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Nutrients, antioxidant and sensory evaluation of complementary food produced from soybeans, orange flesh sweet potato and sorghum fortified with tropical almond seed

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ABSTRACT: It is a known fact that at the age of 6 months, breast milk is no longer sufficient to meet the daily nutrient requirements of an infant; as such, the introduction of complementary foods becomes necessary to fill the energy and nutrient gap. This study determined the nutrients, antioxidant composition, and sensory attributes of the complementary foods produced from a blend of soybeans, orange flesh, sweet potato, and sorghum fortified with tropical almond seed. Raw materials and other ingredients used for this production were purchased from Ojakoko in Owo Local Government, Ondo State. Three samples were formulated in different ratios. Sample SST1: Sorghum: Soybean: Almond Seed (70:20:10); sample OST2: Orange Flesh Sweet Potato: Soybean: Tropical Almond Seed (70:20:10); and sample OSST3: Orange Flesh Sweet Potato: Sorghum: Soybean: Tropical Almond Seed (40:30:20:10). A commercial complementary food was used as a control. Samples were subjected to chemical and instrumental analysis according to the standard method, while a 9-point hedonic scale was used for the sensory characteristics of the samples. The data obtained were statistically analysed using an analysis of variance (ANOVA) performed using Statistical Package for Social Science (SPSS) version 25. The difference was considered statistically significant at $p<0.05$. The results show that ash, fat, crude fibre, and protein were significantly ($p<0.05$) higher in sample SST1. Moisture and carbohydrate content were higher in OSST3 but lower in ash, fat, crude fibre, and protein content. Mineral composition revealed that Na, Ca, K, Mg, Fe, Zn, and Mn were significantly ($p<0.05$) higher in SST1, while P and Se were significantly ($p<0.05$) higher in sample OST2. Beta-carotene, Vitamin E, B1B2, and B6 were significantly ($p<0.05$) higher in sample SST1, while OSST3 had the highest value of vitamin B3 and vitamin B5. The antioxidant content shows that total phenol and flavonoid were significantly ($p<0.05$) higher in sample OSST3, while sample SST1 had the least value for total phenol. The sensory evaluation results show that sample SST1 was the most acceptable in terms of flavour (7.87), aroma (8.00), mouth-feel (7.80), aftertaste (7.80), and colour (7.27). There was no significant difference ($p<0.05$) between samples. In conclusion, the study showed that the addition of OFSP and tropical almonds improved the nutrient content of the complementary foods formulated.

Keywords: Complementary food, OFSP, flavonoid, protein, sorghum, vitamins, minerals.

INTRODUCTION

Malnutrition is one of the principal causes of death for many of the world's children, contributing to more than one-third of under-five deaths globally (UNICEF, 2021). Generally, the risk of malnutrition in the first two years of life has been directly linked with poor complementary food for infants and a high rate of infectious diseases (Ademulegun *et al*., 2021). The first 1000 days (from conception to a child's second birthday) are a critical period for good human nutrition, health, and development, of which the benefit could last throughout the whole life (Adu-Afarwuah *et al*., 2017). Malnutrition (under-nutrition, micronutrient deficiency, and overweight/obesity) during these periods could increase the rate of morbidity and mortality (Black *et al*., 2013). In the long run, nutrition during the first 1000 days may have an impact on infant health. As infants grow, nutrient requirements increase with an increase in age and metabolic function, which cannot be met by breast milk alone. Therefore, the food and nutrient intake of the infants as supplied by breast milk alone could no longer cater for the nutritional needs of the infant, and as such, breast milk needed to be complemented (Ademulegun *et al*., 2021). The characteristics and qualities of complementary food and feeding practices are crucial to the continued development and nourishment of the infant (Bolarinwa *et al*., 2016). The introduction of other foods and liquids, known as complementary foods, to support breast milk is the most brilliant scientific discovery to promote nourishment and prevent malnutrition among this age group (Igyor *et al*., 2010). Therefore, during this period, there is always the need to introduce soft, easily swallowed foods to supplement the nutritional needs of infants in life (Nnam, 2012).

In tropical developing countries like Nigeria, where the supply of animal protein is inadequate to meet the rapid population growth, intense research efforts are currently directed towards the identification and evaluation of food grains, which normally have considerable protein content (Msheliza *et al*., 2018). The addition of legumes to plant-based foods is reported to improve the protein content and provide deficient amino acids in complementary foods (Egounlety, 2002; Ademulegun *et al*., 2021). Enriching complementary foods with soybeans and tropical almonds is a convenient, inexpensive, and highly effective way to upgrade the quality of traditional complementary foods and to provide the nutrition a growing child need. Soybeans work together with cereals to achieve an overall increase in the value of the protein (Msheliza *et al*., 2018). Other seeds are rich in functional components such as vitamin E and pro-vitamin D and are good sources of magnesium, potassium, and phosphorus, as well as other minor minerals such as zinc, magnesium, iron, calcium, sodium, and copper (Amin *et al*., 2019). They are also used for fortification up to 10%, which increases the protein, lysine, mineral contents, total sulphur amino acids, chemical score, protein digestibility, crude fat, and ash of the final product compared to using 100% wheat flour (Broznić *et al.*, 2016; Koh *et al*., 2018; Amin *et al*., 2019). The need for improvement in the nutritional quality of complementary foods cannot be overemphasized. Under the present economic conditions in developing countries, the best means to properly enhance child feeding is by encouraging increased use of inexpensive and available plant protein sources such as legumes, cereals, tubers, and nuts. Therefore, knowledge of the nutrients and antioxidant composition of complementary foods produced from soybeans, orange flesh, sweet potatoes, and sorghum fortified with tropical almond seed will help reduce the occurrence of some micronutrient deficiencies.

MATERIALS AND METHODS

Procurement of raw materials

The grains used are sorghum (*Sorghum bicolor)* and soybean *(Glycine max),* which were supplied by Tunakins Nutrition Farm, Akure, Ondo State, while orange flesh sweet potato (*Ipomoea batatas*) and tropical almond seed *(Terminalia catappa)* were obtained from Mr. Mukaila Farm Limited, Offa, Kwara State, and Shasha Market in Akure, Ondo State, respectively.

Production of complementary foods

The three samples of complementary food (SST, OST, and OSST) were produced in a different ratio using the following ingredients: sorghum (sorghum bicolor), soybean *(Glycine max),* orange flesh sweet potato (Ipomoea batatas), and tropical almond *(Terminalia catappa),* as revealed in Table 1.

Sorghum grains were sorted, washed, oven dried, and milled into flour by adopting the method described by Awolu *et al*. (2015), while soybeans were cleaned, sorted, washed, and boiled in water at 100°C for 30 minutes. It was dehulled manually, sundried, roasted, milled into flour using an attrition mill machine, and sieved to remove coarse material in line with the procedure of Oluwamukomi *et al*., (2005). A modified version of the method described by Adeleke and Odedeji (2010) was adopted for the processing of the orange flesh sweet potato flour.

Chemical analysis of the complementary foods

Samples were analysed for proximate and vitamin composition using standard methods of the AOAC (2012). The moisture content was determined by drying the samples to a constant weight in an electric oven at 105°C for 12 hours. The total nitrogen was determined by the Micro-Kjeldahl method, and crude protein was estimated by multiplying the total nitrogen (N) by 6.25, a conversion factor. The total lipid content was estimated by petroleum ether extraction using a Soxhlet apparatus. The total ash was estimated after incinerating in a muffle furnace for 12 hours at 550°C. Total carbohydrate content was determined by differences.

Determination of mineral contents

The iron, zinc, phosphorus, calcium, sodium, and potassium contents of all the soup samples were determined on

Table 1. Formulation of sorghum, soybeans and orange flesh sweet potato and tropical almond seed.

Samples	Sorghum (%)	Soybean (%)	OFSP	Almond seed (%)
SST	70	20	-	10
OST	-	20	70	10
OSST	30	20	40	10

Key: SST = 70% Sorghum; 20% Soybeans; 10% Tropical almond OST = 70% Orange flesh potato; 20% Soybeans; 10% Tropical almond OSST = 40% Orange flesh potato; 30% Sorghum; 20% Soybeans; 10% Tropical almond, Control (cerelac).

aliquots of the solutions of the ash using UV/visible and atomic absorption spectrophotometers (AOAC, 2012). Phosphorus was determined by the molybdo-vanadate solution method (AOAC, 2012).

Determination of Vitamin A (Beta Carotene)

Two gram (2 g) of the sample was weighed into a 250 ml volumetric flask, and 50 ml of petroleum ether and acetone (2:1 v/v) mixture was added to the extract of ß-carotene. The flask containing the mixture was placed on a shaker to shake at 200 rpm for 20 minutes to ensure uniform mixing at room temperature. The mixture was later centrifuged at 4000 rpm for 10 minutes, and the supernatant was collected and made up to 50 ml with the solvent mixture. The supernatant was transferred to a 250-ml separatory funnel to separate the organic layer (upper layer). The aqueous layer was discarded, and the organic layer was transferred into the 50-ml volumetric flask and made up with a solvent mixture for the reading of ß-carotene. Working standards of ß-carotene in the range of 0–50 ppm or /ml were prepared from stock beta-carotene solutions of 100 ppm concentration. The absorbances of samples as well as working standard solutions were read on a Cecil 2483 UV Spectrophotometer at a wavelength of 450 nm against a blank.

B-carotene (µg/100 g) = absorbance of sample x average gradient x dilution factor.

Determination of Vitamin E (Tocopherol)

A suitable weight of sample (1.0 g) was placed in a 100-ml flask fitted with a reflux condenser, and then 10 ml of absolute alcohol and 20 ml of 1M alcoholic acid were added. Then it was refluxed for 45 minutes and cooled. Fifty (50 ml) liters of water were added, and it was transferred to a separating funnel of low-actinic glass with the addition of another 50 ml of water. The unsaponifiable matter was extracted with 5 × 30 ml diethyl ether, and the combined ether extract free from acid was washed and dried over anhydrous sodium sulphate. The extract was evaporated at a low temperature. Protecting it from sunlight, the residue was dissolved in 10 ml of absolute alcohol, then both the standard and the sample were transferred to a 20 ml volumetric flask, and 5 ml of absolute alcohol was added, followed by 1 ml of concentrated nitric acid. The flask was placed in a water bath at 90°C for 3 minutes. It was cooled under running water, and the volume was made up to 20 ml with absolute alcohol. The absorbance was measured at 470 nm against a blank containing absolute alcohol.

Determination of Vitamin B1 (Thiamine)

Five grammes (5 g) of the sample were homogenised with 50 ml of ethanoic sodium hydroxide. It was filtered into a 100-ml conical flask, 10 ml of the filtrate was pipette, and the colour was developed by adding 10 ml of 5% potassium dichromate and reading the absorbance at 360 nm. A blank solution is also prepared (Okwu and Ndu, 2006).

Determination of Vitamin B2 (Riboflavin)

Five grammes (5 g) of the sample were extracted with 100 ml of 50% ethanol and shaken for one hour. This was filtered into a 100-ml flask, and 10 ml of the extract was pipetted into a 50-ml volumetric flask. 10 ml of 5% potassium permanganate and 10 ml of 30% H_2O_2 were added and allowed to stand over a hot water bath for 30 minutes. 2 ml of 40% sodium sulphate was added. This was made up to a 50-ml mark, and the absorbance was measured at 510 nm using a spectrophotometer.

Determination of Vitamin B3 (Niancin)

Five grammes (5 g) of the sample were treated with 50 ml of IN H_2S0_4 and shaken for minutes. 3 drops of ammonia solution were added to the sample and filtered. The filtrate was pipetted into a 50-ml volumetric flask, and 5 ml of potassium cyanide was added. This was acidified with 5 ml of 0.02N H_2S0_4, and absorbance was measured using a spectrophotometer at 470 nm (Okwu and Ndu 2006).

Determination of Vitamin B6 (Pyridoxine Hydrochloride)

Half (0.5 ml) of the sample was pipette into the test tube. Then 1.5 ml of diazotized p-nitroaniline (5 mM) reagent solution and 3 ml of CTAB are added. The mixture is shaken, then 3 ml of (0.1 N) sodium carbonate solution is added, and the volumes are made up to the mark with 5 ml of distilled water. The mixtures are shaken, and the absorbances are measured at 480 nm against the corresponding reagent blank.

Determination of Vitamin B9

The samples were then centrifuged again at 4000× g for 20 min at 4°C. The final supernatant was then filtered using 0.45-μm filter pore size, 25-mm inner diameter, nylon disposable syringe filters, and the filtrates were purified through solid-phase extraction on strong anion-exchange isolute cartridges. The chromatographic separation method previously described was used, with slight modifications.

Determination of antioxidants

For total alkaloids determination, 5 g of the samples were weighed into a 250-ml beaker, and 200 ml of 10% acetic acid in ethanol was added, covered, and allowed to stand for 4 hours (12). Saponin was extracted for 2 hours in a reflux condenser containing pure acetone in line with a method described by Sofowora (1993). Total Flavonoid content was estimated using the procedure described by Zhishen *et al*. (1999), while phytate was determined using the method described by McCance-Widdowcon as modified by Wheeler and Ferrel (1971).

Statistical analysis

The results were expressed as mean ± standard deviation, and the test for statistical significance was carried out using one-way analysis of variance (ANOVA). The Statistical Package for Social Sciences (SPSS, Version 20) software was used to determine significant differences. Significant means were separated using Duncan's New Multiple Range Test (DNMRT), and differences were considered significant at $p<0.05$.

Ethical approval

Ethical approval reference number RUGIPO/NUD/2023/120 was obtained for the study from the Ethic Committee of the Department of Nutrition and Dietetics, Rufus Giwa Polytechnic, Owo, Ondo State.

RESULTS

Proximate composition of complementary food

Table 2 shows the proximate composition of complementary foods. Sample OSST significantly ($p<0.05$) contained the highest value of moisture (12.29%), while samples SST and OST contained 12.034 and 11.29%, respectively. The ash content shows that sample SST significantly ($p<0.05$) contained 3.29%, while sample OST and OSST had 2.77 and 2.54%, respectively. Sample SST had the highest value for fat content (6.19%), while sample OSST had the least value (5.14%). The crude fibre was significantly ($p<0.05$) higher in sample SST with a value of 4.31%, while C had the least value (3.73%). Sample A had the highest value for protein content (26.46%), while sample OSST had the least value (22.82%). Sample OSST significantly ($p<0.05$) contained the highest value of carbohydrate (53.42%), while samples SST and OST contained 47.71 and 52.87%, respectively.

Minerals composition of complementary food

Table 3 shows that sample SST significantly ($p<0.05$) contained the highest value of sodium (92.50 ppm), while sample OST and sample OSST contained 60.30 ppm and 70.45 ppm, respectively. In the values obtained for calcium content, sample A significantly ($p<0.05$) contained 1.36 ppm, while samples OST and OSST had 1.24 and 1.18 ppm, respectively. Sample SST had the highest value for potassium content (2.05 ppm), while sample OST had the least value (1.70 ppm). The result also showed that magnesium was significantly ($p<0.05$) higher in sample A (26.35 ppm), while OST had the least value (22.47 ppm). Sample SST had the highest value for iron content (1.20 ppm), while sample OST had the least value (0.84 ppm). Sample SST significantly ($p<0.05$) contained the highest value of zinc (2.77 ppm), while samples OST and OSST contained 2.27 ppm and 2.07 ppm, respectively. Sample OST had the highest value for phosphorus content (91.21 ppm), while sample SST had the least value (80.62 ppm).

Vitamins and antioxidant composition of complementary foods

The antioxidant content of the sample is shown in Table 4. Total phenol and flavonoid were significantly ($p<0.05$) higher in sample OSST (18.64 and 25.70 mg/g, respectively). Sample SST had the least value for total phenol (13.45 mg/g), followed by sample OST (17.34 mg/g). Sample SST had the least value of flavonoid (18.44 mg/g), followed by sample OST (25.11 mg/g). Sample SST had the highest beta-carotene (280/100g) and Vitamin E

Table 2. Proximate composition of complementary food.

Proximate (grams)	SST	OST	OSST	Control
Moisture	12.03±0.12^{b}	11.64±0.01^{c}	12.29±0.02^{a}	2.50±0.01^{d}
Ash	3.29±0.03^{a}	2.77±0.05^{c}	2.54±0.03^{d}	3.00±0.01 ^{b}
Crude fibre	6.19±0.01^{a}	5.45±0.06^{b}	5.14±0.02^{c}	4.50±0.01^{d}
Crude fat	4.31±0.01^{b}	3.96±0.03^{c}	3.73±0.02^{d}	10.0±0.01^{a}
Crude protein	16.46±0.05^{a}	13.28±0.01^{b}	12.82±0.01^{c}	15.0±0.01 ^{d}
Total carbohydrate	57.71±0.07^{d}	62.87±0.58^{c}	63.45±0.02^{b}	65.0±0.01^{a}

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same columns are statistically not significant at (P<0.05). Key: SST = 70% Sorghum; 20% Soybeans; 10% Tropical almond OST = 70% Orange flesh potato; 20% Soybeans; 10% Tropical almond OSST = 40% Orange flesh potato; 30% Sorghum; 20% Soybeans; 10% Tropical almond, Control (cerelac).

Table 3. Minerals composition of complementary food.

Minerals (mm/100g)	SST_1	OST_2	$OSST_3$	Control
Sodium	92.50±0.28^{a}	60.30±0.28^{c}	70.45±0.21^{b}	145.0±0.010^{a}
Calcium	1.36±0.14^{a}	1.24±0.14^{b}	1.18±0.07^{c}	600.0±0.010^{a}
Potassium	2.05±0.01^{a}	1.70±0.21^{c}	1.94±0.84^{b}	635.0±0.010^{a}
Magnesium	26.35±0.02^{a}	22.47±0.01^{c}	23.53±0.03^{b}	NA
Iron	1.20±0.00^{a}	0.84±0.00^{c}	0.92±0.00^{b}	6.00±0.010^{a}
Zinc	2.77±0.03^{a}	2.27±0.04^{b}	2.07±0.04^{c}	7.00±0.010^{a}
Manganese	0.72±0.01^{a}	0.35±0.00^{c}	0.47±0.01^{b}	NA
Copper	0.50±0.00^{b}	0.33±0.01^{c}	0.57±0.00^{a}	NA
Phosphorus	80.62±0.01^{c}	91.21±0.00^{a}	90.82±0.02^{b}	NA
Selenium	0.12±0.01^{b}	0.16±0.00^{a}	0.15±0.00^{a}	NA

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same rows are statistically not significant at (P<0.05). **Key:** SST_1 = 70% Sorghum; 20% Soybeans; 10% Tropical almondOST_2 = 70% Orange flesh potato; 20% Soybeans; 10% Tropical almond$OSST_3$ = 40% Orange flesh potato; 30% Sorghum; 20% Soybeans; 10% Tropical almond seed and Control (cerelac).

Table 4. Vitamin and Antioxidant composition of complementary food.

Vitamins(mg/100g)	SST_1	OST_2	$OSST_3$	Control
Vitamin B_1(mg/g)	0.62± 0.12^{b}	0.54±0.12 ^{d}	4.62±0.02 ^{a}	0.60±0.010 ^{c}
Vitamin B_2(mg/g)	0.44±0.10 ^{b}	0.29±0.11^{c}	4.83± 0.01^{a}	0.45±0.010 ^{b}
Vitamin B_3(mg/g)	0.37±0.00^{c}	0.43±0.02^{b}	5.19±0.00^{a}	3.00±0.010^{b}
Vitamin B_5 (mg/100g)	2.48±0.012	2.29±0.019	2.80±0.013	1.60±0.010
Vitamin B_6(mg/g)	3.75±0.35^{a}	2.75±0.07^{b}	2.40±0.14^{d}	0.30±0.010^{b}
Vitamin B_9(mcg/g)	36.20±0.14^{b}	42.50±0.00^{a}	33.95±0.07^{c}	40.0±0.010^{b}
Vitamin C	46.20±0.14^{d}	48.50±0.00^{c}	49.95±0.07^{b}	65.0±0.010 ^{a}
Beta-carotene(mg/100g)	280±0.00^{a}	208±0.00^{a}	120±0.01^{c}	1300±0.010
Vitamin E (mg/100g)	281±0.01^{a}	250±0.00^{b}	243±0.01^{c}	NA
Flavonoid (mg/g)	18.44±0.02^{c}	25.11±0.04^{b}	25.70±0.01^{a}	NA
Total phenol(mg/g)	13.45±0.07^{c}	17.34±0.05^{b}	18.64±0.02^{a}	NA

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same rows are statistically not significant at (P<0.05). **Key:** SST_1 = 70% Sorghum; 20% Soybeans; 10% Tropical almondOST_2 = 70% Orange flesh potato; 20% Soybeans; 10% Tropical almond$OSST_3$ = 40% Orange flesh potato; 30% Sorghum; 20% Soybeans; 10% Tropical almond seed and Control.

(2.81 mg/100g) while sample OSST had the least beta-carotene (120/mg), vitamin E (2.43 mg/100g). Vitamin B6 (32.75 mg/100 g) and vitamin B9 (42.50 mg/100g) were significantly (p<0.05) higher in sample SST and OST, respectively, while sample OSST had the highest value of vitamin B3 (5.19 mg/100 g). The control sample had the highest values of vitamin A (1300 mg/100 g) and vitamin B9 (40 mg/100 g).

Table 5. Sensory evaluation of complementary food.

Samples	Flavour	Aroma	Mouthfeel	After taste	Colour	Acceptability
SST_1	$7.53±0.74^{ab}$	$8.00±0.75^{a}$	$7.80±1.08^{a}$	$7.00±1.31^{a}$	$7.27±1.22^{a}$	$7.60±1.24^{a}$
OST_2	$7.27±0.59^{b}$	$6.73±1.53^{b}$	$6.73±0.78^{a}$	$6.20±1.70^{c}$	$6.60±0.73^{b}$	$6.70±1.50^{b}$
$OSST_3$	$6.87±0.59^{b}$	$6.13±1.52^{b}$	$7.73±0.78^{a}$	$6.90±1.70^{b}$	$6.10±0.73^{c}$	$6. 30±1.50^{c}$
Control	$7.53±0.74^{ab}$	$8.00±0.75^{a}$	$7.80±1.08^{a}$	$7.00±1.31^{a}$	$7.27±1.22^{a}$	$7.60±1.24^{a}$

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same rows are statistically not significant at (P<0.05). **Key:** SST_1 = 70% Sorghum; 20% Soybeans; 10% Tropical almondOST_2 = 70% Orange flesh potato; 20% Soybeans; 10% Tropical almond$OSST_3$ = 40% Orange flesh potato; 30% Sorghum; 20% Soybeans; 10% Tropical almond seed and Control.

Sensory evaluation of complementary food

Table 5 shows the sensory evaluation of the complementary food. Sample OSST had the highest values in terms of flavour (7.87), while sample OST had the lowest flavour (7.27). Sample A had the highest value of 8.00 in terms of aroma. Sample SST had the highest value of mouth feel (7.80), while sample OSST had the least value of 7.44. As for mouth-feel, after taste and colour, there was no significant difference ($p<0.05$) between samples.

DISCUSSION

The moisture contents of the samples were low, but their values were higher than 8.80-10.57% reported by Yusufu *et al*. (2013) on complementary foods formulated from sorghum, African yam bean, and mango mesocarp flour blends. The low moisture content observed in these samples indicated their potential to have a longer shelf life. This is in line with the findings of Vincent (2002). Moisture has implications in terms of the consistency, texture, and microbiological quality of food (Makinde and Ladipo, 2012). Complementary foods should be free from microbial contamination that might expose children to diarrhoea. Olaoye *et al*. (2006) reported that lower moisture content in food lowers and prevents the food from spoilage through microbial contamination.

The ash contents of the samples were lower than 4.0 mg. The percentage of ash in a food or product directly indicates the amount of mineral content present in such food or product. The increase in the percentage of sorghum in all the developed recipes of complementary foods brought about an increase in the ash content of the sample. This finding corroborates the findings of Aduke (2017). Ash is a non-organic compound reflecting the mineral content of food. Nutritionally, ash aids in the metabolism of other organic compounds such as carbohydrate and fat (Sowoola *et al*., 2002). FAO/WHO/UNICEF (2011) reported that the ash content of a complementary food should be less than 5%.

The fat contents of the samples were higher compared to 0.31 to 8.08% obtained by Akinola *et al*. (2014) on the formulation of local ingredient-based complementary food in south-west Nigeria. This could be attributed to the addition of soybeans and tropical almonds, which tend to increase the fat content. This is in agreement with the findings of Abraham *et al*. (2013), who also ascertained an increase in the fat content of maize-sorghum-moringa bread as the level of moringa leaf powder increased in the blend. Fat (essential fatty acids) is very important in the diets of infants, including young children; it also helps in the absorption and utilisation of fat-soluble vitamins (A, D, E, and K) and enhances sensory qualities (Dewey and Brown, 2002).

The crude fibre content of the complementary food samples was analysed, and the values were similar to 3.06% and 4.86% obtained by Chukwu *et al*. (2014) on the chemical composition of locally made complementary food standard recipes in Nigeria. It is very important that special attention be given to the fibre content of complementary foods prepared for infants since their intestines are not mature enough to absorb high fibre content. Actually, the samples meet the criteria set by CAC/GL 08 (1999) and CAC (2011), which report that fibre content should be less than 5%. This is because the presence of high quantities of fibre makes the food bulky and induces flatulence (CAC/GL 08, 1999; CAC, 2011), which might eventually trigger an uncomfortable feeling in the infant. Fibre may influence the efficiency of absorption of some nutrients of great importance in diets with marginal nutrient content (Asma *et al*., 2006).

The values of the protein content in this study were within the limit of the estimated daily amount of protein needed to be supplied by a complementary food required by breastfed infants aged 6–24 months (WHO/UNICEF, 2008). There was a significant ($p<0.05$) increase in the protein content of the samples. This could be due to the substitutional effect caused by the high protein content of soybeans. Soybean is known for its high protein content, which is above 43%, and likewise contains micronutrients helpful for brain development, especially for infants (Nnam, 2002). Abraham *et al*. (2013) reported similar trends. The protein is relatively lower than what was reported by Nwosu *et al*. (2014) in their study on complementary foods prepared from maize flour, soybean flour, and *Moringa oleifera* leaf powder. It can be logically concluded that the level of soybean in this formulation influences the increase in the protein content of the complementary foods. However, the samples meet the Codex Alimentarius Commission Guidelines of 15.00%.

The carbohydrate contents of the other two samples were significantly ($p<0.05$) lower than those of sample SST. The increase in total carbohydrate content of the samples is principally due to an increase in the proportion of orange flesh, potato flour, and sorghum used. The high carbohydrate contents of the samples observed in this study are nutritionally desirable, as children require energy to carry out their rigorous physical and physiological activities as growth continues (Ibironke *et al*., 2012). The Food and Nutrition Board of the National Research Council (2009) reported that more than half of the energy requirements beyond infancy should be provided by carbohydrates, with an emphasis on complex carbohydrates rather than sugars. The recommended minimum intake is 50 to 100 g/day.

The sodium content of the complementary food samples ranged from 60.30 to 92.50 ppm. These values were lower compared with the 132.60 to 140.13 ppm obtained by Mahmoud and Anany (2014) on the nutritional and sensory evaluation of a complementary food formulated from rice, faba beans, sweet potato flour, and peanut oil. Sodium is needed in the body in a small amount to help maintain normal blood pressure and the normal function of muscles and nerves. Sodium regulates homeostasis in the body and, likewise, aids the effective and proper functioning of both the muscles and nerves in the body (Payne, 2012).

Calcium is necessary for the optimal growth and development of infants and young children. The values of calcium obtained in this study were similar to the calcium content of 1.15 to 1.35 ppm obtained by Bolarinwa *et al*. (2016) on complementary foods formulated from malted millet, plantains, and soybean flour blends. The calcium content of the formulations varied significantly ($p<0.05$) among the samples. The increase in calcium content of the sample SST could be a result of increased supplementation (Lutter and Rivera, 2003). Soybean and sweet potatoes yield a positive increase in calcium content. According to the Codex Alimentarius standards, Ca concentrations in complementary foods should not be less than 45.51 mg/g of the dry food. On the basis of this standard, the samples did not exceed the minimum amount (45.51 g/g) specified in the Codex Alimentarius Standards (FAO/WHO, 2002).

The levels of potassium in the blends varied significantly ($p<0.05$) among the samples, and these values were lower than the potassium content of 293.11 to 346.20 mg/100g obtained from complementary foods produced from sorghum, African yam bean, and crayfish flours (Egbujie and Okoye, 2019). Potassium is probably the most sensitive mineral to this type of increase (Adrogué and Madias, 2007). This relatively high content of potassium seems to have been contributed more by sorghum, which had the highest potassium content compared with orange flesh potato flour and tropical almond seed. Potassium is required in the body for regulation of fluid, muscle control, and normal functioning of the nerves (Nieman *et al*., 2012).

The iron content of sample SST (1.20 ppm) was significantly higher ($p<0.05$) than sample B (0.84 ppm). The increase in iron in sample A could be attributed to the fortification of sorghum and soybeans, which tend to increase the concentration of iron. This is a reflection of the superiority of soybeans. It has been shown that when legumes are supplemented with other foods, iron equal to or better than that could be obtained (Mensah and Tomkins, 2003). The recommended nutrient intake value for iron in infants between the ages of 6 months and 3 years is between 1.7 and 11 mg/day (Koletzko *et al*., 2008). One hundred grammes of the complementary food is, therefore, enough to meet the recommended daily intake (RDI) of the infants.

Zinc seems to play a very vital role in the normal growth and development of a foetus during pregnancy, childhood, and adolescence. Zinc is very useful in protein synthesis, immunity, and sexual functions (Adebowale *et al*., 2018). It was deduced from this study that the zinc contents of the samples were in agreement with the Recommended Dietary Allowance (RDA) (Chinma and Igyor, 2007). Furthermore, the findings show that sample SST had the highest value of zinc (2.77 ppm). These results corroborate the findings of Egbujie and Okoye (2019).

However, the manganese, copper, and selenium levels were lower than the recommended values in the Codex standard. This difference could be due to the further enrichment carried out during the final production (Ijarotimi *et al.*, 2012). Vitamins are organic substances required and necessary for the growth and maintenance of good health (WHO, 2013). The use of locally available food items to formulate diets (blends), particularly in a developing country where gross malnutrition is largely attributed to inadequate intake of food materials due to the inability of parents and families to afford the proper diets, is a common practice.

Vitamin B3 (niacin) helps in the reduction of the level of blood cholesterol in humans. The niacin contents of the samples ranged from 4.62 to 5.19 mg/g. The result shows that sample C had the highest value of 5.19 mg/100 g, followed by sample B (4.83 mg/100 g), while sample A had the lowest value (4.62 mg/100 g). The increase in niacin content observed in the samples could be due to the inclusion of soybean and orange-fleshed sweet potato flours in the blends. Meanwhile, the niacin content of the complementary food formulated in this study was higher than the niacin content (3.17–3.72 mg/100g) of complementary food prepared from malted millet, plantain, and soybean blends reported by Bolarinwa *et al*. (2016). The vitamin B6 (pyridoxine) contents of the samples show that sample SST had the highest values of vitamin B6 (32.75 mg/100 g). This finding agreed with the report of Oti and Akobundu (2008). Pyridoxal phosphate is a co-factor in many transamination, decarboxylation, and deamination reactions, most especially in plants. The formation of ACC by ACC synthase requires pyridoxal phosphate as a cofactor, and it is fairly heat-stable. Apart from their role in assisting enzyme substrate reactions, their other functions are equally important. These findings are consistent with the results of previous investigations by Bureau *et al*. (2015). The vitamin B9 content of the samples varied significantly ($p<0.05$) among the samples. The increase in vitamin B9 content of sample OST could be a result of an increase in one or two supplements. The beta-carotene (retinol) contents of the three samples ranged from 0.12 to 0.28 µg/100 µg. These values were lower compared to 108.48 µg/100g obtained by Achikanu *et al.* (2013) from a study on the determination of the vitamin and mineral composition of common leafy vegetables in south-eastern Nigeria. Beta-carotene content in samples OSST and OST was lower than in sample SST. This may be attributed to heat during processing. Anjum *et al.* (2008) also reported a similar reduction in the beta-carotene content of selected Indian vegetables. All the samples differ significantly ($p<0.05$) in their level of beta-carotene. Beta-carotene is an important micronutrient, and its deficiency is of public health concern worldwide. The samples formulated did not meet the nutritional requirement for beta-carotene, which is 400 µg/day (FAO/WHO/UNU 2005). The values of vitamin E obtained in this study were higher than 0.005 g obtained by Oyegoke *et al*. (2018) on vitamin and mineral composition of complementary food formulated from yellow maize, soybean, millet, and carrot composite flours. This may be attributed to the increased extractability of a-tocopherol following denaturation of proteins and a complete breakdown of the cell wall in plants.

The total phenol content of the samples was significantly ($p<0.05$) lower at 21.55 mg/g, as obtained by Mannas (2014). Phenols are diverse secondary metabolites that are commonly found in plant tissues (Grace and Logan, 2000). Total phenol content could be attributed to tropical almond seed. Studies have shown that polyphenol are naturally occurring compounds found largely in fruits and vegetables and are the most abundant antioxidants in human diets. They have been considered powerful antioxidants and proven to be more potent among the antioxidants than vitamin C, E, and carotenoid (Lee and Lee, 2006). Flavonoid help manage diabetes-induced oxidative stress. The Flavonoid content of the samples ranged from 18.44 to 25.70 mg/g; these values were significantly ($p<0.05$) higher compared to the 0.04 to 0.22 mg/g obtained by Uhegbu *et al*. (2011). The concentrations of antioxidant in these complementary foods did not constitute a health hazard, as they are within the safe level (Brown, 2007). The low concentration of sample SST (18.44 mg/g) makes the spices safe for use, which prevents oxidative cell damage and also has strong anticancer activity (Salah *et al*., 2015).

The mean sensory scores of the complementary food were different after taste, flavour, mouth-feel, colour, and overall acceptability. The mean score increased with an increase in the proportion of soybean and potato-fortified samples in all the complementary food samples in terms of all the examined sensory attributes. Panel members detected a new flavour in sample OSST, which indicates that the processing of the soy bean and potato was able to remove the typical flavours associated with the complementary food (Ampofo, 2009). The scores for sensory evaluation show that sample OSST scored the highest value in flavour, while sample OST had the least value of 7.27. There was no significant ($p<0.05$) difference between sample SST and sample OST. The results showed that the panelists had a higher preference for sample OSST than the others. Colour is an important sensory attribute of any food because of its influence on acceptability. It also shows the suitability of the raw materials used for the preparation and provides information about the quality of the product. Although colour is less important for babies, mothers would play a vital role for any complementary food to be successfully utilized and accepted. In terms of taste, the higher score obtained from the sample OSST could be attributed to the desirable synergetic effect of sorghum flavour, which panelists are not familiar with. However, there was no significant difference ($p>0.05$) between the samples. The similarity among them may stem from the familiarity of a desirable flavour from soybean, which was still equally desirable at substitution with either of the samples. Aroma is a distinctive, typically pleasant smell perceived by the olfactory sense. It is also an important sensory attribute for the samples. Panel members detected a new aroma in the sample SST and sample OST. The sample SST was generally acceptable compared to other samples in the study.

Conclusion

The study has shown that complementary food supplemented with orange flesh potato, sorghum, soybeans and tropical almond seed meet the estimated daily amounts of nutrients required in complementary foods, based on the FAO requirement, of which it is counted essential for infant growth. Further findings show that the examined complementary food enhances the proximate value, such as ash, fiber, protein, fat and carbohydrate contents, which could be suggested as a good remedy in preventing malnutrition. The result therefore suggests that this complementary food should be formulated by mothers both in rural and urban areas as it could help solve the problem of protein energy malnutrition in the regions that are devastated by this epidemic.

CONFLICT OF INTEREST

The authors declared no conflicts of interest. The authors alone are responsible for the design, data collection, writing and funding of this research.

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