Journal of Dietitians Association of Nigeria (JDAN) Volume 12. December, 2021 Print ISSN: 2141-8209; eISSN: 2635-3326
Available online at: www.jdan.org.ng; https://www.ajol.info/index.php/jdan/index

DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

NUTRIENTS AND ANTIOXIDANTS COMPOSITION OF COMPLEMENTARY FOODS PRODUCED FROM BROWN LOCAL RICE, SOYBEAN, AND TIGER NUT SUPPLEMENTED WITH ORANGE-FLESHED SWEET POTATO

[*1]Adedayo, O.E, [2]Yisa, O.O, [1]Olanrewaju, O.I and [3]Dele-Olawumi Bukola

[1]Nutrition and Dietetics Department, Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria
[2]Nutrition and Dietetics Department, Federal Polytechnic, Bida, Niger state
[3]Nutrition and Dietetics Department, College of Health Sciences and Technology, Ijero-Ekiti

*Correspondence author: olorioye@gmail.com

ABSTRACT
Background: Infants' care and feeding practices have a major effect on the short-term and long-term nutritional status of children as most of the malnutrition is associated with faltering growth that occurs during the period of complementary feeding.
Objective: This study aimed to evaluate the nutrients and antioxidants composition of complementary food produced from brown local rice, soybean and tiger nut supplemented with orange-fleshed sweet potato
Materials and methods: Raw materials and other ingredients used for this study were purchased from Ojakoko in Owo Local Government, Ondo State. Four samples were formulated using brown local rice, soyabean, Tigernut, and orange flesh sweet potato in different ratios (70:60:50:40, 20:20: 20:20, 5:10:15:20, and 5:10:15:20), respectively. The samples were labeled as $RSTO_1$, RSTO2, $RSTO_3$ and $RSTO_4$. A commercial food was used as a control (D). Samples were subjected to chemical analysis according to standard methods. The data obtained were statistically analyzed using Statistical Package for Social Science (SPSS version 22). ANOVA was used to test for the significant difference among means at $P<0.05$.
Results: Finding shows that moisture, crude fibre, fat, and protein were significantly ($p<0.05$) higher in sample $RSTO_3$ but, protein content was lower than the value in the control Sample $RSTO_1$ had the highest carbohydrate and ash content among the samples. Vitamin B_3, B_6, and B_9 are significantly ($p<0.05$) higher in Sample $RSTO_4$, $RSTO_3$, and$RSTO_1$. All the samples have an appreciable amount of beta-carotene, flavonoid, total phenol, sodium, calcium and potassium. Sample $RSTO_3$ was exceptionally high in minerals but significantly ($p<0.05$) lower than that of the control except for copper and magnesium.
Conclusion: The formulated complementary foods had improved nutrients and antioxidants which can support optimal growth of undernourished children and other age groups.

Keywords: Complementary food, Local brown rice, Orange flesh sweet potato, soybean, tigernut.

INTRODUCTION

The significance of introducing infants to nutritious complementary food cannot be underestimated as such require a devoted mechanism that involves a proper combination of locally inexpensive and readily available cereal-legume-based to provide quality protein and other nutrients. In view of these nutritional challenges, quite a number of studies have investigated ways of formulating quality complementary foods through a combination of available plant-based foods to meet the nutritional needs of infants and under-five children (1,2).

Every year some 10.6 million children die before they reach their fifth birthday (2). Seven out of every 10 of these deaths are due to diarrhoea, pneumonia, measles, malaria, or malnutrition. Childhood malnutrition remains a public health challenge as the underlying cause of morbidity and mortality. The Nigeria Health and Demographic Survey revealed that four out of every ten children are stunted as a result of poor diet and disease, one out of every four are underweight, while 9% are wasted (3).

Curbing the menace of malnutrition in Nigeria is one of the challenges facing the Food and Nutrition professional and that is the exact purpose for the gathering of nutrition stakeholders and food and nutrition professionals yearly to deliberate on strategies and policies to reduce the prevalence of malnutrition across age and provide a healthy society. Malnutrition which is not peculiar to undernutrition alone is the gross inadequate or excess consumption of calories and nutrients which in turn affect proper growth and development and predispose an individual to non-communicable disease in later life (4).

One of the risk factors of malnutrition (under-nutrition) in under-five children is the inappropriate intake of complementary foods (5). Complementary

DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

foods are generally introduced between the ages of six months to two years old as exclusive breastfeeding is discontinued (5). The period of introduction of complementary food is usually period when malnutrition starts in many infants contributing significantly to the high prevalence of malnutrition in children that are less than five years of age all over the world (6), This is due to the fact that many mothers don't seem to understand that other foods added after 6months are to complement breast milk and not to wean off a child from it (7). Lack of this knowledge, coupled with a gross deficiency of nutrients in the complementary foods introduced to the infants are some of the major reasons for the poor growth and mental development in childhood (6; 8). However, the enrichment of cereal-based food with other protein sources such as legumes, and oilseeds have received considerable attention since investigations have revealed that cereals are deficient in lysine and tryptophan but have sufficient Sulphur-containing amino acids which are limiting in legumes (1,7).

Several types of commercial complementary foods marketed in many countries including Nigeria are nutritious but expensive for most Nigerian families, hence, mothers depend on readily available, low-cost food mixtures to feed their infants. This problem might be suppressed by the addition of Local brown rice, soybean and orange flesh sweet potato and tigernut

There is presently limited information regarding the nutrient content from the combination of these ingredients. However, complementary foods produced from the above mixture might be indigent in nutrients such as proteins, fats, and carbohydrates.

Brown rice is whole grain rice. It is the unmilled rice containing the pericarp, the seed coat and nucleus, the germ or embryo, and the endosperm (9). The dark color of brown rice is due to the bran layer and is rich in vitamins like thiamine, niacin, pyridoxine, and minerals like manganese, phosphorus, and iron (10).
Orange flesh sweet potato *(Ipomoea batatas)* has been identified as a viable food commodity with it potential to increase the beta-carotene level of complementary food, improve the absorption of vitamin A (11, 12, and 13).

Soybean products offer a complete essential amino acids profile except for methionine and a range of water-soluble and fat-soluble vitamins (14). Tiger nuts have high nutritional value, high caloric, and moderate protein levels. It is rich in calcium, iron, phosphates, nitrates and is a good additional source of protein (15).

Proper and judicious selection and combination of cheap locally available food crops to replace less nutritious food sources among populations that face malnutrition especially in Africa and Asia countries can be one of the most effective methods in the preparation of nutrient-dense acceptable complementary foods. Formulation and evaluation of the nutrients and antioxidant composition of complimentary food produced from locally available brown local rice and soybean supplemented with orange flesh sweet potato and tiger nut could reduce the prevalence of child malnutrition.

MATERIALS AND METHODS

Procurement of raw materials

The grains (brown local rice (Oryza *sativa*) and soybean (*Glycine max*) were supplied by Tunakins Nutrition farm, Akure, Ondo state while orange flesh sweet potato (*Ipomoea batatas*) and Tiger nut (*Cyperus esculentus L*) were obtained from Mr. Mukaila Farm Limited, Offa, Kwara State and Shasha market in Akure, Ondo state respectively.

Production of complementary foods

The four samples of complementary food ($RSTO_{1,}$ $RSTO_{2,}$ $RSTO_{3,}$ and $RSTO_4$) were produced on a different ratio using the following ingredients: Brown Local rice (Oryza *sativa*), Soybean (*Glycine max*), Orange flesh sweet potato (*Ipomoea batatas*), Tiger nut (*Cyperus esculentus L*) as revealed in Table 1.

Brown local rice grains were sorted, washed, oven-dried, and milled into flour by adopting the method described by Awolu *et al.* (16). The Soybean was cleaned and sorted, washed, and boiled in water at 100ºC for 30 min. It was dehulled manually, sundried, roasted, and was milled into flour using an attrition mill machine, and was sieved to remove coarse material in line with the procedure of Oluwamukomi *et al*. (17). A modified version of the method described by Adeleke and Odedeji (18) was adopted for the processing of the orange flesh sweet potato flour. The method described by Adejuyitan et al. (19) was used with slight modification in the processing of the tigernut flour (figure 1)

Table 1: Formulation of Brown local rice, Soybeans and Orange flesh sweet potato and Tiger Nut

Samples	Brown local rice (%)	Soybean (%)	Tiger nut (%)	OFSP (%)
$RSTO_1$	70	20	5	5
$RSTO_2$	60	20	10	10
$RSTO_3$	50	20	15	15
$RSTO_4$	40	20	20	20

Key: RSTO1 = 70% Brown local rice: 20% soy bean: 5% Tiger nut: 5% Orange flesh sweet potato **RSTO2** = 60% Brown local rice: 20% soy bean: 10% Tiger nut: 10% Orange flesh sweet potato **RSTO3 =** 50% Brown local rice: 20% soy bean: 15% Tiger nut: 15% Orange flesh sweet potato **RSTO4 =** 40% Brown local rice: 20% soy bean: 20% Tiger nut: 20% Orange flesh sweet potato,

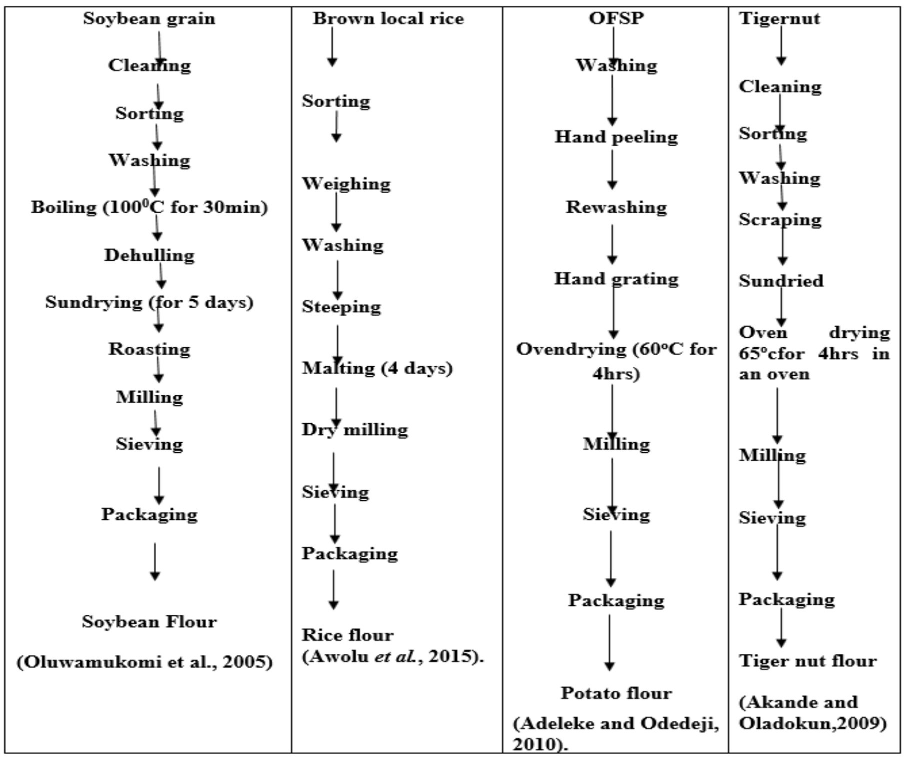

Figure 1: Flow chart for the production of raw materials

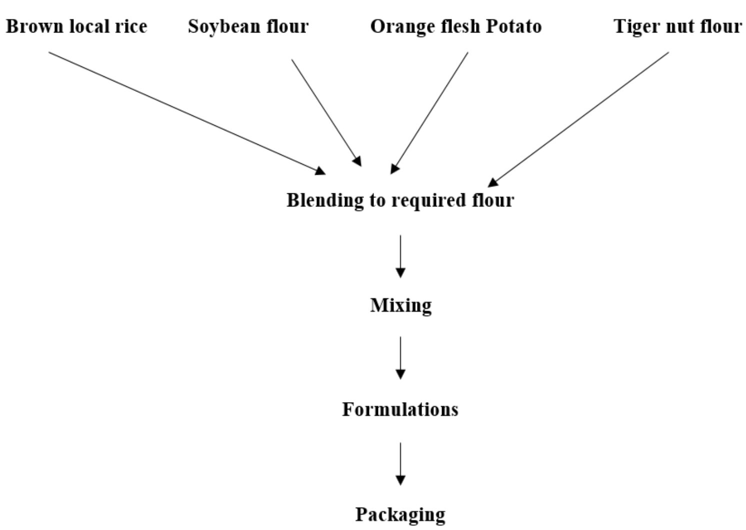

Figure 2: Flow chart for the production of formulation of the complimentary food

Journal of Dietitians Association of Nigeria (JDAN) Volume 12. December, 2021 Print ISSN: 2141-8209; eISSN: 2635-3326
Available online at: www.jdan.org.ng; https://www.ajol.info/index.php/jdan/index
DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

Preparation of samples for laboratory analysis

The prepared flour from each of the raw materials was homogenized based on the percentage as shown in table 1 using the laboratory homogenizer. Each of the composite flour was then packaged in an airtight container and stored in the refrigerator for nutrient analysis.

Proximate Analysis

The proximate analysis was carried out according to AOAC methods (20), to determine moisture, crude fats, ash, crude protein, crude fibre and total carbohydrate.

Determination of moisture content

Clean petri dish with lid was labeled and dried in an oven at 100^0C for 30minutes, then cooled in a desiccator containing reignited CaO as a desiccant and weighed to a constant weight (W_1) using a mettle balance scale. The sample (5.0g) was weighed into petri dish. The dished and sample was weighed again before drying (W_2). The petri dish and sample were transferred into the oven (Galeonkamp size 3, hot box, London, UK) maintained at 105^0C for 3hours. The dish and the content were removed and quickly transferred into a desiccator containing CaO as a desiccant to cool and re-weighed. The sample was returned into the oven and re-dried for a further one hour, cooled, and weighed. The procedure was repeated until a constant weight was attained (W_3). The process was repeated for all the samples and results were recorded in triplicate and the moisture content of each sample was calculated in percentage as follows:

% moisture $= \frac{weight\ loss (w2-w3)}{weight\ of\ sample\ (W1)} \times 100$

Determination of Ash content

The crucibles used were washed, dried in the air oven, and allowed to cool in a desiccator. Accurately 2.0g of the sample was weighed into a crucible and recorded as W1. This was transferred to a muffle furnace at a temperature set at 550^0C for 5hours. The ashing was continued until no black speck or white-grey ash was obtained, the crucibles were taken out and immediately covered and were placed in a desiccator to cool and weighed, this was recorded as W2. % Total Ash$= \frac{weight\ loss\ (W1-W2)}{weight\ of\ sample} \times 100$

Determination of crude fibre

Sample (5g) was weighed (W1), and transferred to a fat extraction apparatus, it was extracted with light petroleum. The sample was transferred to a dry 500ml conical flask and about 200ml of boiling 1.25% sulphuric acid was added and brought to boiling within 1minutes. The content was allowed to boil gently for 30mins, it was filtered through a muslin cloth, it was rinsed well with distilled water and scraped back into flask using a spatula.

Simple procedure was followed using 1.25% sodium hydride after which it was rinsed once with 10% HCL, four times with distilled water and finally with ethanol. The treated sample was sewage into pre-weighed and drained silica dish, oven-dried for 12hours at 105^0C, cooled and wighed (W2). The sample was finally ashed at about 550^0C for 2hours, then cooled in desiccatos and re-weighed (W3).

% Crude Fibre$= \frac{weight\ loss (w2-w3)}{weight\ of\ sample\ (w1)} \times 100$

Orange flesh sweet potato flour | Brown Local brown rice flour | Tigernut flour | Soybean flour

Figure 1: The flours of the sample

Journal of Dietitians Association of Nigeria (JDAN) Volume 12. December, 2021 Print ISSN: 2141-8209; eISSN: 2635-3326
Available online at: www.jdan.org.ng; https://www.ajol.info/index.php/jdan/index
DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

Determination of crude fat

Sample (0.5g) was weighed into thimble and fixed into the Soxhlet extractor; n-hexane was used as the solvent. The hexane was poured into a round bottom flask and placed on the heating mantle. The extraction was done continuously for about $3^{1/2}$hours after which the flask was cooled and disconnected. The thimble with sample was removed and dried to a constant weight in hot air oven at 50^0C. The difference between the weight of thimble before and after extraction was recorded in order to obtain the crude fat extracted. The percentage crude fat content then calculated and expressed on dry basis.

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

Determination of crude protein

The sample (1.0g) was weighed into a kjeldahl flask and (3.0g) of hydrated cupric sulphate (catalyst), twenty (20ml) of sodium sulphate solution (Na_2SO_4) and (0.1ml) of concentrated sulphuric acid (H_2SO_4) was added to sample in the flask. The flask was clamped and heated inside a fume cupboard until the solution become colorless. The clear solution was cooled, diluted with distilled water made up to 100ml. 10ml of the resulting was mixed with 5ml of 40% sodium hydroxide solution in a distillation flask and distilled to release ammonia. The resulting solution from the distillation stage was titrated with 0.1ml hydrochloric acid (HCL). The titre value/end point at which the colour from green to pink was noted and the end protein was calculated using the expression.

$$\%\text{Crude protein} = \frac{14.01\times 6.25\times 25\times T}{w\times 10}\times 100$$

Where:
VF= Total volume of the digest=100ml
W= Weight of the sample digested
T= Titre value
6.25= Conversion factor
N= Normality of HCL in moles per 100ml (0.1N)

Determination of total carbohydrate

The carbohydrate content was determined by difference. The percentage total carbohydrate was estimated to be equal to the sum of percentage moisture, protein, ash and fibre subtracted from 100g. That is %Carbohydrate = 100-(%protein+% fat+%ash+%moisture +%Ash)

Energy value of the complementary foods

The energy value of the foods was calculated using Atwater's conversion factor by multiplying crude fat with 9kcal/37KJ, carbohydrate with 4kcal/17KJ, and crude protein contents with 4kcal/17KJ and sum up all values (21).

Determination of Pro-vitamin A (Beta Carotene), vitamin K and B-complex

Two gramme (2 g) of the sample was weighed into a 250ml volumetric flask, 50ml of petroleum ether: Acetone (2:1v/v) mixture was added to the extract the ß-Carotene. The flask containing the mixture was placed on a shaker to shake at 200rpm for 20min to ensure uniform mixing at room temperature. The mixture was later centrifuged at 4000rpm for 10min and the supernatant collected and made up to 50ml with the solvent mixture in line with the method describe by AOAC (20), while vitamin K and vitamin B-complex was analysed for each of the complementary food sample in according to the AOAC methods (20).

Determination of Antioxidant

Determination of Flavonoid

The total flavonoids content was estimated using the procedure described by Zhichen *et al*. (22), a total of 1 ml of sample were diluted with 200µl of distilled water separately followed by the addition of 150 µl of sodium nitrate (5%) solution. This mixture was incubated for 5 minutes and 15 µl of ammonium chloride (10%) solution was added and allowed to stand for 6 minutes. Then 2ml of Sodium hydroxide (4%) solution was added and made up to 5ml with distilled water. The mixture was shaken well and left for 15 minutes at room temperature. The absorbance was measured at 510nm.The appearance of the pink colour showed the presence of flavonoids content. The total flavonoids content was expressed as rutin equivalent mg RE/100g extract on dry weight basis using a standard curve.

Determination of Total Phenol

The amount of total phenolic extracts was determined according to Xu and Chang (23) with slight modifications. After adding Folin-Ciocalteu reagents and sodium carbonate to aliquots of samples, the mixtures were set in 40^0C water bath for 20 minutes. The absorbance was measured at 740nm using a spectrophotometer and the total phenolic content was expressed as milligrams of gallic acid equivalents (GAE) per gram of defatted sample.

Mineral elements in the complementary foods

Two grams of each sample were ashed in a muffle furnace at 550ºC for 6 to 8 hours. The ash was dissolved with HCl. The analysis of sodium, calcium, potassium, iron, magnesium, copper, and zinc was carried out with a Buck Model 210 VGP atomic absorption spectrometer, USA. In all cases, the air-acetylene flame was used and hollow cathode individual metals were the resonance line source. The calibration plot method was adopted for the analysis.

DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

For each element, the instrument was auto zeroed using the blank (de-ionized water) after which the standard was aspirated into the flame starting from the lowest concentration. The corresponding absorbance value was obtained and the graph of absorbance against concentration was plotted by the instrument. The digested samples were analyzed in duplicates with the average concentration of the metal present being displayed in part per million (ppm) by the instrument after extrapolation from the standard curve.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS, Version 20) software was used to analyze data obtained from laboratory 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). Significant means were separated using Duncan's New Multiple Range Test (DNMRT) and differences were considered significant at $p<0.05$.

RESULTS

Proximate and energy content of the complementary foods

The proximate and energy content of the sample is shown in Table 1. Control Sample had the least value of moisture (2.50%) and ash (3.00%). The control sample was exceptionally higher in crude fat (10.0%) and protein (15.0%) compared to the formulated samples. The Moisture (10.21%), fat (7.48%), fiber (4.79%), and protein (9.62%) were significantly ($p<0.05$) higher in sample $RSTO_3$. Sample $\mathbf{RSTO_1}$ had the highest value for ash (4.39%) and carbohydrate (67.73%). There was no significant difference ($p>0.05$) between the carbohydrate content of the complementary foods and the control sample except for sample $RSTO_3$ (63.79%) which is the lowest and sample $RSTO_1$ (67.73%) with the highest value. All the formulated samples had an appreciable amount of energy but were significantly ($p<0.05$) lower than the control sample.

Table 1: proximate and energy content of the complementary foods

	Samples				
Proximate (grams)	**$RSTO_1$**	**$RSTO_2$**	**$RSTO_3$**	**$RSTO_4$**	**Control**
Moisture	8.53 ± 0.02^{d}	8.79 ± 0.01^{c}	10.21 ± 0.00^{a}	9.65 ± 0.02^{b}	2.50 ± 0.01^{e}
Ash	4.39 ± 0.01^{a}	3.91 ± 0.01^{c}	4.08 ± 0.23^{b}	3.77 ± 0.03^{d}	3.00 ± 0.01^{e}
Crude fibre	3.68 ± 0.03^{d}	4.52 ± 0.00^{b}	4.79 ± 0.02^{a}	3.50 ± 0.00^{e}	4.50 ± 0.01^{c}
Crude fat	6.82 ± 0.02^{e}	7.19 ± 0.01^{d}	7.48 ± 0.01^{b}	7.35 ± 0.00^{c}	10.0 ± 0.01^{a}
Crude protein	8.83 ± 0.01^{e}	9.13 ± 0.05^{d}	9.62 ± 0.01^{b}	9.27 ± 0.03^{c}	15.0 ± 0.01^{a}
Total carbohydrate	67.73 ± 0.05^{a}	66.43 ± 0.02^{b}	63.79 ± 0.00^{c}	66.44 ± 0.10^{b}	65.0 ± 0.01^{b}
Energy value (kcal)	367.62 ± 0.10^{b}	366.95 ± 0.08^{c}	360.96 ± 0.01^{d}	368.99 ± 0.09^{a}	410.0 ± 0.01^{a}

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same column are statistically not significant at ($P<0.05$). **Key: RSTO1 =** 70% Brown local rice: 20% soy bean: 5% Tiger nut: 5% Orange flesh sweet potato **RSTO2** = 60% Brown local rice: 20% soy bean: 10% Tiger nut: 10% Orange flesh sweet potato **RSTO3 =** 50% Brown local rice: 20% soy bean: 15% Tiger nut: 15% Orange flesh sweet potato **RSTO4 =** 40% Brown local rice: 20% soy bean: 20% Tiger nut: 20% Orange flesh sweet potato, **Control** (100% nutrend)

Vitamins and Antioxidants composition of the complementary foods

Table 2 shows the antioxidant and vitamin content of the formulated complementary flour. Beta-carotene (490mg/100g), Vitamin E (0.65mg/100g) and flavonoid (15.84mg/100g), were significantly ($p<0.05$) higher in sample $RSTO_4$ while sample $RSTO_3$had the highest value of total phenol (13.13mg/g). There was no significant difference ($p>0.05$) in vitamin E and flavonoid content of samples $RSTO_1$ and $RSTO_4$. Vitamin B_6 (33.28mg/100g) and vitamin B_9 was significantly ($p<0.05$) higher in sample $RSTO_3$and $\mathbf{RSTO_1}$ (64.20mg/100g) respectively while Sample $RSTO_4$ had the highest value of vitamin B_3 (13.61mg/100g). Sample $RSTO_1$ had the least value vitamin B_3 (12.18mg/100g) and vitamin B_6 (28.67mg/100g) followed by sample $RSTO_2$

Antioxidant and vitamin composition of the complementary foods

	Samples				
Vitamins(mg/100g)	**RSTO$_1$**	**RSTO$_2$**	**RSTO$_3$**	**RSTO$_4$**	**Control**
Beta-carotene(mg/100g)	410±0.002^d	430±0.002^c	480±0.003^b	490±0.002^a	1300±0.010
Vitamin E (mg/100g)	0.65±0.004^a	0.56±0.008^b	0.58±0.003^b	0.65±0.007^a	NA
Vitamin B$_3$	12.18±0.028^d	12.95±0.007^c	13.17±0.041^b	13.61±0.007^a	3.00±0.010^e
Vitamin B$_6$	28.67±0.035^d	31.78±0.048^b	33.28±0.048^a	30.52±0.048^c	0.30±0.010e
Vitamin B$_9$	64.20±0.141^a	51.60±0.141^c	44.75±0.212^d	58.25±0.774^b	40.0±0.010e
Flavonoids (mg/g)	15.79±0.007^a	15.31±0.049^c	15.58±0.021^b	15.84±0.028^a	NA
Total phenol(mg/g)	12.51±0.007^c	10.83±0.007^d	13.13±0.042^a	12.91±0.021^b	NA

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same column are statistically not significant at ($P<0.05$). **Key: RSTO1** = 70% Brown local rice: 20% soy bean: 5% Tiger nut: 5% Orange flesh sweet potato **RSTO2** = 60% Brown local rice: 20% soy bean: 10% Tiger nut: 10% Orange flesh sweet potato **RSTO3 =** 50% Brown local rice: 20% soy bean: 15% Tiger nut: 15% Orange flesh sweet potato **RSTO4 =** 40% Brown local rice: 20% soy bean: 20% Tiger nut: 20% Orange flesh sweet potato, **Control** (100% nutrend)

Mineral composition of complementary foods

The mineral content of the samples is shown in Table 3. Among the formulated samples, sodium (92.65mg), calcium (205.14mg), potassium (130.70mg), zinc (0.84mg), magnesium (13.23mg) and copper (0.41mg) were highest ($p<0.05$) in sample RSTO$_3$.. Sample RSTO$_1$had the least value of Sodium (71.65mg), calcium (153.10mg), potassium (98.30mg), zinc (0.53mg), magnesium (10.65mg) and copper (0.31mg). There was a sequential increase in the mineral content of the complementary foods with an increase in the quantity of tigernut and orange flesh sweet potato except in sample RSTO$_4$ where the minerals decrease due to the decrease in the quantity of brown local rice.

Table 3: Mineral composition of complementary foods

	Samples				
Minerals (mg/100g)	**RSTO$_1$**	**RSTO$_2$**	**RSTO$_3$**	**RSTO$_4$**	**Control**
Sodium (Na)	71.65±0.35^e	84.45±0.21^d	92.65±0.21^b	86.10±0.14^c	145.0±0.010^a
Calcium (Ca)	153.10±0.56^e	165.35±0.21^d	205.14±0.10^b	176.15±1.90^c	600.0±0.010^a
Potassium (K)	98.30±0.14^e	112.15±0.21^d	130.70±0.14^b	125.70±0.28^c	635.0±0.010^a
Zinc (Zn)	0.53±0.01^e	0.71±0.00^d	0.84±0.00^b	0.78±0.00^c	7.00±0.010^a
Magnesium (Mg)	10.65±0.01^d	10.92±0.01^c	13.23±0.01^a	12.72±0.00^b	NA
Copper (Cu)	0.31±0.00^d	0.37±0.00^c	0.41±0.00^a	0.38±0.00^b	NA
Iron (Fe)	0.26±0.00^d	0.250±0.10^d	0.373±0.011^b	0.345±0.02^c	6.00±0.010^a

Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same column are statistically not significant at ($P<0.05$). **Key: RSTO1** = 70% Brown local rice: 20% soy bean: 5% Tiger nut: 5% Orange flesh sweet potato **RSTO2** = 60% Brown local rice: 20% soy bean: 10% Tiger nut: 10% Orange flesh sweet potato **RSTO3 =** 50% Brown local rice: 20% soy bean: 15% Tiger nut: 15% Orange flesh sweet potato **RSTO4 =** 40% Brown local rice: 20% soy bean: 20% Tiger nut: 20% Orange flesh sweet potato, **Control** (100% nutrend)

DISCUSSION

From the study, it was discovered that the moisture content of the complementary food samples varied from 8.53% to 10.21% with sample RSTO$_1$ and sample RSTO$_3$ having the least (8.53%) and highest (10.21%) values, respectively. The values obtained in this study were lower than the moisture content (10.03-12.59%) of complementary food formulated from fermented maize, soybean, and carrot flours as reported by Barber *et al*. (24). The observed lower moisture contents of the fermented products will improve the storage period or keep the quality of the product because low moisture content would prevent the growth of Moulds and reduce moisture-dependent biochemical reactions (25). The low moisture content of the flour sample was within the acceptable limit of not more than 10% for the long storage of flour.

Ash content is an important nutritional indicator of mineral content and a quality parameter that determines contamination with foreign matters (26). The ash content of the samples ranged from 3.77% to 4.39% with sample RSTO$_1$ (4.39%) having the highest value while sample RSTO$_4$ had the least value of ash content. The ash content obtained in this study was higher than the ash content (0.56-2.00%) of complementary food obtained by (20). This higher value obtained in this study may be due to the incorporation of soy flour which had been known to be a good source of minerals (27; 28).

Findings show that fat content was significantly different ($p<0.05$) for all the formulations. These values are higher than the findings of Ebujie and Okoye, (2019) with sample RSTO$_3$ (7.48%) having the

Journal of Dietitians Association of Nigeria (JDAN) Volume 12. December, 2021 Print ISSN: 2141-8209; eISSN: 2635-3326
Available online at: www.jdan.org.ng; https://www.ajol.info/index.php/jdan/index

DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

highest fat content while sample $RSTO_1$had the least fat content. The fat content of the formulated complementary food samples was relatively high and was within the recommended range of dietary allowance for infants and young children. Dietary fat provides energy, essential fatty acids, transport fat-soluble vitamins (A, D, E, and K), and promotes palatability of food (29; 30). The crude fibre content of the complementary food samples ranged from 3.68 to 4.79%. The values obtained in this study were higher than the fibre content (2.72-3.52%) of complementary food reported by Bolarinwa *et al*. (31). The high fiber content in the samples developed in this study could be as a result of the bran of the brown local rice which was not discarded during processing. The study had shown that brown local rice contains a high amount of fibre (32).

The sample $RSTO_3$ had the highest protein content (9.62%). This value despite being the highest was lower than the protein content of the control sample but within the recommended allowance 9-11g/day for infants above 6months (33). Protein is an essential nutrient for proper growth and development of the body of infants and young children and a major structural component of muscle tissues that helps to repair increase and maintain children's muscle mass. Besides, protein is also a component of a child's blood, organs, skin, and glands (33). The carbohydrate content of the complementary foods in this study was within the range of 63.79-67.73%. The high carbohydrate content of the complementary food samples could be due to the high carbohydrate content of brown local rice and orange sweet potato flours used in the formulation (34). However, the carbohydrate content of the complementary foods developed in this study was slightly similar to the carbohydrate content (67.59-78.02%) of complementary food prepared from sorghum, African yam bean and mango mesocarp flour blends reported by Yusufu *et al.* (35). The relatively high carbohydrate content of the formulated complementary foods is an indication that the products will provide the infants with an adequate amount of energy required for optimum growth and development. Although there is no fixed RDA for carbohydrate intake, FAO/WHO (36) has recommended an intake of more than 50g per day as being sufficient to meet the energy needs of infants. In this regard, the samples meet this recommended estimated intake of 65g of weaning food by an infant per day (37).

There was a steady increase in the Vitamin B_3 (Niacin) contents of the samples. Although sample D had the highest value, the increase in niacin content observed in the samples could be due to the inclusion of soybean and orange flesh sweet potato flours in the blends. 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*. (31).

Vitamin B_6 (Pyridoxine) contents of the samples show that sample $RSTO_3$ had the highest values of Vitamin B_6. This finding is inconsistent with previous investigations by Oti and Akobundu (38) and Bureau et al. (39). Vitamin B_6 (pyridoxal phosphate) is a cofactor in many transaminations, decarboxylation, and deamination reactions (40; 41). The Vitamin B_9 content of the samples varied significantly ($p<0.05$) among the samples. The increase in Vitamin B_9 content of sample $RSTO_1$ (64.20mg/100g) could be as a result of the increase of brown local rice.

There was a significant improvement in the beta-carotene level of the formulated samples. As the quantity of brown local rice decreases with an increase in orange flesh sweet potato, the beta-carotene content increased significantly, as compared to sample $RSTO_{1.}$ This result was expected since there is an increase in the quantity of orange flesh sweet potato and tiger nut in each formulation. The beta-carotene content in all three formulations was high enough to meet recommendations set by RDA. This indicates that substituting brown local rice with either 20 or 30% of orange flesh sweet potato will significantly improve the beta-carotene content which will subsequently improve vitamin A status. These results are similar to results obtained by Bonsi *et al*. (42).

The samples are low in vitamin E. More so, there was no significant difference ($P>0.05$) between the samples. This implies that the samples are inadequate to meet infants' recommended dietary intake (vitamin E) of 40mg. Vitamin E helps in maintaining healthy immune systems, fighting infections, synthesis of collagen which gives structure and maintains healthy muscle, vascular tissue, tendons, ligaments, teeth, bones, gum, cartilage, joints, lining, skin, and blood vessels (43;44).

The total phenol and flavonoid content of the samples were reported as adequate. Sample $RSTO_3$ was significantly ($P<0.05$) higher in total phenol while sample $RSTO_1$was significantly ($P<0.05$) higher in flavonoid. These values are higher compare to that (4.50-11.13mg/100g) obtained by Hagos *et al*. (45) for weaning food. The significant reduction in flavonoid content in sample $RSTO_2$ was due to the increase in moisture content of the sample which was able to reduce the antioxidant after processing. Study has

DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

shown that intake of foods rich in flavonoid protects human against diseases associated with oxidative stress. The mechanisms of action of flavonoids are through free radicals scavenging or chelating process and protection against oxidative stress (46).

The levels of minerals; calcium, phosphorus, potassium, iron, zinc and magnesium increased steadily with increase in substitution with soybean, tiger nut flour and orange flesh sweet potato flours. The increase in the mineral content of the formulated complementary food samples confirms the beneficial effect of supplementation. Although, all the mineral content of the samples were lower than the mineral content of the control sample (Nutrend). The calcium content of the samples was relatively high and sufficient to meet the estimated daily amounts of calcium needed from complementary foods (92-301mg) (41). This was also in agreement with the recommended 72% proportion of calcium that needs to be supplied by complementary foods (47). The increase in calcium content observed in all the formulated samples could be attributed to increase in the addition of soybean flour in the products. Nandutu and Howell (48) reported that soybeans are rich source of calcium. The increase in potassium content observed in the blends could be due to the inclusion of high proportion of soybean flour and tiger nut flour in the products. The potassium content obtained in this study was similar to the potassium content (97.56-131.28mg/100g) of complementary food produced from malted millet, plantain and soybean flour blends reported by Bolarinwa *et al*. (31). The level of zinc in the sample was observed to increase with increase in the proportion of soybean flour in the blends. However, soybeans have been reported to be an excellent source of zinc (33). Zinc is an important co-factor for more than 70 enzymes and it plays a central role in cell division, protein synthesis and growth. The deficiency of zinc will result to growth failure, anaemia, enlargement of liver and spleen and impairment of skeletal development.

CONCLUSION

The complementary foods formulated in this study could be used by mothers to feed their infants and children during the complementary feeding period. Sample $RSTO_3$ and $RSTO_4$ had high Protein, fat, carbohydrate and energy contents compared to other samples. These two formulated complementary foods have the potentials compete variably with commercially product complementary foods and to enhance the growth, development and well-being of infants and young children, in addition to the affordability of the products. The two samples were also rich in micronutrients and antioxidants such as sodium, potassium, magnesium, calcium, folic acid, niacin and vitamin B_6 and Beta-carotene, total phenol and flavonoids respectively, thereby prevent micronutrients malnutrition among infants and children in Nigeria and other developing countries of the world.

Ethical approval

Ethical approval was obtained for the study from the Ethic committee of Nutrition and Dietetics department, Rufus Giwa Polytechnic, Owo with reference number (RUGIPO/NUD/GEN/CFF/100).

Declaration of interest

No conflicts of any interest.

Author's contribution

Adedayo, O.E and Olanrewaju, O.I contributed to the conception and design of the study. Dele-Olawumi and Yisa, O.O was involved in the purchase and processing of the complementary food samples. All authors reviewed and edited the draft, and approved the final manuscript. Olanrewaju, O.I wrote the final draft and is responsible for the integrity of the work as a whole

REFERENCES

1. World Health Organization (WHO) Recommendations on Antenatal care for a positive pregnancy experience. Human Reproductive Program, Geneva. 2015. 10pp.
2. National Nutrition and Health Survey (NNHS). Report on the nutrition and health situation of Nigeria. National Bureau of Statistic, 2018. PP 26-29
3. World Health Organization (WHO).Monitoring health for the sustainable development goals. World health statistics 2016 report.
4. World Health Organization (WHO). Vitamins and Minerals requirements in Human Nutrition (2nd ed). Infant and Young Child Feeding, World Health Organization, Lyon, France. 2009, 1357-7298.
5. World Health Organization (WHO). Child growth standards and the identification of severe acute malnutrition in infants and children, A Joint Statement, WHO and UNICEF, 2009.
6. Ibironke SI, Fashakin JB and Badmus OA. Nutritional evaluation of complementary food developed from plant and animal sources. Nutrition and Food Science; 2012, 42(2):111-120
7. Okoye, JI & Ene, GI. Evaluation of Nutritional and Organoleptic Properties of Maize-Based Complementary Foods Supplemented with Black Bean and Crayfish Flours. Global Advanced

DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

Research Journal of Food Science and Technology. 2018, 6(1); 001-009

8. Abiose, SH, Ikujenlola, AV., and Abioderin, FI. Nutritional quality Assessment of Complementary Foods Produced from Fermented and Melted Quality Protein Maize Fortified with Soybean Flour. Poland Journal of Food and Nutritional. Sciences. 2015, 65(1); 49-56
9. Ajimilah, NH. & Rosniyana, A. Brown rice consumption in Malaysia: A new trend? Proceeding of 5th ASEAN FOOD Conference. Kuala Lumpur: 2015. MARDI
10. Babu, DP., Subhasree, RS., Bhakyaraj, R., & Vidhyalakshmi, R. Brown rice; beyond the color reviving a lost health food – a review. American-Eurasian Journal of Agronomy, 2009, 2 (2): 67–72.
11. Burri, BJ, Chang, J, & Neidlinger, TR. Beta Cryptoxanthin- and alpha-carotene- rich foods have greater apparent bioavailability than beta-carotene rich foods in Western diets. *British Journal of Nutrition*, 2011, 105, 212–219.
12. Haque, MR, Hosain, MM, Khatun, H., Alam, R., & Gani, MO. Evaluation of nutritional composition and sensory attributes of weaning food prepared from sweet potato and soyabean. Bangladesh Research Publications Journal, 2013 8, 127–133.
13. Ijarotimi OS, & Keshinro OO. Formulation and nutritional quality of infant formula produced from germinated popcorn, Bambara groundnut, and African locust bean flour. Journal of Microbiology, Biotechnology and Food Science; 2012,1:1358–88
14. Ojinaka, M.C., Ebinyasi, C.S., Ihemeje, A., & Okorie, S.U. Nutritional evaluation of complementary food formulated from blends of soybean flour and ginger modified with cocoyam starch. Advanced Journal of Food Science and Technology, 2013, 5(10); 1325-1335.
15. Bamgbose, AM., Truvbetine, D. & Dada, W. Utilization of Tiger nut (*Cyperus totundus* L) meal in the grits for cockerel starters. Biones. Tech 2003, 89: 245-248.
16. Awolu, OO., Osemeke, RO. and Ifesan, BOT. Antioxidant, functional and rheological properties of optimized composite flour, consisting wheat and amaranth seed, brewers' spent grain and apple pomace. Journal of Food Science Technology. 2015. pp 1-13.
17. Oluwamukomi MO, Adeyemi IA, Oluwalana IB (2005). Effects of soybean enrichment on the physicochemical and sensory properties of gari. Appl. Trop. Agric.,2005 10(Special issue): 44-49
18. Adeleke, R.O and Odedeji, J.O. Functional properties of wheat and sweet potato flour blends. Pakistan Journal of Nutrition 2010,9, 535-538
19. Adejuyitan, J.A, Otunla, E.T, Akande, E.A, Bolarinwa I.F and Oladokun FM. Some physicochemical properties of flour obtained from fermentation of Tiger nut sourced from a market in Ogbomosho, Nigeria. 2009, African Journal of Food Science, 3:51-55
20. AOAC. Official Methods of Analysis,19th ed. Association Of Official Analysis Chemist, Washington, 2012
21. Ferris D.A, Flores R.A, Shanklin C.W, Whitworth M.K. Proximate analysis of food service wastes. *Applied Engineering in Agriculture*; 1995, 11:567–7225.
22. Zhicheng Chen, Yue Sun Shuangpi Tian Extraction of flavonoid from corn silk and biological activities in vitro. Journal of Food Quality 2021, (1): 1-9
23. Xu B.J and Chang, S.K.C (2007). A comparative study on phenolic profiles and antioxidant activities of legumes as Affected by Extraction solvents. *Journal of Food Science, 72;S159-S166*
24. Barber L.I., Obinna-Echem, P.C, Ogburia, E.M Proximate composition, micronutrient and sensory properties of complementary food from fermented maize, soybean and carrot flours. Skye Journal of Food Sciences 2017, 6 (3): 033-039.
25. Onimawo, I.A. and Akubor, P.I. Food Chemistry (Integrated Approach with Biochemcial background). 2nd Edition, Joytal Printing Press, Agbowo. 2012
26. Mishra, G., Mishra, A. A., & Shukla, R. N. (2014). Development of pulse, banana and pineapple pomace based weaning food and its quality evaluation during storage. International Journal of Development Research, 2014,4, 1257–1262.
27. Onoja, U.S. and Obizoba, I.C. Nutrient composition and organoleptic attributes of gruel based on fermented cereal, legume, tuber and root flour. *Journal of tropical* Agriculture Food Environment and Extension; 2009, 8: 162-168.
28. Tasnim, F., Suman, M., Trissa, S., Hossain, M. and Zahurul, H. Formulation and nutritional evaluation of a healthy vegetable soup powder supplemented with soy flour, mushroom and moringa leaf. Food Science and Nutrition 2017, 5: 911 – 920.
29. Makinde, F. M., & Ladipo, A. T. Physico-chemical and microbial quality of sorghum based complementary food enriched with soybean (Glycine max) aand sesame (sesamum indicum). Journal of Food Technology, 2012, 10(2), 46–49.

DOI: https://dx.doi.org/10.4314/jdan.v12i1.9

30. Michaelsen, K. F. Feeding and nutrition of infants and young children: Guidelines for the WHO European region, with emphasis on the former Soviet countries (No. 87). WHO Regional Office Europe ,2000
31. Bolarinwa IF., Olajide, JO, Oke MO, Olaniya, SA, Faromik, OG. Production and quality evaluation of complementary food from malted millet, plantain and soybean blends. International Journal Science Engineering Research; 2016, 7(5): 663-674.
32. Ayo, J., Ayo, V., Popoola, C., Omosebi, M. and Joseph, L. Production and evaluation of malted soybean-acha composite flour bread and biscuit. African Journal of Food Science and Technology 2014, 5: 21 – 28.
33. Wardlaw GM, Hampl JS Perspective in Nutrition, 7th ed. McGraw-Hill press, New 2007, 1-758
34. Oluwamukomi M.O, Adeyemi I.A, Oluwanlana I.B. Effect of soybean supplementation on the physicochemical and sensory properties of garri pp. 2005, 44 -49
35. Yusufu, PA., Egbunu, FA. Egwujeh, SID. Opega, GL. and Adikwu, MO. (2013). Evaluation of Complementary food prepared from sorghum, African yam bean (*Sphenostytis stenocarpa)* and mango mesocarp flour blends. Pakinstan Journal of Nutrition 2013,12 (2): 205-208.
36. WHO/FAO. Preparation and use of Food-Based Dietary Guidelines. A report of a joint FAO/WHO consultation. WHO technical series 880 Geneva, 1998
37. Farzana, T. and Mohajan, S. Effect of incorporation of soy flour to wheat flour on nutritional and sensory quality of biscuits fortified with mushroom. *Food Science and Nutrition* 2015,3(5): 363 – 369.
38. Oti E, and Akobundu ENT. Potentials of cocoyam-soybean crayfish mixtures in complementary feeding. *Nigerian Agricultural Journal*; 2008,39(2):137-145
39. Bureau, S., Mouhoubi, S., Touloumet, L., Garcia, C., Moreau, F., Be ´douet, V. & Renard, M.G.C. Are folates, carotenoids and vitamin C affected by cooking? Four domestic procedures are compared on a large diversity of frozen vegetables. Food Science. Technology. 2015, 64: 735–741.
40. Bernhardt S, & Schlich E. Impact of different cooking methods on food quality: Retention of lipophilic vitamins in fresh and frozen vegetables. Journal of Food Engineering; 2006, 77:327–333
41. Egbujie AE, Okoye JI. Chemical and sensory evaluation of complementary foods produced from sorghum, African yam bean and crayfish flours. International Journal of Food Science and Nutrition. 2019, 1; 114-119
42. Bonsi EA, Plahar WA, Zabawa R. Nutritional Enhancement of Ghanaian Weaning Foods Using the Orange Flesh Sweetpotato (*Ipomeabatatas*). AJFAND, 2014,14:5-8.
43. Okwu DE and Josiah C. Evaluation of chemical composition of two Nigerian medicinal plants, African Journal of Biotechnology. 2006, 5(4); 357-361.
44. Dixit A.K. Soybean consistent and their functional benefits, in: V.K. Tiwari, B.B. Mishra (Eds.), Opportunity, challenge and scope of natural products in medicinal chemistry, Research signpost Publication, Kerala, India, 2011, pp. 367–383
45. Hagos H. K, Teklebrhan, W.A & Lijalem T.W. Effect of germination process on nutrients and phytochemicals contents of faba bean (Viciafaba L.) for weaning food preparation, Cogent Food & Agriculture, 2018,4:1, 1545738
46. Shahidi, F. and Naczk, M.. Phenolic compounds in grains. In: Food phenolics, source, Chemistry, Effect Application, Technolic publishing company Inc. Lancaster P. A. 1995,pp. 3-39.
47. Dewey, KG. & Brown, KH. Update on Technical Issues Concerning Complementary Feeding of Young Children in Developing Countries and Implications for Intervention programs. *Food Nutrition Bulletin*, 2013,24 (1), 5 – 28.
48. Nandutu, A. and Howell, N. Nutritional and rheological properties of sweet potato based infant food and its preservation using antioxidants. African Journal of Food Agriculture Nutrition and Development; 2009, 9(4): 1076-1090.