Effect of African Breadfruit Seed and Broken Rice Flour Blends Supplementation on Physicochemical and Sensory Attributes of Unripe Cooking Banana Based Complementary Foods

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***Abstract* - This study investigated the suitability of unripe cooking banana, African breadfruit seed and broken rice in the production of complementary foods. The flour blends were prepared in varying proportions of 100:0:0 (A), 95:5:0 (B), 85:10:5 (C), 75:15:10 (D) and 65:20:15 (E) while the commercial formula (F) served as control. The functional, nutritional, anti-nutritional and sensory properties were determined using standard methods. The loose bulk density, packed bulk density, water absorption capacity, oil absorption capacity, gelatinization temperature and swelling index of the flour samples ranged from 0.35-0.67 g/ml, 0.63-0.87 g/ml, 2.40-4.06 g/g, 1.37-1.76 g/g, 70.00-79.30 ºC and 1.45-2.07 ml/ml, respectively. There was significant ($p<0.05$) increase in moisture, crude protein, crude lipid, ash and crude fibre content of the flour blends with sample E having the highest value in each, with a decrease in the carbohydrate and energy values. Selected mineral composition (Zn, Ca. Fe, Na and K) of the complementary flour samples was higher than that of the control. The anti-nutrient result showed that there was a significant ($p<0.05$) increase in the oxalate and tannin contents and a decrease in the phytate and phenol levels with increasing substitution of the flour blends. The sensory scores of the gruel produced from control was most preferred with respect to overall acceptability followed by samples A and D.**

***Keywords* - blends, processing, malnutrition, score, complementary, packaging, crop**

I. INTRODUCTION

An appropriate diet is critical in the growth and development of children especially in the first two years of life [1]. WHO [2] recommends exclusive breast feeding for the first six months of life, with the addition of complementary foods at six months with continued breast feeding until at least the age of two. The Inadequate intake of proteins in developing countries has led to various forms of malnutrition in both children and adults [3]. Appropriate complementary feeding depends on accurate information and skilled support from the family, community and healthcare system. Inadequate knowledge about appropriate complementary food and feeding practices is often a greater determinant of malnutrition than the lack of food. Knowledge of mothers about these factors will be of help in planning interventions to improve feeding practices.

Banana (*Musa acuminata*) is the largest herbaceous plant in the world [4]. Cooking banana (*Musa ABB cardaba*) is a triploid hybrid cultivar originating from the Philippines. It is predisposed to rapid postharvest spoilage due to its physiological metabolic activities and high moisture content [5]. It is primarily meant for cooking though it can also be eaten raw and they are used in a similar way to the plantain type [6]. Cooking banana provides many health benefits and it is also fit for infants feeding since it contains vitamin B_6, manganese, vitamin C, potassium, fibre, protein, folate, riboflavin, niacin and vitamin A. Cooking banana is one of the affordable fruit in the market place and it is found all year round and everywhere in the world.

African breadfruit (*Treculia africana*), is a tropical African leguminous crop of the family *Moraceace* and genus *Treculia*. It is an important food crop in Nigeria, and is widely grown in the humid South Eastern ecological zone [7]. The crop constitutes a strategic reserve of essential food nutrients that are available at certain critical period of the year when common sources of other food nutrients are short in supply or out of season. The seed is a rich protein source (25-35%) therefore among the plants consumed in the world; it is one of the richest in terms of its benefits [8]. The raw seed contains 10% oil, 40-45% carbohydrates and also a good amount of vitamins and minerals [9], [10].

Rice is a major staple food for nearly half of the population in the world and approximately 600 million tons are harvested annually worldwide [11]-[13]. The rice grain consists of 75-80% starch, 12% water and only 7% protein with a full complement of amino acids [14]. Broken rice, rice bran and rice husk are the main by-products of the rice industry [13]. The level of broken grains after milling usually exceeds 30% and the product contains unhusked grains as well as bran and husk fractions [15]. This broken rice fraction which otherwise may be used as animal feed or left unused could be transformed into various value added products like rice flour, rice milk, rice puddings etc. as an alternative source of carbohydrate for novel infant feed formulations [12], [13]. The objective of this study was therefore to provide information on the nutritional, anti-nutritional, functional and sensory properties of unripe cooking banana, African breadfruit seeds and broken rice flour blends in the development of complementary food.

II. MATERIALS AND METHODS

2.1 Material Procurement:

Cooking banana was purchased from Akpanandem market in Uyo metropolis, breadfruit seeds were purchased from Fiongaran market in Ini L.G.A, Akwa Ibom State while broken rice was purchased from Stine Industries Limited, Amichi, Nnewi L.G.A, Anambra State, Nigeria.

2.2 Material Preparation:

2.2.1 Preparation of Unripe Cooking Banana Flour:

The unripe cooking banana fruits were processed into flour according to [16]. The cooking banana fruits were removed from the bunch, washed and steamed at 100 ºC for 10 min using a water bath (model Griffin) to control enzymatic browning. The fruits were immediately cooled and peeled using a sharp knife and sliced at an average thickness of 1 cm. The sliced pieces were placed in a tray and dried in a cabinet oven (model pp 22 US, Genlab, England) at 60 ºC for 7 h. It was milled using a hammer mill (model Corona) and sieved through a mesh of 425 µm pore size sieve to obtain the fine flour. The flour was packaged in an air tight plastic container and stored in the refrigerator (model Haier Thermocool) at 4 ºC prior to analysis.

2.2.2 Preparation of African Breadfruit Seed Flour:

The breadfruit seed flour was produced following a method as described by [17]. The breadfruit seeds were parboiled for 25 min and poured into 7 mm sieve to drain. The seeds were immediately dehulled using single hand-crank disc mill (model LC-80, Gilson, USA), cooled and oven-dried (model pp22 US, Genlab, England) at 60 ºC for 24 h. The sample was milled with a hammer mill (model Corona), sieved through a mesh of 425 µm pore sieve size and packaged in a tight plastic container and stored in the refrigerator (model Haier Thermocool) at 4 ºC until used for product formulation and analysis.

2.2.3 Preparation of Broken Rice Flour:

The broken rice flour was produced following the method as described by [18]. Broken rice grains were sorted to remove extraneous and foreign materials, washed and allowed to drain. The rice was oven-dried (model pp22 US, Genlab, England) at 60 ºC for 7 h and milled using hammer mill (model Corona) and sieved through a mesh of 425 µm pore sieve size to obtain fine flour and packaged in an air-tight plastic container, labeled and stored in a refrigerator (model Haier Thermocool) at 4 ºC prior to analysis.

2.2.4 Formulation of Unripe Cooking Banana, Breadfruit Seed and Broken Rice Composite Flour Blends:

The blending of the unripe cooking banana flour, African breadfruit seed flour and broken rice flour were done as shown in Table1 in proportions of 100:0:0, 95:5:0, 85:10:5, 75:15:10, 65:20:15 for samples A, B, C, D and E, respectively using a mechanical blender (HR 7762-90, Philips, China) to obtain uniform blends. Sample F (commercial formula) served as control. The flour blends were packaged in an airtight containers and stored at ambient temperature (27±2 ºC) prior to analysis.

Table 1. Sample formulation (%) for unripe cooking banana, African breadfruit seed and broken rice flour

Flour blend	Unripe cooking banana flour	Breadfruit seed Flour	Broken rice flour
A	100	0	0
B	95	5	0
C	85	10	5
D	75	15	10
E	65	20	15
F (commercial formula)			

2.3 Analysis

2.3.1 Determination of Proximate Composition and Caloric Value:

The flour samples were analysed for their moisture, crude protein, crude fat, ash and crude fibre contents according to the method described by [19]. Carbohydrate was determined by difference i.e. % carbohydrate = 100 – (%moisture + %crude protein + %crude fat + %ash + %crude fibre). The caloric value was calculated using Atwater factor as described by [20] i.e. Energy value = (crude protein x 4) + (crude fat x 9) + (carbohydrate x 4).

2.3.2 Determination of Selected Mineral Composition:

The selected minerals were determined using the method described by [21]. Zinc, calcium and iron was determined using atomic absorption spectrophotometer (model SP9, Pye unicam Ltd, Cambridge, UK). Sodium and potassium were estimated by standard flame emission photometer (model 405, corning, UK).

2.3.3 Determination of Anti-Nutritional Factors:

Total oxalate was determined using the method described by [22]. Phytic acid was determined using the method described by [23]. The method of [24] was used for the determination of tannins and the concentration of phenol in the samples was determined using the method of [25].

2.3.4 Determination of Functional Properties:

Bulk density, water absorption capacity, oil absorption capacity and gelatinization temperature were determined according to the method of [22]. Swelling index was carried out following the method described by [26].

2.3.5 Sensory Evaluation of Complementary Food:

Sensory characteristics of the complementary food were evaluated for different sensory attributes by twenty (20) semi trained mothers (panelist) drawn from Use Offot community in Uyo metropololis, Akwa Ibom State. All the panelists were briefed before the commencement of the evaluation process. Sensory attributes evaluated were appearance, taste, flavour, mouthfeel, consistency, aftertaste and overall acceptability. The rating were on a nine- point hedonic scale ranging from 9 (like extremely) to 1(dislike extremely) according to [27]. All panelists were complementary mothers and water at room temperature was provided to rinse the mouth between evaluations.

2.4 Statistical Analysis:

Data were subjected to statistical analysis using Analysis of Variance (ANOVA). The means were then separated with the use of Duncan's New Multiple Range Test (DNMRT) at $p<0.05$ using the Statistical Package for the Social Sciences (SPSS) 20.0 software.

III. RESULTS

3.1 Proximate Composition and Caloric Value of Complementary Flour Blends:

Table 2 depicts the result of proximate composition of complementary food from different blends of unripe banana flour, breadfruit seed flour and broken rice flour. Significant ($p<0.05$) increases were observed in the moisture, crude protein, crude lipid, ash and crude fibre contents as the levels of substituting with breadfruit seed and broken rice flour increases. Moisture content ranged from 7.20% for sample A to 8.62% for sample E. Sample F gave the lowest value (2.73%). Crude protein content ranged from 1.10% (sample A) to 12.55% (sample E) while sample F had 7.79%. Crude lipid content in the flour blend ranged from 1.80-3.48% for samples A to E, respectively. Highest value (4.81%) was found in sample F. Similarly, sample E had the highest ash content of 3.53% while the lowest value (1.86%) was found in sample E with sample F having the value of 2.46%. The crude fibre content ranged from sample A (1.07%) to sample E (2.85%) and sample F having the highest value (3.23%). Conversely, carbohydrate content reduced significantly ($p<0.05$) from 86.97% for sample A to 68.97% for sample E while sample F had 78.98%. Also, the addition of breadfruit seed and broken rice had significant effect on energy value ranging from 357.40 kcal for sample E to 368.48 kcal for sample A with sample F having the highest value of 390.37 kcal.

3.2 Mineral Composition of Complementary Flour Blends:

The result of mineral composition of unripe cooking banana, breadfruit seed and broken rice flour blends is shown in Table 3. The zinc content increased significantly ($p<0.05$) ranging from 0.89 mg/100g (sample A) to 1.29 mg/100g (sample E) with sample F having the lowest value of 0.86 mg/100g. The calcium content ranged from 2.72-4.74 mg/100g for samples E and B, respectively, and sample F having 2.85 mg/100g. There was significant ($p<0.05$) effect on the iron content of the different proportions of blends ranging from 0.93 mg/100g for sample B to 1.61 mg/100g for sample D. Sample F exhibited the higher value of 1.65 mg/100g. The sodium content ranged from 3.61-4.80 mg/100g for samples E and C, respectively while sample F had 4.46 mg/100g. The potassium content ranged between 6.64 mg/100g for sample A to 9.46 mg/100g for sample C while sample F had 8.94 mg/100g.

3.3 Anti-Nutritional Composition of Complementary Flour Blends:

The result of the anti-nutritional composition of complementary flour blends made from unripe cooking banana, African breadfruit seed and broken rice flour blends is shown in Table 4. There was significant ($p<0.05$) increase in the oxalate content of the formulated complementary food when compared with the sample F. It ranged from 64.15 mg/100g (sample A) to 80.03 mg/100g (sample E) while sample F had the highest oxalate content of 145.42 mg/100g. There was a significant ($p<0.05$) decrease in the phytate content of the formulated flour blends from 33.05-30.09 mg/100g for samples A and E, respectively while 29.62 mg/100g was recorded for sample F.

Table 2. Proximate composition (%) and energy value (kcal) of complementary flour blends

Sample (CB:BS:BR)	Moisture	Crude protein	Crude lipid	Ash	Crude fibre	CHO	Energy
A (100:0:0)	$7.20^{d}\pm0.05$	$1.10^{f}\pm0.02$	$1.80^{e}\pm0.00$	$1.86^{f}\pm0.01$	$1.07^{f}\pm0.02$	$86.97^{a}\pm0.05$	$368.48^{b}\pm0.20$
B (95:5:0)	$7.29^{d}\pm0.01$	$3.82^{e}\pm0.02$	$2.48^{d}\pm0.06$	$2.50^{d}\pm0.03$	$1.55^{e}\pm0.01$	$82.36^{b}\pm0.02$	$367.04^{c}\pm0.76$
C (85:10:5	$7.86^{c}\pm0.09$	$5.78^{d}\pm0.02$	$2.52^{cd}\pm0.03$	$2.74^{c}\pm0.04$	$2.26^{d}\pm0.02$	$78.84^{c}\pm0.03$	$360.61^{d}\pm0.12$
D (75:15:10)	$8.10^{b}\pm0.05$	$9.10^{b}\pm0.03$	$2.57^{c}\pm0.03$	$3.10^{b}\pm0.03$	$2.62^{c}\pm0.02$	$74.51^{d}\pm0.05$	$357.57^{f}\pm0.13$
E (65:20:15)	$8.62^{a}\pm0.04$	$12.55^{a}\pm0.09$	$3.48^{b}\pm0.02$	$3.53^{a}\pm0.02$	$2.85^{b}\pm0.04$	$68.97^{f}\pm0.13$	$357.40^{e}\pm1.22$
F (control)	$2.73^{e}\pm0.02$	$7.79^{c}\pm0.02$	$4.81^{a}\pm0.02$	$2.46^{e}\pm0.02$	$3.23^{a}\pm0.02$	$78.98^{e}\pm0.01$	$390.37^{a}\pm0.06$

Values are means ± Standard Deviation of triplicate determinations. Means in the same column with different superscript are significantly ($p<0.05$) different. CB = Cooking banana Flour, BS = African breadfruit seed flour BR = Broken rice flour, F = Commercial formula

Table 3. Mineral composition (mg/100g) of complementary flour blends					
Sample CB:BS:BR	Zinc	Calcium	Iron	Sodium	Potassium
A (100:0:0)	$0.89^{d}\pm0.00$	$3.35^{b}\pm0.02$	$1.24^{e}\pm0.00$	$3.81^{d}\pm0.01$	$6.64^{f}\pm0.01$
B (95:5:0)	$0.95^{c}\pm0.00$	$4.74^{a}\pm0.01$	$0.93^{f}\pm0.00$	$3.67^{e}\pm0.01$	$9.06^{b}\pm0.01$
C (85:10:5	$0.87^{e}\pm0.00$	$2.81^{e}\pm0.01$	$1.36^{d}\pm0.00$	$4.80^{a}\pm0.01$	$9.46^{a}\pm0.17$
D (75:15:10)	$1.18^{b}\pm0.00$	$2.99^{c}\pm0.01$	$1.61^{b}\pm0.00$	$4.04^{c}\pm0.02$	$7.24^{d}\pm0.01$
E (65:20:15)	$1.29^{a}\pm0.00$	$2.72^{f}\pm0.01$	$1.49^{c}\pm0.00$	$3.61^{f}\pm0.01$	$7.03^{e}\pm0.01$
F (control)	$0.86^{f}\pm0.00$	$2.85^{d}\pm0.01$	$1.64^{a}\pm0.00$	$4.46^{b}\pm0.01$	$8.94^{c}\pm0.01$
Values are means ± Standard Deviation of triplicate determinations. Means in the same column with different superscript are significantly (p<0.05) different. CB = Cooking banana flour, BS = African breadfruit seed flour BR = Broken rice Flour, F = Commercial formula					

Table 4. Anti-nutrient composition of complementary flour blends				
Sample CB:BS:BR	Oxalate (mg/100g)	Phytate (mg/100g)	Tannin (mg/100g)	Phenol (mg/100g)
A (100:0:0)	$64.15^{f}\pm0.01$	$33.05^{a}\pm0.01$	$18.63^{e}\pm0.03$	$88.92^{a}\pm0.02$
B (95:5:0)	$69.25^{e}\pm0.01$	$32.24^{b}\pm0.00$	$18.85^{d}\pm0.07$	$87.67^{b}\pm0.01$
C (85:10:5	$76.43^{d}\pm0.37$	$31.50^{c}\pm0.01$	$26.45^{c}\pm0.01$	$64.90^{c}\pm0.01$
D (75:15:10)	$78.92^{c}\pm0.02$	$30.66^{d}\pm0.01$	$31.02^{b}\pm0.02$	$64.03^{d}\pm0.01$
E (65:20:15)	$80.03^{b}\pm0.02$	$30.09^{e}\pm0.01$	$38.48^{a}\pm0.01$	$57.67^{e}\pm0.01$
F (control)	$145.42^{a}\pm0.02$	$29.62^{f}\pm0.53$	$2.31^{f}\pm0.01$	$14.55^{f}\pm0.01$
Values are means ± Standard Deviation of triplicate determinations. Means in the same column with different superscript are significantly (p<0.05) different. CB = Cooking banana flour, BS = African breadfruit seed flour BR = Broken rice flour, F = Commercial formula				

The lowest tannin contents (2.31 mg/100g) was observed in sample F when compared to the formulated complementary flour blends ranging from 18.63-38.48 mg/100g for samples A and E, respectively. The total phenol content was found to be the lowest in sample F with a value of 14.55 mg/100g and in the formulated complementary blends it ranged from 57.67 (sample E) to 88.92 mg/100g (sample A).

3.4 Functional Properties of Complementary Flour Blends:

Table 5 shows the result of the functional properties of complementary flour blends from unripe cooking banana, breadfruit seed and broken rice. The loose and packed bulk density of the complementary flour blends decrease significantly (p<0.05). It ranged from 0.48-0.67 g/ml (loose bulk density) and 0.79-0.87 g/ml (packed bulk density). The complementary flour blends had higher values compare to control with 0.35 g/ml and 0.63 g/ml for loose and packed bulk density, respectively. The water absorption capacity of the flour ranged from 2.40 g/g (sample E) to 3.06 g/g (sample A) where sample F had 4.06 g/g. The oil absorption capacity of the flours increased as the percentage of banana decreased, it ranged from 1.37 g/g for sample A to 1.58 g/g for samples D and E with a greater increase in the sample F (1.76g/g). Gelatinization temperature increased significantly and ranged from 75.00 ºC for sample A to 79.30 ºC for sample E with a decrease value (70.00 ºC) in sample F. The swelling index ranged from 1.45 g/ml for sample E to 2.21 g/ml for sample B compared to sample F having 2.07 g/ml.

Table 5. Functional properties of cooking banana, African breadfruit seed and broken rice complementary flour blends						
Sample CB:BS:BR	Loose bulk density(g/ml)	Packed bulk density (g/ml)	Water abs. capacity (g/g)	Oil Abs. capacity (g/g)	Gelatinization temp (ºC)	Swelling index (ml/ml)
A (100:0:0)	$0.67^{a}\pm0.03$	$0.87^{a}\pm0.01$	$3.06^{b}\pm0.11$	$1.37^{d}\pm0.05$	$75.00^{e}\pm1.00$	$2.02^{b}\pm0.11$
B (95:5:0)	$0.63^{ab}\pm0.02$	$0.82^{b}\pm0.01$	$2.73^{c}\pm0.11$	$1.46^{cd}\pm0.05$	$76.00^{d}\pm1.73$	$2.21^{a}\pm0.08$
C (85:10:5	$0.52^{bc}\pm0.07$	$0.82^{b}\pm0.02$	$2.66^{c}\pm0.05$	$1.49^{bc}\pm0.05$	$76.70^{c}\pm0.58$	$1.77^{c}\pm0.07$
D (75:15:10)	$0.48^{cd}\pm0.06$	$0.81^{b}\pm0.02$	$2.57^{cd}\pm0.05$	$1.58^{b}\pm0.05$	$78.00^{b}\pm1.73$	$1.69^{c}\pm0.02$
E (65:20:15)	$0.48^{cd}\pm0.02$	$0.79^{b}\pm0.01$	$2.40^{d}\pm0.10$	$1.58^{b}\pm0.05$	79.30a±1.15	$1.45^{d}\pm0.06$
F (control)	$0.35^{d}\pm0.14$	$0.63^{c}\pm0.03$	$4.06^{a}\pm0.11$	$1.76^{a}\pm0.06$	$70.00^{f}\pm1.00$	$2.07^{b}\pm0.05$
Values are means ± Standard Deviation of triplicate determinations. Means in the same column with different superscript are significantly (p<0.05) different. CB = Cooking banana Flour, BS = African breadfruit seed flour, BR = Broken rice flour, F = Commercial formula						

3.5 Mean Sensory Scores of Complementary Foods:

The mean sensory scores of complementary food produced from unripe cooking banana, breadfruit seed, and broken rice flour blends is shown in Table 6. There was significant (p<0.05) effect on the gruel prepared from the flour blends as it ranged from 5.70-6.85, 5.20-6.10, 5.35-6.15, 5.50-6.35, 5.50-6.30 and 5.65-6.40 for appearance, taste consistency, flavour, mouthfeel, aftertaste and overall acceptability, respectively. Control had the highest rating scores when compared with the samples A, B, C, D and E in terms of appearance, taste, consistency, flavour, mouthfeel, aftertaste and overall acceptability whose value was 7.75, 8.25, 7.50, 7.95, 7.65, 7.65 and 8.20, respectively. Samples A and D had the highest acceptability amongst the formulated gruel and were next to being preferred after control.

Table 6. Sensory evaluation of reconstituted cooking banana, African breadfruit seed and broken rice complementary foods

Sample CB:BS:BR	Appearance	Taste	Consistency	Flavour	Mouthfeel	After taste	Overall acceptability
A (100:0:0)	$6.70^{c}\pm1.71$	$6.10^{b}\pm1.33$	$6.15^{b}\pm1.59$	$6.35^{b}\pm1.63$	$6.10^{bc}\pm1.58$	$6.30^{b}\pm1.26$	$6.40^{b}\pm1.50$
B (95:5:0)	$6.70^{c}\pm1.68$	$5.35^{d}\pm2.00$	$5.85^{bc}\pm1.56$	$6.05^{c}\pm1.79$	$5.75^{d}\pm1.71$	$5.50^{d}\pm1.98$	$5.80^{d}\pm1.85$
C (85:10:5)	$6.15^{d}\pm1.72$	$5.65^{c}\pm1.49$	$5.65^{c}\pm1.78$	$5.70^{d}\pm1.59$	$5.90^{c}\pm1.41$	$5.50^{d}\pm1.46$	$6.30^{c}\pm1.41$
D (75:15:10)	$6.85^{b}\pm0.93$	$5.50^{c}\pm1.82$	$5.35^{d}\pm1.53$	$6.35^{b}\pm1.56$	$6.35^{b}\pm1.30$	$5.85^{c}\pm1.56$	$6.40^{b}\pm0.88$
E (65:20:15)	$5.70^{e}\pm1.68$	$5.20^{d}\pm1.64$	$5.55^{cd}\pm1.39$	$5.50^{d}\pm1.46$	$5.50^{e}\pm1.67$	$5.60^{cd}\pm1.72$	$5.65^{e}\pm1.42$
F (control)	$7.75^{a}\pm0.78$	$8.25^{a}\pm0.55$	$7.50^{a}\pm1.19$	$7.95^{a}\pm1.19$	$7.65^{a}\pm1.30$	$7.65^{a}\pm1.75$	$8.20^{a}\pm1.43$

Values are means ± Standard Deviation of triplicate determinations. Means in the same column with different superscript are significantly ($p<0.05$) different. CB = Cooking banana Flour, BS = African breadfruit seed flour, BR = Broken rice flour, F = Commercial formula

IV. DISCUSSION

4.1 Proximate Composition and Caloric Value of Complementary Flour Blends:

The low moisture content of formulated samples was within the acceptable limit of not more than 10% for the long storage of flour [28]. Crude protein content is the principal component of body tissues. It is the essential nutrient for growth. Increase in crude protein content could be as a result of the increase in the proportion of breadfruit seed as reported by [29] to be 20.l%. The variation may be due to varietal differences. Control had the highest value in this study which was lower than the value (17.57%) reported by [16] for *Treculia africana*. The formulated complementary flour blends corresponds with the permitted level (15%) [30]. Crude lipid also increases the energy density of the complementary flour blends. Fat is an important component of cell membranes, it is needed in the human body for proper cell reactions and intracellular transportation of material [31]. Fat content usually plays a role in the shelf life stability of flour samples [32]. The relatively low fat content observed in this study makes them suitable raw materials for production of complementary foods. The values were lower than the 4.93-5.25% reported by [33] for maize, plantain and soybean flour blends. Consumption of high fibre food products has been linked to reduction in hemorrhoids, diabetes, high blood pressure and obesity [34], [35]. The crude fibre content became significantly ($p<0.05$) higher as the proportion of breadfruit seed and broken rice increased. The values were higher than the 0.13-0.22% reported by [33] for maize, plantain and soybean flour but it was in correlation with the [36] of not more than 5%. The ash content in the food indicates the presence of mineral contents. The increase in ash content of complementary flour blends is an indication that breadfruit seed had more mineral content than cooking banana [37]. The values obtained are in correlation with the value (<3%) by [38], but samples D and E were higher than the codex standard and this observation could be due to high content of ash (2.60%) present in African breadfruit seed as reported by [39]. The decrease in carbohydrate content could be due to the high amount of starch and sugar content present in the banana flour [40], [41] and also due to increase in the protein and fat content which is an indicative of modification. The carbohydrate content of the blends was higher than that of unripe banana and pigeon pea flour ranging from 55-79.86% [42]. The Food and Nutrition Board [30] reported that more than half of the energy requirements beyond infancy should be provided by carbohydrate with emphasis on complex carbohydrates rather than sugars. Sample D and E were in agreement with the values (60-75%) approved by [38] while the samples A, B and C were higher and this could be due to the fact that blending of two or more plant based food materials increases the nutrient density of the product [43]. The caloric value of the formulated blends were a little lower than the range values (400-425 kcal) approved by [38]. The caloric density is very important in the preparation of complementary foods. The stomach of babies is limited, so they cannot eat more than a certain amount in one feeding, there may also be difficulty in feeding the baby too many times in a day. Therefore, it is important that the calorie density in the complementary food preparation should be high so that the baby would get sufficient calories and other nutrients in a small number of feedings.

4.2 Mineral Composition of Complementary Flour Blends:

Minerals are essential for the maintenance of the overall mental physical wellbeing and are important constituents for the development and maintenance of bones, teeth, tissues, muscles, blood, and nerve cells [44]. The zinc content of the formulation was higher than the value (0.89 mg/100g) reported for sweet potato, millet and soybean complementary flour blends [45] but lower than the range values (8.67-10.84 mg/100g) for rice-soy mango blends [13]. The calcium content were lower than the range values (4.13-6.67 mg/100g) reported by [46] for yellow maize, soybeans and jackfruit seed flour blends but agrees with the findings of [44]. Iron functions as part of hemoglobin, which transports oxygen in the blood and myoglobin which enhances the amount of oxygen available for use during muscle contraction [47]. Iron content of the formulated blends was higher than the range values of 0.7-5.9 mg/kg reported by [48] for banana, soybean, and maize flour blends. This could be due to the differences in variety as banana variety. Sodium content of the formulated blends was lower than the control. The values for formulated blends were lower than the value (132.60 mg/100g) by [31] for rice, germinated-decoated faba bean, orange-fleshed sweet potato flour, and peanut oil complementary food. Potassium content was predominant mineral observed in the samples. Potassium content was higher than the values (1.64-4.69 mg/100g) reported by [44] but lower than the values reported by [45].

4.3 Anti-nutritional composition of Complementary Flour Blends:

The oxalate content of both the formulated samples and the control were higher than the range values of 8.12-17.47 mg/100g for unripe banana, pigeon pea and sweet potato flour blends [44]. The high content have been associated with the high amount of oxalate present in unripe banana [22]. In humans, the consumption of large doses of oxalic acid causes gastroenteritis, shock, low plasma calcium and renal damage [49]. Oxalates bind with calcium preventing absorption in the alimentary canal [50]. The oxalate content was found to be lower than the lethal dose of 200-500 mg/100g reported by [51]. The phytate content of formulated blends and control were lower than the values reported by [44], [52]. All samples were higher than the 25 mg/100g for permissible level [53] which could be due to the inclusion of broken rice. It has been reported by [54] that the contents of phytic acid in milled white rice varies with a wide range from 55-183 mg/100g depending on their varieties and location, however processing method that best reduced the phytate level in broken rice should be adopted. The tannin content reported for the formulated blends were in line with the values reported by [44] for unripe banana, pigeon pea and sweet potato flour blends. Tannins are polyhydric phenols present in virtually all parts of plants and are known to inhibit trypsin, chymotrypsin, amylase and lipase activities [55]. They form complexes with protein leading to a reduction in digestibility of those nutrients [56]. The total phenolic content of the flour blends and control was lower than the 145.850-116.425 mgGAE/100g reported for pre-gelatinized taro flour, maize, soya, sugar and vitamin [57]. Since tannin and phenol are plants polyphenol which have ability to form complexes with metal ions and with macromolecules such as protein and polysaccharides, their permissible level is 90 mg/100g [58].

4.4 Functional properties of Complementary Flour Blends:

Functional properties of a food material are parameters that determine its application and end use [59]. It usually shows how the food materials under investigation will interact with food components directly or indirectly affecting processing applications, food quality and ultimate acceptance (mother/infant). The packed bulk density values correlated with the range values (0.48-0.92 g/ml) as reported by [44]. Bulk density is used to evaluate the flour heaviness, handling requirements, and type of packaging materials suitable for storage and transportation of food materials [60]. Bulk density is influenced by particle size and moisture content (hygroscopic nature) of the flours. Low bulk density is desirable in complementary feeding as samples could be prepared using a small amount of water yet give the desired energy nutrient density [61]. The ability of the formulated complementary food to absorb water was highest in 100% cooking banana which gradually decreased as the level of substitution increased. This may be attributed to the low protein and high carbohydrate contents of unripe cooking banana flour, as carbohydrate have been reported to greatly influence the water absorption capacity of foods [62]. This implies that the low water absorption capacity of the flour blend would be desirable for making thinner gruel with high caloric density per unit value [63]. Oil absorption capacity measures the ability of food material to absorb oil. Increase in oil absorption capacity in this study could be due to the hydrophobic character of protein in the flour. The presence of protein in the breadfruit seed exposes the more non-polar amino acids to the fat and enhances hydrophobicity as a result of which the flour absorbs more oil [64]. Sample E had the highest gelatinization temperature. The temperature increases as the banana content in the composite flour reduced and African breadfruit seed increased. The variation in the gelation characteristics of composite flours could be attributed to the relative ratio of protein, carbohydrate and lipids that make up the flours and the interaction between such components [65]. Swelling index of flours is an indication of the imbibition of water by granules during heating [66]. The variation in values could be as a result of the differences in particle size, hydration rate and processing methods of the flour. Reduction in values at the increase level of fortification corroborates with the findings of [67]. The range of values in this study are lower than the findings reported for unripe cooking banana, pigeon pea and orange fleshed sweet potato flour blends [68].

4.5 Sensory Evaluation of Complementary Foods:

Sensory evaluation of complementary food made from unripe cooking banana, African breadfruit seed and broken rice flour blend was considered one of the important tests affecting, to a large extent, their acceptability. The commercial formula was preferred to the fortified complementary foods. This could be due to the fact that consumers are used to the commercial product [69] and also because flavouring, sweetening and other sensory enhancing agents are incorporated into the commercial product during its formulation [70]. Sample A and D were most generally acceptable amongst the formulated samples.

V. CONCLUSION

The present study established that formulation of complementary foods from unripe cooking banana, African breadfruit seed and broken rice flour blends increased the nutritional composition with higher value for crude protein, ash, crude fibre, zinc, calcium, iron, potassium and sodium contents compared with the control. Reductions in anti-nutrient contents (phytate and phenol) were found in formulated samples. Functional properties showed reduction in bulk density, water absorption capacity and swelling index which is advantageous as this would assist in the preparation of gruels with low viscosity and high calorie density per unit volume that can be easily swallowed by babies. The sensory score of the overall acceptability showed that the control was most acceptable. Though, complementary food produced from the flour blends up to 15% breadfruit seed flour and 10% broken rice flour compared favourably with the control. The implication of these findings is far reaching since all the components used in the formulation were obtained from local resources. It would go a long way in ameliorating the usual symptoms of protein-energy malnutrition commonly prevalent in developing countries such as Nigeria.

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