.05$) among the samples except in PQR and YZ*. The results obtained in this study are not at par with the reported values 1.80 to 1.78 % by Aluge *et al.* (2016) for wheat-malted sorghum and soybean flour blends. Crude fibre content increased with increasing substitution with malted sorghum flour, this could account for the high fibre content in sample CMD (2.000g defatted flour: 78.720 g cassava flour and 19.280 g malted sorghum flour). Crude fibre has been known to promote health as it aids digestion in human. Crude fibre is capable of eliminating the build-up of junks in the intestine and also regulates bowel movement in humans (Sobota *et al.,* 2010). Numerous studies have shown that insoluble dietary fibre prevents constipation, increase the mass and volume of faeces, accelerates intestinal peristalsis and has an inhibitory effect on the development of tumors in the large intestine (Bingham, 2004).

The carbohydrate content ranged from 72.38 to 83.84 %, with the highest and least values recorded for sample CSM and STU, respectively. The results obtained in this study are in agreement with the reported values 74.31 to 88.72 % by Iwe *et al.* (2017) for high quality cassava and wheat flour blends. Carbohydrate containing foods are potential source of energy when broken down into simple units which are needed for daily activities by humans.

The energy content of the composite flour blends ranged from 332.48 to 366.55 kcal. The highest and least values were recorded in sample CSM and SCM, respectively. These results obtained are in consonance with the reported values 316.32 to 401.67 kcal by Abu *et al.* (2016). For cassava, wheat, soybean and sweet potato flour blends. The elevated energy levels/concentration for the flours might be attributed to either individual food materials or composite mixture effect of complex carbohydrates from other nutrient carbon skeletons. These energy concentrations of variant flours suggest that they could be used in the management of protein-energy malnutrition since there is enough quantity of carbohydrate to derive energy (Butt and Batool, 2010).

Table 3 shows the physical properties of bread products from composite flour blends. The loaf volume of the bread samples ranged from 200 to 276 cm^3. The highest and lowest values were recorded in sample CSM and VWX, respectively. There were significant ($p<0.05$) differences among the samples with the exception of DCM. The results obtained in this study are similar to the reported values 151 to 158 cm^3 by Sahreen *et al.* (2020) for bread made from amaranth-wheat flour composite. The volume of bread samples increased significantly at higher concentration of malted sorghum and defatted soy flour, as well as the supplementation of xanthan powder, thus increase the bread volume (Sanz-Panella *et al.,* 2013).

The weight of bread loaf from composite of flours ranged from 110 to 182 g; with the highest values recorded in sample products CMD and ABC while the least values was recorded in VWX, respectively. There were significant ($p<0.05$) differences among the samples except DEF. The results obtained in this study are not in consonance with the reported values 474.00 to 489.30 g by Sahreen *et al.* (2020) for bread wheat flour. The increased weight of composite of samples CMD, ABC and CSM could be attributed to high water absorbing capacity and thus in heavy dough due to low air entrapment (Ameh *et al.,* 2007).

The specific volume of bread ranged from 1.57 to 2.19 cm^3/g. The highest and lowest values were recorded in sample CSM and PQR, respectively. Significant differences ($p<0.05$) were seen in all the samples except in JKL and CSM, respectively. The results obtained in this study are relatively similar to the reported values 3.10 to 3.32 cm^3/g by Sahreen *et al.* (2020) for amaranth-wheat based bread. Consonant reports were recorded in the work by Ropciuc *et al.* (2021) for bread made from wheat and Purple potato flours. The addition of cassava flour significantly improves the volume of the bread. The specific volume increase for high proportions of cassava flour; this increasing the quality of the core (Ropciuc *et al.,* 2021). Similarly, Zelada *et al.* (2019) working with quinoa and guar flours obtained mean loaf specific volume of 0.979 to 1.84 cm^3/g. According to Hager *et al.* (2012), one important parameter in bread making, known to strongly influence consumer's choice, is loaf specific volume, because from an economic point of view, a high ratio of volume per weight is desired.

The firmness of the bread ranged from 8.44 to 12.52 N. The results obtained in this study are in consonance with the reported values 10.49 to 20.48 N by Bartosova and Szabo (2013) for bread produced from spelt wheat flour. Sample YZ had the lowest values of firmness while PQR had the highest; with no significant differences. Bread firmness is expressed as the maximum force needed to compress the bread sample. The low maximum force indicates soft bread texture which is desirable by consumers.

The viscosity of the dough ranged from 24.44 to 49.00 mm. The results obtained in this study are lower when compared to the reported values 66.67 to 93.33mm by Ropciuc *et al.* (2019) for bread produced from wheat-purple potato flour. The tensile strength/viscosity of the dough increases with increasing cassava flour dose. This is explained by the fact that the added cassava replace the wheat flour and the gluten content is reduced (Ropciuc *et al.,* 2019).

The torque values of the samples ranged from 0.12 to 0.93 N/m; with sample DEF and JKL recording the highest and least values, respectively. There were significant ($p<0.05$) differences among the samples. The results obtained from this study are in agreement with the reported values 0.268 to 0.872 N/m by Fanari *et al.* (2021) for dough made from wheat incorporated with water and salts. The maximum torque indicates the water content function. Maximum torque shows a linear dependence on water content.

Textural properties of bread from composite flour blends is presented in Table 4. The hardness of the bread ranged from10.46 to 18.20 N. The highest and least hardness was recorded in sample JKL and DCM, respectively. The results obtained in this study are in consonance with the reported values 10.49 to 20.48 N by Bartosova and Szabo (2013) for spelt wheat bread. Similar report was also recorded in the work by Chikpah et al. (2021) where 8.03 to 22.64 N were reported for wheat –orange fleshed sweet potato flour. Bread crumb hardness is expressed as the maximum force needed to compress the bread crumb sample. The low maximum force indicates soft bread. The hardness of bread increases significantly as the proportion of cassava flour added to all samples obtained increases.

Springiness of the bread samples ranged from 0.69 to 0.93 mm. The highest and lowest values are recorded in sample DCM and JKL, respectively. The values obtained in this study are in agreement with the reported values 0.70 to 0.90 mm and 0.715 to 0.997 mm by Zelada *et al.* (2019) and Chikpah *et al.* (2021) for gluten-free bread formulated with guar gum and bread made from proportion of wheat flour substituted with OFSP flour, respectively. According to Cornejo and Rosell (2015), high springiness values are preferred because it is related to the bread freshness and elasticity; a reduction in resilience or springiness characterizes loss of elasticity, because both properties indicate the ability of a material to return to its original shape after stressing. In this study, the highest springiness was reached with a combination of 14.787 g defatted soy flour, 80.000g cassava flour and 5.213 g malted sorghum; this is the highest dose of cassava flour with significant low value of malted sorghum.

The cohesiveness of the bread from composite blends ranged from 0.83 to 0.85 mm with sample DCM and VWX recording the highest and least values, respectively. There were significant differences ($p<0.05$) among the samples. The results obtained in this study are in line with the values 0.717 to 0.886 mm reported by Chikpah *et al.* (2021) for bread products from wheat - OFSP flour blends; though these values obtained in this work is relatively higher when compared to the reported values 0.443 to 0.665 mm by Dvorakova *et al.* (2012) for bread produced form buck wheat and rye flour blends. As reported by Onyango *et al*,cohesiveness characterizes the extent to which material can be deformed before it ruptures, and reflects the internal cohesion of the material. Bread crumb with high cohesiveness is desirable because it forms a bolus, instead of disintegration during mastication, whereas low cohesiveness indicates increased susceptibility of the bread to fracture or crumble.

Chewiness of the bread ranged from 6.41 to 8.65 kg. The highest and lowest values for chewiness were recorded in sample DCM (4.787 g defatted soy flour; 80.000g cassava flour: 50.213 g malted sorghum) and GHI (19.123g defatted soy flour: 69.316 g cassava flour: 18.028 g malted sorghum), respectively. The results obtained in this study are higher compared to the reported values 0.27 to 3.032 kg reported by Chikpah *et al.* (2021) for bread made from wheat-OFSP flour composite blends. Ropciuc *et al.* (2021) reported lower values of 1.332 to 5.715 kg for bread made from wheat and purple potato flour blends.

The resilience of the bread from composite blends of defatted soy flour, cassava flour and malted sorghum ranged 0.35 to 0.78. The highest and lowest values were recorded in sample PQR and GHI, respectively. There were significant ($p<0.05$) differences among the samples with the exemption of MCD and CSM. The results obtained in this study are not in agreement with the reported values 1.2 to 2.3 reported by Ropciuc *et al.* (2021) for bread produced from the blends of wheat and purple potato flours. Resilience is an indication of the ability of a material to return to its original shape after undergoing stress (Cornejo and Rosell, 2015).

5. CONCLUSION

Cassava and malted sorghum could be used as replacement for wheat flour in the formulation of bread, enhancing the nutritional and textural properties of the product. In this study wheat was substituted with cassava and germinated sorghum to examine the changes in physicochemical and textural profile analysis. Results demonstrated that the bread made with 19.123g defatted soy-flour, 69.317g cassava flour and 11.560g malted sorghum had the highest level of protein but the least carbohydrate content.

REFERENCES

[1] AACC Inernational (2000) Approved methods of American Association of Cereal Chemistry, Scientific Research. An Academic Publisher, Saint Paul Minnesoth, USA.

[2] Abu, M.S., Aso, R.E., Onuche, J.I. Yohana, R.E., Mashi, R.L. & Ahmad, S.H. (2021). Proximate Composition, Mineral Content and Functional Properties of Composite Flours and Microbiological/Sensory Analysis of Composite Flour Bread. *Journal of Researching Agriculture and Animal Science* 8(8):1-8.

[3] Alibi, M.O. & Oluwatosin, B.C. (2001). Creating Awareness on Utilization of Soybean Flour for Baked Products in the Catering Industry, A Preliminary Study of Physical Properties and Acceptability of Soy cake. *African Journal of Biotechnology* 7, 2623-2625.

[4] Ampofo, V. (2009). Production and sensory Analysis of Soybean and Wheat Flour composite cake. HND Dissertation, Cape Coast Polytechnic, Cape Coast, Ghana.

[5] Ameh, M.O., Gernah, D.I. & Igbabul, B.D. (2007). Physico-chemical and sensory evaluation of wheat bread supplemented with stabilized undefatted rice bran. *Journal of Food and Nutrition Sciences,* 4, 43-48.

[6] AOAC (2011). Official Method of Analyticals Chemists, Washington DC, USA.

[7] Asiedu, J.J**.** **(**1989**)**. Processing of Tropical Crops-A Technological approach. Macmillan Press Ltd, London.

[8] Awika, J.M. & Rooney, L.W. (2004). Review: Sorghum phytochemical and their potential impact on human health. *Phytochemistry* 65, 1199-1221.http://dx.doi.org/10.1016/j.phytochem.2004. 04.001.

[9] Bartosova, M.L. & Szabo, J.K. (2013). Texture Analysis of Spelt Wheat Bread. *Journal of Microbiology, Biotechnology and Food Sciences* (2): 2249-2255.

[10] Bingham, S. (2004). EPIDEMIOLOGY OF Dietary Fibre and Colorectal Cancer. In-Vander Kamp, J.w., ASP, N.G., Miller Jones, J. & Schaafsma, G., Eds., Dietary Fibre-*Bioactive Carbohydrates for Food and Feed, Academic Publishes, Wageningen,* 179-182.

[11] Butt, M.S. & Batool, R. (2010). Nutritional and Functional Properties of some Promising Legume Protein Isolates. *Pakistan Journal of Nutrition,* 9(4):373-379.

[12] Chikpah, S.K., Korese, J.K., Hensel, O., Sturm, B. & Pawelzik, E. (2021). Rheological properties of dough and bread quality characteristics as influenced by the proportion of wheat flour substitution with orange-fleshes sweet potato flour and baking conditions. LWT-*Food Science and Technology,* 147(2021) 111515.

[13] Chisenga, S.M., Workneh, T.S., Bultosa, G. & Laing, M. (2019). Proximate composition, cyanide content, and particle size distribution of cassava flour from cassava varieties in Zambia. *AIMS Agriculture and Food,* 4(4):869-891.

[14] Conte, P., Del Caro, A., Balestra, F. &, Piga, A & Fada, C. (2018). Bee polen as a functional ingredient in gluten-free bread: a physical. Chemical, technological and sensory approach. LWT-*Food Science Technology* 90:1-7.

[15] Cornejo, F. & Rosell, C.M. (2015). Physicochemical properties of long rice grain varieties in relation to gluten free bread quality. LWT-*Food Science and Technology,* 62(2):1203-1210.

[16] Dvorakova, P., Buresova, I. & Kracmar, S. (2012). Textural Properties of Bread Formulations Based on Buck Wheat and Rye Flour. ACTA Universitatic Agricultural et Silvicultural Mendelianae. Vol. Lx (5). 61-68.

[17] Dziedzoave, N.T., Abass, A.B., Amoa-Awua W.K.A. & Sablah, N. (2006). Quality Management Manual for Production of High Quality Cassava Flour. International Institute of Tropical Agriculture.

[18] Eke-Ejiofor, J. & Williams, L. (2016). Evaluation of Defatted soybean flour inclusion on the properties of Rice based Biscuits. *International Journal of Food Science* 4:63-71.

[19] Elemo, G.N., Elemo, B.O. & Okafor, J.N.C. (2011). Preparation and Nutritional Composition of a Weaning Food Formulated from Germinated Sorghum (*sorghum bicolor)* and Steamed Cooked Cowpea (Vignaunguiculata Walp). *American Journal of Food Technology* 6, 413-421. http://dx.doi.org/10.3923/ajft.2011. 413.421.

[20] Encina-Zelada, C.R., Cadavez, V., Monteiro, F., Teixeira, JA. & Gonzale-Barron, U. (2019). Physicochemical and textural quality attributes of gluten-free bread formulated with guargum. *European Food Research and Technology,* 245, 443-458.https://doi.org/10.1007/s00217-018-3176-3.

[21] Fanari, F., Ingo, F.C. Y., Desogus, F., Grosso, M. & Wilhelm, M. (2021). Durum Wheat Dough Torgue Measurements: Characterization and Study of the Mixing Process Parameter as a Function of Water and Salt Amounts. *Chemical Engineering Transactions,* vol. 87.Doi:10.3303/CET2187035.

[22] Foschia, M., Horstmann, S., Arendt, E.K & Zannmi, E. (2016). Nutritional therapy-facing the gap between coeliac disease and gluten-free food. *International Journal of Food Microbiology* 239:113-124.

[23] Gernah, D.I., Ariahu, C.C. & Ingbian, E.K. (2011). Effect of malting and lactic fermentation of some chemical and functional properties of maize (Zea mays). *American Journal of Food Technology* 6:404-412.

[24] Ghodke, S.K. (2009). Effect of Xanthan and guar ghum on dough stickiness and staling in chapatti-an Indian unleavened flat bread. *International Journal of Food Engineering* 5 (3): article 7.

[25] Hager, A.S., Wolter, A., Czerny, M., Bez, J., Zannini, E. & Arendt, E.K. (2012). Investigation of product quality sensory profile and ultrastructure, of breads made from a range of commercial gluten-free flours compared to their wheat counterparts. *European Food Research and Technology,* 235(2):333-344.

[26] Hugo, L.F., Rooney, L.W. & Taylor, J.R.N. (2000). Malted Sorghum as a Functional Ingredient in Composite Bread, Cereal *Chemistry Journal*, 77, 428-432.

[27] IITA (2006). Cassava Recipes for Household Food Security. Printed in Nigeria by International Institute of Tropical Agriculture (IITA). Pp10-25.

[28] Iwe, M.O., Okereke, G.O. & Agiriga, A.N. (2014). Production and Evaluation of Bread Made from Modified Cassava Starch and Wheat Flour Blends. Agrotechnology 4:133.

[29] Iwe, M.O. & Agriga, A.N. (2015). Effect of Different Harvesting Regimes on the Pasting Properties of Selected Varieties of Banana- A Response Surface Study. *Agrotechnology 4:132.*

[30] Iwe, M.O., Michael, N., Madu, N.E., Obasi, N.E., Onwuka, G.I, Nwabueze, T.U. & Onuh, J.O. (2017). Physicochemical and Pasting Properties of High-Quality Cassava and Wheat Flour Blends. *Agrotechnology* 6(3) : 167.

[31] Kent, N.L. (1984). Technology of cereals. Pergamon Press, Oxford, London.

[32] Khattab, R.Y. & Arntfields, S.D. (2009). Nutritional Quality of Legume Seeds As Affected by some Physical Treatments. LWT- Food Science and Technology, 42, 1113-1118.http://dx.doi.org/10.1016/j.wt.2009.02.004.

[33] Kieffer, R., Belitz, H., Zweier, M., Ipfelkofer, R. & Fischbeck, G. (1993). A 10-g microversion of the rapid mix-test zeitschriftfurlebensmiltel 197,134-136. https://doi.org/10.100/BFO1260309.

[34] Mikesa, F. (2020). Review on some cereal and legume based composite biscuits. *International Journal of Agricultural Science and Food Technology* 6(2):101-109.

[35] Moore, M.M., Heinbockel, M., Dockery, P., Ulmer, H.M. & Arendt, E.K. (2006). Network formation in gluten-free bread with application of transglutaminase. *Cereal Chemistry* 83(1): 28-36.

[36] Moreira, R., Chenlo, F. & Torres, M.D. (2013). Effect of Chia (*Sativa hispanical) a*nd hydrocolloids on the rheology of gluten-free doughs based on chestnut flour. LWT-*Food Science Technology* 50(1) : 160-166.

[37] Mridula, D., Gupta, R.K. & Manikantan, MR.R. (2007). Effect of incorporation of sorghum flour to wheat flour on quality of biscuit fortified with defatted soy flour. *America Journal Food Technology* 2 (5): 428-434.

[38] Naqash, F., Gani, A & Masoodi, F.A. (2017). Gluten-free baking: combating the challenges-a review. *Trends Food Science and Technology* 66:98-107.

[39] Ndife, J., Obiegbuna, J. & Ajayi, S. (2013). Comparative Evaluation of the Nutritional and Sensory Quality of Major Commercial Whole-Wheat Breads in Nigeria Market. *Advance Journal of Food Science and Technology* 5, 1600-1605.

[40] Ocheme, O.B. (2007). Effect of Storage of millet flour on the quality and acceptability of millet flour porridge (Enyiokwolla). *Journal of Food Technology,* 5(3), 215-219.

[41] Okoli, E.V., Okolo, B.N., Moneke, A.N. & Ire, F.S. (2010). Effects of Cultivar and Germination Time on Amylolytic Potential Extract Yield and Work Fermenting Properties of Malting Sorghum. *Asian Journal of Biotechnology*, 2, 14-26.

[42] Olaoye, O.A., Onilude, A.A. & Idowu, O.A. (2006). Quality Characteristics of Bread Produce from Composite Flours of Wheat, Plantain and Soybeans. *African Journal of Biotecnology* 5:1102-1106.

[43] Onesmo, N.O. (2011). Effects of malting and fermentation on the composition and functionality of sorghum flour. Dissertations & Theses in Food Science and Technology. Retrieved from http://digitalcommuna.unl.edu/ foodscidiss/12.

[44] Onyango, C., Mutungi, C., Unbehend, G. & Lindhauer, M.G. (2011). Modificaiton of gluten-free sorghum batter and bread using maize, potato, cassava or rice starch. LWT- *Food Science and Technology* 44(3):681-686.

[45] Opeyemi, O.A., Stephen, A.A. & Osundahunsi, O.F. (2016). Effect of Malted sorghum on Quality characteristics of Wheat-Sorghum-Soybean Flour for Ptential Use in Confectionaries. *Food and Nutrition Sciences*, 7, 1241-1252.

[46] Oppong, D., Eric, A., Samuel, O.K. & Patrick, S. (2015). Proximate composition and some functional properties of soft wheat flour. *International Journal of Innovative Research in Science, Engineering and Technology*, 4(2): 753-758.

[47] Osundahunsi, O.F. & Aworh, O.C. (2003). Nutritional Evaluation with Emphasis on Protein Quality of Maize Based Complementary Foods Enriched with Soya Bean and Cowpea Tempeh. *International Journal of Food Science & Technology*, 38, 809-813.http://dx.doi.org/10.1046/j/365-2621 .2003.00736.x

[48] Pamplona, R. (2005). Encylopedia of Food and Their Healing Power Properties of Wheat-Plantain Composite Flours. *African Journal of Food Nutrition,* 7,1-22.

[49] Ropciuc, S., Oroian, M., Leahu, A. & Damian, C. (2021). Evaluation of the rheological properties of the dough and the characteristic of bread with the addition of purple potato. *Sciendo*, 32(2), 125-131.

[50] Sahreem, N., Farhana, M.A., Murtaza G., Shaiq, G., Khalid, G., Alabida, J. & Darakshan, M. (2020). Physical, Textural, Rheological, and Sensory Characteristics of Amaranth-Based Wheat Flour Bread. Hindawi *International Journal of Food Science* https//doi.org/10.1155/2020/8874872.

[51] Sanz-Panella, J.M., Wronkowskab, M., Soral-Smietanab, M. & Haros, H. (2013). Effect of Whole amaranth flour on bread properties and nutritive value. *Food Science and Technology*, vol. 50 (3), 679-685.

[52] Scheeman, B.O. (2002). Gastrointestinal physiology and functions. *British Journal of Nutrition* 88:159-163.

[53] Sobota, A., Sykut-Domanska, E. & Rzedzicki, Z. (2010). Effect of Extrusion-Cooking Process on the Chemical Composition of Corn-Wheat Extrudates, with Particular Emphasis on Dietary Fibre Fractions. *Polish Journal of Food and Nutrition Sciences,* 60,251-259.

[54] Taylor, J.R.N., Schober, T.J. & Bean, S.R. (2006). Review: Novel Food and Non-food uses of sorghum and millets. *Journal of Cereal Sciences* 44,252-271. http://dx.doi.org/10.1016/j.jcs.2006.06.009.

[55] Tharise, N., Julianti, E. & Nurminahi, M. (2014). Evaluation of Physico-chemical and Functional Properties of Composite Flours from Cassava, Rice, Potato, Soybean and Xanthan gum as alternative to wheat flour. International Food Research Journal, 21 (4):1641-1649.

[56] Wu, H.M. (1983). Production and Textural Properties of Soy-Cheese Whey Curd. *Journal of Food Science,* 48, 1562-1563. http://dx.doi.org/10.1111/j.1365-2621.1983.tbo3540.x

[57] Yannakoulia, M., Keramopoulos, A. & Matalas, A.L. (2004). Bone mineral density in young active females: the case of dancers. *International Journal of Sport Nutrition Exercise Metabolism* 14:285-297.