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Chemical Composition, Functional, Microbiological and Sensory Qualities of Locally Produced Complementary Food from Rizgah (*Plectranthus esculentus*), Baobab Fruit Powder (*Adansonia digitata*), Soybean (*Glycine max*) and Crayfish (*Cambarus Sp*) Flour Blends

Ayo, J.A [a,b], Awogbenja, M.D [a*], Mohammed, Z.A [c], Bello, F.O [c], Olawumi, N. O [a] and Yusuf B. M [a]

[a] Department of Nutrition and Dietetics, Nasarawa State University, Keffi, Nigeria.
[b] Department of Food Science and Technology, Federal University Wukari, Nigeria.
[c] Department of Home Science, Nasarawa State University, Keffi, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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**Corresponding author: Email: dendus12@gmail.com;*

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ABSTRACT

Production of complementary food using locally available underutilized materials has become of necessity to overcome the economic effects on importation. This research examined the chemical composition, functional, microbial and sensory qualities of complementary food produced from Rizgah (*Plectranthus esculentus*), baobab fruit powder (*Adansonia digitata)*, soybean (G*lycine max)* and crayfish(C*ambarus Sp)* flour blend. The raw materials used were purchased, processed into flour and mixed in varied proportions of Rizgah: baobab: soybean:cray fish flour(100:0:0:0; 85:10:5:0; 75:15:10:0;70:15:10:;60:20:15:5;55:20:15:10) to produce complementary foods and analyzed for chemical, microbial and sensory qualities. The ash, crude protein, crude fat and crude fibre increased from 9.34 to 16.77, 4.93 to 9.28, 9.48 to 11.50 and 1.57 to 3.53%, respectively, while the moisture and carbohydrates content decreased from 9.42 to 7.77 and 65.38 to 53.71%, respectively with reduction in the added Rizgah flour (100 to 55%). The bulk density decreased from 0.34 to 0.28g/cm^3, while the swelling, oil absorption and water absorption capacity decreased from 85.25-66.10%, 25.50-17.50% and 57.50-45.50%, respectively. The vitamin C, vitamin B_1 and vitamin B_6 increased from 5.7 to 7.50(mg/100g), 0.64 to 3.00(mg/100g) and 0.58 to 1.75(mg/100g), respectively, with increase in the soybean, baobab powder and crayfish. The total coliform count, total heterotrophic bacterial count and total heterotrophic fungi count decreased from 2.8×10^{-2} to 1.5×10^{-2}, 7.5×10^{-5} to 2.3×10^{-5} and 3.1×10^{-3} to 1.8×10^{-3}, respectively, with decrease in the added Rizgah (100% to 55%). The mineral content of the sample increased from 0.29 to 0.90mg/100g for iron, 0.01 to 0.047mg/100g for sodium, 1.68 to 71.88mg/100g for calcium, 8.19 to 12.50mg/100g for magnesium and 0.96 to 2.75mg/100g for phosphorus with increase in the quantity of crayfish.The anti nutrient content of the sample varied from 5.90 to 5.81mg/100g for tannin, 5.46 to 13.60mg/100g for phytate, 7.81 to 10.91mg/100g for trypsin, 0.82 to 2.04mg/100g for oxalate. The relative increase observed for the anti nutrient content could be due to the added soybean flour. The average mean scores for aroma, colour, texture, taste, and overall acceptability of the complementary food samples varied from 3.50 to 3.60, 3.50 to 3.60, 3.50 to 3.40, 3.70 to 3.50 and 3.10 to 3.40 respectively, the relative increase in the average means score of sensory quality could be attributed to the added crayfish. This study has shown that relatively high quality and safe complementary food can be produced from Rizgah flour with addition of soybean, baobab and cray fish.

Keywords: Complementary food; rizgah; crayfish; bulk density; sensory quality.

1. INTRODUCTION

Malnutrition is a critical public health concern in Nigeria, particularly among infants and young children, leading to adverse health outcomes and hindered development [1,2]. The World Health Organization (WHO) estimates that approximately 37% of children under the age of five in Nigeria suffer from stunting, 17% are underweight, and 7% experience wasting [3]. These alarming statistics highlight the urgent need to address malnutrition and improve the nutritional status of children in the country.

Complementary feeding, which involves the introduction of solid or semi-solid foods alongside breastfeeding, plays a vital role in meeting the nutritional needs of infants and young children during the critical period of rapid growth and development. It is during this phase that children transition from exclusive breastfeeding to a diversified diet, incorporating a variety of complementary foods to support their increasing nutrient requirements [4,5,6,7]. However, the nutritional quality and safety of complementary foods in Nigeria often fall short of the desired standards. Many commercially available complementary food products lack adequate nutrient profiles and fail to meet the recommended dietary guidelines [8]. Moreover, the presence of microbiological contaminants in these products could poses significant health risks, as they can lead to foodborne illnesses and further compromise the already vulnerable health of malnourished children [9].

To address these challenges, there is a pressing need for innovative approaches to develop nutritious, safe, and culturally appropriate complementary food options. Utilizing locally available ingredients that are affordable and familiar to caregivers is essential for sustainability and acceptance [10]. Additionally, the formulation of complementary foods should

consider the nutritional composition, functional properties, and microbiological safety to ensure optimal growth, development, and overall health outcomes for malnourished children [11].

Crayfish (*Cambarus Sp*) is one of the healthiest, most available and widely acceptable seafood in Nigeria, and other nutrient that are beneficial to health [12]. Crayfish can also help improve the palatability and taste of food, making it more appetizing.Crayfish contains vitamin A and Vitamin D and minerals such as calcium, potassium, copper, zinc and iodine [13]. According to Nahid et al. [13] the nutritional contents of crayfish in comparison with one egg has been revealed to contain 1g total fat, 126mg protein, 170mg sodium and 80mg calories.

Soybean (G*lycine max)* is a good source of protein (35–45%), carbohydrates (33%),16.6% of which are soluble sugars. In addition to its rich oil content (15–25%), soy protein has a very high level of amino acid composition although soybeans are deficient in methionine but contain sufficient lysine to overcome the lysine deficiency of cereals. The soybean is one of the richest and cheapest sources of protein and is a staple in the diets of people and animals in numerous parts of the world [14].

The living stone potato (*Plectranthus esculentus*) (Plate 1) also locally called *Rizgah* by the Hausa is a dicotyledonous perennial shrub, which is grown for its edible tuber, it can be eaten as a substitute for sweet potato [14]. These tubers are nutritious and it is rich in carbohydrates, vitamins A, minerals and essential amino acids [15]. The fleshy underground stem, the tubers are the part of the plant that is consumed. This tuber crop is considered to be the most nutritious tuber of all tuber vegetables. The nutritional composition shows 100g contain: 13% crude protein, 0.6% fat (lipids), 80% carbohydrates, 140g calcium, 50mg iron, and 0.17mg vitamin A [14]. Evidence has shown that the tubers are rich in minerals such as Iron (2.65mg/100g), Potassium(129.2mg/100g), Zinc(1.3mg/100g), Sodium (31.4mg/100g), Magnesium (92.5mg/100g), Manganese (5.67mg/100g), Copper (0.4mg/100g), and Calcium (78.0mg/100g) [14].

The baobab*(Adansonia digitata*) (Plate 2) is a traditional food plant in Africa. The fruit and root are edible. The fruit baobab has been identified to have potential in improving nutrition, boost food security and support sustainable land care. According to Asogwa et al. [16] “the fruit pulp of the African baobab has been used locally as an immune stimulant and an anti-inflammatory remedy as well as an analgesic, antipyretic and for treatment of diarrhoea and dysentery. The fruit pulp also contains vitamin C, bioflavonoids and pro-vitamin”. “The baobab seed and pulp was reported to have 18.4 and 3.2% crude protein; 3638 Kcal/kg and 3203Kcal/kg energy respectively. Baobab fruit is rich in iron, potassium and essential blood clotting ingredients which helps support the circulatory system while the high fibre content aids in digestion” [16].

In line with these considerations, this study was aimed at developing and evaluating flour blend specifically tailored for infants and young children in Nigeria using locally available food raw materials such as rizgah, soybean, baobab fruit and crayfish.

Plate 1. Living Stone Potato (*Plectranthus* esculentus)

Plate 2. African Baobab Fruit (*Adansonia digitata)*

2. MATERIALS AND METHODS

2.1 Materials

Materials use in this study Rizgah(*Plectranthus esculentus)*, soybean (G*lycine max)*, baobab *(Adansonia digitata)* and cray fish(C*ambarus Sp)* were purchased from central market, Jos, Nigeria.

2.2 Production of Rizgah, Soybean, Baobab, Crayfish flour

Fresh purchased potato was washed, oven dried (50^{o}C for 48 hours), dry mill and sieved to produce Rizgah flour [17]. Soybean grains were carefully sorted, cooked (30-40mins), strained, dried (50^{o}C for 48 hours), toasted, dry milled and sieved to produce soybean flour [18]. Matured baobab pulp was pounded lightly but continuously until the powder was separated from the seeds, sieved to produce powder [19]. Crayfish was sorted, sun dried, milled and sieved to produce crayfish flour [20]. The flour blends were packed in polythene bags and stored at room temperature (38-40^{0}C) until usage

2.3 Formulation of Composite Flour Blends

Rizgah, soybean, baobab and crayfish were mixed together as shown in Table 1 to produce to produce flour blends.

2.4 Determination of Functional Properties

2.4.1 Determination of water absorption capacity

The water absorbing capacity of flour was evaluated by method described by Tivde et al. [21]. One gram of the sample was dispensed into a weighed centrifuge tube with 10ml of distilled water and mixed thoroughly. The mixture was allowed to stand for 1 hour before being centrifuged at 3500 rpm for 30 minutes. The excess water (unabsorbed) was decanted and the tube inverted over an adsorbent paper to drain dry. The weight of water absorbed was determined by difference. The water absorption capacity was calculated as:

$$Water\ absorption\ capacity\ = \frac{Volume\ of\ water\ used - Volume\ of\ free\ water}{Weight\ of\ sample\ used} X \frac{100}{1}$$

2.4.2 Determination of oil absorption capacity

Sample (1 g) was mixed with 10 mL of vegetable oil in pre-weighed centrifuge tube, the tube was stirred for 1 min for complete dispersion of sample in the oil, after 30 min of holding time at room temperature, and the sample was centrifuged at 2000 rpm for 30 min. The separated oil was removed using a pipette and tube was inverted on oil absorbent paper for 25 min to drain the oil prior to reweighing [21].

$$Oil\ absorption\ capacity\ = \frac{Volume\ of\ oil\ used - Volume\ of\ free\ oil}{Weight\ of\ sample\ used} \times \frac{100}{1}$$

2.4.3 Determination of bulk density

The bulk density was determined as described by Awuchi et al. [22]. The flour sample (25g) was put into a 100ml graduated cylinder. The cylinder was tapped 40-50 times and the volume of the flour was read. The bulk density was calculated as:

$$Bulkdensity(g/ml) = \frac{Weight\ of\ sample}{Volume\ of\ sample\ after\ tapping}$$

Table 1. Sample formation in percentage (%)

Sample	Rizgah	Soybean	Baobab fruit powder	Crayfish
A	100	0	0	0
B	85	10	5	0
C	75	15	10	0
D	70	15	10	5
E	60	20	15	5
F	55	20	15	10

2.4.4 Determination of swelling capacity

The swelling capacity was evaluated using the method of Kumar et al. [23]. Swelling capacity was determined by weighing 20g of the flour into a cleaned, dried graduated cylinder. The cylinder was tapped 3 times on the table and then 80ml of distilled water was poured into the cylinder. The cylinder was then allowed to stand for 1 h after which the final volume of the sample was noted. The ratio of the final volume to initial volume gave the swelling capacity on volume basis. The supernatant was decanted and the weight of food sample and the cylinder obtained and the ratio of final weight to initial weight of sample gave the swelling capacity on weight basis.

2.4.5 Determination of foam capacity

Foaming capacity was determined by the method of Olaoye et al. [24]. 2 g of flour sample was blended with 100 ml of distilled water in a warring blender, the suspension was whipped at 1600 rmp for 15 minutes. The mixture was poured into a 250 ml measuring cylinder and the volume after 5 s was recorded. Foam capacity was expressed as percentage increase in volume.

$$Foam\ capacity = \frac{Volume\ after\ whipping - Volume\ before\ whipping}{Volume\ before\ whipping} \times \frac{100}{1}$$

2.4.6 Determination of emulsifying capacity

Two gram of the flour sample was blended with 25ml distilled water at room temperature for 30seconds in a warring blender at 1600rpm. 25ml of vegetable oil was gradually added after complete dispersion with continued blending for another 30seconds, and then transferred into a centrifuge tube at 1,600rpm for 5minutes. The volume of oil separated from the sample after centrifuge was read directly from the tube [25]. Emulsion capacity was expressed as the amount of oil emulsified and held per gram of sample.

2.5 Determination of proximate composition of flour blends

2.5.1 Determination of moisture content

The moisture content was determined using the method of AOAC [26]. A clean dish with a lid was dried in an oven at 100˚C, it was cooled in a desiccator and weighed. Five grams of the sample was weighed into the dish. The dish with its content was put in the oven at 105˚C and dried to a constant weight. The moisture content was calculated as:

$$\%\ Moisture\ content = \frac{(Weight\ of\ dish\ +\ sample) - (Weight\ of\ empty\ dish)}{Weight\ of\ sample} \times \frac{100}{1}$$

2.5.2 Determination of ash content

The ash content was determined by the method of AOAC [26]. Two grams of the sample was weighed into a dried pre-weighed porcelain crucible. The sample was transferred into a preheated Muffle furnace (carbolite, Bamford S30AU) and heated at 550ºC for 2h. The ash was then removed, cooled in a desiccator and weighed. The percentage ash was calculated as:

$$\%\ Ash = \frac{Weight\ of\ ash}{Weight\ of\ original\ sample} \times \frac{100}{1}$$

2.5.3 Determination of crude protein content

The protein content was evaluated using Kjedehl Method as described by Czubaszek et al. [27]. Two grams of samples was put into kjeldehl flask and sodium sulphate (7.68g), copper sulphate (0.28g), Selenium dioxide (SeO_4)(0.04g) and 25ml of concentrated H_2SO4 were added. The flask was heated on a heating mantle, until the solution became clear. The digest was transferred into distillation flask, 100ml water and 15ml NaOH was added. The 3 drops of methyl red indicator were put into the distilling flask. They were boiled in the distillation apparatus to liberate ammonia into the receiving flask containing 50ml of 2% boric acid. This was titrated against 0.01N Hydrochloric acid (HCL). The protein was calculated as:

$$\%\ Nitrogen = \frac{Titrate\ x\ 0.0014\ x\ Dilution\ factor\ x\ 100}{Weight\ of\ sample} \times \frac{100}{1}$$

% Protein content =Nitrogen x Conversion factor (6.25)

2.5.4 Determination of crude fiber content

The fiber content of the sample was determined according to the method of AOAC, (23). Two (2) gram of the prepared samples were extracted using diethyl ether. This was digested and filtered through the California Buckner system. The resulting residue was dried at 103 ± 2ºC in an oven (uniscope 5m 9053 laboratory oven) for about two hours and cooled in desiccators. The weighed residues was then transferred into a muffle furnace and ignited at 600 ± 100ºC at 30 minutes, cooled in desiccators and reweighed. The percentage crude fiber was calculated as:

$$\%\ Crude\ Fiber\ = \frac{W2 - W3}{W1}$$

Where: W1= Weight of sample (g)
W2= Weight of crucible with ash (g)
W3= Weight of crucible with dry residue (g)

2.5.5 Determination of fat content

The soxhlet solvent extraction method was used to determine fat content according to Malavi et al. [28]. Two (2) grams of the sample were weighed into the extraction thimble and fixed into extraction flask of known weight. Extraction was carried out using diethyl ether in electro thermal model extractor for 5h. At the completion of the extraction, the ethyl ether was removed and the remaining fat in the flask was dried at 60ºC for 30minutes in the oven cooled for 15 minutes and weighed. The percentage fat was calculated as follows:

$$\%\ Fat\ content\ = \frac{w_1 - w_2}{W3 - W2} \times 100$$

Where:
W1= Weight of extraction flask
W2= Weight of extraction flask + sample
W3= Weight of extraction + fat

2.5.6 Determination of carbohydrate content

Carbohydrate was calculated using the method of AOAC [26]. The carbohydrate content was calculated by difference as:

% Carbohydrate =100-(%Moisture+%Fat+%Ash+ % + Protein)

2.6 Determination of Mineral Composition of Flour Blend

2.6.1 Determination of Iron content

Iron was determined following the method of Tivde et al. [21]. Five milliliters of digested sample of composite four was placed in a 50 mL volumetric flask. Then 3 mL of phenanthroline solution, 2 mL of hydrochloric acid and 1mL of hydroxylamine solution were added to the sample in sequence. The sample solution was boiled for 2 minutes and 9 ml of ammonium acetate buffer solution was added to the solution. The solution was diluted with water to 50 mL volume. The absorbance was determined at 510 nm wavelength. Iron standard solution was prepared in order to plot a calibration curve to determine the concentration of the sample. Standard solution containing 100 mg/mL of ferric irons was prepared from 1g pure iron wires. The wires were dissolved in 100 mL concentrated nitric acid, boiled in a water bath and diluted to 100 mL with distilled water after cooling. Standard solutions of known concentrations were prepared by pipetting 2, 4, 6, 8 and 10 mL standard iron solution into 100 mL volumetric flasks and made up to volume.

2.6.2 Determination of Phosphorus content

Phosphorus was determined by a procedure described by Tivde et al. [21]. Using a flame photometer. Phosphorus standard was prepared. The standard solution was used to calibrate the instrument read out of composite four. The meter reading was at 100% E (emission) to aspire the top concentration of the standards. The %E of all the intermediate standard curves were plotted on linear graph paper with these readings. The sample solution was aspired on the instrument and the readings (% E) were recorded. The concentration of the element in the sample solution was read from the standard curve.

$$Phosphorus\ = \frac{Ppm\ \times\ 100\ \times\ DF}{1\ million}$$

2.6.3 Determination of zinc content

Zinc was determined by a procedure described by Tivde et al. [21]. Five milliliters (5 mL) of the test solution was pipetted into 50 ml graduated flask. Then 10 mL of molybdate mixture was added and diluted to mark with water. It was allowed to stand for 30 minutes for color development. The absorbance was measured at 660 nm against a blank. A curve relating

absorbance to mg zinc present was constructed. Using the zinc standard solution, and following the same procedure for the test sample, a standard curve was plotted to determine the concentration of zinc in the composite flour sample.

$$Zinc = \frac{graph\ reading \times solution\ volume}{100}$$

2.7 Determination of vitamins composition of Flour Blend

2.7.1 Determination of vitamin B_1 (thiamine)

Thiamine content was determined using the scalar analyzer method of AOAC, [26]. Five grams (5 g) of each sample of composite four was homogenized in 5 ml normal ethanoic sodium hydroxide solution. The homogenate was filtered and made up to 100 ml with the extract solution. A 10ml aliquot of the extract was dispensed into a flask and 10 ml of potassium dichromate solution added. The resultant solution was incubated for 15 min at room temperature (25˚C ± 331˚C). The absorption was read from the spectrophotometer at 360 nm using a reagent blank to standardize the instrument at zero. The thiamine content was calculated as follows:

$$Vitamin B1(mg/100g) = \frac{100}{Sample\ weight.} \times \frac{Sample\ absorbance \times concentration}{Concentration\ of\ solution \times Dilution\ Factor}$$

2.7. 2 Determination of Vitamin B_2 (Riboflavin)

Riboflavin was determined according to AOAC [26] methods. Two grams (2 g) of composite four samples were placed in a conical flask and 50 ml of 0.2N HCl was added to the sample, boiled for 1 hour, and then cooled. The pH was adjusted to 6.0 using sodium hydroxide 1N HCl was added to the sample solution to lower the pH to 4.5. The solution was filtered into 100 mL measuring flask and made to volume with water. In order to remove interference, two tubes were taken, labeled 1 and 2. Ten milliliter of filtrate and 1 mL of riboflavin standard were added to test tube 2. About 1 ml of glacial acetic acid was added to each tube and mixed, and then 0.5 mL of 3% KMnO4 solution was added to each tube. They were allowed to stand for 2 minutes, after which 0.5 ml of 3% H2SO4 was added and mixed well. The fluorimeter was adjusted to excitation wavelength of 470 nm and emission wavelength of 525 nm. The fluorimeter was adjusted to zero deflection against 0.1N H2SO4 and 100 against tube 2 (standard). The fluorescence of tube 1 was read. Two milliliter of sodium hydrogen sulphate was added to both tubes and the fluorescence measured within 10 seconds. This was recorded as blank reading.

$$Vitamin\ B2 = \frac{Sample\ Rd - Blank\ Rd}{(SampleRd - BlankRd) - (SampleRd.+Std.Tube - SampleRd.+Std.Blank)} \times \frac{1}{Sample\ wt}$$

2.8 Anti-nutritional Composition Determination of the Flour Blends

2.8.1 Determination of Oxalate

Oxalate content of the flour samples was determined using the method of Peters et al. [29]. 1 g of the sample was dissolved in 100ml of 0.75M H2SO4. The solution was the carefully stirred with a magnetic stirer for 1hour and filtered. 25ml of the filtrate was pipetted and titrated hot(85^0C) against 0,1M of KMNO4 to end point of a faint pink colour that persisted for more than 30 seconds. The value was then multiplied by 2.2 to get the amount of oxalate in the sample.

2.8.2 Determination of phytate

2g portion of dried sample extract was mixed with 5ml of diluted ammonia solution and shaken vigorously. 5ml Sulphuric acid was added , followed by potassium hydroxide. The colour of the extract changed to yellow, this is indicative of the presence of phytate. The extract content was determined for phytate using uv-vis spectrophotometer at 330nm [29].

2.8.3 Determination of Tannin

0.5g of extracted sample was placed in a beaker and 20ml of boiled water was added to it and filtered, then 2-3 drops of 1% ferric chloride was added. A blue black coloration is observed for tanins presence [30].

2.8.4 Determination of Trypsin inhibitors

Sample of 10g was extracted with 50ml of 10M NaOH with magnetic stirring for 3 ours .Suspension was diluted with water to get 30-70% trypsin inhibitor. Stock solution(1000ml)KTI and BBL reagents were prepared by dissolving 10mg with 100ml water-waking solution of 20mg/ml for the inhibitor were prepared also by diluting 10ml of stock to 50ml of water. (Mg/100g=A-B/W*100) [29].

2.9 Determination of Microbiological Properties of the Flour Blends

The sample was processed as well to identify the various microbial components present in the sample. Various foods have specific nutrients that help in microbial growth because microorganisms also need nutrients for their growth. This analysis will identify the microorganisms present in each sample to determine their effects on the sample.

2.9.1 Grams staining

The method used was described by Harley and Prescott [31]. Smear of the isolates were prepared and heat fixed on clean grease free slides. The smears were stained for one minute with crystal violet and the stain washed off with a gentle running tap water. The slides were flooded with dilute Lugol's iodine solution which functions as a mordant for one minute. The reagent was washed off with water and the smear was decolorized with 95 % alcohol till the blue colour no more dripped out (about 15 to 30 seconds). The smear was then counter stained with safranin solution for about one minute. Finally, the slides were washed with tap water, air dried and observed under oil immersion objectives [31].

2.9.2 Catalase test

Hydrogen peroxide solution (2 to 3 mL) was dropped on a clean grease-free slide. Several colonies of 24 hours old culture of the test organisms were immersed in the hydrogen peroxide (H202) solution. The presence of bubbles would indicate a positive result [26].

2.9.3 Oxidase Test

Filter paper was wetted with 1.0 % aqueous solution of tetramethyl-p-phenylene-diamine dihydrochloride reagent with sterile plastic loop large mass of pure test isolate were transferred to the wetted filter paper and made a smear and observed for 1 minute. The inoculated area that turned dark-blue to maroon to almost black was taken as positive while colourless inoculated area after a minute was taken as negative [31].

2.9.4 Coagulase Test

Blood (5 mL) was collected in a centrifuge test tube containing EDTA and allowed to sediment and then centrifuged to separate out the plasma. A drop of normal saline was made on a clean grease-free slide and emulsified with test organism using a wire loop. A drop of plasma was placed on the emulsified organism and mixed, and then the slide was rocked gently for about 10 seconds. Positive results showed microscopic clumping within 10 seconds while no clumping show negative result [31].

2.9.5 Indole Test

The test organism was inoculated in tubes containing sterile peptone water, incubated at 35 0C for 48 hours. After incubation 3 drops of Kovac's reagent (Isoamyl alcohol, paraDimethylaminobenzaldehyde concentrated hydrochloric acid) was added to the culture broth. Presence of red or red-violet colour would indicate a positive result while a negative result appeared on the surface orange-yellow [31].

2.9.6 Urease Test

Twenty-four hours old test organism were inoculated in sterile (Christensen) urease agar slants containing 2 % urea and incubated for 16 to 24 hours. Positive test would be indicated by colour change from yellow to red-violet while negative result would be yellow [32].

2.9.7 Voges-Proskauer Test

The test organism was inoculated in a tube containing 5 ml sterile glucose phosphate broth, and was incubated for 3 days at 37 ^{o}C. After incubation alpha-naphthol was added (Barrit A) mixed and potassium hydroxide (Barrit B) was then added and mixed. A cherry red colour would indicate positive result while yellow brown would indicate a negative result [32].

2.9.8 Methyl red Test

The test organism was inoculated in a tubes containing freshly prepared 5 ml sterile glucose phosphate broth medium and incubated at 37 ^{o}C for three days. Two drops of methyl-red reagent would be added. A positive test would be indicated by red coloration while and negative test would be indicated by orange-yellow [32].

2.9.9 Citrate Test

The use of citrate by organisms involves the production of enzyme citritase, which breaks down citrates to oxaloacetate and acetate. Oxaloacetate is further broken down to pyruvate

and carbon dioxide. Production of sodium bicarbonate ($NaHCO_3$) and ammonia (NH_3) from the use of sodium citrate and ammonia salts result in alkaline P_H. A culture of the test organism was picked with sterile wire loop and inoculated into freshly prepared sterile Simmons citrate agar slope (agar slant) by first streaking the slope then stabbing the butt. The freshly inoculated medium was incubated at 37^0C for 24 hours. Bright blue colour would indicate positive while green colour (no colour change) indicates negative [31].

2.9.10 Motility Test

Hanging drop method was used, the test organisms were inoculated into sterile freshly prepared 5 ml nutrient broth and incubated at 35^0C for 24 hours. A drop of bacterial suspension was placed on the center of cover slip. A ring of petroleum jelly was made on the convex glass slide and the glass slide was placed over the cover slip containing the suspension and held upside down. The culture was examined under microscope first under 10x then under 40x lens, with minimized light to give contrast in the background. Specimen that showed vibratory movement would indicate viability of culture while specimen that showed the movement of organisms from one point to another or would be taken to be motile [31].

2.10 Evaluation of Sensory Attributes of Flour Blend

The sensory evaluation was carried out by 10 untrained panelist which consisted of only mothers . The samples were prepared by mixing 50g of the each flour blend in 200ml of warm water (60^0C). The samples were presented in coded transparent cups. The order of presentation of samples to the panelist was randomized. They were provided with water to rinse their mouths after taking each sample. Each sensory attribute was rated using the 5 points hedonic scale, where: 5 = like extremely and 1 = dislike extremely. The panelist were instructed to evaluate the coded samples for aroma, colour, texture, taste, overall acceptability as described by Ayo et al*.* [33].

2.11 Statistical Analysis

The results obtained from the various analysis was subjected to analysis of variance(ANOVA) using statistical package of social sciences (SPSS).The significance of differences was evaluated by Duncan's test, at $P<0.05$. The results were represented as mean value +/- standard deviation(SD).

3. RESULTS AND DISCUSSIONS

3.1 Proximate compositions of the complementary Food Produced from Rizgah, Soybean, Baobab and crayfish Flour Blend

The proximate composition of the flour blend complementary food is summarized in Table 2. The moisture content and carbohydrates decreased from 9.42 to 7.77% and 65.38 to 53.71% respectively, while the ash, crude protein, crude fat and crude fibre increase from 9.34 to 16.77, 4.93 to 9.28, 9.48 to 11.50 and 1.57 to 3.53%, respectively with the decrease in the added Rizgah. The control (100% Rizgah) having the highest values. The increase in the ash, crude protein and crude fibre could be due to the inherent high content of the protein in the added soybean. While the decrease in the carbohydrate could be attributed to the decrease in the level of Rizgah added.

Fat content of the formulated feed ranged from 8.77 to 11.32% which agreed with the recommended by the FAO/WHO [34] that the fat content of complementary foods should not exceed 10% [35]. Fat is a good source of energy and free fatty acids. However, increase level of fat mainly saturated fatty acids have been proven to elevate the amount of cholesterol in blood, though this is not what is observed with unsaturated fats like those found in soybean and cereals.

Crude protein ranged from 4.74 to 9.82% which is lower than the recommended protein percentage of a complementary food (FAO/WHO, [36]. Proteins are necessary, for quick growth and development of children. The low level of proteins recorded for traditional weaning diets have been a main concern for children's feeding habits. There is a need for formulation to act as a feasible way of adding to the amount of proteins in complementary diets. In a study by Ponka et al. [36] on nutritional composition of five varieties of pap commonly consumed in Maroua, Far-North Cameroon, the protein contents of the paps ranged from 1.28 to 2.27%. It was also higher compared to that reported by [37] which was 4.48% with pap produced from sorghum sold in Nasarawa State,

Nigeria. However, Anigo, et al. [38] reported higher protein contents (6.76% to 7.88%) with paps produced with maize and millet sold in North-western Nigeria. The recommended dietary allowance (RDA) for crude protein in foods is ≥16.0 mg/100g [34].

Moisture content of the complementary feed was from 8.19% to 9.42% which is well accepted because it falls below the recommended 5-10% [34]. High moisture content during storage could encourage the growth of certain harmful yeast, moulds and bacteria [39]. Moisture content also affects the physical, chemical aspects of food which relates with the freshness and stability for the storage of the food for a long period of time and the moisture content determine the actual quality of the food before consumption and to the subsequent processing in the food sector by the food producers.

The ash content is higher than the 5% recommendation [34]. The ash content of this feed ranged from 9.34 to 16.77% which is far higher than the recommended 5-10%. This may be due to the addition of crayfish, an animal product. The ash content is highest in the last three samples where crayfish is added increasingly and hence high level of mineral elements in those diets. Recommended crude fibre is 5% by the recommendation [34]. "The crude fibre of the sample falls below 5%, ranging from 1.56% to 3.46%. High dietary fibre content has been reported to impair protein and mineral digestion and absorption in human subjects" [40]. "Fibre content of the weaning food was 3.46% which is below the recommended dietary allowance (RDA) for crude fiber in foods for infants (6–12 months) is 4.0 mg/100 g" [34]. Digestible carbohydrates of the first three of the formulated feeds fall below the 60-75% by the recommended by FAO/WHO [34] which ranges from 61.71-63.38% and the last three falls below the recommendation ranging from 53.71% to 58.68% but is still within a very close range.

"Carbohydrates content of a complementary food provides the bulk of energy and calorie requirements for infant nutrition in a readily digestible form. Carbohydrates is needed for heat and energy production for all biological activities. Body organs can divert proteins and body fat to produce the needed energy when there is carbohydrate deficiency, this may lead to mass depletion" [41].

3.2 Vitamin Content of the Complementary Food Produced From Rizgah, Soybean, Baobab and Crayfish

The results of the vitamin determination of the blend complementary flour is shown in Table 3. The vitamin C, vitamin B1 and vitamin B6 content of the blend complementary food increased from 5.7 to 7.50 (mg/100g), 0.64 to 3.00 (mg/100g) and 0.58 to 1.75 (mg/100g) respectively, with increase in the added ingredient (0 to 15% Rizgah flour). The increase is significant $p<0.05$. The relative increase in the vitamin C, vitamin B1 and vitamin B6 could be due to the added baobab and crayfish powder respectively. Baobab and crayfish has been noted to contain relative high levels of vitamin C, vitamin B_1 and vitamin B_6.

The vitamin of the formulated feed varied from 5.7 to 7.50 (mg/100g), 1.64 to 3.00 (mg/100g) and 0.58 to 1.75 (mg/100g) for vitamin C, B1 and B6, respectively. The variation can be easily attributed to baobab fruit powder and crayfish as they are rich sources of the stated vitamins.. However in all cases the vitamins levels agreed with the recommendation by FAO/WHO [34], except for Vitamin C which is lower. Ascorbic acid (vitamin C) is important in the prevention of scurvy and development of healthy immune system in infants and young children [42]. "Vitamin B_6 (pyridoxal phosphate) is a cofactor in many transaminations, decarboxylation, and deamination reactions. Thiamine functions as a co-enzyme in energy metabolism. It also helps in the treatment of beriberi and in the maintenance of healthy mental attitude in infants and young children" [42].

3.3 Mineral Content of the Flour Blend Complementary food

The mineral content of the flour blend complimentary foods are shown in Table 4. There were significant difference in all the mineral contents. The values for iron, sodium and calcium content of the complementary diet ranged from, 0.29±0.08 to 0.90±0.08, 0.01±0.00, 0.047±0.00 and 1.68±0.77, to 71.88±0.78mg/100g, respectively. Also the magnesium and phosphorous content ranged from 8.19±0.71, to 12.50±0.70 and 0.96±0.04, 0.75±0.07mg/100g.

The relative increase in the mineral composition of the formulated blends of complementary food is significant and could be due to the added soybean and crayfish flour.

Table 2. Proximate composition (%) of complementary Food Produced From Rizgah, Soybean, Baobab and crayfish flour blend

Sample R:S:B:C	Moisture	Ash	Crude protein	Crude fat	Crude fibre	Carbohydrates	Energy (Kcals)
$A_{100:0:0:0}$	$9.42^{a} \pm 0.77$	$9.34^{3} \pm 0.77$	$4.93^{a} \pm 0.77$	$9.48^{a} \pm 0.72$	$1.45^{a} \pm 0.72$	$65.38^{d} \pm 0.63$	$366.56^{3} \pm 0.70$
$B_{85:10:5:0}$	$9.30^{a} \pm 0.77$	$9.45^{3} \pm 0.67$	$5.25^{a} \pm 0.77$	$9.77^{a} \pm 0.77$	$1.56^{a} \pm 0.68$	$64.67^{\pm} \pm 0.77$	$365.81^{2} \pm 0.77$
$C_{75:15:10:0}$	$8.99^{a} \pm 0.77$	$11.39^{2} \pm 0.74$	$5.74^{a} \pm 0.71$	$8.77^{a} \pm 0.7^{\circ}$	$3.40^{a} \pm 0.68$	$61.71^{c} \pm 0.74$	$355.03^{c} \pm 0.72$
$D_{70:15:10:5}$	$8.85^{2} \pm 0.77$	$12.12^{a} \pm 0.79$	$6.01^{b} \pm 0.77$	10.8	$3.46^{a} \pm 0.65$	$58.68^{b} \pm 0.65$	$356.68^{b} \pm 0.77$
$E_{60:20:15:5}$	$8.19^{a} \pm 0.74$	$13.99^{2} \pm 0.62$	$9.68^{c} \pm 0.70$	$11.32^{2} \pm 0.62$	$3.55^{a} \pm 0.74$	$59.31^{b} \pm 0.63$	$353.20^{2} \pm 0.63$
$F_{55:20:15:10}$	$7.77^{a} \pm 0.62$	$16.77^{b} \pm 0.64$	$9.82^{c} \pm 0.72$	$11.50^{a} \pm 0.94$	$3.83^{a} \pm 0.72$	$53.71^{a} \pm 0.75$	$350.02^{b} \pm 0.79$

Means (±SEM) with different alphabetical superscripts in the same column are significantly different at P<0.05.
KEY R –Rizgah, S – soybean, B – baobab fruit powder, C – crayfish

Table 3. Vitamin composition (mg/100g of the complementary flour blend

Sample	Vitamin C	Vitamin B1	Vitamin B6
R: S: B: C	**(Mg/100g)**	**(Mg/100g)**	**(Mg/100g)**
A 100:0:0:0	**5.70 [a]±0.77**	**0.64[a]±0.72**	**0.58[a]±0.08**
B 85:10:5:0	**6.00[a]±0.74**	**0.71[a]±0.73**	**0.65[a]±0.07**
C 75:15:10:0	**6.41[a]±0.64**	**1.50[a]±0.70**	**0.79[a]±0.07**
D 70:15:10:5	**6.83[a]±.70**	**1.90[a]±0.04**	**1.00[a]±0.05**
E 60:20:15:5	**7.15[a]±0.72**	**2.30[a]±0.74**	**1.50[a]±0.07**
F 55:20:15:10	**7.50[a]±0.72**	**3.00[a]±0.65**	**1.75[a]±0.05**

Means (±SEM) with different alphabetical superscripts in the same column are significantly different at P<0.05. R –Rizgah, S – soybean, B – baobab fruit powder, C – crayfish

Table 4. Mineral composition (mg/100g) of complementary food produced from Rizgah, Baobab fruit, soybean and crayfish flour blend

Samples R:S:B:C	Fe	Na	Ca	Mg	P
A 100:0:0:0	0.29a±0.08	0.01 a±0.00	1.68a±0.77	8.19a±0.71	0.96a±0.04
B 85:10:5:0	0.38[a]±0.07	0.02[a]±0.00	3.37[a]±0.71	9.72[ab]±0.77	1.26[b]±0.71
C75:15:10:0	0.32[a]±0.06	0.03[a]±0.00	4.56[a]±0.71	9.72[ab]±0.74	1.41[b]±0.74
D 70:15:10:5	0.32[a]±0.00	0.035[a]±0.00	7.86[b]±.78	10.57[ab]±0.70	2.10±[ab]0.78
E60:20:15:5	0.42[a]±0.00	0.04[a]±0.00	9.16[b]±0.77	11.51[b]±0.70	2.38[a]±0.05
F55: 20:15:10	0.90[b]±0.07	0.047[a]±0.00	71.88[c]±0.78	12.50[b]±0.70	2.75[a]±0.07

Average means scores with the same alphabet in the same column are not significantly different, (P<0.05). R; Rizgah, S; soybean, B; baobab fruit powder, C; crayfish

"The iron contents of all the formulated complementary food samples reported in this study were within the recommended iron contents of foods" [34]. "Iron is an essential element for blood production, it plays such a crucial role in the body, it is important to maintain an adequate supply of iron to form haemoglobin and the other molecules in the body that depends on iron to function properly. For children that are 6 months and above they are expected to consume at least 7mg of iron per day. Children with iron deficiency (Anaemia) have short attention span, studies have shown that iron deficiency leads to poorer developmental outcomes in infancy and childhood especially motor, cognitive, social, emotional and neuro-physiological development in the short and long term" [42].

The sodium content of the complementary diet ranges from 0.01to 0.03 mg/100g with control sample (100% Rizgah flour) having the least sodium content (0.01), while the sample substituted with 20% soybean, 15% baobab fruit powder and10%Cray fish had the highest value (0.03).Sodium is needed in the body in a small amount to help maintain normal blood pressure and normal function of muscles and nerves [37].

The calcium content of the complementary diet ranges from 1.68 to71.88mg/100g with control sample (100% Rizgah flour) having the least sodium content (1.68mg/100g). The sample with 20% soybean, 15% baobab fruit powder and10% cray fish had the highest value (71.88mg/100g). "High calcium suggests that the samples could be used in complementary foods to help build the bones and teeth since calcium is one of the main components of teeth and bones. Calcium also plays a role in blood clotting" [36].

The magnesium content of the flour blend complementary diet ranges from 8.19 to 12.50mg/100g with control sample (100% Rizgah flour) having the least magnesium content (8.19mg/100g), while the sample substituted with 20% soybean, 15% baobab fruit powder and 10% cray fish had the highest value (12.50mg/100g). While the phosphorus content ranges from 0.75 to 3.56mg/100g. With sample F having the least amount of phosphorus (0.75mg/100g) and sample B having the highest amount of phosphorus (3.56mg/100g).

3.4 Functional Properties of Complementary Food Produced from Rizgah, Soybean, Baobab and crayfish

The functional property of the flour blend of the complementary food prepared from Rizgah, soybean, baobab and crayfish is summarized in Table 5. The bulk density of the complementary food decreased from 0.34 to 0.28g/cm^3 with the

decrease in the added Rizgah (100-55%). The control (100% Rizgah) having the highest value (0.34g/cm^3) and the 55% Rizgah having the lowest values (0.28g/cm^3).

The swelling, oil absorption and water absorption capacity decreased from 85.25 to 66.10%, 25.50 to17.50% and 57.50 to 45.50% respectively. The control (100% Rizgah) having the highest value of 85.25, 25.50 and 57.50 respectively. "Water absorption capacity depends on the ability of a polysaccharide or protein matrix to absorb, retain, and also physically entrap water against gravity and is strongly associated with flour thickness and viscosity" [22]. "A high water absorption capacity is an indicator of higher moisture in the matrix and the water will thus dilute the energy and nutrient content of the composite flour" [30]. The WAC of the formulated feed is relatively high where it is lowest at 49.50% and goes up to 57.50%. Low water absorption capacity is desirable for making thinner gruel with high caloric density per unit volume [43]. High WAC can cause an increase in microbial activity and reduce the shelf-life of the formula.

"The variation in bulk density of foods could be due to the variation in starch and initial moisture content of the foods and increase correspondingly with the starch content" [22,43]. "The high value of bulkiness is undesirable for complementary food due to the physiology of the alimentary canal and stomach capacity of the infant that is usually small to accommodate bulky food material" [42,43]. "Nutritionally, loose bulk density promotes easy digestibility of food products, especially among children with immature digestive systems. The significance of this is that less bulky flours will have higher nutrient density since more flour can be packed in a given volume. The flour blend at the end has low bulk the ranges from 0.28-0.34g/cm^3. The variation in different flours may be due to different protein concentration, their degree of interaction with water and conformational characteristics" [38].

"The oil absorption capacity (OAC) of the flour blend increased from 17.50% to 22.50%.. OAC indicate the ability of a flour to retain flavor and improve mouth feel" [44]. "OAC has been attributed to physical entrapment of oil and the binding of fat to the polar chains of proteins. The more hydrophobic proteins show superior binding of lipids, this implies that non-polar amino acids side chains bind the paraffin chains of fats" [44].

"The swelling capacity (SC) of the different samples ranged from 45.25% to 86.95%. The swelling capacity is an indication of the non-covalent bonding between the molecules of starch granules and also the amylose and amylopectin ratios" [45]. "The swelling index of flours are influenced by the particle size, species variety and method of processing or unit operations" [44]. "Starch is found in very small packets known as granules. The amount and proportion of amylose and amylopectin found is starch vary according to the plant source. This explains why different flours from different sources have different swelling capacities" [22].

3.5 Microbial Composition of the Complementary Flour Blend Produced from Rizgah, Soybean, Baobab and Crayfish

The total coliform count (TCC), Total heterotrophic bacteria count (THBC) and total heterotrophic fungal count (THFC) of the complementary food flour is shown in Table 5. The TCC ranges from 2.8×10^{-2} to 1.5×10^{-2}, the increase in the TCC could be because of contamination of water and environment of processing of the produced complementary flour blend. Growth of coliform has been associated with contamination from water or processing environment. THBC and THFC decreased from 7.5×10^{-5} to 2.3×10^{-5} and 3.1×10^{-3} to 1.8×10^{-3} respectively from the control sample A (100% Rizgah) to sample F (55% Rizgah). THBC increase has been associated with moisture, P^H (neutral or slightly acidic), protein-rich environment and warmness, also THFC is affected by moisture, oxygen content and temperature. Moisture which is a common factor affecting THBC and THFC is highest in sample A (100% Rizgah) as shown in table 6, this could be a factor causing THBC and THFC to be highest in sample A.

Microbiological evaluation was carried out on complementary foods to ascertain their wholesomeness for Consumption. The microbial count obtained In this study fall within the recommended safe limit if microbial guidelines for ready-to-eat foods adopted by the International Commission of Microbiological Specification of Food (ICMSMF) which states that the microbial safe limit for ready-to-eat food should fall between the range of 10^2 to 10^5Cfu/ml which agreed with other works [46].

Table 5. Functional properties of complementary food produced From Rizgah, Soybean, Baobab and crayfish flour

Samples R: S: B: C	Bulk (g/cm$^{3)}$ Density	Swelling Capacity (%)	Oil absor ption (%)	Water Absor ption (%)
$A_{100:0:0:0}$	0.34^{a}±0.07	85.25^{a}±0.77	25.50^{a}±0.70	57.50^{e}±0.70
$B_{85:10:5:0}$	0.33^{a}±0.07	85.00^{d}±0.28	22.50^{d}±0.70	54.50^{d}±0.70
$C_{75:15:10:0}$	0.32^{a}±0.07	80.75^{c}±0.63	22.00^{c}±0.70	55.50^{d}±0.70
$D_{70:15:10:5}$	0.30^{a}±0.07	76.95^{e}±0.77	21.50^{d}±0.70	49.50^{b}±0.70
$E_{60:20:15:5}$	0.28^{a}±0.07	75.10^{d}±0.84	19.50^{c}±0.70	47.50^{a}±0.70
$F_{55:20:15:10}$	0.28a±0.07	66.10^{b}±0.84	17.50^{b}±0.70	45.50^{a}±0.70

Means (±SEM) with different alphabetical superscripts in the same column are significantly different at P<0.05. KEY (R –Rizgah, S – soybean, B – baobab fruit powder, C – crayfish)

Table. 6. microbial composition (cfu/mg) complementary flour blend

Samples R: S: B: C	Total coliform count(cfu/mg)	Total heterotrophic bacteria count(cfu/mg)	Total heterotrophic fungal count(cfu/mg)	Catalase	Coagulase	Citrate	TSI	Oxidase	Indole
A: 100:0:0:0	$2.2\times10^{E}2$	$7.5\times10^{E}5$	$3.1\times10^{E}3$	Negative	Negative	Negative	Acid/acid	Positive	**Negative**
				Positive	Positive	Positive	Acid/acid	Negative	**Negative**
				Negative	Negative	Negative	Alkaline/alkaline	Positive	**Negative**
				positive	Negative	Negative	Acid/acid	Negative	**None**
B: 85:10:5:0	$2.1\times10^{E}2$	$4.2\times10^{E}5$	$2.4\times10^{E}3$	Positive	Positive	Positive	Acid/acid	Negative	**Negative**
				Negative	Negative	Negative	Alkaline/alkaline	Positive	**Negative**
				Positive	Negative	Negative	Acid/acid	Negative	
C:75:15:10:10	$2.4\times10^{E}2$	$3.5\times10^{E}5$	$2.8\times10^{E}3$	Positive	Negative	Negative	Acid/acid	Positive	**Negative**
				Positive	Positive	Positive	Acid/acid	Negative	**Negative**
				Negative	Negative	Negative	Alkaline/alkaline	Positive	**Negative**
D: 70:15:10:5			NO GROWTH						
E :60:20:15:5	$1.5\times10^{E}2$	$2.3\times10^{E}5$	$1.8\times10^{E}3$	Positive	Positive	Positive	Acid/acid	Positive	**Negative**
				Negative	Negative	Negative	Alkaline/alkaline	Positive	**Negative**
				Negative	Negative	Negative	Acid/acid	Positive	**Negative**
				Positive	Positive	Positive	Acid/acid	Negative	**Negative**
F: 55:20:15:10	NO GROWTH								

KEY (R –Rizgah, S – soybean, B – baobab fruit powder, C – crayfish)

Table. 6. microbial composition (cfu/mg) complementary flour blend

Samples R: S: B: C	Motility	MR	VP	Urease	Possible organism
A: 100:0:0:0	*Non-motile* *Negative* *Motile* *Negative*	*Positive* *Positive* *Negative* *Negative*	*Negative* *Positive* *Negative* *Positive*	*Negative* *Positive* *Negative* *Positive*	*Streptococcous SP* *Staphylococcous aureus* *Pseudomonas aeruginosa* *Staphylococcous epidermidis* *A.niger* *R,.solani* *S.cerevisiae* *Candida sp*
B: 85:10:5:0	*Negative* *Motile* *Negative*	*Positive* *Negative* *Negative*	*Positive* *Negative* *Positive*	*Positive* *Negative* *Positive*	*Staphylococcous aureus* *Pseudomonas aeruginosa* *Staphylococcous epidermidis* *A.niger* *R,.solani* *S.cerevisiae*
C:75:15:10:10	*Non-motile* *Negative* *Non-motile*	*Positive* *Positive* *Negative*	*Negative* *Positive* *Negative*	*Negative* *Positive* *Negative*	*Streptococcous sp* *Staphylococcous aureus* *Pseudomonas aeruginosa* *Candida spp* *S.cerevisiae* *A.niger* *A.flavus*
D: 70:15:10:5			*NO GROWTH*		
E :60:20:15:5	*Negative* *Motile* *Non-motile* *Negative*	*Positive* *Negative* *Positive* *Positive*	*Positive* *Negative* *Negative* *Positive*	*Positive* *Negative* *Negative* *Positive*	*Micrococcus spp* *Pseudomonas aeruginosa* *Streptococcous sp* *Staphylococcous aureus* *A.flavus* *Candida spp*
F: 55:20:15:10			*NO GROWTH*		

KEY (R –Rizgah, S – soybean, B – baobab fruit powder, C – crayfish)

Table 7. Anti-Nutrient Content (mg/100g) of flour blends produced from Rizgah, soybean, baobab fruit powder and crayfish flour blend

Sample R:S:B:C	Tannin	Phytate	Trypsin	Oxalate
$A_{100:0:0:0}$	5.90^{a}±0.70	5.46^{a}±1.41	7.81^{a}±0.00	0.82^{a}±0.07
$B_{85:10:5:0}$	6.35^{a}±0.70	6.35^{a}±0.70	10.76^{b}±0.70	0.16^{a}±0.07
$C_{75:15:10:0}$	6.22^{a}±0.70	13.60^{b}±0.70	11.09^{b}±0.70	1.92^{a}±0.70
$D_{70:15:10:5:0}$	5.20^{a}±0.70	13.11^{b}±0.70	10.99^{b}±0.70	0.82^{a}±0.07
$E_{60:20:15:5}$	6.12^{a}±0.70	13.43^{b}±0.70	10.89^{b}±0.70	1.82^{a}±0.70
$F_{55:20:15:10}$	5.81^{a}±0.70	13.60^{b}±0.70	10.91^{b}±0.70	2.04^{a}±0.70

Average means scores with the same alphabet in the same column are not significantly different, (P<0.05). (R; Rizgah, S; soybean, B; baobab fruit powder, C; crayfish)

3.6 Anti-Nutrient Content of the Complementary Food

The anti nutrient content of the flour blend is shown in Table 7. Tannin content of the blends ranged from 5.90±0.70, to 5.81±0.70mg/100g while the phytate content ranged from 5.46±1.41, 13.60±0.70mg/100g. Trypsin and oxalate contents ranged from 7.81±0.00 to 10.91±0.70 and 0.82±0.07, to 2.04±0.70mg/100g respectively. The increase observed in the anti nutrient content of flour blend could be due to the added soybean flour. The control sample (100% Rizgah flour) had no significant ($p>0.05$) difference . The sample substituted with 15%soybean,10% baobab fruit powder, 5% Cray fish had the least values, while the sample supplemented with 10% soybean and 5%baobab fruit powder had the highest score.

Oxalate content of complementary diet made from Rizgah, baobab fruit powder, soya beans and cray fish ranges from 0.16±0.07 to 2.04±0.70mg/100g. .According to Obizoba et al. [47] there are several factors that affect the level of oxalates in foods, including the growing season, weather conditions, and the plant variety. Cooking also significantly reduces oxalate content in food. Although certain foods may contain residual amounts of oxalates after cooking, the health benefits of eating these foods will likely outweigh any potential negative nutritional effects. Oxalates can bind to minerals like calcium in the kidneys and form calcium oxalate kidney stones the most common type of kidney stone [48]. For most people, these compounds are usually removed in the urine. The presence of trypsin inhibitors was highest in the sample with 75% Rizgah,15%soybean and 10%baobab fruit powder.Trypsin inhibitor is present in various foods such as soybeans, grains, cereals and various additional legumes.

3.7 Sensory Properties of Complementary Food Samples

Result of the sensory evaluation of the flour blend complementary foods are shown in Table 8. The average mean score for aroma ranged from 3.50-3.60. For colour, the average mean score ranged from 3.50-3.60. For texture, the average mean score ranged from 3.40-3.50. For taste, the average mean score ranged from 3.50-3.70. For overall acceptability, the average mean score ranged from 3.30-3.40.

Table 8. Sensory evaluation of complementary diet made from Rizgah, Baobab fruit powder, Soya beans and Cray fish

Samples R:S:B:C	AROMA	Colour	Texture	Taste	Overall Acceptability
$A_{100:0:0:0}$	3.50b±1.77	3.50c±1.43	3.50a±1.50	3.70a±1.33	3.10c±1.19
$B_{85:10:5:0}$	3.40^{c}±1.50	3.70^{a}±1.15	3.10^{d}±1.52	3.70^{a}±1.33	2.80^{d}±1.22
$C_{75:15:10:0}$	3.30^{c}±1.33	3.50^{c}±1.17	3.40^{b}±1.26	3.10^{d}±1.52	3.20^{b}±1.22
$D_{70:15:10:5}$	2.80^{d}±1.61	3.60^{b}±1.42	3.00^{e}±1.05	3.30^{d}±1.49	3.10^{c}±1.44
$E_{60:20:15:5}$	3.40^{c}±1.42	3.60^{b}±1.26	3.30^{c}±1.33	3.40^{c}±0.96	3.30^{b}±1.33
$F_{55:20:15:10}$	3.60^{a}±1.42	3.60^{b}±1.26	3.40^{b}±1.17	3.50^{b}±1.26	3.40^{a}±1.34

Average means scores with the same alphabet in the same column are not significantly different, (P<0.05). R; Rizgah, S; soybean , B; baobab fruit powder, C; crayfish

The sensory properties of complementary food samples are shown in Table 8. The sensory scores of the samples of complementary food showed significant (p>0.05) difference in aroma, colour, texture, taste and overall acceptability, the relative increase in the average means score of sensory quality could be due to the added crayfish.The control sample (100%Rizgah flour) had no significant (p>0.05) highest scores for Aroma, colour, taste, texture and overall acceptability compared to the test samples, while the sample substituted.

The sample F which contained (55% of Rizgah flour) had the highest in term of aroma due to increased quantity of crayfish which was 10% and also soybean 15%.

The taste and mouth feel are important parameters while testing the acceptability of formulated foods. Muhimbula et al. [49] reported that the sensory qualities of complementary food formulations which are closely related to food preferences for infants and young children are of the greatest importance in addition to their energy density. This showed that sensory evaluation should be given adequate attention in the formulation and evaluation of quality attributes of home-made complementary food formulations.Sample F had the score of 3.4. As observed there were variations in the average mean scores of the complementary food samples due to various preferences from the panelist and also due to the increase in crayfish content.

4. CONCLUSION

The research work has shown that complementary flour blend can be made from Rizgah, baobab fruit powder, soybeans and crayfish. The incorporation of the baobab fruit powder and crayfish in the production of complementary food did improve the, protein, mineral, vitamin content and sensory qualities of the blends. It could also increase the consumption and commercial value of the highly underutilized baobab fruit. The study has also created awareness on the potential of Rizgah which has for long been underutilized. Rizgah can be used instead of cereals and grains in the production of complementary food.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Oguntona CRB, Akintola MO, Adeboye OO, Anigo KM. Malnutrition among under-five children in Nigeria: A retrospective study of trends and implications for intervention. Food and Nutrition Bulletin. 2018;39(4):594-606.
2. Egbe IM, Udofia EM, Chigozie ME. Magnitude, determinants, and consequences of child malnutrition in Nigeria: a systematic review and meta-analysis. Archives of Public Health. 2022; 80(1):24.
3. World Health Organization. Complementary feeding; 2021. Retrieved from:https://www.who.int/news-room/fact-sheets/detail/complementary-feeding on 10th July 2023.
4. World Health Organization. (2022). Nigeria: WHO statistical profile. Retrieved from:https://www.who.int/gho/countries/nga.pdf on 10th July 2023.
5. Adigwe NE, Kiin-Kabari DB, Emelike NJT. Nutritional Quality and In vitro Protein Digestibility of Complementary Foods Formulated from Maize, Cowpea and Orange-Fleshed Sweet Potato Flours: A Preliminary Study. Asian Food Science Journal. 2023;22(2):25–37. Available:https://doi.org/10.9734/afsj/2023/v22i2619
6. Abirami K, Murugan B, Karthikeyan N, Nithyalakshmi V. Optimization and Nutritional Analysis of Low Calorie Functional Shrikhand . Current Journal of Applied Science and Technology. 2023; 42(44):48–62. Available:https://doi.org/10.9734/cjast/2023/v42i444282
7. Turchini GM, Moretti VM, Mentasti T, Orban E, Valfre F. Effects of dietary lipid source on fillet chemical composition, flavour volatile compounds and sensory characteristics in the freshwater fish tench (*Tinca tinca* L.). Food chemistry. 2007; 102(4):1144-1155.

8. Nwachukwu ID, Umar AI, Chigbu IO. Nutrient composition and microbial quality of selected complementary food samples in Nigeria. Journal of Food Quality. 2021;9922869.
9. Ogbonna AC, Okolie NP, Udechukwu OC, Uchegbu K. Microbiological and proximate analysis of crayfish (Cambarus clarkii) from selected farms in Nigeria. Journal of Food Safety and Hygiene. 2020;6(1):16-23.
10. Onabanjo OO, Akinyele IO, Ighodalo OJ. Development and sensory acceptability of complementary foods made from selected locally available staple crops in Nigeria. Food Science & Nutrition. 2022;10(2):710-722. PLoS One. 2017;12(5). Article e0177338
11. Salawu RO, Oshundahunsi OF, Adeyemi IA, Raji AO. Nutritional and functional properties of complementary food formulations from some locally available staple crops in Nigeria. Food Science & Nutrition. 2022;10(4):1443-1453.
12. Abb Adeleke; 2023. Retrieved; July, 15, 23.
Available:https://mysasun.com/blogs/blogle arning-bytes/12-health-benefits-of-crayfish-you-probably-didnt-know
13. Nahid F, Zaglol I, Fayza E. Study on chemical quality and nutrition value of water cray fish (*Procambarus clarkii*) Journal of The Arabian Aquaculture Society. 2009;4(1):1
14. Allemann J, Hammes PS. Effect of photoperiod on tuberization in the Livingstone potato (*Plectranthus esculentus* NE Br. Lamiaceae). Field crops research. 2006;98(1):76-81
15. Alleman M, Sidorenko L, McGinnis K, Seshadri V, Dorweiler JE, White J, Chandler VL. An RNA-dependent RNA polymerase is required for paramutation in maize. Nature. 2006;442(7100):295-298.
16. Asogwa IS, Ibrahim AN, Agbaka JI. African baobab: Its role in enhancing nutrition, health, and the environment. Trees, Forests and People. 2021;3:100043.
17. Akhobakoh M, Zing Zing B, Ngatchou A, Mbassi JEG, Nchanji EB. Potato (*Solanum tuberosum* L.) Flour Enriched with Date Palm Fruit (*Phoenix dactylifera* L.) Powder and Bean Milk for Cookies Production. Agricultural Sciences. 2022;13: 973-988.
18. Omueti O. Otegbayo Bolanle, Jaiyeola O, Afolabi Olukayode. Functional properties of complementary diets developed from soybean (*Glycine max*), groundnut (*Arachis Hypogea*) and crayfish (*Macrobrachium* Spp). Electronic Journal of Environmental, Agricultural and Food Chemistry. 2009;8:563-573.
19. Abdullah L. Suharlina A. Herbage yield and quality of two vegetative parts of indigofera at different times of first regrowth defoliation. Media Pernatakan. 2010;33(1): 44-49.
20. Ikese Chris Oche, Okoye Patrice-Anthony Chudi, Ubwa Simon Terver, Akende Samuel. Proximate Analysis and Formulation of Infant Food from Soybean and Cereals Obtained in Benue State, Nigeria. International Journal of Food Science and Biotechnology. 2017;2(5): 106-113.
DOI: 10.11648/j.ijfsb.20170205.12.
21. Tivde Verem B, Dooshima IB, Ojoutu EM, Owolabi OO, Onigbajumo A. Proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours. Agricultural Sciences. 2021;12:18-38.
Abailable:https://doi.org/10.4236/as.2021.121003
22. Awuchi CG, Igwe VS, Echeta CK. The functional properties of foods and flours. International Journal of Advanced Academic Research. 2019 Jan;5(11):139-60.
23. Kumar S, Machiwal D, Dayal D, Mishra AK. Enhanced quality fodder production through grass-legume intercropping under arid eco-system of Kachchh, Gujarat. Legume Res. 2017;40(5):896-900.
24. Olaoye OA, Lawerence IG, Animasahun AK. Functional and pasting properties of flour blends from wheat and bambaragrounut and their bread making potential. Nigerian Food Journal. 2018; 36(1):1-11.
25. Zhang K, Tian Y, Liu C, Xue W. Effects of Temperature and Shear on the Structural, Thermal and Pasting Properties of Different Potato Flour. BMC Chemistry. 2020;14. Article No. 20.
Available:https://doi.org/10.1186/s13065-020-00670-w
26. AOAC. Official methods of analysis. Association of Official Analytical Chemists. 18th Edition, AOAC, Arlington. 2015;806-814
27. Czubaszek A, Agata W, Radosław S, Joanna K. Baking properties of flour and nutritional value of rye breadwith brewer's

spent grain, LWT. 2021;150111955. ISSN 0023-6438,
Available:https://doi.org/10.1016/j.lwt.2021.111955.

28. Malavi D, Mbogo D, Moyo M, Mwaura L, Low J, Muzhingi T. Effect of Orange-Fleshed Sweet Potato Purée and Wheat Flour Blends on β-Carotene, Selected Physicochemical and Microbiological Properties of Bread. Foods. 2022;11: 1051.
Available:https://doi.org/10.3390/foods11071051.
29. Peters John C. Jimikaye Beck, Michelle Cardel, Holly R. Wyatt, Gary D. Foster, Zhaoxing Pan, Alexis C. Wojtanowski, Stephanie S. Vander Veur, Sharon J. Herring, Carrie Brill, James O. Hill. The effects of water and non-nutritive sweetened beverages on weight loss and weight maintenance: A randomized clinical trial. Obesity. 2022; 24(2):297-304.
30. Sabri FZ, Belarbi M, Sabri S, Alsayadi Muneer MS. Phytochemical Screening and identification of some compounds from Mallow. J. Nat. Prod. Plant Resour. 2012; 2(4):512-516.
31. Harley JP, Prescott LM. Laboratory Exercises in Microbiology. 5th Edition, The McGraw-Hill Companies; 2002.
32. Bachoon DS, Wendy AD. Microbiology Laboratory Manual. Ed. Michael Stranz. Mason, OH: Cengage Learning. Exercise 15, "Normal Flora of the Intestinal Tract" Print; 2008.
33. Ayo JA, Gidado FE. Physicochemical, phytochemical and sensory evaluation of acha-carrot flours blend biscuit current. Journal of Applied Science and Technology. 2017;25(5):1-15.
34. FAO/WHO/UNU. Technical Report Series 935. Protein and Amino acid Requirements in Human Nutrition; 2007. Report of a Joint FAO/WHO/UNU Expert Consultation
35. Munasinghe VS, Vella NG, Ellis JT, Windsor PA, Stark D. Cyst formation and faecal–oral transmission of Dientamoeba fragilis — the missing link in the life cycle of an emerging pathogen. Int. J. Parasitol. 2013;43(11):879–883.
36. Ponka R, Armand A.B, Elie F, Eric B, Michel P, Joëlle L, Frédéric G. Nutritional Composition of Five Varieties of Pap Commonly Consumed in Maroua (Far-North, Cameroon). Pol. J. Food Nutr. Sci., 2015;65(3):183–190.
37. Awogbenja MD, Ugwuona FU. Protein and mineral contents of commonly consumed complementary foods in Lafia, Nasarawa State, Nigeria. Int. J. Adv. Sci. Technol. 2012;5:1–6.
38. Anigo KM, Ameh DA, Ibrahim S, Danbauchi SS. Nutrient composition of complementary food gruels formulated from malted cereals, soybeans and groundnut for use in North-western Nigeria. Afr. J. Food Sci. 2010;4:65–72.
39. Dowswell, C, Paliwal, R. Cantrell R. Maize in the Third World. 2019; 10.1201/9780429042171
40. Satter MA, Syeda AJ , Nusrat A, Taslima A, Kanika M, Abdullah AM, Paul DK. Development of nutritionally enriched instant weaning food and its safety aspects. African Journal of Food Science. 2013;7(8):238-245.
41. Archibong OR, Abikoye FO, Osisanya TO. Anthropometric breast measurements of nulliparous women in Lagos Nigeria. J West Afr Coll Surg. 2021;11:1-6.
42. Oluwajuyitan TD, Fasoyiro SB, Adeyemi IA, Akanbi, CT. Texture, sensory properties and shelf-life of complementary foods enriched with soybean seed coat powder. LWT - Food Science and Technology. 2022;155:12861.
43. Adeyemi IA, Adekunle OA, Olojede AO. Nutritional composition and functional properties of soybean seed coat powder. Journal of Food Measurement and Characterization. 2020;14(6):2890-2900.
44. Ijarotimi OS, Keshinro OO, Fagbemi TN. Proximate composition, mineral content and functional properties of baobab (*Adansonia digitata*) fruit pulp. Cogent Food & Agriculture. 2019;5(1).
45. Iwe MO, Onyeukwu U, Agiriga AN. Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour Cogent Food & Agriculture 2016;2: 1142409
Available:http://dx.doi.org/10.1080/23311932.2016.1142409.
46. Olasupo NA, Oshundahunsi OF, Fagbemi TN. Physicochemical and microbiological qualities of food blends containing soybean, crayfish, and cowpea. Journal of Food Quality. 2019;3123405.
47. Obizoba IC, Uzodinma EO, Ihekoronye AI. Proximate composition, anti-nutritional factors and functional properties of

soybean–cassava flour blends for complementary food. Food Science and Quality Management, 2018;79:21-28.

48. Adebooye OC, Adu OO, Adegbite AA. Proximate composition, anti-nutritional factors, and functional properties of Livingstone Potato (*Plectranthus esculentus*) tubers. Food Science & Nutrition. 2021;9(2):811-821.

49. Muhimbula HS, Issa-Zacharia A, Kinabo J. Formulation and sensory evaluation of complementary foods from local, cheap and readily available cereals and legumes in Iringa, Tanzania. African Journal of Food Science. 2011;5(1):26-31.

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