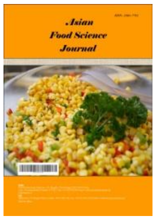

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Physico-chemical and Sensory Properties of Bread Prepared from Wheat and Orange-Fleshed Sweet Potato (Flour, Starch and Non-Starch Residue Flour) Blends

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Authors' contributions

This work was carried out in collaboration among all authors. Author OAK designed the study, performed the statistical analysis. Author CCA wrote the protocol, wrote the first draft of the manuscript and managed the analyses of the study. Author BDI managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Bread was produced from wheat (*Trititum spp*) orange flesh sweet potato (*Ipomoea batatas L.*) flour, starch and non-starch residue blends. The orange-fleshed sweet potatoes were washed, peeled, sliced, dried and milled to flour. The starch and non-starch residue were also produced from the orange-fleshed sweet potatoes. Different proportions of wheat and flour, wheat and starch and wheat and non-starch residue of orange-fleshed sweet potato with increasing level of orange-fleshed sweet potato at 10, 20, 30 and 40% addition in wheat were prepared. Control samples were 100% wheat flour (A_0), 100% orange-fleshed sweet potato flour (A_1), 100% orange-fleshed sweet potato starch (B_1) and 100% orange-fleshed sweet potato non-starch residue (C_1). Breads from these different proportions were formulated. The proximate, mineral, vitamin, physical properties and sensory attributes of the bread samples and their composites were determined. The GENSTAT Statistical Software (version 17.0) was used for data analyses. The Proximate

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compositions of the bread ranges as follows; moisture 26.30-36.21%, protein 0.85-7.89%, fat 6.33-8.93%, fiber 0.82-4.92%, ash 0.56-2.11% and carbohydrates 41.26-64.84%. The physical properties of the breads ranged from 210.60-254.00 g, 0.05-2.40 mm, 317.60-440.60 cm^3 and 1.25-2.10 for loaf weight, oven spring, loaf volume and specific volume respectively. Mineral and vitamin composition for breads samples ranged respectively thus for calcium 18.45-33.21 zinc 0.92-6.27, magnesium 0.28-19.33, phosphorus 31.00-319.60 and potassium 56.30-352.60, vitamin B1, 0.10-0.37, vitamin B2, 0.07-1.23, vitamin B6, 0.09-1.25, vitamin B12 0.04-1.13 mg/100 g, vitamin C 0.12-14.17 mg/100 g and vitamin A 0.00-8193 µg/100 g.The sensory evaluation results indicated that up to 20% substitution of wheat flour with orange-fleshed sweet potato flour, starch and non-starch residue flours was acceptable in bread formulation.

Keywords: Proximate composition; loaf weight; loaf volume; mineral; vitamin and oven spring.

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, fiber, 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 normally consumed at breakfast, lunch, and sometimes dinner [3]. There is no household or family in Nigeria that does not consume bread at least once a day, since its consumption cut across socioeconomic class and is acceptable to both children and adults. Bread has gained wide consumer acceptance for many years in Nigeria [4,5]. Bread and other baked products are however relatively expensive, as they are produced from wheat which, as a result of climatic reasons, does not grow well in the tropics and has to be imported [6].

Composite flour can be defined as a mixture of several flours obtained from roots and tubers, cereal, legumes, etc., with or without the addition of wheat flour [7]. Usually, the aim of producing composite flour is to get a product that is better than the individual components. Composite flour is considered advantageous in developing countries as it reduces the importation of wheat flour and encourages the use of locally grown crops as flour [8,9,10] also defined composite flour as a mixture of flours obtained from tubers which are rich in starch such as cassava, yam, potato, and protein-rich flour and cereals, with or without wheat flour that is created to satisfy specific functional characteristics and nutrient composition For example, wheat with sweet potatoes [11], wheat and cassava [12].

Sweet potato (*Ipomea batatas)* is a tuber of the herbaceous climbing plant known in Britain much earlier than the Irish potato. Sweet potato is another of the world’s most important food crops and an important staple in Nigeria and other developing countries [13]. It is a low input crop and is used as vegetable, a desert, a source of starch and animal feed [13].

The orange-fleshed sweet potato (OFSP) varieties are rich in β-carotene, the major precursor of vitamin A. This biofortified variety was developed using conventional breeding practices drawing on sweet potato rich genetic diversity. According to Nteranya and Adiel [14], the OFSP (along with the yellow root cassava) are examples of how research can be transferred to development on a continent-wide scale. Furthermore, they added that new employment and income generation opportunities were created through improved value chains and the development of novel products contributing to a more stable food system and predictable source of income. The objectives of this research work were to evaluate the Physico-chemical and sensory attributes of bread substituted with orange-fleshed sweet potato flour, starch and non-starch residue flour blends.

2. MATERIALS AND METHODS

2.1 Source of Raw Materials

Orange-fleshed sweet potato, OFSP (*Ipomea batatas L. Lam*), (Mother’s delight) was purchased from the Raw Material Research and Development Centre (RMRDC) commercial outlet in Kaduna. Baking materials: wheat flour (Dangote), sugar (Dangote), yeast (Instant dry yeast, Hangzou, China), margarine (Simas), salt (Mr. Chef) were purchased from a Supermarket in Kaura Namoda, Zamfara State. Packaging material: Johnson's polyethylene ziplock double zipper storage bags (26.8 x 27.3 cm; 17.7 x 19.5 cm) were purchased from the Abubakar Gumi Central Market, Kaduna. All laboratory materials and reagents used were of analytical grade. The raw materials were properly cleaned by removing extraneous matter prior to their subjection to different processing treatments.

2.2 Preparation of Raw Materials

2.2.1 Production of orange-fleshed sweet potato (OFSP) flour

Native Orange fleshed sweet potato (OFSP) flour was produced according to the method of Avula [15], with modification. OFSP tubers were washed and peeled manually with knives, keeping them in water to prevent enzymatic browning. The tubers were trimmed and sliced thinly (manually) and oven dried at 60°C, milled, sieved (0.5 mm), packaged in polyethylene bag and labeled accordingly (Fig. 1).

2.2.2 Production of OFSP Starch and non-starch residue

Starch was prepared from sweet potato roots according to the method of Soison et al. [16], with modification as presented in Fig. 2. Roots were cleaned under running tap water, then manually peeled and milled in a food processor (MK-5080, National, Malaysia) by adding 1:1 (w/w) of clean water ratio for 2 min at medium speed. After filtering through sieve, the residue was subjected to repeated extraction with water (1:0.5, w/w). The filtrate was mixed and filtered through muslin cloth. The starch slurry was allowed to settle for 2-3 h at room temperature (30±2°C). The supernatant was poured off. The starch in the bottom of container was re-suspended in water, filtered through cloth bag and kept in the refrigerator (8±1°C) to settle. The settling process was repeated three times. The sediment starch was dried in a convection oven at 50°C for 6 h, cooled to room temperature, packed and sealed in polyethylene bags. Non starch residue pulled together from the filtering processes was oven dried at 60°C for 7 h, cooled to room temperature, packaged, and labeled accordingly. Dried starch and non-starch residue were milled, sieved, packaged and refrigerated prior to use.

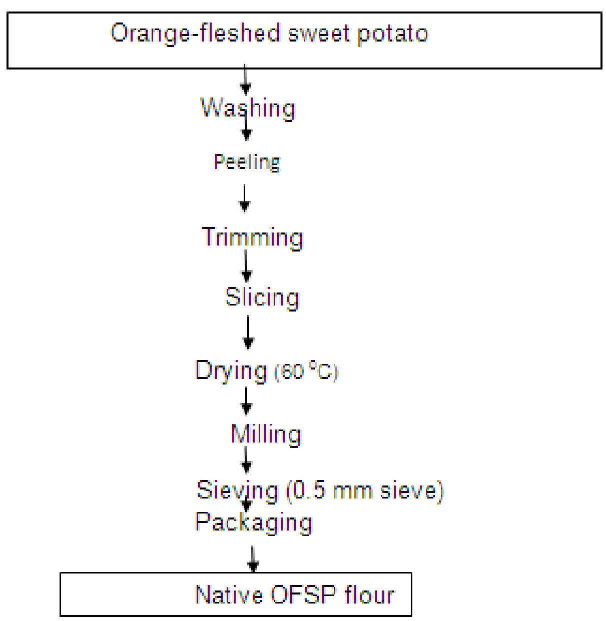

Fig. 1. Flow chart for the production of native orange-fleshed sweet potato (OFSP) flour
Source: Avula [15] with modification

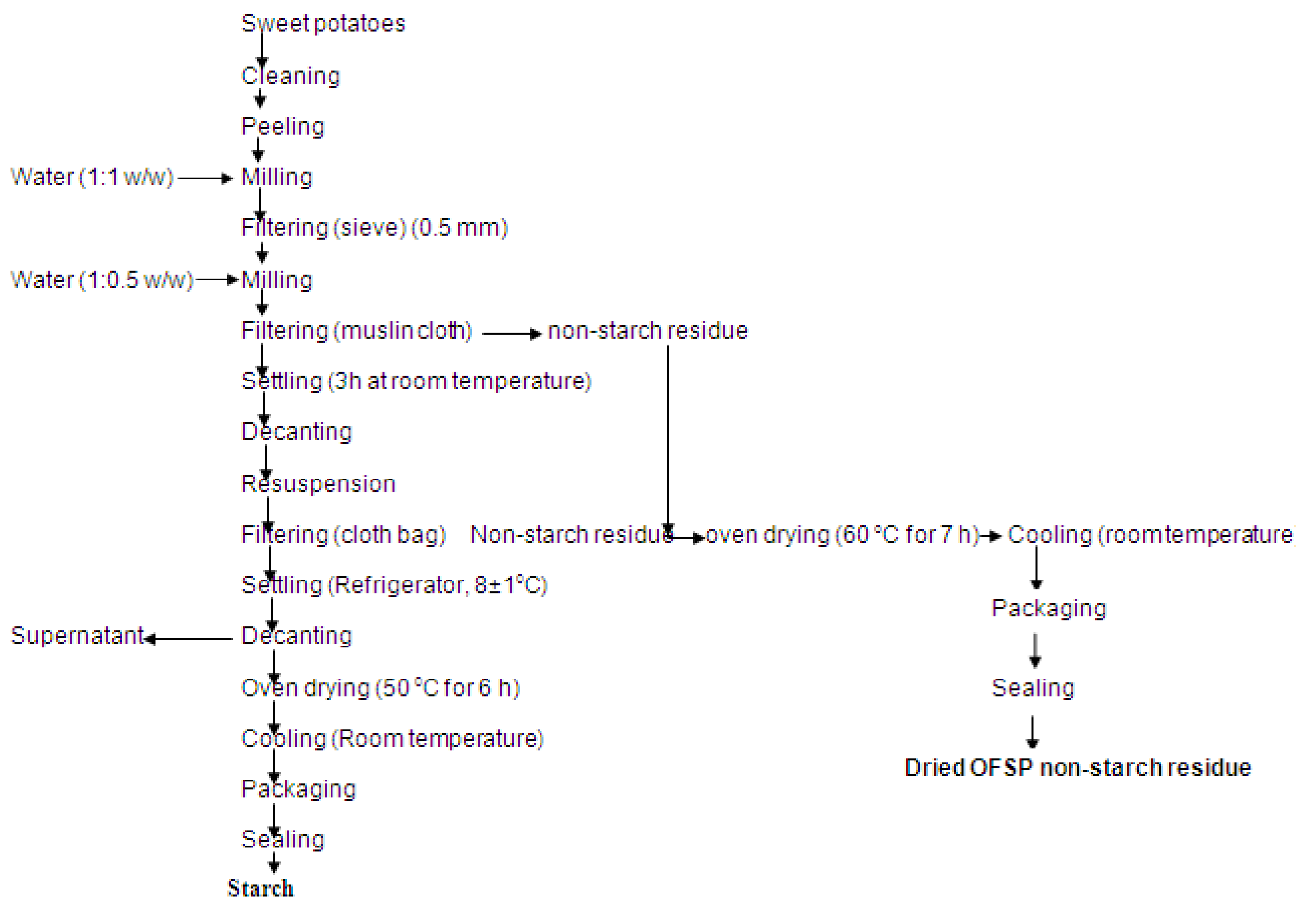

Fig. 2. Flow chart for the production of orange-fleshed sweet potato starch and non-starch residue
Source: Soison et al. [16] with modification

2.2.3 Blend formulation

Various flour blends of wheat flour (WF) and either OFSP flour, starch or non-starch residue were produced with 10, 20, 30, and 40 percent OFSP component into wheat flour, respectively. (Table 1).

2.2.4 Production of bread and composite bread

Bread and composite bread were produced using the Straight dough method [17]. Ingredients (wheat flour or composite flour, fat, water, instant dry yeast, sugar and salt) (Table 2) were mixed together in various proportions for 15 min. After mixing, the dough was kneaded properly until soft, moulded, and shaped into greased pans for proofing. The dough was proofed in a proofing cabinet for 2 hours at 50°C and thereafter baked in a preheated electric oven at 230°C for 30 min. Bread samples were de-panned, cooled, packed in polyethylene bags and stored at ambient temperature till subsequent analyses (Fig. 3).

2.3 Determination of Proximate Composition

The proximate composition of the bread samples were determined by the standard methods described by the AOAC [19]. Carbohydrate content was determined by difference [20].

2.3.1 Moisture

Moisture content was determined using the air oven drying method. A clean dish with a lid was dried in an oven (GENLAB, England B6S, serial no: 85K054) at 100°C for 30 min. It was cooled in a desiccator and weighed. 2 g of sample was then weighed into the dish. The dish with its content was then put in the oven at 105°C and dried to a fairly constant weight. The loss in weight from the original sample (before heating) was reported as percentage moisture.

$$\%\,Moisture = \frac{weight\ loss\ (W2-W3)}{Weight of Sample\ (W2-W1)} x\ 100 \qquad (1)$$

$Where$

$W1\ =\ weight\ of\ dish,$
$W2\ =\ weight\ of\ dish\ +\ sample\ before\ drying,$
$W3\ =\ weight\ of\ dish\ +\ sample\ after\ drying.$

2.3.2 Crude protein

The Kjeldahl method was used to determine crude protein. Two (2 g) of sample was weighed into a Kjeldahl digestion flask using a digital weighing balance (3000 g x 0.01 g 6.6 LB). A catalyst mixture weighing 0.88 g (96% anhydrous sodium sulphate, 3.5% copper sulphate and 0.5% selenium dioxide) was added. Concentrated sulphuric acid (7 ml) was added and flask swirled to mix content. The Kjeldahl flask was heated gently in an inclined position in the fume chamber until no particles of the sample was adhered to the side of flask. The solution was heated more strongly to make the liquid boil with intermittent shaking of the flask until clear solution was obtained. The solution was allowed to cool and diluted to 25 ml with distilled water in a volumetric flask. 10 ml of diluted digest was transferred into a steam distillation apparatus. The digest was made alkaline with 8 ml of 40% NaOH. To the receiving flask, 5 ml of 2% boric acid solution was added and 3 drops of mixed indicator was dropped. The distillation apparatus was connected to the receiving flask with the delivery tube dipped into the 100 ml conical flask and titrated with 0.01 M HCl. A blank titration was done. The percentage of nitrogen was calculated from the formula:

$$\%\,Nitrogen = \frac{(S-B)\times 0.0014\times 100\times D}{sample\ weight} \qquad (2)$$

Where,

S = sample titre,
B = Blank titre,
S - B = Corrected titre,
D = Dilution factor
% Crude Protein = % Nitrogen x 6.25 (correction factor).

2.3.3 Crude fat

Crude fat was determined using the Solvent extraction method. 5 g sample was weighed into a thimble and loose plug fat free cotton wool was fitted into the top of the thimble with its content inserted into the bottom extractor of the Soxhlet apparatus. Flat bottom flask (250 ml) of known weight containing 150 – 200 ml of 40 – 60°C hexane was fitted to the extractor. The apparatus was heated and fat extracted for 8 h. The solvent was recovered and the flask (containing oil and solvent mixture) was transferred into a hot air oven (GENLAB, England B6S, serial no: 85K054) at 105°C for 1 h to remove the residual moisture and to evaporate the solvent. It was later transferred into a desiccator to cool for 15 min before weighing. The Percentage of fat content was calculated as

$$\%\,CrudeFat = \frac{Weight\ of\ extracted\ fat}{Weight\ of\ Sample}\, x\ 100 \qquad (3)$$

Table 1. Blend formulation

Sample Code	Description
A0	100% Wheat Flour
A1	100% OFSP Flour
A2	90:10 Wheat Flour: OFSP Flour
A3	80:20 Wheat Flour: OFSP Flour
A4	70:30 Wheat Flour: OFSP Flour
A5	60:40 Wheat Flour: OFSP Flour
B1	100% OFSP Starch flour
B2	90:10% Wheat Flour: OFSP Starch flour
B3	80:20% Wheat Flour: OFSP Starch flour
B4	70:30% Wheat Flour: OFSP Starch flour
B5	60:40% Wheat Flour: OFSP Starch flour
C1	100% Non-starch Residue flour
C2	90:10% Wheat Flour: Non-starch Residue flour
C3	80:20% Wheat Flour: Non-starch Residue flour
C4	70:30% Wheat Flour: Non-starch Residue flour
C5	60:40% Wheat Flour: Non-starch Residue flour

OFSP: Orange fleshed sweet potato

Table 2. Ingredients for production of bread

Component	Bread composition
Flour (g)*	100
Yeast (g)	2.5
Sugar (g)	5
Salt (g)	1
Fat (g)	3.00
Water (ml)	65

** Wheat or composite flour Source: Igbabul et al. [18] with modification*

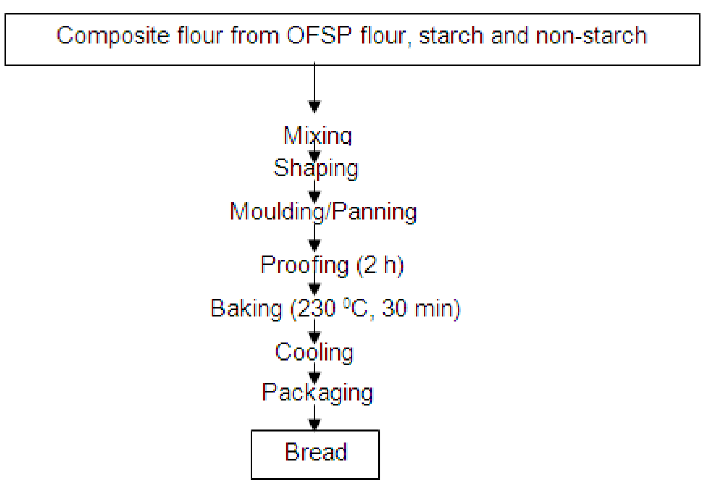

Fig. 3. Flow chart for the production of bread and composite bread
Source: Dabels et al. [17], with modification

2.3.4 Crude fiber

Two gram (2 g) of the sample was extracted using diethyl ether. This was digested and filtered through the California Buchner system. The resulting residue was dried at 130 ± 2°C for 2 h, cooled in a desiccator and weighed. The residue was then transferred in to a muffle furnace (Shanghai box type resistance furnace, No.: SX2-4-10 N) and ignited at 550°C for 30 min, cooled and weighed. The percentage of crude fiber content was calculated as:

$$\% \, Crude \; fibre = \frac{Loss \; in \, weight \; after \; incineration}{Weight \; of \; original \; food} \times 100 \qquad (4)$$

2.3.5 Ash

Two gram **(**2 g) of sample was weighed into an ashing dish which had been pre-heated, cooled in a desiccator and weighed soon after reaching room temperature. The crucible and content was then heated in a muffle furnace (Shanghai box type resistance furnace, No.: SX2-4-10 N) at 550°C for 6-7 h. The dish was cooled in a desiccator and weighed soon after reaching room temperature. The total ash was calculated as percentage of the original sample weight.

$$\% \, Ash = \frac{(W3 - W1)}{(W2 - W1)} x \; 100 \qquad (5)$$

$Where$:

$W1 = Weight \; of \; empty \; crucible,$
$W2 = Weight \; of \; crucible + sample \; before \; ashing,$
$W3 = Weight \; of \; crucible + content \; after \; ashing.$

2.3.6 Carbohydrate

Carbohydrate content was determined by difference, viz:

$$\% \, Carbohydrate = 100 - (\% \, Moisture + \%Protein + \%Fat + \%Ash + \%Fibre) \qquad (6)$$

2.4 Determination of the Mineral Content

The mineral content (Ca, Zn, P and K) of the bread samples were determined using the standard methods described by the AOAC [18]. The bread samples produced from wheat, orange-fleshed sweet potato flour, starch and non-starch residue flour blends were subjected to mineral content determination, the Ca was determined by precipitation method, Zn and Mg by Absorption spectrophotometer, P by calorific method and K determined by Flame Photometry.

2.5 Determination of the Vitamin Content

The bread samples produced were subjected to vitamin content determination, the B1, B2, B6 and B 12 were determined by High-Performance Liquid Chromatography (HPLC) and Vitamin A by AAS as described by AOAC [19].

2.6 Determination of the Physical Properties

The physical properties (loaf weight, oven spring, loaf volume, and specific volume) of the bread samples were determined using standard methods described by Mepba et al. [21].

2.6.1 Loaf weight

The bread samples were weighed using a weighing balance (Model KD- BN (CN), V5 0-2010).

2.6.2 Oven spring

Each dough height was measured before baking using a straight-edged metric rule and height of loaf was measured again after baking. The difference in height of the respective loaves were recorded as the oven spring.

$$Oven \; Spring = Height \; after \; baking - Height \; before \; baking \qquad (7)$$

2.6.3 Loaf volume

Determination of loaf volume was by a modification of the seed displacement method of Giami et al. [22]. Loaf volume was measured 50 min. after loaves were removed from the oven. A box of fixed dimensions (27.5 ×11 ×12.5 cm) of internal volume 3781.25 cm^3 was filled with pearl millet grain; a straight edge ruler was used to cut off all grains above the container rim. The grains were poured out and weighed (W_1). A weighed loaf was placed in the container and the weighed seeds were used to fill the container and leveled off as before. The overspill was weighed (W_2) and from the weight obtained, volume of pearl millet displaced by the loaf was calculated using the following equation.

$$Loafvolume(cm^3) = \frac{W_2 \times actual\ volume\ of\ container}{W_1} \quad (8)$$

$Where$

$W1 = Weight\ of\ pearl\ millet\ that\ filled\ the\ container$
$W2 = Weight\ of\ pearl\ millet\ grains\ displaced\ by\ the\ loaf$

2.6.4 Specific volume

The specific loaf volume was determined by dividing the loaf volume by its corresponding loaf weight (cm^3/g). Thus, it is the ratio between loaf volume and loaf weight.

$$Specific\ Volume\left(\frac{\mathrm{cm}^3}{\mathrm{g}}\right) = \frac{Loaf\ Volume}{Loaf\ \mathrm{Weight}} \quad (9)$$

2.7 Determination of the Sensory Attributes

2.7.1 Test for acceptability

A semi-trained panel of 20 judges made up of male and female staff and students of the Department of Food Technology, Federal Polytechnic, Kaura Namoda, Zamfara State was used. The panelists were educated on the respective descriptive terms of the sensory scales and requested to evaluate the various bread samples for taste, appearance, texture, aroma and overall acceptability using a 9-point Hedonic scale, where 9 was equivalent to like extremely and 1 meant dislike extremely. Presentation of coded samples were done randomly and portable water was provided for rinsing of mouth in between the respective evaluations [20].

2.8 Statistical Analyses

Data generated from the respective analyses were compiled appropriately and subjected to Analysis of Variance. Mean separation for sensory results was done using the Fischer's least significance difference test. All other data had the means separated using the Duncan Multiple Range test (GENSTAT Statistical package, version 17.0).

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Bread and Composite Breads

Among the control bread samples, the moisture contents are not significantly ($p>0.05$) different but the moisture contents of the breads showed an increased value with the addition of orange-fleshed sweet potato flour, starch and non-starch residue respectively. A similar increased trend was observed by Mais [23] and Aprianita et al. [24] for flour, starch and non-starch residue of sweet potato. The values of the protein contents of the bread samples are significantly ($p<0.05$) different. With the addition of orange-fleshed sweet potato flour, starch and non-starch residue, protein values increased but lower protein values were recorded for the control bread samples of B_1 and C_1. Eric [25], Eke-Ejiofor [26] and Soison et al. [16] reported low protein contents of sweet potato starch. The increased protein contents in the composite breads could be attributed to the high protein content in wheat more than in orange-fleshed sweet potato [23,27]. The result is in agreement with the findings of Greene and Bovel-Brenjamin [28] who reported 7.7 and 7.5 % protein contents found in bread supplemented with sweet potato flour. Fat acts as lubricating agent which improves the quality of the bread in terms of texture and flavour. Also, fat provides energy and is essential as it carries along fat soluble vitamins A, D, E and K [29]. The bread samples also recorded increased values of fat with the addition of orange-fleshed sweet potato flour, starch and non-starch residue. The fat contents of the orange-fleshed sweet potato flour breads are higher than those of starch and non-starch residue breads which are similar to the findings of Zhenghong [30].

The crude fiber contents of the composite breads compare favorably with the wheat control bread but higher than the control breads from orange-fleshed sweet potato flour, starch and non-starch residue. But greater fiber contents are found in composite breads of orange-fleshed sweet potato flour than in starch and non-starch residues. The increase was as the result of high fiber content of composite bread of orange-fleshed sweet potato flour than in starch and non-starch residue. Fiber consumption has been linked to decreased incidence of heart disease, various types of cancer and diverticulosis [31]. The high fiber contents of the composite breads of orange-fleshed sweet potato flour suggest that they would be ideal food for people suffering from obesity, diabetes, cancer and gastrointestinal disorders [32]. Sample A_5 recorded the highest ash content. High ash contents were observed in breads produced from orange-fleshed sweet potato flour more than breads produced from orange-fleshed sweet potato starch and non-starch residue.

Table 3. Proximate (%) composition of bread and composite breads

Sample	Moisture	Protein	Fat	Fiber	Ash	Carbohydrate
A0	29.37^{ab}±0.06	7.05^{cd}±0.02	6.82^{b}±0.01	4.92^{l}±0.01	2.01^{d}±0.01	49.84^{de}±0.04
A1	30.14^{abc}±0.02	7.89^{h}±0.01	8.82^{gh}±0.01	1.23^{c}±0.01	0.56^{a}±0.01	51.37^{e}±0.01
A2	32.16^{bcde}±0.06	7.01^{c}±0.00	8.52^{f}±0.01	4.34^{h}±0.03	2.02^{d}±0.01	45.95^{bcd}±0.06
A3	31.38^{bcd}±0.35	7.09^{cde}±0.00	8.78^{g}±0.21	4.67^{i}±0.01	2.10^{d}±0.01	45.99^{bcd}±0.17
A4	34.20^{cde}±0.01	7.10^{cde}±0.00	8.93^{h}±0.00	4.72^{j}±0.01	2.09^{d}±0.01	42.97^{ab}±0.01
A5	36.21^{e}±0.14	7.11^{de}±0.01	8.55^{f}±0.01	4.77^{k}±0.01	2.11^{d}±0.00	41.26^{a}±0.12
B1	29.32^{ab}±0.01	0.85^{a}±0.05	6.93^{b}±0.01	1.01^{b}±0.01	1.48^{c}±0.35	60.41^{f}±0.43
B2	34.68^{de}±0.78	7.06^{cd}±0.06	7.20^{cd}±0.01	3.65^{e}±0.05	1.15^{b}±0.06	46.27^{bcd}±0.74
B3	33.27^{bcde}±0.51	7.22^{fg}±0.01	7.39^{e}±0.01	3.61^{d}±0.01	1.10^{b}±0.00	47.42^{cde}±0.52
B4	34.08^{cde}±0.08	7.17^{ef}±0.12	7.27^{de}±0.01	3.62^{de}±0.00	1.10^{b}±0.00	46.77^{bcd}±0.06
B5	36.02^{e}±0.13	7.29^{g}±0.00	7.16^{cd}±0.04	3.62^{de}±0.00	1.12^{b}±0.00	44.80^{abc}±0.09
C1	26.30^{a}±7.09	1.09^{b}±0.00	6.33^{a}±0.01	0.82^{a}±0.01	0.63^{a}±0.01	64.84^{g}±7.11
C2	33.24^{bcde}±0.07	7.24^{fg}±0.01	7.13^{c}±0.00	3.83^{f}±0.00	1.23^{b}±0.00	47.34^{cde}±0.06
C3	33.05^{bcde}±0.06	7.25^{fg}±0.05	7.10^{c}±0.01	3.88^{g}±0.00	1.30^{bc}±0.09	47.44^{cde}±0.12
C4	34.55^{de}±0.50	7.28^{g}±0.01	7.15^{cd}±0.06	3.82^{f}±0.00	1.22^{b}±0.01	45.99^{bcd}±0.55
C5	33.33^{bcde}±0.04	7.28^{g}±0.01	7.11^{c}±0.01	3.82^{f}±0.01	1.22^{b}±0.01	47.25^{bcde}±0.03

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts differ significantly (p<0.05). Key:A0= 100% wheat flour. A1= 100% OFSP, A2= 90:10 Wheat flour: OFSP flour. A3= 80:20 Wheat flour: OFSP flour. A4= 70:30 Wheat flour: OFSP flour. A5= 60:40 Wheat flour: OFSP flour. B1= 100% OFSP Starch. B2= 90:10 Wheat flour: OFSP Starch. B3= 80:20 Wheat flour: OFSP Starch. B4= 70:30 Wheat flour: OFSP Starch. B5= 60:40 Wheat flour: OFSP Starch. C1= 100% Non-starch Residue. C2= 90:10 Wheat flour: Non-starch Residue. C3= Wheat flour: Non-starch Residue. C3= 80:20 Wheat flour: Non-starch Residue. C4= 70:30 Wheat flour: Non-starch Residue. C5= 60:40 Wheat flour: Non-starch Residue.

Table 4. Mineral composition (mg/100 g) of bread and composite breads

Sample	Calcium	Zinc	Magnesium	Phosphorus	Potassium
A0	25.24^{bc}±0.12	2.10^{de}±0.00	3.90^{e}±0.00	241.70^{d}±0.56	301.20^{cde}±1.27
A1	29.61^{g}±0.56	6.27^{h}±0.08	0.28^{a}±0.05	300.20^{i}±0.04	60.20^{a}±1.41
A2	25.64^{cd}±0.50	2.05^{d}±0.06	3.91^{e}±0.01	256.70^{f}±0.67	60.20^{a}±1.41
A3	26.05^{de}±0.06	2.11^{de}±0.01	3.92^{e}±0.00	258.70^{g}±0.79	254.20^{bc}±63.41
A4	25.91^{de}±0.02	2.12^{e}±0.00	3.91^{e}±0.00	259.10^{g}±0.08	301.10^{cde}±0.15
A5	26.00^{de}±0.00	2.12^{e}±0.00	3.93^{e}±0.00	259.20^{g}±0.01	303.20^{cde}±0.23
B1	18.45^{a}±0.36	1.11^{b}±0.01	19.33^{f}±0.01	31.00^{a}±0.06	216.10^{b}±4.17
B2	26.20^{e}±0.02	0.94^{a}±0.03	1.76^{b}±0.05	214.80^{c}±2.69	262.10^{bcd}±70.85
B3	26.20^{e}±0.02	0.92^{a}±0.01	1.75^{b}±0.03	215.60^{c}±0.45	315.20^{de}±1.34
B4	25.05^{b}±0.06	1.93^{c}±0.01	1.79^{b}±0.01	216.20^{c}±0.12	314.30^{de}±0.04
B5	24.95^{b}±0.05	1.93^{c}±0.01	1.79^{b}±0.00	215.60^{c}±0.45	319.70^{e}±0.69
C1	33.21^{h}±0.11	2.44^{g}±0.01	3.19^{cd}±0.01	123.10^{b}±0.12	56.30^{a}±0.01
C2	29.23^{g}±0.05	2.37^{f}±0.01	2.92^{c}±0.72	244.20^{e}±0.00	317.80^{de}±2.16
C3	28.26^{f}±0.10	2.38^{f}±0.01	3.43^{d}±0.01	269.20^{h}±0.02	331.60^{e}±0.50
C4	28.39^{f}±0.01	2.38^{f}±0.00	3.43^{d}±0.00	299.30^{i}±0.09	339.00^{e}±0.16
C5	28.41^{f}±0.01	2.39^{fg}±0.01	3.45^{d}±0.00	319.60^{j}±0.71	352.60^{e}±0.61

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts differ significantly (p<0.05). Key:A0= 100% wheat flour. A1= 100% OFSP, A2= 90:10 Wheat flour: OFSP flour. A3= 80:20 Wheat flour: OFSP flour. A4= 70:30 Wheat flour: OFSP flour. A5= 60:40 Wheat flour: OFSP flour. B1= 100% OFSP Starch. B2= 90:10 Wheat flour: OFSP Starch. B3= 80:20 Wheat flour: OFSP Starch. B4= 70:30 Wheat flour: OFSP Starch. B5= 60:40 Wheat flour: OFSP Starch. C1= 100% Non-starch Residue. C2= 90:10 Wheat flour: Non-starch Residue. C3= 80:20 Wheat flour: Non-starch Residue. C4= 70:30 Wheat flour: Non-starch Residue. C5= 60:40 Wheat flour: Non-starch Residue.

Carbohydrate provides heat and energy for all forms of body activities and as such its inadequacy can cause the body to divert proteins and body fat to produce needed energy and this might lead to depletion of body tissues [33]. Addition of wheat flour significantly reduced the carbohydrate contents of the composite breads of wheat and orange-fleshed sweet potato flour, starch and non-starch residue due to the higher carbohydrate content in orange-fleshed sweet potato more than wheat [27].

3.2 Mineral Composition of Bread and Composite Breads

Calcium is necessary for supporting bone formation and growth; it also helps in the maintenance of healthy teeth, skeletal and soft tissue, mucous membranes and skin [34]. Sample C_1 which is the bread produced from orange-fleshed sweet potato non-starch residue had the highest calcium content followed by sample A_1 which is the bread produced from orange-fleshed sweet potato flour. Perhaps the non-starch residue has more deposits of calcium than its flour and starch counterparts.

Zinc plays an important role in body where deficiency symptoms are shown in many ways. Zinc is required for good immune system function, cell growth, wound healing, and insulin function [35]. Significantly ($p<0.05$), orange-fleshed sweet potato flour bread was higher in zinc content than all other samples and sample B_3 had the least zinc content.

The highest magnesium content was found in the bread of orange-fleshed sweet potato starch while the orange-fleshed sweet potato flour bread had the lowest.

The breads recorded high values of phosphorus but more prominent in the breads of orange-fleshed sweet potato non-starch residue which had the highest phosphorus content in sample C_5. The least content reported was in the bread produced from orange-fleshed sweet potato starch. The composite breads recorded appreciable content of phosphorus.

The orange-fleshed sweet potato non-starch residue had highest potassium content. The amount of calcium, zinc, magnesium, phosphorus and potassium increased significantly in the composite breads in relative to the control breads and this could be attributed to the presence of minerals in orange-fleshed sweet potato as reported by Ganiyat et al. [36], Gisele et al. [37] and Satheesh and Solomon [38] thereby agreeing with Igbabul et al. [18] and Oluwalana et al. [39] who reported increased minerals in composite bread. All the bread samples appeared to be good sources of minerals.

3.3 Vitamin Content of Bread and Composite Breads

There was an observed increased vitamin B_1 with the composite bread of orange-fleshed sweet potato flour (A_2-A_5) more the breads from 100% orange-fleshed sweet potato flour (A_1) and starch (B_1). Vitamin B_2 (riboflavin) plays a crucial role in the body's metabolism. The bread samples showed high vitamin C contents in the control bread samples of 100% orange-fleshed sweet potato flour, starch and non-starch residue. The values tended to decrease with wheat flour and consequently in the composite flours. This could be attributed to the vitamin C content of orange-fleshed sweet potato [40,41] and the lack of vitamin C in wheat as earlier reported by Dabels [17].

Vitamin A is an essential nutrient required for maintaining immune function. It is often known as retinol because it produces the pigment in the retina of the eye [42]. Vitamin A refers to provitamin A carotenoids and the preformed retinols, plus their metabolites. Vitamin A had its significant ($p<0.05$) highest content in the control bread of orange-fleshed sweet potato flour(A_0) and was followed by the control bread of orange-fleshed sweet potato non-starch residue(C_1). Composite breads of orange-fleshed sweet potato flour and non-starch residue showed appreciable vitamin A contents. The high content of vitamin A in the breads of orange-fleshed sweet potato the flour and non-starch residue was due to the high vitamin A content of orange-fleshed sweet potato [43].

3.4 Physical Properties of Bread and Composite Breads

Physical properties are properties that can be measured or observed without changing the chemical nature of the substance. The inclusion of orange-fleshed sweet potato flour, starch and non-starch residue significantly ($p<0.05$) affected the physical properties of normal wheat control bread. Mais [23] observed similar results. The observed increase in weight of composite breads of orange-fleshed sweet potato flour, starch and non-starch residue more than the bread from 100 % wheat was as a result of less retention of carbon-dioxide gas in the blended dough, hence providing dense bread texture. Also, the higher moisture contents of the composite breads observed in the proximate composition could have contributed to the higher loaf weight relative to 100 % wheat bread [32]. The results of this study are in-line with the findings of Sengev et al. [44]; Amir et al. [45], Igbabul et al. [18] and Ufot and Inemesit [32], who reported increased bread loaf weight with the increased substitution of wheat flour with sweet potato, *Moringa oleifera* leaf powder, cocoa pod husk powder, maize/orange-fleshed sweet potato and unripe plantain respectively.

The dilution effect of the wheat gluten was the reason for the observed increased oven spring in composite breads in relation to the breads produced from 100 % orange-fleshed flour, starch and non-starch residue. The loaf volume and specific volume of the composite breads of orange-fleshed sweet potato flour, starch and non-starch residue are significantly lower than the bread produced from 100 % wheat flour. The reason for this trend could be due to the reduction in the amount of gluten and a lower ability of the dough to enclose air. The substitution of orange-fleshed sweet potato in both flour, starch and non-starch residue may have reduced the gluten content and this might explain the observed decreases in some of the baking characteristics of the composite breads. Several other researchers have also observed reduction in the loaf volume and specific volume of bread when non wheat flours were incorporated to wheat flour [46,47]. Reduction in these baking characteristics with the addition of orange-fleshed sweet potato flour, starch and non-starch residue could lower acceptability of the bread samples. The lower specific loaf volume of the breads could be responsible for their higher loaf weights [39].

3.5 Sensory Attributes of Bread and Composite Breads

Taste is a sensory parameter that affects the quality and acceptability of food products. The 100 % wheat bread tasted significantly ($p<0.05$) better than other products. Taste scores of bread of orange-fleshed sweet potato starch (B_1) and its composite breads (B_2-B_5) were not significantly ($p>0.05$) different from each other. Also, composite breads of orange-fleshed sweet potato non-starch residue (C_2-C_5) showed no significant ($p>0.05$) difference in their taste scores.

Table 5. Vitamin content of bread and composite breads

Sample	Vitamins (mg/100g)					
	B1	**B2**	**B6**	**B12**	**C**	**A(µg/100g)**
A0	0.28^{e}±0.00	0.10^{abc}±0.00	0.52^{b}±0.00	0.31^{bcde}±0.01	0.12^{a}±0.01	0.00^{a}±0.00
A1	0.10^{a}±0.00	1.23^{f}±0.01	0.92^{f}±0.01	0.04^{a}±0.03	6.39^{d}±0.01	8193.00^{k}±0.08
A2	0.29^{f}±0.00	0.10^{ab}±0.00	0.54^{cd}±0.01	0.32^{cde}±0.00	0.18^{a}±0.00	609.00^{f}±0.16
A3	0.29^{f}±0.00	0.14^{abcd}±0.01	0.54^{de}±0.00	0.32^{cde}±0.00	0.28^{a}±0.01	765.00^{g}±2.04
A4	0.30^{f}±0.00	0.16^{bcd}±0.00	0.53^{bcd}±0.00	0.31^{bcde}±0.00	0.31^{a}±0.00	889.00^{h}±0.62
A5	0.29^{f}±0.01	0.18^{cd}±0.00	0.54^{de}±0.00	0.33^{e}±0.01	0.61^{ab}±0.02	1000.00^{i}±0.16
B1	0.12^{b}±0.00	0.07^{a}±0.01	0.09^{a}±0.00	1.13^{f}±0.01	14.17^{f}±0.06	0.00^{a}±0.00
B2	0.21^{c}±0.00	0.13^{abcd}±0.01	0.53^{bc}±0.01	0.30^{bc}±0.01	1.22^{bc}±0.01	0.00^{a}±0.00
B3	0.21^{c}±0.00	0.19^{d}±0.00	0.53^{bcd}±0.00	0.29^{b}±0.00	1.25^{bc}±0.06	0.00^{a}±0.00
B4	0.23^{d}±0.00	0.13^{abcd}±0.00	0.52^{b}±0.00	0.31^{bcde}±0.00	1.24^{bc}±0.01	0.00^{a}±0.00
B5	0.23^{d}±0.00	0.14^{abcd}±0.00	0.52^{b}±0.00	0.33^{e}±0.01	1.36^{bc}±0.04	0.00^{a}±0.00
C1	0.37^{g}±0.00	0.82^{e}±0.13	1.25^{g}±0.01	2.23^{g}±0.01	13.01^{e}±1.41	7993.00^{j}±3.67
C2	0.29^{f}±0.00	0.13^{abcd}±0.01	0.53^{cd}±0.01	0.30^{b}±0.01	1.93^{c}±0.01	53.00^{b}±0.03
C3	0.29^{f}±0.00	0.13^{abcd}±0.00	0.54^{de}±0.01	0.30^{bcd}±0.00	1.93^{c}±0.00	86.00^{c}±0.11
C4	0.29^{f}±0.00	0.13^{abcd}±0.00	0.55^{e}±0.00	0.31^{bcde}±0.00	1.99^{c}±0.00	128.00^{d}±2.18
C5	0.29^{f}±0.00	0.14^{abcd}±0.00	0.55^{e}±0.00	0.32^{de}±0.00	2.02^{c}±0.01	170.00^{e}±14.62

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts differ significantly ($p<0.05$). Key:A0= 100% wheat flour. A1= 100% OFSP, A2= 90:10 Wheat flour: OFSP flour. A3= 80:20 Wheat flour: OFSP flour. A4= 70:30 Wheat flour: OFSP flour. A5= 60:40 Wheat flour: OFSP flour. B1= 100% OFSP Starch. B2= 90:10 Wheat flour: OFSP Starch. B3= 80:20 Wheat flour: OFSP Starch. B4= 70:30 Wheat flour: OFSP Starch. B5= 60:40 Wheat flour: OFSP Starch. C1= 100% Non-starch Residue. C2= 90:10 Wheat flour: Non-starch Residue.C3= 80:20 Wheat flour: Non-starch Residue. C4= 70:30 Wheat flour: Non-starch Residue. C5= 60:40 Wheat flour: Non-starch Residue.

Table 6. Physical properties of bread and composite breads

Sample/ parameters	Loaf weight (g)	Oven spring (mm)	Loaf Volume (cm^3)	Specific volume cm^3/g
A0	$210.60^{a}\pm0.77$	$1.27^{e}\pm0.06$	$440.60^{n}\pm0.78$	$2.10^{k}\pm0.01$
A1	$224.60^{b}\pm3.63$	$0.05^{a}\pm0.07$	$421.60^{m}\pm0.71$	$1.88^{j}\pm0.04$
A2	$225.70^{b}\pm0.81$	$1.65^{f}\pm0.07$	$400.10^{l}\pm0.08$	$1.78^{i}\pm0.01$
A3	$229.00^{c}\pm1.41$	$1.35^{ef}\pm0.07$	$391.60^{k}\pm0.71$	$1.71^{h}\pm0.01$
A4	$230.60^{cd}\pm0.74$	$0.35^{abc}\pm0.07$	$389.70^{j}\pm0.78$	$1.69^{gh}\pm0.01$
A5	$232.50^{d}\pm0.72$	$0.65^{cd}\pm0.21$	$390.20^{j}\pm0.13$	$1.68^{g}\pm0.01$
B1	$237.00^{e}\pm2.85$	$0.85^{d}\pm0.12$	$375.10^{i}\pm0.01$	$1.59^{f}\pm0.02$
B2	$238.60^{ef}\pm0.67$	$2.15^{g}\pm0.07$	$371.60^{h}\pm0.70$	$1.56^{ef}\pm0.00$
B3	$240.60^{fg}\pm0.71$	$2.10^{g}\pm0.00$	$370.20^{g}\pm0.00$	$1.54^{de}\pm0.00$
B4	$241.60^{fg}\pm0.62$	$2.20^{g}\pm0.00$	$367.70^{f}\pm0.55$	$1.53^{d}\pm0.01$
B5	$242.50^{g}\pm0.67$	$1.50^{ef}\pm0.00$	$367.70^{f}\pm0.70$	$1.52^{d}\pm0.00$
C1	$246.00^{h}\pm0.02$	$0.60^{bcd}\pm0.28$	$330.60^{e}\pm0.54$	$1.35^{c}\pm0.01$
C2	$247.50^{hi}\pm0.68$	$2.40^{g}\pm0.14$	$328.70^{d}\pm0.71$	$1.33^{c}\pm0.00$
C3	$250.00^{ij}\pm0.04$	$1.50^{ef}\pm0.28$	$321.70^{c}\pm1.01$	$1.29^{b}\pm0.01$
C4	$252.10^{jk}\pm0.01$	$0.30^{ab}\pm0.14$	$320.10^{b}\pm0.01$	$1.27^{ab}\pm0.00$
C5	$254.00^{k}\pm1.39$	$0.85^{d}\pm0.21$	$317.60^{a}\pm0.79$	$1.25^{a}\pm0.01$

Values are means ± standard deviations of triplicate determinations. Means in the same column with different superscripts differ significantly ($p<0.05$). Key: A0= 100% wheat flour. A1= 100% OFSP, A2= 90:10 Wheat flour: OFSP flour. A3= 80:20 Wheat flour: OFSP flour. A4= 70:30 Wheat flour: OFSP flour. A5= 60:40 Wheat flour: OFSP flour. B1= 100% OFSP Starch. B2= 90:10 Wheat flour: OFSP Starch. B3= 80:20 Wheat flour: OFSP Starch. B4= 70:30 Wheat flour: OFSP Starch. B5= 60:40 Wheat flour: OFSP Starch. C1= 100% Non-starch Residue. C2= 90:10 Wheat flour: Non-starch Residue. C3= 80:20 Wheat flour: Non-starch Residue. C4= 70:30 Wheat flour: Non-starch Residue. C5= 60:40 Wheat flour: Non-starch Residue.

Table 7. Sensory evaluation of bread and composite breads

Sample	Taste	Appearance	Texture	Aroma	Overall acceptability
A0	$7.60^{d}\pm0.83$	$6.00^{a}\pm0.76$	$7.13^{d}\pm0.74$	$7.47^{d}\pm0.83$	$7.60^{d}\pm0.63$
A1	$4.20^{a}\pm0.77$	$3.60^{b}\pm0.83$	$3.73^{a}\pm0.88$	$3.73^{a}\pm0.70$	$5.60^{a}\pm0.83$
A2	$5.80^{c}\pm0.68$	$6.07^{a}\pm0.59$	$5.73^{b}\pm0.70$	$5.67^{b}\pm0.72$	$7.00^{c}\pm0.76$
A3	$6.07^{c}\pm0.70$	$6.13^{a}\pm0.74$	$6.00^{bc}\pm0.76$	$6.07^{bc}\pm0.70$	$6.40^{b}\pm0.74$
A4	$6.07^{c}\pm0.70$	$5.93^{a}\pm0.59$	$6.27^{c}\pm0.59$	$6.20^{bc}\pm0.77$	$6.33^{b}\pm0.62$
A5	$5.27^{b}\pm0.70$	$5.73^{a}\pm0.70$	$5.80^{bc}\pm0.68$	$6.33^{c}\pm0.72$	$6.27^{b}\pm0.59$
LSD	0.53	0.51	0.53	0.54	0.51
B1	$6.00^{a}\pm0.65$	$3.80^{a}\pm0.68$	$3.13^{a}\pm0.74$	$3.00^{a}\pm0.65$	$5.87^{a}\pm0.74$
B2	$6.40^{a}\pm0.51$	$6.40^{b}\pm0.51$	$6.07^{b}\pm0.70$	$6.20^{b}\pm0.67$	$7.20^{c}\pm0.56$
B3	$6.40^{a}\pm0.74$	$6.40^{b}\pm0.74$	$6.60^{cd}\pm0.63$	$6.33^{bc}\pm0.62$	$6.60^{b}\pm0.63$
B4	$6.33^{a}\pm0.72$	$6.27^{b}\pm0.70$	$6.13^{bc}\pm0.83$	$6.40^{bc}\pm0.63$	$6.20^{ab}\pm0.56$
B5	$6.40^{a}\pm0.51$	$6.20^{b}\pm0.56$	$6.87^{d}\pm0.64$	$6.67^{c}\pm0.62$	$6.53^{b}\pm0.52$
LSD	0.46	0.47	0.52	0.47	0.44
C1	$5.20^{a}\pm0.68$	$2.40^{a}\pm0.51$	$5.13^{a}\pm0.64$	$4.07^{a}\pm0.70$	$5.20^{a}\pm0.77$
C2	$6.73^{b}\pm0.59$	$4.67^{b}\pm0.62$	$6.33^{bc}\pm0.49$	$6.13^{c}\pm0.64$	$6.20^{b}\pm0.68$
C3	$6.53^{b}\pm0.52$	$5.20^{c}\pm0.68$	$6.07^{b}\pm0.59$	$6.20^{c}\pm0.68$	$6.33^{b}\pm0.62$
C4	$6.47^{b}\pm0.52$	$5.47^{c}\pm0.52$	$6.53^{c}\pm0.52$	$5.13^{b}\pm0.74$	$5.93^{b}\pm0.70$
C5	$6.40^{b}\pm0.51$	$5.60^{c}\pm0.63$	$6.33^{bc}\pm0.49$	$6.07^{c}\pm0.70$	$6.00^{b}\pm0.65$
LSD	0.41	0.43	0.40	0.51	0.50

Means in the same column with different superscripts differ significantly (p<0.05).Key: A0= 100% wheat flour. A1= 100% OFSP, A2= 90:10 Wheat flour: OFSP flour. A3= 80:20 Wheat flour: OFSP flour. A4= 70:30 Wheat flour: OFSP flour. A5= 60:40 Wheat flour: OFSP flour. B1= 100% OFSP Starch. B2= 90:10 Wheat flour: OFSP Starch. B3= 80:20 Wheat flour: OFSP Starch. B4= 70:30 Wheat flour: OFSP Starch. B5= 60:40 Wheat flour: OFSP Starch. C1= 100% Non-starch Residue. C2= 90:10 Wheat flour: Non-starch Residue. C3= 80:20 Wheat flour: Non-starch Residue. C4= 70:30 Wheat flour: Non-starch Residue. C5= 60:40 Wheat flour: Non-starch Residue.

According to Sudha et al. [48], progressive increase in supplementation with non-wheat flour, appearance turns towards darker leading to lower acceptability. On the contrary to the above assertion by Sudha et al. [48], composite breads of orange-fleshed sweet potato starch were significantly (p<0.05) more acceptable in appearance than bread produced from 100% wheat flour. This could be attributed to the appealing nature/colour of the orange-fleshed sweet potato. The appearance turned less acceptable in 100% breads of orange-fleshed sweet potato flour (A_1), starch (B_1) and non-starch residue(C_1), as deduced from scores obtained for A_1, B_1 and C_1.

The 100% wheat bread had the highest textural score and was significantly (p<0.05) different from other bread samples except that from 80:20 and 60:40 composites of orange-fleshed sweet potato starch (B_3 and B_5). Lower textural values were recorded in the breads from orange-fleshed sweet potato flour, starch and non-starch residue. Composite breads of both orange-fleshed sweet potato flour(A_2-A_5), starch (B_2-B_5) and non-starch residue (C_2-C_5) showed higher textural values than their individual breads (A_1, B_1 and C_1).

Aroma is another attribute that influences the acceptability of baked good products even before they are tasted. Also, bread samples of 100% orange-fleshed sweet potato flour, starch and non-starch residue were significantly low in aroma. This could be attributed to the fact that Panelists were too used to the aroma breads produced from wheat flour than other breads of non-wheat flour.

Overall acceptability was determined on the basis of quality scores obtained from evaluation of taste, appearance, texture and aroma. The decrease in the general acceptability of composite breads in this study was reported in another study on wheat/yam composite bread by Amandikwa et al. [49]. Mepba [21] and Joseph et al. [50] reported similar decreased values of overall acceptability of wheat based breads supplemented with plantain and ripe banana slices flours respectively.

4. CONCLUSION

The bread and composite breads recorded higher moisture contents, the protein, fat, fiber and ash contents of the flour, bread from orange-fleshed sweet potato flour (A_1), starch (B_1) and non-starch residue (C_1) were low, but higher contents were observed in their composite flour, bread. There was an observed higher content of fat in the composite bread than in the 100% wheat bread. The phosphorus and potassium contents of the bread were high as compared to calcium, zinc and magnesium in their mineral contents. The vitamin C contents of the bread from orange-fleshed sweet potato flour (A_1), starch (B_1) and non-starch residue (C_1) were high but decreased in their composites bread. The bread sample from wheat (A_0), orange-fleshed sweet potato starch and its composites (B_1-B_5) recorded no value of vitamin A, but grandeur values of vitamin A was observed in the bread of orange-fleshed sweet potato flour and its composites (A_1-A_5).

The study showed that the bread and composite breads produced from orange-fleshed sweet potato flour, starch and non-starch residue weigh more than the bread produced from wheat flour. It also showed that both the wheat (A_0) bread tasted better than the composite bread formulated from orange-fleshed sweet potato flour, starch and non-starch residue but the breads produced from orange-fleshed sweet potato starch composites (B_2-B_5) appeared better than that produced from wheat (A_0). The results of the overall acceptability of the breads revealed that wheat flour can be supplemented with orange-fleshed sweet potato flour without greatly affecting the overall acceptability of the its bread.

The study revealed that up to 20% substitution of orange-fleshed sweet potato flour, starch and non-starch residue flours for wheat flour was acceptable in bread formulation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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