



Evaluation of Nutritional Composition and Sensory Attributes of Breadfruit-Soybean Flour Blends for Complementary Foods

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SOA and AOK designed the study, wrote the protocol and the first draft of the manuscript. Authors TPO and JOA managed the literature searches and performed the statistical analysis. All authors contributed towards the execution of the protocol in the lab. All authors read and approved the final manuscript.

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ABSTRACT

The objectives of this study were to produce complementary foods from locally available, underutilized and inexpensive food materials (breadfruit and soybean), to assess their nutrients value and evaluate their sensory acceptability. Breadfruit and soybean flours were mixed in ratios 100:0, 90:10, 80:20, 70:30 and 60:40 (w/w) respectively. Proximate and mineral compositions of the blends were determined using standard analytical methods; energy value was estimated using the Atwater factor. The blends were prepared for sensory evaluation by cooking with the addition of vegetable oil and sucrose and then subjected to sensory evaluation using a commercial complementary food as control. The crude protein, crude fat, ash and crude fiber contents increased significantly with increased inclusion of soybean flour from 5.36 to 22.02 g/100 g, 1.03 to 6.03 g/100 g, 1.06 to 2.55 g/100 g and 4.77 to 5.86 g/100 g respectively while carbohydrate content reduced from 81.81 to 55.24 g/100 g. The energy value ranged from 357.97 to 363.31 kcal/100 g. The samples contained 66.74 - 76.50 mg/100 g sodium, 687.43 - 725.65 mg/100 g potassium, 64.00 - 103.04 mg/100 g calcium, 145.76 - 242.51 mg/100 g phosphorus, 4.80 - 9.98

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mg/100 g iron and 3.18 – 4.61 mg/100 g zinc. The result of the sensory evaluation showed that 70:30 complementary food was the most preferred and acceptable in terms of all the sensory attributes evaluated and it compared favourably with the control. This sample also showed a promising capacity to meet the Recommended Dietary Allowances (RDAs) of protein, carbohydrate, potassium, phosphorus, iron and zinc for infants (7 -12 months). This study has shown that complementary food produced from breadfruit and soybean flour has appreciable nutritional density in terms of proximate and mineral compositions and could be used as a substitute for expensive commercial complementary foods especially among families with low income in Nigeria and other developing countries of the world.

Keywords: Complementary food; breadfruit; soybean; proximate composition; mineral composition; sensory acceptability.

1. INTRODUCTION

Complementary foods are foods that are appropriately timed, nutritionally adequate and hygienically prepared given to infants along with continued breastfeeding from six months of age [1]. It is a fact that breast milk is the perfect food for babies during the first six months of life [2]. As infants grow beyond this age, there is a need to introduce nutritious complementary foods, otherwise called weaning foods, which can meet the nutritional needs of growing infants. In Nigeria, most of the complementary foods both at commercial and home-made levels are cereals based. There is a lot of demand for cereals and cereal products due to the fact that cereals constitute a major source of staple food for the majority of people. This scenario, coupled with the problem of food shortage especially in developing countries (which is expected to worsen when the COVID-19 pandemic is over), has pushed the price of commercial complementary foods beyond the financial capacity of most low-income earners. This has resulted in preparation of traditional/home-made complementary foods that are very low in both quality and quantity. Traditional/home-made complementary foods in developing countries has been reported to be low in protein content and lack important nutrients that are needed for normal growth and development [3]. Effort to identify and include non-cereal, rarely used and inexpensive food materials with appreciable nutrient density in the production of complementary food is therefore important. Adoption of this approach will help to sustain and improve the availability of affordable quality complementary foods especially in developing countries where a large proportion of the population live below the poverty level and where the incidence of protein-energy malnutrition is prevalent [4,5].

Breadfruit (*Artocarpus altilis* (Parkinson) Fosberg) can be found in many countries of the tropical region, it is an underutilized, multipurpose, perennial plant which was first domesticated in the Pacific region [6]. It was successfully introduced to Ifewara, a town in the South-western Nigeria, from where it has spread to other towns and cities. The fruit tree is highly prolific and fruit yield is always high and more than demand. Breadfruit is high in carbohydrates and contains a good quantity of protein, minerals, vitamins and fibre [7,8]. It can thus be considered as a suitable food resource for the production of complementary food. Breadfruit has to be subjected to heat treatment before consumption; this perhaps is one of its peculiar characteristics differentiating it from other fruits. The fruit is prepared for consumption in various forms, by boiling, roasting, frying, boiling and pounding; it has also been processed into starch and flour. In terms of cost breadfruit is relatively cheaper than most staple crops, its price in the market is about one third the price of yam [9]. Soybean (*Glycine max* (L) Merrill) remained one of the best sources of plant protein and a good source of all indispensable amino acids that are essential for health, with a digestibility value of 91.41% [10,11]. Soybean could be used as an essential part of functional foods and for enhancement of product quality [12]. The problem of its utilization in food, which is its antinutritional factors, has been reported to be easily taken care of by simple thermal processing operations. Soybean has been used to increase the protein content of various food items; however there are few reports on its use in combination with breadfruit flour for complementary foods. This article reports the nutritional composition (proximate and mineral) and sensory acceptability of complementary food produced from blends of breadfruit and soybean flours.

2. MATERIALS AND METHODS

2.1 Sources of Materials

Freshly harvested matured unripe breadfruits used for this study were obtained from a farm in Ore, Ondo State, Nigeria. Soybeans, commercial complementary food and other materials were purchased from Kings Market, Ado-Ekiti, Ekiti State, Nigeria.

2.2 Production of Breadfruit Flour

Breadfruit flour was produced according to the method described by Mayaki et al. [9] with modification. Freshly harvested matured breadfruits were washed with clean water, peeled manually, cored and sliced into chips. Breadfruit chips were parboiled in hot water at 100°C for 10 minutes, drained and oven-dried at 70°C for 15 hours. Dried breadfruit chips were milled in hammer mill; the resulting flour was sieved (500 µm) and packaged in high density polyethylene bags (Fig. 1).

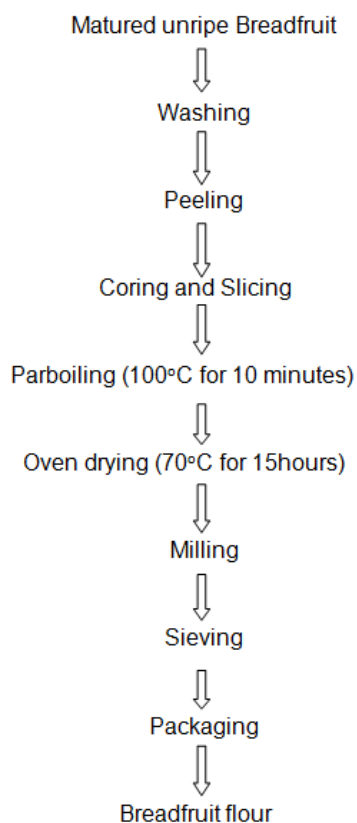


Fig. 1. Flow chart for the production of breadfruit flour

2.3 Production of Soybeans Flour

Production of soybean flour was carried out according to the method described by Tariqul-Islam et al. [13]. Soybeans were sorted and cleaned to remove pebbles, stones and other extraneous materials. The beans were added to already boiling water and allowed to boil for about 20 minutes, the beans were drained from the boiling water, washed and then dehulled manually. Dehulled soybeans were dried in a hot air oven at 65°C for 16 hours. The dried beans were milled into flour in a hammer mill, sieved (500 µm) and packaged in high polyethylene bags (Fig. 2).

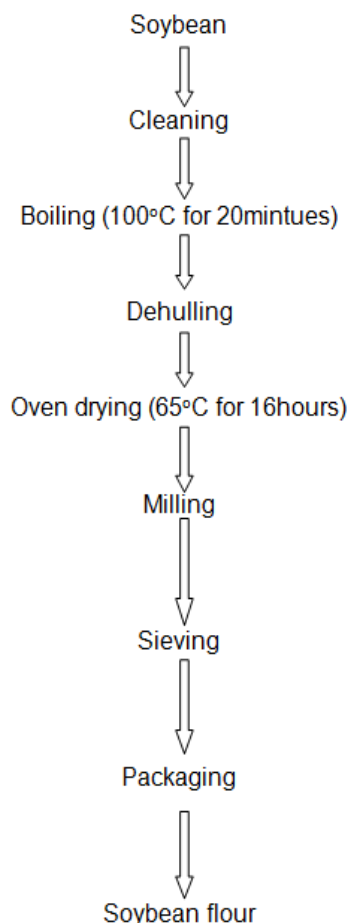


Fig. 2. Flow chart for the production of soybean flour

2.4 Formulation of Breadfruit-Soybean Complementary Foods

Five different blends of breadfruit-soybean complementary foods consisting of breadfruit and

soybean flour in ratios 100:0, 90:10, 80:20, 70:30 and 60: 40 (w/w) respectively were produced. Each sample was thoroughly mixed into homogenous flour using an electric homogenizer, packaged in high density polyethylene bags and stored at ambient temperature.

2.5 Chemical Analysis

2.5.1 Proximate composition and energy content

Moisture, protein, crude fat, crude fibre and ash contents of the samples were determined by standard methods of AOAC [14], carbohydrate content was obtained by difference. The energy content was determined using the Atwater factor and reported as kcal/100 g.

2.5.2 Mineral composition

Concentrations of mineral elements in the samples were determined using Atomic Absorption Spectrophotometer (Jenway, Model 7315; Bibby Scientific Ltd, UK). Phosphorus concentration was determined using a spectrophotometric method which is based on the measurement of absorbance of the yellow colour formed by the reaction of the element with molybdate vanadate solution [14].

2.5.3 Sensory evaluation

Complementary food samples were prepared by cooking each of the breadfruit-soybean flour blends for 12 minutes, with the addition of 5% (v/w) vegetable oil to improve fat content and 6% (w/w) sucrose to enhance the sweet taste of the samples. The samples were allowed to cool moderately and were evaluated by 18 semi-trained panelists comprising nursing mothers and students of Federal Polytechnic Ado-Ekiti. The panelists were asked to indicate their preference in terms of colour, taste, aroma, mouthfeel and overall acceptability on a nine (9) point hedonic scale where 9 = like extremely and 1 = dislike extremely. A commercial complementary food (cerelac) was used as control.

2.6 Statistical Analysis

Data obtained were analyzed statistically using analysis of variance (ANOVA) and significant differences were established at $p \leq 0.05$. Standard statistical software (SPSS version 21.0; SPSS Inc., Wacker Drive, Chicago, Illinois, USA) was used.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

The proximate composition of breadfruit-soybean complementary food is presented in Table 1. A cursory look at the result showed that the inclusion of soybean increased the proximate principles of the complementary foods except carbohydrate. The moisture contents of the samples ranged from 5.97 to 8.30 g/100 g, this range is relatively low and would enhance the shelf stability of the complementary samples. The values of moisture content reported in this study were comparable with the range (6.49 – 7.03 g/100 g) reported for maize-plantain-soybean flour blends [15]. The inclusion of soybean flour increased the protein content of the complementary foods; the sample produced from 60% breadfruit flour and 40% soybean flour (60BF40SB) had the highest protein content of 22.02 g/100 g. The protein contents of 60BF40SB and 70BF30SB (70% breadfruit flour and 30% soybean flour) were significantly higher than 15 g/100 g, 13.80 – 16.10 g/100 g and 2.17 – 5.23 g/100 g reported for commercial complementary food, maize-bambara nut complementary food [16] and commonly used local complementary foods in North-Western Nigeria [17] respectively. The relatively higher protein content of breadfruit-soybean complementary foods suggests that they could assist in improving the protein intake of infants.

There were significant differences in the values of crude fat of all the samples; the values were in the range of 1.03 to 6.03 g/100 g, this range was significantly lower than 9 g/100 g reported for the control. However, sample containing 60% breadfruit flour and 40% soybeans flour met the stipulated minimum level of 6 g/100 g fat in a complementary food [18]. The addition of vegetable oil during the preparation of the complementary food would have increased the fat content of the complementary foods beyond the level reported. Fat in complementary food increases the energy density of food and serves as a transport vehicle for fat soluble vitamins which are needed for normal growth and development of infants. The ash content of breadfruit flour alone was 1.06 g/100 g, this was increased to 2.55 g/100 g at 40% level of soybean flour inclusion. The ash contents of the samples were lower than the values (3.47 – 4.53 g/100 g) reported for complementary food produced from maize, sesame and crayfish [19]. Ash, which is important for the metabolism of

other nutrients in the body, is an index of total mineral elements in a given sample. The values of crude fibre of the complementary foods in this study were significantly higher than the values (1.43 – 1.73 g/100 g) reported for plantain-cowpea based complementary foods by Olapade et al. [20] and 2.8 g/100 g reported for the control. Even though no adequate intake value for fiber has been established, it is recommended that from 6 months of age fiber content of infants' foods should be gradually increased to provide 5 grams of fiber per day by 1 year of age [21]. It appears that breadfruit-soybean complementary foods, with fibre content range of 4.77 to 5.86 g/100 g, will meet the fibre needs of infants above 6 months of age better than the control. The carbohydrate content varied from 55.24 to 81.81 g/100 g, carbohydrate content reduced with increase in the level of soybean flour inclusion. The energy value of the samples, which ranged from 357.97 to 363.31 kcal/100 g, increased with increase in the amount of soybean flour in the samples. Carbohydrate usually contributes to the energy value of food sample. Although soybean, which is majorly a protein and fat legume, reduced the carbohydrate content of the breadfruit-soybean complementary foods, its significant contribution to the protein and fat contents of the complementary foods was responsible for the increase in energy value. Fat is a proximate principle with high energy content.

3.2 Mineral Composition

There were significant differences in the sodium contents of the complementary foods (Table 2). Sodium content of 100% breadfruit flour was 76.50 mg/100 g; the inclusion of soybean flour reduced the sodium content of the complementary foods with 60:40 breadfruit-soybean sample having the least value of 66.74 mg/100 g. Sodium contents of the complementary foods were significantly lower than 135 mg/100 g reported for the control. Sodium is valuable for the maintenance of osmotic balance and pH of body fluid and blood, and the normal function of nerves and muscles. Potassium was the most abundant mineral element in the breadfruit-soybean complementary foods with values ranging from 687.43 to 725.65 mg/100 g. There was fluctuation in the potassium content of the samples; values obtained were however comparable to the recommended dietary potassium requirement (700 mg) for infants between age 7 – 12 months [22].

Calcium content increased with increase in the level of soybean flour inclusion, 100% breadfruit flour had the least calcium content of 64.00 mg/100 g while 60:40 breadfruit-soybean sample had the highest value of 103.04 mg/100 g. Calcium is important for proper bone and tooth development in children and the maintenance of healthy nerves and muscles. However, the ability to absorb and use calcium in the body depends on the presence of other nutrients especially vitamin D. The values of phosphorus content of the complementary foods were between 145.76 mg/100 g and 242.51 mg/100 g, these values were significantly higher than the range (112.90 – 120.60 mg/100 g) reported for complementary food produced from blends of maize, plantain and soybean flours [15]. Inclusion of soybean flour in the blend progressively increased the iron content of the sample from 4.80 mg/100 g for 100% breadfruit flour to 9.98 mg/100 g for samples containing 40% soybean flour. The iron contents of the complementary foods especially samples with higher level of soybean flour were significantly higher than 7.5 mg/100 g reported for the commercial complementary food used as control in this study but lower than the recommended dietary iron requirement (11 mg) for infants between age 7 – 12 months [22]. Most full term infants are born with adequate iron store that are not depleted until about 4 to 6 months of age [23], after this period there is a need for adequate intake of iron to prevent iron deficiency anemia. Iron, which is a vital component of hemoglobin, is required for proper growth and the formation of healthy blood cells. The higher the level of soybean flour in the formulation the higher the zinc content, the values ranged from 3.18 to 4.61 mg/100 g, these values were lower than 5.5 mg/100 g reported for the control sample but compared favourably with the recommended dietary zinc requirement (4.1 mg) for infants between age 6 – 8 months [24].

3.3 Sensory Acceptability

The result of sensory evaluation is presented in Table 3. Sensory properties of complementary food, which greatly influence preference and acceptability of foods among infants and young children, are crucial just like energy and protein. There was no significant difference in the colour of all the breadfruit-soybean complementary foods, however their colour was significantly different from the colour of control. This difference may be a result of the interaction of various materials used in the production of the

Table 1. Proximate composition of breadfruit-soybean flour complementary food samples and commercial complementary food (control)

Sample	Moisture (g/100 g)	Crude Protein (g/100 g)	Crude Fat (g/100 g)	Ash (g/100 g)	Crude fiber (g/100 g)	Carbohydrate (g/100 g)	Energy value (Kcal/100 g)
100BF	5.97±0.22 ^c	5.36±0.20 ^f	1.03±0.00 ^f	1.06±0.03 ^c	4.77±0.10 ^d	81.81±0.22 ^a	357.97 ^d
90BF10SB	6.17±0.10 ^c	8.63±0.21 ^e	2.83±0.02 ^e	1.91±0.05 ^b	4.92±0.08 ^{cd}	75.54±0.43 ^b	362.15 ^b
80BF20SB	6.94±0.10 ^b	14.01±0.35 ^d	3.71±0.01 ^d	2.21±0.07 ^{ab}	5.32±0.10 ^{bc}	67.81±0.51 ^c	360.67 ^c
70BF30SB	7.83±0.21 ^a	17.70±0.20 ^b	4.68±0.05 ^c	2.52±0.05 ^a	5.69±0.11 ^{ab}	61.58±0.37 ^d	359.24 ^c
60BF40SB	8.30±0.10 ^a	22.02±0.55 ^a	6.03±0.04 ^b	2.55±0.04 ^a	5.86±0.18 ^a	55.24±0.28 ^e	363.31 ^b
Control	2.70 ^d	15.00 ^c	9.00 ^a	2.50 ^a	2.80 ^d	68.00 ^c	422.00 ^a

Means of triplicate determination ± standard deviation

Values in the same column with different superscript are significantly different (P≤0.05)

100BF = 100% Breadfruit Flour, 90BF10SB = 90% Breadfruit Flour and 10% Soybean Flour, 80BF20SB = 80% Breadfruit Flour and 20% Soybean Flour, 70BF30SB = 70% Breadfruit Flour and 30% Soybean Flour, 60BF40SB = 60% Breadfruit Flour and 40% Soybean Flour

Table 2. Mineral composition of breadfruit-soybean flour complementary food samples and commercial complementary food (control)

Sample	Na (mg/100 g)	K (mg/100 g)	Ca (mg/100 g)	P (mg/100 g)	Fe (mg/100 g)	Zn (mg/100 g)
100BF	76.50±1.00 ^b	725.65±3.50 ^a	64.00±1.00 ^f	145.76±13.6 ^f	4.80±0.20 ^e	3.20±0.10 ^d
90/10BF/SB	76.01±0.00 ^b	711.00±2.95 ^b	69.00±0.65 ^e	175.80±10.00 ^e	5.35±0.30 ^e	3.18±0.00 ^d
80/20BF/SB	72.98±1.00 ^c	714.20±2.60 ^b	81.42±1.50 ^d	201.89±13.50 ^d	6.63±0.20 ^d	3.75±0.12 ^c
70/30BF/SB	69.00±2.00 ^d	695.92±2.00 ^c	93.97±2.10 ^c	228.42±21.60 ^c	8.38±0.10 ^b	4.02±0.20 ^c
60/40BF/SB	66.74±1.00 ^e	687.43±1.87 ^d	103.04±2.02 ^b	242.51±22.00 ^b	9.98±0.25 ^a	4.61±0.10 ^b
Control	135.00 ^a	520 ^e	450 ^a	320 ^a	7.5 ^c	5.5 ^a

Means of triplicate determination ± standard deviation

Values in the same column with different superscript are significantly different (P≤0.05)

100BF = 100% Breadfruit Flour, 90BF10SB = 90% Breadfruit Flour and 10% Soybean Flour, 80BF20SB = 80% Breadfruit Flour and 20% Soybean Flour, 70BF30SB = 70% Breadfruit Flour and 30% Soybean Flour, 60BF40SB = 60% Breadfruit Flour and 40% Soybean Flour

Table 3. Mean sensory score of reconstituted breadfruit-soybean flour complementary food samples and commercial complementary food (control)

Sample	Colour	Taste	Aroma	Mouthfeel	Overall acceptability
100%BF	6.57 ^d	6.14 ^d	6.50 ^b	6.29 ^c	6.27 ^c
90BF10SB	6.62 ^b	6.69 ^{cd}	6.31 ^b	6.76 ^{bc}	6.50 ^{bc}
80BF20SB	6.77 ^b	6.85 ^{cd}	6.69 ^b	6.83 ^{bc}	7.02 ^b
70BF30SB	7.03 ^b	7.89 ^{ab}	7.61 ^a	7.39 ^b	7.79 ^a
60BF40SB	6.49 ^b	7.23 ^{bc}	6.85 ^b	7.00 ^{bc}	6.92 ^b
Control	8.40 ^a	8.54 ^a	8.31 ^a	8.26 ^a	8.28 ^a

Values in the same column with different superscript are significantly different ($P \leq 0.05$)

100BF = 100% Breadfruit Flour, 90BF10SB = 90% Breadfruit Flour and 10% Soybean Flour, 80BF20SB = 80% Breadfruit Flour and 20% Soybean Flour, 70BF30SB = 70% Breadfruit Flour and 30% Soybean Flour, 60BF40SB = 60% Breadfruit Flour and 40% Soybean Flour

Table 4. Comparison of most preferred breadfruit-soybean flour complementary food (70BF30SB) with Recommended Dietary Allowances (RDAs) for infants (7 – 12 months)

Nutrient	70BF30SB (per 100 g)	RDA (7 – 12 months) (per day)*	Extent of meeting RDA (%)**
Protein (g)	17.70	11.00	160.91
Fat (g)	4.68	30.00	15.60
Ash (g)	2.52	NA	-
Fiber (g)	5.69	NA	-
Carbohydrate (g)	61.58	95.0	64.82
Energy (kcal)	359.24	638 (7 months)***	56.31
		806 (12 months)***	44.57
Na (mg)	69.00	370.0	18.65
K (mg)	695.92	700.0	99.42
Ca (mg)	93.97	27.0	34.80
P (mg)	228.421	275.0	83.06
Fe (mg)	8.38	11.0	76.18
Zn (mg)	4.02	3.0	134.00

* IOM (2005); ** Calculation is based on 100g of the breadfruit-soybean complementary foods

*** Average for male and female infants

control which were not present in the breadfruit-soybean complementary foods. There were significant differences between the taste, aroma and mouthfeel of breadfruit-soybean complementary foods and the control. The aroma of all the complementary foods was significantly the same except for sample 70BF30SB. Complementary food produced from 100% breadfruit was the least preferred in terms of taste and mouthfeel with mean scores of 6.14 and 6.29 respectively. 70BF30SB was the most preferred in terms of taste (7.89), aroma (7.61) and mouthfeel (7.39) among the breadfruit-soybean complementary samples; and there was no significant difference between its taste and aroma and that of the control. The overall acceptability mean score of breadfruit-soybean complementary foods increased with increase in the level of soybean flour inclusion up to 30% but thereafter reduced. This observation may be due to the perception of high beany taste and aroma in the sample that contains soybean flour

proportion higher than 30%. 70BF30SB was the most preferred with a mean score of 7.79, the overall acceptability of this sample was significantly different from that of other breadfruit-soybean complementary samples. The result also showed that 70BF30SB sample compared favourably with the commercial complementary food used as control in this study as there was no significant difference between the mean sensory score of these two samples in terms of overall acceptability. Overall acceptability gives a measure of consumers' general preference for food samples.

3.4 Comparison of Most Preferred Sample (70BF30SB) with Recommended Dietary Allowances (RDAs) for Infants (7 – 12 Months)

The extent to which 100 g of the most preferred breadfruit-soybean flour complementary food

(70BF30SB) met the recommended dietary allowances (RDAs) for infants between ages 7 to 12 months is shown in Table 4. The sample is adequate to meet the daily protein need of infants as it exceeds the RDA value. It could only meet 15.60% of the daily fat need of infants. However, with the addition of vegetable oil during the preparation of the complementary food it is expected that the capacity of the sample to meet RDA for fat would have greatly increased. 100 g of the complementary food met 64.82% of the daily carbohydrate need of infants; with the possibility of consumption of more than 100 g in a day, the sample may meet RDA for carbohydrate to a greater extent. The energy content of the complementary food was 359.24 kcal/100 g; this is lower than the recommended energy requirement values of 638 kcal (7 months) and 806 kcal (12 months). The eventual energy difference between the sample and the recommended energy requirement is expected to be minimal due to the addition of vegetable oil and sucrose during the preparation of the sample. In terms of mineral elements the complementary food showed a promising capacity to meet RDAs of potassium, phosphorus, iron and zinc with percentages of 99.42%, 83.06%, 76.18% and 134.00% respectively. However, for sodium and calcium the samples fell short of the RDAs.

4. CONCLUSION

This study has shown that complementary food of appreciable nutritional quality can be produced from blend of breadfruit and soybean flours, two underutilized and relatively inexpensive crops. Complementary food produced from 70% breadfruit and 30% soybean flours was the most preferred and acceptable in terms of all the sensory attributes evaluated, it could, therefore, be used in complementary feeding especially in developing countries where the problem of protein-energy malnutrition is prevalent.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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