

Quality Evaluation of Composite Bread Produced from Wheat, Maize and Orange Fleshed Sweet Potato Flours

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Abstract The research was carried out to evaluate the effect of addition of yellow maize (YM) and orange fleshed sweet potato (OFSP) flours on the quality of wheat bread. Maize and sweet potato were processed into flour and mixed with wheat flour for bread production. Five samples of bread were produced and denoted as Samples A to E. Sample A was the control with 100% wheat flour, while Sample B to E had maize and sweet potato flours added in an increasing order of 5 to 20%. The physical properties of the bread loaves were evaluated and the result decreased significantly with increasing levels of yellow maize and orange fleshed sweet potato flours. The loaf volume varied from 340 to 182 cm³ and the bread specific volume ranged from 1.35 to 0.99 cm³/g. The result of the proximate composition showed that moisture and protein contents decreased significantly ($p < 0.05$) with increase in yellow maize and orange fleshed potato flours varying from 34.97 to 29.97% and 13.12 to 7.67% respectively. The fat, crude fibre, ash and carbohydrate contents of the bread samples generally increased significantly ($p < 0.05$) with increase in maize and orange fleshed potato flours. The result of the mineral content revealed that β -carotene and calcium increased significantly with increased levels of maize and sweet potato. The values of magnesium iron and phosphorus in the bread samples had no definite trend. The result of the sensory properties showed that there was significant difference in the texture and taste of 100% wheat bread and the other samples. The 100% wheat bread recorded the highest scores in all the parameters evaluated however all the other samples were well accepted. There was a decrease in the values of overall acceptability, appearance and flavor of the bread samples with increasing levels of maize and sweet potato flours but the decrease was not significantly different.

Keywords: composite bread, orange fleshed sweet potatoes, yellow maize flour

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1. Introduction

Bread can be described as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of processes involving mixing, kneading, proofing, shaping and baking [1]. Bread is an important staple food in both developing and developed countries and constitutes one of the most important sources of nutrients such as carbohydrate, protein, fibre, vitamins and minerals in the diets of many people worldwide [2]. The consumption of bread in Nigeria is on a steady increase because it is a convenient and ready to eat food [3] normally consumed at breakfast, lunch, and sometimes dinner.

Wheat, the basic ingredient in bread production is imported into Nigeria [4] involving huge expenditure of foreign exchange leading to high cost of the bread. In order to make bread affordable by low income earners who constitute the larger population of consumers, there is the need to use novel sources of crops such as orange fleshed sweet potato (OFSW) and yellow maize (YM) as

flour substitute for the wheat. Thus maize and sweet potato can be used to produce composite flours for bread production. Yellow maize and orange fleshed potato is reported to be rich in β carotene (precursor of vitamin A) and other nutrients [5,6], therefore OFSW and YM would solve the problem of vitamin A deficiency reported by WHO [7].

Maize (*Zea mays*) is one of the most important cereal grains in the world, it serves as a staple food for approximately 400 million people in developing countries and it is used as a food ingredient and animal feed [8]. About half of the estimated 603 million tones world production of maize is produced in the developing countries including Nigeria [9]. Various types of maize exist including pop, flint, dent, floury and sweet cultivars which have different physicochemical properties. The yellow maize cultivar was chosen for this work because it is rich in beta-carotene, a pro vitamin A that enhances good eye sight in children and adults. According to [10] a large number of deaths in developing countries such as Nigeria are linked to chronic malnutrition; some of the problems caused by deficient diets include scurvy, night blindness, kwashiorkor and anemia.

Sweet potato (*Ipomoea batatas*) is another of the world's most important food crops and an important staple in Nigeria and other developing countries [5,8]. It is a low input crop and is used as vegetable, a desert, a source of starch and animal feed [11]. In Nigeria, sweet potato is mostly consumed as a snack (*asondo*), roasted, boiled, used with fresh yams in pounded yam and as a sweetener in beverage production. Processing sweet potato into flour would increase its utilization and can serve as a source of nutrients such as carbohydrates, beta-carotene (pro vitamin A), vitamin C, vitamin B₆, minerals such as calcium, phosphorus, iron, potassium, magnesium and zinc and can contribute to the color, flavor and dietary fibre of processed food products such as bread [5,12,13,14] and also enhance its use in other food preparations, [15]. The development of appealing processed products from composite flour of sweet potatoes will therefore play a major role in raising awareness on the potential of the crop. The beta carotene content would be very useful in alleviating vitamin A deficiency among children below six years and adults. The prevalence of vitamin A deficiency in Nigeria and other African countries is very high. The use of sweet potatoes as substitute for sugar would reduce the quantity of sugar needed for bread production leading to lower cost of production and price of bread and enhanced health for the consumers.

The production of composite flours using various crops for confectionary and bakery goods has been carried out by many researchers, among which are; cassava/wheat flour [16] wheat/ taro flour [17], wheat/ pumpkin flour [18] and tiger-nut/wheat flour [19]. However very little information is available on the composite flour of maize/sweet potatoes/wheat for bread production. According to [20] Composite flour technology has many advantages among which are; it plays a vital role to complement the deficiency of essential nutrients. It saves hard currency; promote high yielding local plant species and enhances overall use of domestic agriculture. Thus the aim of this work is bread production from the composite flours of yellow maize, orange fleshed potatoes and wheat, which would ensure food security, enhanced health, combat malnutrition problems, increase farming and economic activities on African continent leading to wealth creation.

2. Materials and Methods

2.1. Source of Raw Materials

Wheat flour (Golden penny), yellow maize, salt, sugar (sucrose), bread improver, and dry baker's yeast were purchased from a local market in Makurdi. Orange fleshed sweet potatoes were purchased at Agbo market in Vandeikya Local Government of Benue state. Equipments such as blender, mixer, kneader, bowl, knife, digital weighing scale, measuring cylinder, boiler, baking pans, stirrer and oven were obtained in the food processing laboratory of University of Agriculture Makurdi. All other chemicals used were of analytical grade.

2.2. Preparation of Raw Materials

2.2.1. Preparation of Orange Fleshed Sweet Potato Flour

The sweet potato flour was produced using the method described by [6]. The orange fleshed sweet potato tubers were peeled and cut into thin pieces manually. The potato slices were then first immersed in 1% NaCl solution and in a solution containing potassium metabisulphite (1%) and citric acid (0.5%) for 30 min to prevent browning reactions and enhance the colour of the flour. Drying of sweet potato slices was done on perforated trays in a tray dryer (M/s. Balaji Enterprises, Saharanpur, India) at 55°C till constant weight. The dried sweet potato chips were milled into flour using the laboratory grinder (M/s. Sujata, New Delhi, India) and passed through 250 µm mesh sieve, packed in airtight containers and stored in the refrigerator till further use. The flow chart for the production of sweet potato flour is shown in Figure 1.

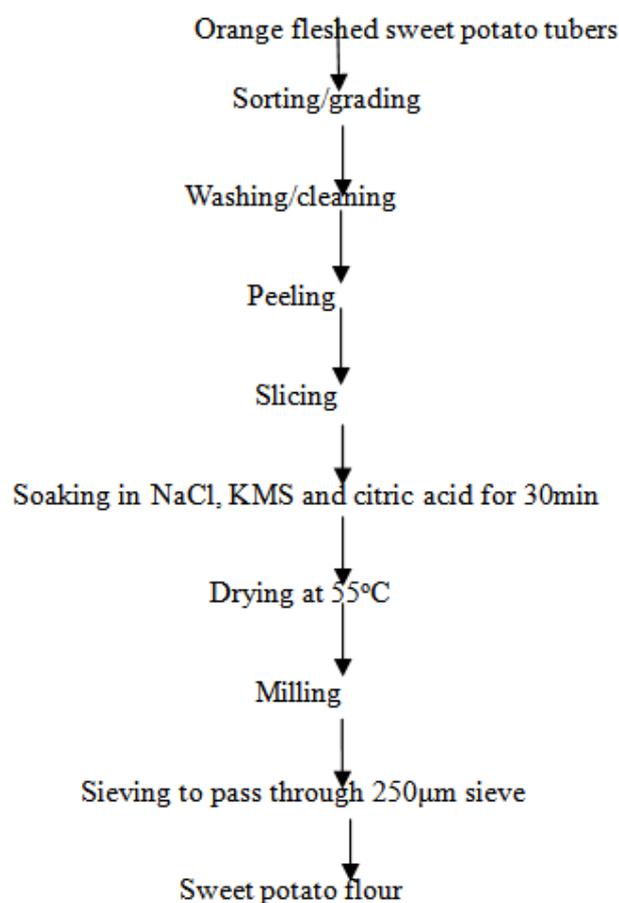


Figure 1. Flow chart for production of orange fleshed sweet potato flour. Source: Modified Singh *et al.*, (2008)

2.2.2. Preparation of Yellow Maize Flour

The method of [21] was used to prepare the maize flour. Yellow maize kernels were sorted to remove stones, dirt and other foreign materials. Water was sprinkled on cleaned maize seeds so as to allow absorption of water by the grains, toughening the pericarp and germ so they do not splinter during milling. The grains were left for about 10 min before dehulling and milling. The flour was sieved using 250 µm mesh size as shown in Figure 2.

2.3. Formulation of Composite Flour and other Ingredients for Bread Production

Five different samples of bread were produced and coded as A, B, C, D and E. Sample A served as the control

and contained 100% wheat. Samples A, B, C and D consisted of wheat/maize/potato flours and the other ingredients for bread production are presented in Table 1.

Table 1. Recipe formulation for bread production. Source: Modified Islam et al., (2011)

SAMPLES					
INGREDIENTS	A	B	C	D	E
Wheat flour (g)	100	90	80	70	60
maize (g)	0	5	10	15	20
Sweet potato (g)	0	5	10	15	20
Salt (g)	2.5	2.5	2.5	2.5	2.5
Yeast (g)	2.5	2.5	2.5	2.5	2.5
Fats (g)	2	2	2	2	2
Sugar (g)	2	2	2	2	2
Water (ml)	65	65	65	65	6

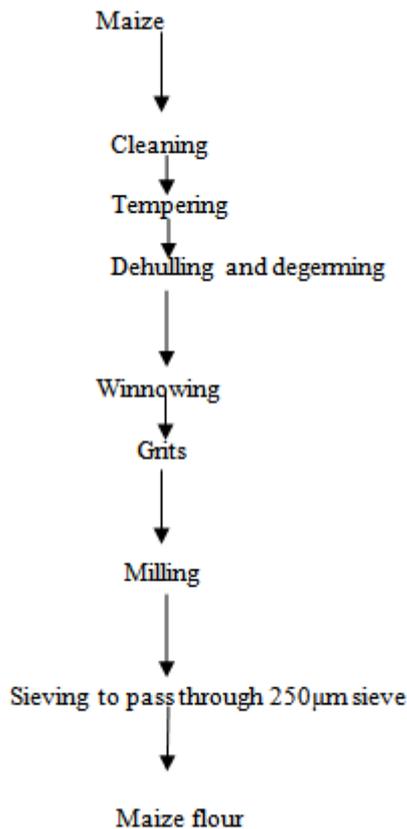


Figure 2. Production of Maize flour. Source: Houssou and Ayemor (2002)

2.4. Bread Production by the Straight Dough Method

The straight dough method was used to produce the bread. This method involves the addition of all the ingredients (flour, salt, water, sugar, yeast etc) at mixing stage and kneading same to obtain the dough [23]. The different dough samples were placed in baking pans smeared with vegetable oil and was covered for the dough to ferment resulting in gas production and gluten development for about 1 hour. The dough was then baked in the oven at 230°C for 30 minutes. The baked loaves were carefully removed from the pans and allowed to cool and packaged in polyethylene bags for analysis. The flow chart for bread production is shown in Figure 3.

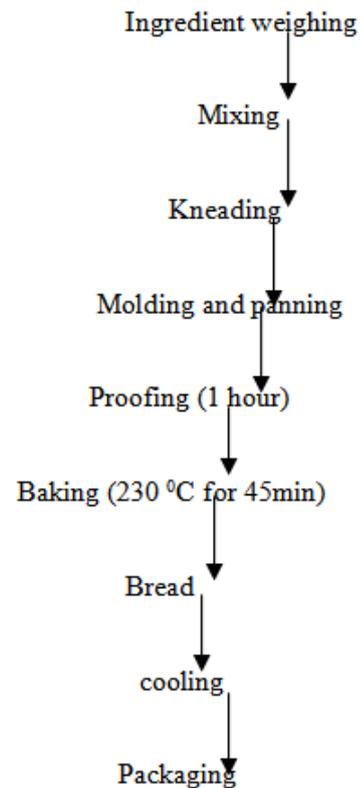


Figure 3. Flow chart for bread production

2.5. Determination of Physical Properties of The Bread Loaves

The Loaf volume was measured by seed displacement method of [25]. Loaf weight was determined by simple weighing using an electronic balance while Specific volume was obtained by dividing the loaf volume of bread by its corresponding loaf weight. Thus, Specific volume = $v / wt \text{ (cm}^3/\text{g)}$.

2.6. Determination of Proximate Composition of Bread Loaves.

Proximate analysis was carried out on the bread loaves to determine the moisture, ash, crude fibre, fat, protein and carbohydrate content.

2.6.1. Moisture Content

The moisture content was determined by hot air oven method as described by [26]. An empty crucible was weighed and 2g of the sample was transferred into the crucible. This was taken into the hot air oven and dried for 24 hours at 100°C. The crucible and its contents were cooled in the desicator and their weights taken. The loss in weight was regarded as moisture content and expressed as;

$$\%moisture = \frac{weight\ loss}{weight\ of\ sample} \times 100$$

2.6.2. Ash Content

Ash content was determined using the method of [26]. About 5 g of each sample was weighed into crucibles in duplicate, and then the sample was incinerated in a muffle furnace at 550°C until a light grey ash was observed and a constant weight obtained. The sample was cooled in the

desiccator to avoid absorption of moisture and weighed to obtain ash content.

$$\text{Ash}(\%) = \frac{\text{weight of ash}}{\text{weight of sample}} \times 100$$

2.6.3. Crude Fibre

Crude fibre was determined using the method of [26]. About 5 g of each sample was weighed into a 500 ml Erlenmeyer flask and 100 ml of TCA digestion reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes counting from the start of boiling. The flask was removed from the heater, cooled a little then filtered through a 15.0 cm number 4 Whatman paper. The residue was washed with hot water stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight at 105°C. After drying, it was transferred to a desiccator and weighed as W_1 . It was then burnt in a muffle furnace at 500°C for 6 hours, allowed to cool, and reweighed as W_2 .

$$\% \text{ crude fibre} = \frac{W_1 - W_2}{W_0} \times 100$$

W_1 = weight of crucible + fiber + ash

W_2 = weight of crucible + ash

W_0 = Dry weight of food sample

2.6.4. Fat Content

The soxhlet extraction method described by [26] was used in determining fat content of the samples. About 2g of the sample was weighed and the weight of the flat bottom flask taken with the extractor mounted on it. The thimble was held half way into the extractor and the weighed sample. Extraction was carried out using (boiling point 40-60°C). The thimble was plugged with cotton wool. At completion of extraction which lasted for 8 hours, the solvent was removed by evaporation on a water bath and the remaining part in the flask was dried at 80°C for 30 minutes in the air oven to dry the fat and then cooled in a desiccator. The flask was reweighed and percentage fat calculated as

$$\% \text{ Fat} = \frac{\text{weight loss}}{\text{weight of sample}} \times 100$$

2.6.5 Protein Content

The micro Kjeldal method as described by [26] was used to determine crude protein. About 2 g of the sample was put into the digestion flask. Ten grams of copper sulphate and sodium sulphate (catalyst) in the ratio 5:1 respectively and 25 ml concentrated sulphuric acid were also added to the digestion flask. The flask was placed into the digestion block in the fume cupboard and heated until frothing ceased giving clear and light blue green coloration. The mixture was then allowed to cool and diluted with distilled water until it reached 250 ml of volumetric flask. Distillation apparatus was connected, and 10 ml of the mixture was poured into the receiver of the distillation apparatus also 10 ml of 40% sodium hydroxide was added. The released ammonia by boric acid was then treated with 0.02 m of hydrochloric acid until the green color change to purple. Percentage of nitrogen in the sample was calculated using the formula below:

$$\text{Nitrogen}(\%) =$$

$$\frac{(\text{Titre} - \text{Blank}) \times 14.008 \times \text{Normality}}{\text{weight of sample}} \times 100$$

$$\% \text{ crude protein} = \% \text{ Nitrogen} \times 6.25$$

2.6.6. Determination of Carbohydrate Content

The carbohydrate content was calculated by difference according to [27].

2.7 Determination of Mineral Content

The mineral content of the bread samples was determined by using the method described by [26]. The ash obtained from the ash analysis earlier was used in the determination of the minerals content. The ash was placed in porcelain crucibles, then few drops of distilled water were added, followed by 2ml of concentrated hydrochloric acid. 10 ml of 20% HNO_3 were added, evaporated on the hot plate. The samples were filtered through Whatman filter paper into 100 ml volumetric flask. The mineral elements; iron, magnesium and calcium were determined by atomic absorbance spectrophotometer. (AA800 perkin-Elmer, Germany). The phosphorus in the sample filtrate was determined using Vanadomolybdate reagent at 400 nm using colorimetric method (Colorimeter SP20, Bausch and Lomb).

2.8. Determination of B-Carotene Content

β -carotene was determined using the method of [28]. Five grams of bread crumbs was weighed into a separating funnel (250 ml), 2 ml of NaCl solution was introduced into it and shaken vigorously, followed by 10 ml of ethanol, then 20 ml of methane. The mixture was shaken vigorously for 5 minutes and allowed to stand for 30 minutes after which the lower layer was ran off. The absorbance of the top layer was determined at a wavelength of 460 nm using a Hachdrel/5 model spectrophotometer (England).

$$\text{Total carotenoid} \left(\frac{\text{mg}}{100} \right) =$$

$$\frac{\text{Absorbance}}{\text{Specific extinction coefficient} \times \text{path length of cell}}$$

Where, molar extinction coefficient (Σ) = 15×10^4

Specific extinction efficient = $\Sigma \times$ molar mass of beta-carotene

Molar mass of β -carotene = 536.88 g/mol.

Path length of cell = 1 cm

2.9. Sensory Evaluation

The five samples of bread were coded and presented to fifteen member panel of judges who are familiar with the product for sensory evaluation. The panelists scored the colour, flavor, taste, texture and overall acceptability of the bread using a nine point hedonic scale, where 9 indicates extremely like and 1 extremely dislike [27].

2.10. Statistical Analysis

All analytical determinations were conducted in duplicates. Means and standard deviations were calculated.

Data obtained was subjected to analysis of variance (ANOVA) [29] where significant differences existed, Tukey's test was used in separating the means described by [27].

3. Results and Discussion

3.1. Physical Properties of Bread Loaves

The physical characteristics of the bread from wheat/maize/sweet potato flour blends are presented in Table 2. The loaf volume and specific volume of the bread decreased significantly ($P < 0.05$) with increased substitution with yellow maize and OFSW flours. Sample A with 100% wheat flour recorded the highest values of 340 cm³ and 1.35 cm³/g for loaf volume and specific volume while sample E had the lowest values of 182 cm³ and 0.99 cm³/g, for loaf volume and specific volume respectively. This could be attributed to the decrease in structure forming proteins in wheat which lowered the ability of the dough to rise during proofing leading to reduction in the bread volume. The loaf weight of maize/sweet potato composite bread increased significantly ($p < 0.05$) with increasing levels of yellow maize and orange fleshed potato flours. The weights of all the maize and orange fleshed potato based bread were significantly higher than 100% wheat bread. The same trend was observed by [4,19,30] in bread production from different composite flours.

Table 2. physical characteristics of wheat/ maize/ sweet potato bread samples

Parameters	Samples					LS D
	A	B	C	D	E	
loaf volume (cm ³)	340±1.0 ^{0a}	256±1.0 ^{0b}	220±0.0 ^{6c}	200±1.0 ^{0d}	182±0.0 ^{5e}	2.85
loaf weight (g)	183.84±0.05 ^e	200±1.0 ^{0d}	217.82±0.06 ^c	240.98±1.00 ^b	251.85±1.00 ^a	2.67
LSV (cm ³ /g)	1.85±0.0 ^{1a}	1.28±0.0 ^{2b}	1.01±0.0 ^{5b}	0.83±	0.72±0.0 ^{6c}	0.01

Values are means ± SD duplicate determinations
 Values with different superscript within the same row are significantly different ($p < 0.05$)
 LSD= Least significant difference.
 LSV= Loaf specific volume
 A=100% wheat flour (control); B=90% wheat, 5% maize, 5% sweet potato; C=80% wheat flour, 10% maize, 10% sweet potato; D=70% wheat, 15% maize, 15% sweet potato; E=60% wheat, 20% maize, 20% sweet potato.

3.2. Proximate Composition of Bread Loaves

The result of the proximate composition of bread from wheat/maize/sweet potato flour blends is shown in Table 3. The moisture and protein contents of the bread loaves decreased significantly ($p < 0.05$) with increasing levels of maize and sweet potato flours. The 100% wheat bread recorded 34.97% moisture and 13.12% protein while composite bread consisting of 60% wheat, 20% maize and 20% sweet potato recorded 29.97% moisture and 7.65% protein. The decrease in moisture content of the bread samples with increasing levels of composite flour may increase the shelf life of the bread while the decrease in protein content could be attributed to the low protein

content of maize and sweet potato flours. This implies that bread with the low protein content should be consumed with other protein rich diet to make up for the low protein. The fat, ash, fibre and carbohydrate contents of the bread increased with increasing levels of maize/sweet potato flours. The increased fat content could be attributed to the high fat content in maize and the increased ash content could come from both maize and sweet potato which are reported to contain high minerals. Similar result was reported by [31]. The increase in fibre and carbohydrate could also be attributed to the maize and sweet potato flours which are reported to be high in both nutrients [31,32,33]. This implies that the bread would be a source of high energy and nutrients dense food for consumers. According to [34] crude fibre contributes to the health of the gastrointestinal system and metabolic system in man.

Table 3. proximate composition of wheat/ maize/ sweet potato bread samples

Parameters (%)	Samples					LS D
	A	B	C	D	E	
Moisture	34.97±0.05 ^a	29.93±1.06 ^c	29.70±0.02 ^d	30.33±1.57 ^b	29.97±0.05 ^e	0.047
Protein	13.12±0.02 ^a	12.02±0.01 ^b	10.96±0.03 ^c	8.76±0.01 ^d	7.65±0.01 ^e	0.031
Fat	2.96±0.06 ^c	3.52±0.08 ^d	3.78±0.02 ^c	4.53±0.06 ^b	5.50±0.02 ^a	0.092
Crude fibre	0.77±0.03 ^c	0.79±0.01 ^d	0.84±0.01 ^c	0.89±0.06 ^b	0.95±0.01 ^a	0.022
Ash	1.39±0.01 ^e	1.48±0.03 ^d	2.03±0.05 ^c	2.49±0.02 ^b	2.97±0.05 ^a	0.071
Carbohydrate	46.71±0.01 ^e	52.18±0.02 ^d	52.42±0.01 ^c	52.85±0.05 ^b	53.35±0.01 ^a	0.049

Values are means ± SD duplicate determinations
 Values with different superscript within the same row are significantly different ($p < 0.05$)
 LSD= Least significant difference.
 A=100% wheat flour (control); B=90% wheat, 5% maize, 5% sweet potato; C=80% wheat flour, 10% maize, 10% sweet potato; D=70% wheat, 15% maize, 15% sweet potato; E=60% wheat, 20% maize, 20% sweet potato.

3.3. Mineral/ Vitamin Composition of the Bread Samples

The mineral/ vitamin composition of the composite bread is presented in Table 4. The calcium and β-carotene contents of the bread increased significantly with increase in maize and sweet potato flours from 0.73-1.11 mg/100 g and 0.58-4.56 mg/100 g respectively. The work reported on maize and sweet potato showed that these crops are rich in nutrients. [35,36]. Calcium is necessary for supporting bone formation and growth. The increased β-carotene content could be from both the yellow specie of maize and orange fleshed potato flours. These crops are reported to be high in β-carotene, [5]. The β-carotene which is pro vitamin A is an essential nutrient required for maintaining immune function [37]. It also helps in the maintenance of healthy teeth, skeletal and soft tissue, mucous membranes and skin. It is often known as retinol because it produces the pigment in the retina of the eye. The values for magnesium, phosphorus and iron showed no definite trend but varied significantly ($P < 0.05$) from one another. Magnesium is essential to good health because it helps to maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune system and keeps bones strong. Phosphorus works closely with calcium to build strong bones and teeth.

It is stored in the bone as calcium phosphate. Bread rich in these nutrients would enhance the health of both children and adults.

Table 4. Minerals / Vitamin content of wheat/ maize/ sweet potato bread samples

Parameters(mg/100g)	Samples					LS D
	A	B	C	D	E	
Calcium	0.73±0.01 ^e	0.76±0.01 ^d	0.84±0.01 ^c	0.96±0.01 ^b	1.11±0.01 ^a	0.036
Magnesium	0.55±0.01 ^c	0.37±0.01 ^e	0.67±0.02 ^a	0.45±0.01 ^d	0.58±0.01 ^b	0.033
Phosphorous	0.06±0.01 ^c	0.07±0.01 ^a	0.05±0.01 ^e	0.07±0.01 ^b	0.05±0.01 ^d	0.001
Iron	3.31±0.01 ^b	03.16±0.01 ^c	1.99±0.01	2.67±0.01 ^d	3.38±0.01 ^a	0.037
β-carotene	0.58±0.01 ^e	0.59±0.01 ^d	2.26±0.10 ^c	3.55±0.01 ^b	4.56±0.02 ^a	0.041

Values are means ± SD duplicate determinations

Values with different superscript within the same row are significantly different (p<0.05)

LSD= Least significant difference.

A=100% wheat flour (control); B=90% wheat, 5% maize, 5% sweet potato; C=80% wheat flour, 10% maize, 10% sweet potato; D=70% wheat, 15% maize, 15% sweet potato; E=60% wheat, 20% maize, 20% sweet potato.

3.4. Sensory Evaluation of the Bread Loaves

The result of the mean sensory scores is presented in Table 5. The scores for overall acceptability and appearance varied from 7.27-6.6 and 7.47-6.93 respectively. There was decrease in the scores as maize and sweet potato flours were added however the decrease was not significant (P>0.05). The result revealed that the texture and taste of the bread varied significantly (P<0.05) between the (control) sample A with 100% wheat and the other samples B to E incorporated with maize and sweet potato flours. In general all the bread samples compared well with the control sample, and were well accepted. The study has shown that maize/sweet potato flour could be used with wheat as composite flours to produce acceptable bread.

Table 5. Mean Sensory Scores of Bread produced from wheat/ maize/ sweet potato flour blends

Samples Attributes	A	B	C	D	E	LSD
Taste	7.20 ^a	6.87 ^b	6.47 ^b	6.67 ^b	6.80 ^b	1.28
Flavour	7.01 ^a	6.80 ^b	6.07 ^b	5.80 ^b	6.47 ^b	1.23
Texture	7.20 ^a	6.67 ^b	6.60 ^b	6.27 ^b	7.13 ^b	1.12
Appearance	7.47 ^a	6.93 ^a	7.20 ^a	6.93 ^a	7.33 ^a	1.01
Overall acceptability	7.27 ^a	6.73 ^a	6.87 ^a	6.60 ^a	7.27 ^a	1.05

Values are means ± SD duplicate determinations

Values with different superscript within the same row are significantly different (p<0.05)

LSD= Least significant difference.

A=100% wheat flour (control); B=90% wheat, 5% maize, 5% sweet potato; C=80% wheat flour, 10% maize, 10% sweet potato; D=70% wheat, 15% maize, 15% sweet potato; E=60% wheat, 20% maize, 20% sweet potato.

4. Conclusion

The study has shown that 20% yellow maize and 20% orange fleshed sweet potato could be used as wheat substitute to produce bread that would be well accepted by the consumers. The bread produced from wheat, yellow maize and orange fleshed potato had increased nutrients of carbohydrate, fibre, fat, ash, calcium and β-carotene-the

precursor of vitamin A. Thus, the bread would enhance the health, growth and well being of the consumers. The use of maize and sweet potato in bread production would promote production, value addition and diversification of utilization of the crops in Nigeria and environs. This would create wealth and enhance food security.

Statement of Competing Interests

The authors have no competing interest.

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