

PHYSIOCHEMICAL AND SENSORY EVALUATION OF COOKIES PRODUCED FROM COMPOSITE FLOURS OF WHEAT, BAMBARA NUT AND ORANGE FLESHED SWEET POTATO

¹Ubbor, S. C., ¹Arukwe, D. C., ³Ejechi, M. E., and ²Ekeh, J. I

¹Department of Food Science and Technology,

²Department of Agriculture/Home Economics Education,

^{1,2}Michael Okpara University of Agriculture, Umudike, Abia State

³Farming System Research Program, National Root Crops Research Institute, Umudike, PMB 7006 Umuahia. Abia State.

Corresponding author's email: stellaubbor@gmail.com

ABSTRACT

This study aimed at investigating the use of wheat, Bambara nut and orange fleshed sweet potato composite flours in the production of cookies. Enriched cookies were produced using wheat, Bambara nut and Orange Fleshed Sweet Potato flour blends in the ratios: 100:0:0, 90:5:5, 90:0:10, 80:10:10 and 80:5:15 and were labeled BVB, ACC, LVG, BCN and CFC respectively. Sample BVB (100% wheat flour) served as the control. The functional properties of the flour blends were determined, as well as the proximate and beta-carotene (pro-vitamin A) composition of the cookies. Also, the physical parameters and sensory qualities of the enriched cookies were evaluated. The moisture content, protein, fat, fibre, ash and carbohydrate ranged from 5.70 to 8.57%, 9.62 to 11.93%, 11.02 to 13.02%, 2.33 to 4.03%, 1.23 to 1.54% and 63.33 to 68.79% respectively. The energy value ranged from 405.46 to 420.03 k/cal. There were significant differences ($p < 0.05$) in the functional properties of the flour blends. The result also revealed that the β -carotene (pro-vitamin A) increased with increase in substitution of orange fleshed sweet potato. The results showed significant differences ($p < 0.05$) in physical properties of the cookies in weight, diameter, break strength, density and volume while there were no significant differences ($p > 0.05$) in thickness and spread ratio. The sensory analysis indicated that all the samples had high level of acceptability in their sensory attributes, but sample BVB and ACC had the best overall acceptability ratings of 7.50 and 7.10 respectively. Therefore, enriched cookies produced from the blends were acceptable.

Keywords: Cookies, wheat, Bambara nut, Orange fleshed sweet potato, β -carotene

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INTRODUCTION

Cookies are forms of confectionary products usually dried to low moisture content (Okaka, 2009). Compared to biscuit, they tend to be larger with a softer chewer texture. They are consumed extensively all over the world as snack food and on a larger scale in developing countries where protein and caloric malnutrition are prevalent (Chinma and Gernah, 2007). Cookies are the most popular

baked items consumed among all age groups in many countries because they have a very acceptable taste and their low water activity allows a long shelf life (Chauhan *et al.*, 2015; Usman *et al.*, 2015). Conventionally, cookies are produced from wheat flour due to its gluten which improves its texture (Oluwafemi and Seidu, 2017). In Nigeria, reliance on wheat flour in the bakery industries has over the years restricted the use of other cereals and tuber crops available to domestic use.

Recently, government has collaborated with the research institutes to encourage the use of composite flours in the production of food products such as cookies, bread etc. Several studies have reported the use of composite flour in cookies production (Akusu *et al.*, 2019; Obinna-Echem and Robinson, 2019; Ukeyima *et al.*, 2019; Bello *et al.*, 2020). All these efforts were aimed at improving the nutritional values of the cookies and also to enhance crop utilization. Besides, the increasing phenomenon of urbanization coupled with growing number of working mothers, have profoundly contributed to the popularity and increased consumption of cookies (Gernah *et al.*, 2010). All these and more have led to concerted efforts to explore the feasibility of using cookies as a vehicle for micronutrient fortification (Temesgen *et al.*, 2015).

Wheat (*Triticum aestivum*) is a leading cereal crop which is mainly utilized for human consumption. The principal use of wheat grains is as flour. Wheat flour is used in production of bread and noodles (Kurmar *et al.*, 2011). Various studies showed applicability of wheat grains in processing of cookies (Ikuomola *et al.*, 2017) and chinchin of desirable texture and flavour (Adebayo-Oyetoro *et al.*, 2017). Ikuomola *et al.* (2017) showed that it could be possible to produce nutritious and acceptable cookies through the substitution of wheat flour with malted barley bran. Cookies of acceptable quality were produced from composite flours of wheat, *acha* and mung beans (Dabels *et al.*, 2016).

Bambara nut (*Vigna subterranean*) can be used as flour for baking. As a legume, it is high in protein that play important role in human nutrition. A detailed study shows that it contains 20-26% crude protein, (high in lysine; 6.6%) and makes excellent source of supplementing proteins in the diet (Asselberg, 1998). Bambara nut has vitamins and minerals such as iron, phosphorus and

calcium. It also has a high content of crude fibre and high level of sulphur containing amino acids which are limited in cereals.

In Nigeria, the consumption of ready-to-eat baked product is continually growing and there has been an increase in reliance on imported wheat (Akpapunam and Darbe, 1999). Moreover, Nigeria grows less wheat but grows other staple crops such as sweet potato, cassava, yam and cereals that can be used for bakery foods. It would therefore be of economic advantage if wheat can be replaced with flour from tubers, legumes and cereals hence reducing the reliance on its importation and thus enhance the industrial utilization of local crops.

Sweet potato (*Ipomoea batatas*) is a starch-rich tuber crop that is consumed across Nigeria (Okorie and Onyeneke, 2012). Sweet potato is categorized as “poor man’s food” or “famine crop” despite its tremendous potential to contribute to a food-based approach to promote food security (Mitra *et al.*, 2012). Majority of sweet potato varieties are less nutritive, but the orange-fleshed sweet potato (OFSP) variety rich in beta-carotene is considered as a very cheap source of vitamin A especially for young children (Effiong *et al.*, 2018). The poor households in most Sub-Saharan countries cannot afford to consume the highly bioavailable vitamin A animal food source on a regular basis (Vimala, 2011). In this regard OFSP is believed to represent the least expensive, year-round source of dietary vitamin A available to poor families (Vimala, 2011).

Composite flour is a mixture of varying proportion of two or more flour which may contain or may not contain wheat flour and used for production of bread, pastries, cake and other confectionery products that are conventionally produced from wheat flour with the intention of increasing the essential nutrients in human diet and increase the

economic relevance of indigenous crops (Okoye and Obi, 2017). The use of composite flours have some advantages for developing countries such as Nigeria in terms of enhancement of nutritional quality of food, utilization of under-exploited crops, thus, preventing them from going into extinction and reduction in the importation of wheat flour, thereby saving of foreign exchange (Hasmadi *et al.*, 2014). The bakery products produced using composite flour are usually of good quality, with some characteristics similar to wheat-flour products, though the texture and the properties of the composite flour bakery products are different from those made from wheat flour, with an increased nutritional value and the appearance (Hasmadi *et al.*, 2014). Ubbor and Akobundu (2009) successfully produced cookies from composite flours of watermelon seed, cassava and wheat and concluded that a nutritious and acceptable biscuit can be produced by replacing wheat with up to 20 % watermelon seed flour and 15% cassava flour. In most developing countries like Nigeria, the import of wheat had an increasingly adverse effect on the balance of trade. For this reason and more the FAO and these developing countries initiated replacing of wheat needed for making baked goods, wholly or partly with flour obtained from local staples (Gernah *et al.*, 2010). The main objective of this study was to evaluate cookies produced from composite flours of wheat, bambara nut and orange fleshed sweet potato. The specific objectives were to determine the functional properties of the composite flours and also the physical and chemical properties of the cookies samples produced.

MATERIALS AND METHODS

Raw Materials Procurement

The bambara nut seeds, wheat and other ingredients such as margarine, eggs, salt, sugar and baking powder used for this study were purchased at Ubani Ibeku main market,

Umuahia, while the orange fleshed sweet potatoes, UMUSPO3 were purchased from National Root Crops Research Institute (NRCRI) Umudike, Umuahia, all in Abia State, Nigeria.

Production of Flours

Bambara nut flour: The bambara nut flour was produced using the method as described by Mazahib *et al.* (2013). The bambara nut seeds were carefully cleaned, sorted to remove foreign materials. The seeds were steeped in clean water for 14 h at room temperature ($24 \pm 2^{\circ}\text{C}$). Thereafter, the steeped seeds were washed twice with clean tap water and then boiled for 25 min, drained and dehulled manually. The dehulled seeds were rinsed and oven dried (Uniscope laboratory oven model SM9023) at 60°C for 24 h and milled with attrition mill (model SK-30-SS Food Grade). The bambara flour was sieved using 0.4mm sieve and packaged with a transparent polyethylene bag until needed.

Orange fleshed sweet potato flour: The orange fleshed sweet potato flour was produced using the method as described by Singh *et al.* (2008). The orange fleshed sweet potato procured from NRCRI, were sorted, washed, peeled and sliced to 1-3mm thickness with stainless steel kitchen knife. The sweet potato slices were blanched in boiling water for 2 min to inactivate the enzymes in the tubers, after which they were drained, dried at 60°C for 24h (using Uniscope laboratory oven model SM9023) and milled into flour with attrition mill (model SK-30-SS Food Grade). The resultant flour was sieved to fine flour using 0.4 mm sieve mesh. The flour was then packaged in a transparent polyethylene bag until needed.

Wheat flour: The whole wheat grains were cleaned, sorted to remove foreign materials such as stones, sands and dirt. The wholesome wheat grains were washed with clean tap water and soaked for 6 h. The soaked grains were re-washed, drained, oven dried at 60°C

for 6 h then milled using attrition mill (model SK-30-SS Food Grade) and sieved into fine wheat flour with 0.4 mm sieve mesh, then packaged in a transparent polyethylene bag.

Formulation of Composite Flour

The formulation of the composites of wheat, bambara nut and orange fleshed sweet potato flours are shown in Table 1. The formulation was done so as to enhance the nutrient (particularly protein and Pro vitamin A) content of the cookies.

Cookies Formulation and Preparation

The cookies were formulated from the standard cookies recipe given as follows: composite flour (600g), sugar (180g), margarine (240g), milk powder (72g), baking powder (12g) and egg (90g). The cookies were prepared according to the method as described by Oyewole *et al.* (1996). The weighed sugar and margarine were creamed with a wooden spoon at medium speed until it became fluffy in a mixing bowl. The eggs were then whisked into it and blended by mixing. Milk was added to the mixture and afterwards the flour and other ingredients such as vanilla flavour, nutmeg and baking powder were added and mixed thoroughly to form dough. It was kneaded until it became smooth and lumpless and then rolled out thinly. The dough was cut with a cookie cutter into sizes and shapes of 6cm diameter, and then placed gently on the baking pan greased with margarine and then put inside the oven. The five blend formulations were baked using temperature of 190°C for 20 min. After baking, the cookies were spread on the clean working table and allowed to cool, then packaged in transparent polyethylene bags.

Proximate Analysis and Energy Value Determination

Determination of moisture content

Moisture content of the cookies was determined according to the method of AOAC (2010). Two grams of each of the

milled cookie samples were weighed into different moisture cans. They were then placed in an oven at 150 °C for 3 h, drying was stopped after obtaining two consecutive values differing by 0.001. The samples were cooled in a desiccator and weighed. Moisture content of the cookies was then calculated as follows:

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

where: W_1 = initial weight of empty can,

W_2 = weight of empty can + sample before drying,

W_3 = final weight of empty can + sample after drying.

Determination of ash content

The method described by AOAC (2010) was used to determine the ash content of the cookies. Porcelain crucible were dried and cooled in desiccators before weighing. Two grams of the milled cookies samples were weighed into the crucible and the weight taken. The crucible containing the samples were placed into the muffle furnace and ignited at 550 °C. This temperature was maintained for 3 h. The muffle furnace was then allowed to cool; the crucibles were then brought out, cooled and weighed. The ash content was calculated as follows:

$$\% \text{ Ash} = \frac{W_2 - W_1}{\text{Weight of sample}} \times 100$$

Where: W_2 = weight of crucible + ash,

W_1 = weight of empty crucible.

Determination of fat content

The fat content of the cookie samples was determined using solvent extraction in a soxhlet apparatus as described by AOAC (2010). Two grams of each of the milled cookie samples were wrapped in a filter paper and placed in a soxhlet reflux flask which is connected to a condenser on the upper side and to a weighed oil extraction flask full with

two hundred milliliters of petroleum ether. The ether was brought to its boiling point, the vapour condensed into the reflux flask immersing the samples completely for extraction to take place on filling up the reflux flask siphons over carrying the oil extract back to the boiling solvent in the flask. The process of boiling, condensation, and reflux was allowed to go on for four hours before the defatted samples were removed. The oil extract in the flux was dried in the oven at 60 °C for thirty minutes and then weighed.

$$\% \text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Determination of crude fibre

The crude fibre of the cookie samples was determined according to the AOAC (2010) method. Two grams of each of the milled cookies were boiled under reflux for 30 min with 200 ml of solution containing 1.25 g of tetraoxosulphate (vi) acid (H₂SO₄) per 100 ml of solution. The solution was filtered through linen on a flauted funnel and washed with water until the washing is no longer acidic. The residue was then transferred to a beaker and boiled for thirty minutes with 100 ml of solution. The final residue was filtered through a thin but closer pad of washed and ignited asbestos in a Gosh crucible. The residue was then dried in an electric oven and weighed. The residue was incinerated, cooled and weighed. Crude fibre content of the biscuit was then calculated as follows:

$$\% \text{ Crude fibre} = \frac{W_2 - W_3}{W_1}$$

Where: W₁ = weight of sample used, W₂ = weight of crucible plus sample,

W₃ = weight of sample crucible

Determination of crude protein

Crude protein of the cookie samples was determined using the Kjeldahl method as described by AOAC (2010). One gram of the

milled cookies sample was introduced into the digestion flask. Kjeldahl catalyst (Selenium tablets) was added to the sample. Twenty milliliters of concentrated sulphuric acid was added to the sample and fixed to the digester for eight hours until a clear solution was obtained. The cooled digest was transferred into 100 ml volumetric flask and made up to the mark with distilled water. The distillation apparatus was set and rinsed for ten minutes after boiling. Twenty milliliters of 4 % boric acid was pipetted into conical flask. Five drops of methyl red was added to the flask as indicator and the sample was diluted with 75 ml distilled water. Ten milliliters of the digest was made alkaline with 20 ml of sodium hydroxide (NaOH) (20 %) and distilled. The steam exit of the distillatory was closed and the change of color of boric acid solution to green was timed. The mixture was distilled for 15 min. The filtrate was then titrated against 0.1 N Hydrochloric acid (HCl).

The total percentage of protein was calculated:

$$\% \text{ protein} = \% \text{ nitrogen} \times \text{conversion factor} (6.25).$$

Determination of carbohydrate content

Carbohydrate content of the cookie samples was determined by difference as described by AOAC (2010).

$$\% \text{ carbohydrate} = 100 - \% (\text{protein} + \text{fat} + \text{fibre} + \text{ash} + \text{moisture content}).$$

Determination of energy value

The energy value was estimated using Atwater factors as described by AOAC (2010). The energy value was calculated by multiplying the proportion of protein, fat and carbohydrate by their respective physiological fuel value of 4, 9, and 4 kcal/g respectively and taking the sum of their products.

The energy value was calculated thus:

$$F_e = (\% \text{ CP} \times 4) + (\% \text{ CF} \times 9) + (\% \text{ CHO} \times 4)$$

Where: F_e = Food energy (in grain calories),
 CP= Crude protein

CF= Crude fat, CHO= Carbohydrate

Beta-Carotene Determination

This was done using the method described by Delia *et al.* (2004). Five grams (5g) of the cookies samples was weighed and crushed in mortar, 30ml of cold acetone was used to extract the carotenoid and it was filtered by suction through a sintered glass funnel. The mortar, pestle funnel and residue were washed with 50mls acetone through the funnel to the suction flask. About 20mls of petroleum ether was poured into 500ml separating funnel containing each of the filtrate and slowly brine water was introduced using washed bottles to the lining of the separating funnel, then the lower aqueous phase was discarded. The washing was done 3-4 times to remove residual acetone, after which the petroleum ether phase was collected in a 50ml volumetric flask which was made to pass through a funnel containing anhydrous sodium sulfate to remove residual water (glass wool was placed to hold the sodium). It was made up to mark using petroleum ether and absorbance read at 450nm using a spectrophotometer.

Calculation:

Total carotenoid content mg/g = $\frac{A}{x \text{Volume(ml)} \times 10^4 \times \text{Df}}$

$A^{1\%}_{1\text{cm}}$ x weight of sample

Where; A = Absorbance

Volume = Total volume of extract

$A^{1\%}_{1\text{cm}}$ = Absorbance coefficient of Beta carotene in pet Ether (2592)

Df = Dilution factor

Multiply by 100 to give the carotenoid content mg/100g.

Determination of Functional Properties of Flour

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Determination of water absorption capacity

Water absorption capacity was determined as described by Onwuka (2018). One (1 g) of the flour sample was weighed and placed into a conical graduated centrifuge tube. A warring whirl mixer was used to mix the sample thoroughly, 10 ml was added and sample was allowed to stay for 30 m at room temperature and then centrifuged at $5000 \times g$ for 30 m. The volume of the free water (supernatant) was read using 10 ml measuring cylinder. Water absorption was calculated as the amount of water absorbed (total minus free water) x 1 g/ml.

Determination of oil absorption capacity (OAC)

The method of Onwuka (2018) was adopted for the determination of OAC. Refined soybean oil with density of 0.92 g/mL was used. One (1) gram of the flour sample was mixed with 10 mL of the oil (V_1), for 30 s. The sample was allowed to stand for 30 min at room temperature and then centrifuged (Centurion scientific, Model k241) at 10,000 rpm for 30 min. The amount of oil separated as supernatant (V_2) was measured using 10 mL cylinder. The difference in volume was taken as the oil absorbed by the samples. The result obtained was calculated using the equation below:

$$\text{Oil absorption capacity} = \frac{(V_1 - V_2)P}{\text{Weight of sample}}$$

Where, V_1 = the initial volume of oil used,
 V_2 = the volume not absorbed

P = the density of oil (0.92 g/mL)

Determination of bulk density

A 10 ml capacity graduated measuring cylinder was weighed and the flour ample was gently filled into the cylinder. The bottom of the cylinder was gently tapped on the laboratory bench severally until there was no diminution of the sample level after filling to

the 10 ml mark. Bulk density (g/ml) was then calculated as weight of sample (g)/volume of sample (ml) according to Onwuka (2018).

Determination of wettability

Wettability of the flour samples was determined according the method described by Onwuka (2018). One (1) gram of each of the flour samples was weighed using an analytical balance and were each added into a 25 ml graduated measuring cylinder with a diameter of 1 cm. The finger was then placed over the open end of the cylinder in each case, inverted and was clamped at a height of 10 cm from the surface of a 600 ml beaker containing 500 ml of distilled water. The finger was then removed and the test sample was allowed to dump. The wettability was recorded as the time required for the sample to become completely wet.

Determination of emulsification capacity (EC)

Two grams (2 g) of flour sample was blended with 12.5 ml distilled water at room temperature for 30sec in a blender at 200 rpm. After complete dispersion, 12.5 ml vegetable oil was gradually added and continued blending for another 30 seconds. The blended sample was transferred into a centrifuge tube and centrifuged at 1600 rpm for 5 min. The volume of oil separated from the sample after centrifuge was read directly from the tube. Emulsion capacity was expressed as the amount of oil emulsified and held per gram of sample (Onwuka, 2018).

Physical Analysis of Cookies

Determination of weight, diameter, and thickness

The weight, diameter and thickness of the cookies were determined according to the method described by Ayo *et al.* (2007). The weight of the cookie samples was determined through the aid of a weighing balance. The height and diameter was determined by measuring them with a calibrated ruler

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Determination of volume and density

The volume and density of cookies were determined according to the method of Akubor and Ishiwu (2013). Volume of cookies was calculated as length x width x height. Density was calculated as weight/volume.

Determination of spread ratio

The spread ratio was determined using Gomez *et al.* (1997) method. Three rows of five well-formed cookies were made and the height measured. Also the same cookies were arranged horizontally edge to edge and sum diameter measured. The spread ratio was calculated thus:

$$\text{Spread ratio} = \frac{\text{Diameter}}{\text{Height}}$$

Determination of break strength

The break strength of the cookies was determined using Okaka and Isieh (1990) method. Biscuit of known thickness was placed between two parallel wooden bars (3 cm apart). Weight was added on the cookies until the cookie snapped. The least weight that caused the breaking of the cookies was regarded as the break strength of the cookies.

Sensory Properties

The method described by Iwe (2014) was adopted. The organoleptic properties of the cookies samples were tested by 20 pre-trained panelists selected from Food Science and Technology Department of Michael Okpara University of Agriculture, Umudike. The pre-trained panelists were instructed prior to the exercise.

All samples were put on different plates and served to the panelists with portable water to rinse their mouth after each testing so as not to interfere with the taste of the preceding

samples. Quality attribute such as appearance, taste, Aroma, texture, crispiness and General acceptability of the products were scored on a 9point hedonic scale. The degree of likeness was expressed as follows: Like extremely 9, like very much 8, like moderately 7, like slightly 6, neither like nor dislike 5, Dislike slightly 4, Dislike moderately 3, Dislike very much 2, Dislike extremely 1. Like extremely to like slightly constitute good while dislike slightly to dislike extremely constitutes poor. Neither like nor dislike indicates that the product was neither good nor bad.

Statistical Analysis

The data obtained was subjected to analysis of variance of a completely randomized design using the Statistical Product for Service Solution version 23.0, while treatment means were separated using Duncan's multiple range test at 95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION

Proximate Composition of Cookies from Blends of Wheat, Bambara Nut and Orange Fleshed Sweet Potato Flours

The proximate compositions of the cookies are presented in Table 2. There were significant differences ($p < 0.05$) between all the measured parameters. The protein content of the cookies was significantly different ($p < 0.05$) from each sample except sample ACC (90% WF: 5% BNF: 5% OFSP) and CFC (80% WF: 5% BNF: 15% OFSP). The protein content ranged from 9.62 to 11.93% with sample BVB (100 % WF) having the least mean value while BCN (80% WF: 10% BNF: 10% OFSP) had the highest mean value. The least value of protein in sample BVB could be attributed to non-incorporation of legume (bambara nut) which contains substantial amount of protein. Also, the range of protein obtained in this study is within that (11.02 – 13.15%) reported by Arukwe (2020) for biscuits produced from wheat, cocoyam and pigeon pea composite flours but lower

than that (12.15 – 20.92%) obtained by Arukwe *et al.* (2021) for cookies produced from wheat, sorghum and African yam bean blends. Protein is crucial to the regulation and maintenance of the body.

The carbohydrate contents of the cookies were significantly different ($p < 0.05$) from each other except sample BCN (80% WF: 10% BNF: 10% OFSP) and CFC (80% WF: 5% BNF: 15% OFSP). The carbohydrate content ranged from 63.33 to 68.79% with sample CFC (80% WF: 5% BNF: 15% OFSP) having the least mean value while LVG (90% WF: 0% BNF: 10% OFSP) had the highest mean value. The increase in carbohydrate content in LVG could be due to increase in proportion of the OFSP in the flour blends. However, the carbohydrate contents of the cookies were generally high which compared favourably with that (65.95 – 71.68%) reported by Arukwe (2020) for biscuits produced from wheat, cocoyam and pigeon pea blends. Therefore, the relative high carbohydrate content of the cookies made it a cheap source of energy.

The moisture content of the cookies was significantly different ($p < 0.05$) from each other except sample BVB (100% WF) and LVG (90% WF: 0% BNF: 10% OFSP). The moisture content ranged from (5.70 to 8.57%) with sample BCN (80% WF: 10% BNF: 10% OFSP) having the least mean value while CFC (80% WF: 5% BNF: 15% OFSP) had the highest mean value. The high moisture content obtained in CFC could be attributed to high moisture content of root crops (Orange fleshed sweet potatoes).

However, the range of moisture content obtained was below 10%, which was in agreement with SON (2007) recommended moisture level for safe storage. From the result, the moisture content of cookies was low, which is an indication that the product will have a longer shelf life.

The fat content of the cookies was significantly different ($p < 0.05$) and ranged from 11.02 to 13.02% with sample LVG (90% WF: 0% BNF: 10% OFSP) having the least mean value while BCN (80% WF: 10% BNF: 10% OFSP) had the highest mean value. The increase in fat content in BCN could be due to the increase in proportion of the bambara nut in the flour blends which Yusuf *et al.* (2008) reported that it contains 6.00 to 7.00% fat.

The fibre content of the samples was significantly different ($p < 0.05$) except sample BVB (100% WF) and CFC (80% WF: 5% BNF: 15% OFSP). The fibre content ranged from 2.33 to 4.03% with sample LVG (90%WF: 0% BNF: 10% OFSP) having the least mean value while BCN (80% WF: 10% BNF: 10% OFSP) had the highest mean value. Also, the fibre content obtained was at the same range with that (1.05 – 3.20%) reported by Arukwe (2020) for biscuits produced from wheat, cocoyam and pigeon pea blends. Sample BCN increased in fibre content due to increase in proportion of bambara nut and orange fleshed sweet potato flour. The increase in fibre was observed as an improvement in the nutrient status since they are agents in food which aids in absorption during digestion process.

Ash content of the cookies was significantly different ($p < 0.05$) except for sample ACC (90% WF: 5% BNF: 5% OFSP) and CFC (80% WF: 5% BNF: 15% OFSP). The ash content of the samples ranged from 1.23 to 1.54% with sample BVB (100% WF) having the least mean value while BCN (80% WF: 10% BNF: 10% OFSP) had the highest mean value. The increase of flour blends substitution in sample BCN yielded more ash compared to BVB. Also, the results obtained were found lower than values (1.83 – 3.95%) reported by Arukwe *et al.* (2021) for cookies produced from blends of African yam bean, sorghum and wheat. Iwe *et al.* (2016)

affirmed that the ash content of food gives an idea of the total quantity of the mineral elements in the food.

Beta-Carotene Content of Cookies from Wheat, Orange Fleshed Sweet Potato and Bambara Nut Flour Blends

The beta-carotene (pro-vitamin A) content of the cookies was significantly different ($p < 0.05$) from each other (Table 3). From the results, sample BVB (100% WF) had the least mean value of 5.51 $\mu\text{g}/100\text{g}$ while CFC (80% WF: 5% BNF: 15% OFSP) had the highest mean value of 10.33 $\mu\text{g}/100\text{g}$. The high values of beta-carotene in sample LVG, BCN and CFC indicated that they are good sources of vitamin A and can significantly contribute towards reducing vitamin A deficiency among children from 6 months to 5 years of age (Imdad *et al.*, 2010). Sample BVB (100% wheat flour) had the least mean value which showed that wheat is a poor source of beta-carotene. In contrast to sample CFC (80% WF: 5%BNF: 15% OFSP), it could be said that the increase in proportion of orange fleshed sweet potato in the flour blends resulted in the high yield of beta-carotene.

Functional Properties of Flour Blends of Wheat, Orange fleshed sweet potato and Bambara nut

The functional properties of the samples are presented in Table 4. The bulk density (BD) ranged from 0.77 to 0.81 g/ml. Sample BCN (80% WF: 10% BNF: 10% OFSP) was significantly different ($P < 0.05$) from other samples having the least mean value while LVG (90% WF: 0% BNF: 10% OFSP) and CFC (80% WF: 5% BNF: 15% OFSP) had highest mean value respectively. Bulk density gives an indication of the relative volume of packaging material required and high bulk density is a good physical attribute when determining the mixing quality of a particulate matter (Udensi and Eke, 2000). The oil absorption capacity ranged from 1.93 to 2.22 with sample ACC (90% WF: 5%

BNF: 5% OFSP) having the least mean value while LVG (90% WF: 0% BNF: 10% OFSP) had the highest absorption. There was significant different ($p < 0.05$) among the blends. Oil flavours and gives soft texture to food as absorption of oil by food products improves mouth feel and flavour retention. The increase in oil absorption may be attributed to the presence of more hydrophobic proteins which show superior binding of lipids (Issoufou *et al.*, 2017).

The water absorption capacity ranged from 1.13 to 2.03 ml/g with sample BVB (100% WF) having the least mean value while BCN (80% WF: 10% BCN: 10% OFSP) had the highest mean value. There was significant different ($p < 0.05$) among different blends. Water absorption capacity is important in bulking and consistency of products as well as in baking applications (Niba *et al.*, 2001).

The emulsion capacity ranged 45.04 to 61.56 g/ml with sample LVG (90% WF: 0% BNF: 10% OFSP) having the least mean value while BVB (100% WF) had the highest mean value. High emulsion capacity is an indication that the flour samples could be an excellent emulsifier in various foods (Andres *et al.*, 2006).

The wettability ranged from 0.24 to 1.55 min/sec with sample BCN having the least mean value while BVB (100% WF) had the highest mean value. There was significant different ($p < 0.05$) among the blends. Wettability is a function of ease of dispersing flour samples in water. Sample BCN (80% WF: 10% BNF: 10% OFSP) with the least wettability dissolved fastest in water.

Physical Properties of Cookies from Wheat, Orange flesh sweet potato and Bambara nut flour blends

The weight, diameter and volume (Table 5) ranged from 30.76 to 36.05g, 6.19 to 6.52cm and 24.82 to 27.33cm³ respectively. The density did not follow any trend in increment

or decrement but it was observed that weight and volume increased as substitution of wheat flour with bambara nut and orange fleshed sweet potato from 5 to 15%. These results were similar to those reported by Okpala and Ofoedu (2018) for biscuit produced from blends of wheat and sweet potato flours fortified with brewer's spent grain flour. Thickness and spread ratio ranged from 0.82 to 0.87cm and 7.52 to 7.95 respectively. There was no significant difference ($p < 0.05$) in thickness and spread ratio which is an indication that the samples correlated with each other in sizes. The spread ratio is an indicator of cookie quality. Okaka and Isieh (1990) also reported a similar trend in biscuits produced from wheat and cowpea flours. The break strength of the samples ranged from 10.28 to 12.95kg respectively with sample BVB (100% WF) having the least mean value while BCN (80% WF: 10% BNF: 10% OFSP) and CFC (80% WF: 5% BNF: 15% OFSP) had the highest mean value respectively. There was significant different ($p < 0.05$) among the samples. The break strength decreased with decrease in percentage of bambara nut and orange fleshed sweet potato flour.

Sensory Properties of Cookies from Wheat, Orange Fleshed Sweet Potato and Bambara Nut Blends

The results for sensory evaluation of the cookies are presented in Table 6. The results obtained showed no significant different ($p > 0.05$) in appearance. The appearance values showed that sample LVG (90% WF: 0% BNF: 10% OFSP) was most preferred with highest mean value of 7.00. This could be due to 10% substitution of OFSP with 90% wheat flour as OFSP possess an appealing colour. The colour of the baked cookies which is the principal part of the general appearance is an important parameter in the assessment of baked products. The textures of food products reflect the mouth feel. There

was no significant different ($p>0.05$) in texture of the cookies products. Sample ACC (90% WF: 5% BNF: 5% OFSP) had the highest mean value of 6.45 while CFC (80% WF: 5% BNF: 15% OFSP) had the least mean value of 5.45.

The cookies produced from 100% wheat flour (BVB) tasted better than those substituted with bambara nut and orange fleshed sweet potato having highest mean value of 7.15 while BCN (80%WF: 10% BNF: 10% OFSP) had the least taste with mean value of 5.45. Aroma is another attribute that influences the acceptance of baked goods even before they are tasted. Substitution of wheat flour with either bambara nut flour or orange fleshed sweet potato flour at different levels did not significantly affect the sensory scores of aroma. The highest mean value of 6.80 (like slightly) in aroma was obtained in sample BVB (100% WF). Crispness is a desirable quality of cookies. Crispness scores were significantly different ($P<0.05$) among the samples. The crispness ranged from 5.20 to 6.50 with sample CFC (80% WF: 5% BNF: 15% OFSP) having the least mean value while ACC (90% WF: 5% BNF: 5% OFSP) had the highest mean value. The less crispness in sample CFC (80% WF: 5% BNF: 15% OFSP) could be attributed to be increased incorporation of wheat with bambara nut and orange fleshed sweet potato flour.

The general acceptability level of the cookies was high which ranged from 6.35 to 7.50. Sample BVB (100% wheat flour) was most preferred with highest mean value of 7.50 ranking 8.0 on hedonic rating which interprets 'like very much'. Notwithstanding, the variations in the overall score of the cookies in the sensory evaluation, all samples possess an appealing colour, texture, taste, aroma and crispness. Also, all bambara nut and orange fleshed sweet potato substituted cookies were acceptable to the panelists scoring 70% and

above. Therefore, cookies with up to 20% level of bambara nut and orange fleshed sweet potato flour could be baked with satisfactory performance and acceptance.

CONCLUSION

From the results obtained in this study, wheat flour could therefore be replaced with up to 10% bambara nut flour and 15% orange fleshed sweet potato flour in cookie production without affecting the sensory qualities. The enriched cookies with bambara nut and orange fleshed sweet potato substitutions (composite) were found to be nutritionally superior to the 100% wheat cookies. The appreciable content of protein of the cookies could play an important role in combating or reducing Protein Energy Malnutrition (PEM) in developing countries. Also cookies with 15% substitution of orange fleshed sweet potato (CFC) had the highest value of beta-carotene (pro-vitamin A) than cookies produced with 100% wheat flour (BVB). The high pro-vitamin A content of the enriched cookies could be utilized to alleviate the vitamin A deficiency which is a serious public health problem in Africa.

Therefore, production of cookies from flour blends of wheat, bambara nut and orange fleshed sweet potato will not only improve the nutritional quality of the product, but also enhance the utilization of the legume and root crop.

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APPENDICES

Table 1: Formulation of composite flour wheat, bambara nut and orange fleshed sweet potato (%)

SAMPLE CODES	WHEAT FLOUR(WF)	BAMBARA FLOUR(BF)	OFSP FLOUR
1. BVB	100	-	-
2. ACC	90	5	5
3. LVG	90	-	10
4. BCN	80	10	10
5. CFC	80	5	15

KEY: WF=Wheat flour, BF=Bambara flour, OFSP=orange fleshed sweet potato, BVB=100% WF (100:0:0), ACC=90% WF: 5%BF: 5% OFSP (90:5:5), LVG=90% WF: 0% BF: 10% OFSP (90:0:10), BCN=80% WF: 10% BF: 10% OFSP (90:10:10), and CFC=80% WF: 5%BF: 15% OFSP (80:5:15).

Table 2: Proximate Compositions and Energy Values of Cookies from Wheat, Orange fleshed sweet potato and Bambara nut flour blends

Parameters (%)	Samples				
	BVB	ACC	LVG	BCN	CFC
Moisture	6.40 ^c ±0.05	7.33 ^b ±0.06	6.37 ^c ±0.15	5.70 ^d ±0.17	8.57 ^a ±0.12
Crude Protein	9.62 ^d ±0.05	11.11 ^b ±0.10	10.15 ^c ±0.02	11.93 ^a ±0.03	10.97 ^b ±0.55
Fat	11.32 ^d ±0.02	12.34 ^b ±0.03	11.02 ^c ±0.03	13.02 ^a ±0.03	12.03 ^c ±0.03
Crude Fibre	3.64 ^b ±0.03	3.01 ^c ±0.02	2.33 ^d ±0.10	4.03 ^a ±0.03	3.67 ^b ±0.03
Ash	1.23 ^d ±0.04	1.42 ^b ±0.03	1.34 ^c ±0.03	1.54 ^a ±0.02	1.46 ^b ±0.03
Carbohydrate	67.78 ^b ±0.41	64.72 ^c ±0.24	68.79 ^a ±0.21	63.78 ^d ±0.10	63.33 ^d ±0.69
Energy (k/cal)	411.59 ^c ±1.4	414.38 ^b ±0.39	414.95 ^b ±0.96	420.03 ^a ±0.79	405.46 ^d ±0.35

Values are Means ± standard deviation of triplicate determinations ^{a-c} Means bearing the same superscripts within the same rows are not significantly (P>0.05) different.

KEY: BVB=100% WF (100:0:0), ACC=90% WF: 5%BF: 5% OFSP (90:5:5), LVG=90% WF: 0% BF: 10% OFSP (90:0:10), BCN=80% WF: 10% BF: 10% OFSP (90:10:10), and CFC=80% WF: 5%BF: 15% OFSP (80:5:15)

Table 3: β -Carotene Content of Cookies from Wheat, Orange fleshed sweet potato and Bambara nut flour blends

Parameters ($\mu\text{g}/100\text{g}$)	Samples				
	BVB	ACC	LVG	BCN	CFC
β -Carotene	5.51 ^e ±0.14	6.29 ^d ±0.02	8.60 ^b ±0.04	8.40 ^c ±0.02	10.33 ^a ±0.06

Table 4: Functional Properties of the flour blends

Parameters	Samples				
	BVB	ACC	LVG	BCN	CFC
BD(g/ml)	0.80 ^a ±0.00	0.80 ^a ±0.00	0.81 ^a ±0.17	0.77 ^b ±0.00	0.81 ^a ±0.02
OAC (g/ml)	2.03 ^b ±0.04	1.93 ^c ±0.03	2.22 ^a ±0.03	1.94 ^c ±0.04	2.02 ^b ±0.02
WAC(g/ml)	1.13 ^e ±0.03	1.63 ^b ±0.00	1.23 ^d ±0.03	2.03 ^a ±0.03	1.53 ^c ±0.04
EC(g/ml)	61.56 ^a ±0.5	53.40 ^d ±0.15	45.04 ^e ±0.04	60.06 ^b ±0.06	55.55 ^c ±0.05
W(Min/sec)	1.55 ^a ±0.02	0.42 ^c ±0.02	1.12 ^b ±0.02	0.24 ^e ±0.04	0.35 ^d ±0.04

BD=bulk density, OAC=oil absorption capacity, WAC=water absorption capacity, EC=emulsion capacity, W=wettability

Table 5: Physical properties of cookies from Wheat, Orange fleshed sweet potato and Bambara nut flour blends

Parameters	Samples				
	BVB	ACC	LVG	BCN	CFC
Weight (g)	30.76 ^d ±0.04	32.18 ^c ±0.04	32.84 ^c ±0.47	36.05 ^a ±0.23	35.10 ^b ±0.23
Diameter(cm)	6.32 ^b ±0.04	6.31 ^b ±0.01	6.26 ^b ±0.10	6.52 ^a ±0.02	6.19 ^b ±0.01
Volume (cm ³)	26.30 ^{ab} ±0.74	25.48 ^{ab} ±0.77	25.38 ^{ab} ±0.59	27.33 ^a ±1.12	24.82 ^b ±0.33
Density(g/cm ³)	1.17 ^c ±0.03	1.26 ^{bc} ±0.04	1.29 ^b ±0.04	1.32 ^{ab} ±0.07	1.42 ^a ±0.01
Thickness(cm)	0.87 ^a ±0.02	0.82 ^a ±0.02	0.83 ^a ±0.01	0.82 ^a ±0.03	0.83 ^a ±0.02
Spread ratio	7.52 ^a ±0.09	7.75 ^a ±0.19	7.59 ^a ±0.19	7.95 ^a ±0.25	7.66 ^a ±0.23
Break strength (kg)	10.28 ^c ±0.04	10.70 ^{bc} ±0.49	11.27 ^b ±0.00	12.95 ^a ±0.16	12.95 ^a ±0.16

Table 6: Sensory properties of cookies from Wheat, Orange fleshed sweet potato and Bambara nut flour blends

Parameters	Samples				
	BVB	ACC	LVG	BCN	CFC
Appearance	6.65 ^a ±1.27	6.90 ^a ±1.29	7.00 ^a ±1.49	6.60 ^a ±0.94	6.25 ^a ±1.68
Texture	6.10 ^a ±1.33	6.45 ^a ±1.10	5.85 ^a ±1.69	5.85 ^a ±1.35	5.45 ^a ±2.06
Taste	7.15 ^a ±1.31	6.40 ^{ab} ±1.57	5.75 ^b ±1.29	5.45 ^b ±1.80	6.40 ^{ab} ±1.57
Aroma	6.80 ^a ±1.20	6.10 ^{ab} ±1.33	6.00 ^{ab} ±1.62	5.35 ^b ±1.90	6.20 ^{ab} ±1.58
Crispness	6.05 ^{ab} ±1.64	6.50 ^a ±0.89	5.75 ^{ab} ±1.89	5.25 ^b ±1.71	5.20 ^b ±2.12
General Acceptability	7.50 ^a ±1.47	7.10 ^{ab} ±1.07	6.70 ^{ab} ±1.34	6.35 ^b ±0.88	6.35 ^b ±1.63

Values are Means ± standard deviation of the determinations ^{a-c} Means with the same superscripts within the same rows are not significantly different (P>0.05)

KEY: BVB=100% WF (100:0:0), ACC=90% WF: 5%BF: 5% OFSP (90:5:5), LVG=90% WF: 0% BF: 10% OFSP (90:0:10), BCN=80% WF: 10% BF: 10% OFSP (90:10:10), and CFC=80% WF: 5%BF: 15% OFSP (80:5:15).