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EVALUATION OF THE NUTRITIONAL COMPOSITION, SENSORY AND PHYSICAL PROPERTIES OF A POTENTIAL WEANING FOOD FROM LOCALLY AVAILABLE FOOD MATERIALS – BREADFRUIT (*ARTOCARPUS ALTILIS*) AND SOYBEAN (*GLYCINE MAX*)

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Key words: nutritional composition, sensory evaluation and physical properties of soy-breadfruit

A potential weaning diet was developed from locally available least expensive food items, using local processing methods. The supplement mixtures were breadfruit and soybean. The ingredients were mixed at different ratios of 90:10, 80:20, 70:30, and 60:40 and 50:50% of breadfruit and soy flour, respectively. The results of a proximate analysis of the supplements showed that their protein content accounted for 7.82–20.92%, that of carbohydrates – for 53.36–75.42%, and that of fat – for 6.77–16.30%, whereas energy values ranged from 1654.3 to 1864.0 KJ/100 g, and that they contained appreciable quantities of P, Zn, Fe, Mg, Ca, K and Na. The bulk density generally decreased with increasing SB supplementation. SBF 1 had the lowest (0.361 g/mL) while SBF 5 had the highest (0.425 g/mL) values of that parameter. SBF 1 had the highest water absorption capacity (WAC) (490 mL/g) and SBF 5 had the lowest value of that parameter (310 mL/g). The results demonstrate that at 40% soy flour supplementation, the meal could meet satisfactorily the Recommended Dietary Allowances (RDA) for children of 1 to 3 years of age and that it has tolerably low antinutrients level.

INTRODUCTION

Weaning is the transition from exclusive breastfeeding to family foods and it is usually a period between 6 and 18 or 24 months of age, and is a very vulnerable period. It is the time when protein energy malnutrition (PEM) starts in many infants, contributing to the 40% prevalence of malnutrition in children less than five years of age worldwide [FAO/WHO, 1992]. Epidemiological studies have shown that the prevalence of protein energy malnutrition among the under five years of age children in developing countries is high, due to late weaning, low quality of weaning food and infectious diseases [Pelletier *et al.*, 1994; Amy *et al.*, 2000]. This is because diets in these areas are predominantly starchy, the major crops being roots, tubers and cereals. This is particularly true among the low-income class who wean their babies on foods high in carbohydrates, such as cocoyam, yam, potato, cassava *etc*., but low in proteins, vitamins and minerals [Awoyinka *et al.*, 1992; Matilda *et al.*, 1993].

Apart from cereals and roots, breadfruits are the commonest staple food in the tropics. Breadfruit has a considerable untapped potential as a nutritious food particularly among the low-income groups of the society in developing countries, and has an advantage over cereals and roots as it yields two or three times as much minerals and vitamins as cereals and roots [Amusa *et al.*, 2002]. As a complementary food for infants, breadfruit alone will not adequately supply protein. However, the protein quality of breadfruit can be greatly improved by combining it with other protein sources, such as soybeans, which are important sources of protein. Several researchers have established the production of weaning foods from animal and plant sources [Agbede & Aletor, 2003]. However, some of these foods are either not readily available or become unaffordable to the target groups, especially the rural nursing mothers, as a result of some difficulties in the production process or availability of the recipe ingredients [Aregai, 2000]. This necessitates the search for cheap, readily available, easy-to-prepare alternatives to cater for the nutritional needs of children.

However, before a definitive conclusion can be reached on the use of soy-breadfruit blend as weaning food, its nutritional composition and physical properties need to be evaluated. The study reported here, the first in a series, is concerned with the evaluation of the nutritional composition, sensory and physical properties of soy-breadfruit blends with a view to determine their suitability for use in weaning diets. The evaluation of the biological value of the blends is the subject of an on-going research work.

MATERIALS AND METHODS

MATERIALS

The major raw materials used in this work were mature

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healthy, freshly harvested breadfruit (*Artocarpus altilis*) and soybean (*Glycine max* L. Merri). Breadfruit was obtained from the local market in Akure, Ondo State. Soybean (Ibadan-2000 1485-1D) was obtained from the International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria. The raw materials were washed three times with tap water and later with distilled water, air-dried and collected into separate sterile plastic containers.

METHODS

Breadfruit (BF) flour. Freshly harvested, washed and air-dried BF were peeled, sliced into chips of 2 mm thickness and soaked in 75-ppm sodium metabisulphite solution at 25°C for five minutes. They were then drained, blanched (100°C, 10 min), oven dried (60°C, 24 h), milled and sieved through a 0.4 mm mesh screen.

Soybean (SB) flour. The soybean seeds were washed and soaked in 0.5% sodium hydrogen carbonate solution at a temperature of 30°C for 2 h. The seeds were cooked for 30 min at a temperature of 100°C. The seeds were dehulled, oven dried at a temperature of 60°C 24 h in an air drought oven. The dried seeds were milled and sieved through a 0.4 mm mesh screen. The blends were prepared (homogenously) and labeled as shown in Table 1.

TABLE 1. Breadfruit and soy flour blends.

Samples	Breadfruit (%)	Soybeans (%)
SF 0	0	100
BF 0	100	0
SBF 1	90	10
SBF 2	80	20
SBF 3	70	30
SBF 4	60	40
SPS 5	50	50

Chemical analyses. Triplicate samples of each blend were analysed for moisture, fat, protein (N x 6.25), crude fiber and ash in accordance with the procedures of AOAC [1995]. Total lipids were estimated by petroleum ether extraction. Carbohydrate content was estimated by difference. Gross energy was determined using a Gallenkamp Autobomb automatic adiabatic bomb calorimeter (London, UK). The total ash was estimated after ashing for 12 h at 550°C. Calcium, and iron contents were determined in an ash sample using a Buck Model 200A flame atomic absorption spectrophotometer, while phosphorous content was determined using the vanadomolybdate method [AOAC, 1995].

Antinutritional factors. The trypsin inhibitory activity, urease activity, lectin, saponin, phytic acid and nitrate contents of the food samples were determined according to standard procedures.

Physical analysis. Water absorption capacity (WAC) was determined as described by Beuchart [1977], while the bulk density was determined according to the procedures of Narayana and Narasinga [1984].

Sensory evaluation. The sensory evaluation was carried out on the following attributes: taste, appearance, aroma, mouth (texture), colour and overall acceptability by a panel of ten members using a 9-point hedonic scale. The rating of the samples ranged from 1 (Dislike extremely) to 9 (Like extremely).

Statistical analysis. The statistical significance of the observed differences among the means of triplicate readings of experimental results was evaluated with the analysis of variance (ANOVA), while means were separated using Duncan's Range Test. These analyses were carried out using GenStat 6.1 [2002] computer program.

TABLE 2a. Macronutrient (g/100 g) and mineral (mg/Kg) compositions of developed samples.

Nutrients	BF 0	SB 0	SBF 1	SBF 2	SBF 3	SBF 4	SBF 5	CS
Energy (KJ)	1582.5	1923.9	1654.3	1692.9	1734.31	1779.46	1864.04	1681.93
Moisture (g)	6.83	5.11	5.76	5.44	4.96	4.65	4.22	4.00
Protein (g)	1.88	39.07	7.82	11.66	14.46	18.35	20.92	16.67
Fat (g)	4.71	23.34	6.77	8.97	10.05	12.44	16.30	9.38
Fiber (g)	2.88	4.90	1.48	2.12	1.60	2.06	1.37	5.21
Ash (g)	2.23	3.41	2.75	2.88	2.77	2.92	3.47	2.40
CHO (g)	81.27	23.48	75.42	68.93	66.16	59.58	53.36	62.34
Ca	138.4	227.6	147.3	155.3	165.2	174.1	183.0	390.0
Mg	99.5	56.1	95.2	90.8	86.4	82.1	77.8	783.1
Zn	14.5	139.8	27.0	39.6	52.1	64.6	77.2	325.8
Fe	71.9	122.0	76.7	81.9	86.9	91.9	97.0	164.9
K	669.0	648.0	665.1	663.2	661.3	659.4	657.5	750.7
Na	671.0	581.3	662.0	653.1	644.1	635.1	626.2	918.5
P	1620.0	240.0	1482.0	1344.0	1206.0	1068.0	930.0	1226.7
Mn	26.3	-	23.7	21.0	18.4	15.8	13.2	-
Cu	49.5	-	44.6	39.6	34.7	29.7	24.8	-

(SP 0 = 100% breadfruit; SF 0 = 100% soy flour, SBF 1 = 90:10% of breadfruit and soybean; SBF 2 = 80:20% of breadfruit and soybean; SBF 3 = 70:30% of breadfruit and soybean; SBF 4 = 60:40% of breadfruit and soybean; SBF 5 = 50:50% of breadfruit and soybean: CS= control sample (Nutrend))

RESULTS AND DISCUSSION

Table 2a shows the results of the nutritional composition of soy-breadfruit blends. The values varied as follows; moisture content from 4.22 to 5.76%, protein from 7.82 to 20.92% and fat from 6.77 to 16.30%, while others including fiber, ash and carbohydrates varied from 1.37 to 2.12%, 2.75 to 3.47% and 53.36 to 75.42%, respectively. The energy values varied from 1654 to 1864 KJ. There were significant improvements in the protein status and energy values of soy-enriched breadfruit flours; the protein content and energy values increased with increasing soy flour substitution. This trend with increasing soy flour substitution is, however, not unexpected since soybean is rich in proteins and fats. This finding confirms earlier reports on the beneficial effect of vegetable protein and fat supplementation [Agbede & Aletor, 2003]. The protein contents of all the soy-breadfruit flours, except SBF 4 and SBF 5, were lower than those of the control sample. The protein content of SBF 4 and SBF 5 was significantly ($p<0.05$) higher than that of the control sample. The energy values of all soy-breadfruit flours, except SBF 1, were higher than those of the control food sample. The increase in the nutritional quality of food (in terms of protein and energy values) that was fortified with vegetable proteins (soybeans) has been reported by many researchers [Hwei-Ming *et al.*, 1997; Edem *et al.*, 2001].

Also Table 2a shows the results of the mineral compositions of breadfruit, soy-breadfruit flours and control sample. The mineral composition of the samples varied as follows: calcium: 147.3–183.0 mg; magnesium: 77.8–95.2 mg; zinc: 27.0–27.0 mg; iron: 76.7–97.0 mg; potassium: 657.5–665.1 mg; sodium: 626.2–662.0 mg; phosphorous: 930.0–1482.0 mg; manganese: 13.2–23.7 mg, and copper: 24.8–44.6 mg. All the mineral composition of the soy-breadfruit samples was lower than that of the control food sample. The higher mineral content of the control food sample was due to its enrichment with those minerals.

The levels of antinutritonal factors of the food samples were determined as well (Table 2b). The values ranged as follows: trypsin inhibitor 2.0–11.2 mg/g, urease activity 0.049–0.023%, saponin 0.3–1.47 mg/g, phytic acid 0.29–1.49 mcg/g, nitrate 0.50–2.52 mcg/100 g, and lectin was not detected in the samples. The levels of the antinutritional factors obtained in this study are relatively low when compared with the raw values, still they are within the tolerable range for animal consumption. These results are in line with the findings of other researchers [Rackis, 1974; Krogdahl *et al.*, 1994; Ollis *et al.*, 1994].

The nutritional composition of the soy-breadfruit flours would be capable of meeting the RDAs of children between 6 months 3 years of age. To meet these daily nutrient requirements of these children about 76.5 to 204.6 g of soy-breadfruit blend would have to be consumed per day [FAO/WHO, 1974]. Increasing the soy flour content in breadfruit flour thus results in a nutritionally dense product capable of improving the nutritional status of consuming children. However, before a definitive conclusion can be reached on the suitability of these blends for the weaning diet, their biological value (part II of this paper) has to be known and reconciled with their respective chemical composition.

Table 3 shows the results of a sensory evaluation. It was observed that there was a significant difference between the control food samples and soy-breadfruit flours in term of overall acceptability. The control food sample was rated higher than the soy-breadfruit flours. This could be attributed to the fact that consumers have been used to the control sample, which consists of maize and soybeans. The 50% soy flour supplementation was rated next to the control food sample, but there was no significant difference between that sample and 40% soy flour supplementation in overall acceptability and in terms of meeting the RDA requirement of the weaning children. This suggests that the supplementation with over 40% soy protein causes only minimal alteration in the nutritive value of soy-breadfruit. It is, therefore, suggested that 40% soy protein supplementation (which can be obtained by mixing four parts of soy bean

TABLE 3. Sensory evaluation scores for reconstituted soy-breadfruit and commercial infant formula.

Sample	Appearance	Taste	Aroma	Mouth feel	Overall acceptability
SBF 1	6.0^{d}	6.3^{d}	6.0^{e}	6.6^{d}	7.0^{d}
SBF 2	6.3^{d}	5.5^{cd}	6.2^{c}	5.9^{cd}	6.9^{c}
SBF 3	6.5^{c}	6.1^{c}	6.4^{c}	6.6^{c}	6.5^{c}
SBF 4	6.9^{b}	6.7^{b}	6.6^{b}	6.9^{b}	7.1^{b}
SBF 5	7.6^{ab}	7.0^{ab}	7.2^{ab}	7.0^{ab}	7.3^{ab}
CS	8.1^{a}	8.3^{a}	8.3^{a}	8.5^{a}	8.8^{a}

Means with similar letters are not significantly different from each other at the 5% statistical level; SBF = 90:10% of breadfruit and soybean; SBF = 80:20% of breadfruit and soybean; SBF = 70:30% of breadfruit and soybean; SBF = 60:40% of breadfruit and soybean; SBF = 50:50% of breadfruit and soybean; CS = control sample (Nutrend)

TABLE 2b. Level of antinutritional factors in the samples.

Sample	Trypsin inhibitor activity (mg/g)	Urease activity (%)	Saponin (mg/g)	Phytic acid (mcg/100 g)	Nitrate (mcg/100 g)	Lectin activity
BF 0	ND	ND	ND	ND	ND	ND
SF 0	22.4	0.049	3.00	2.99	5.04	0.000`
SBF 1	2.0	0.004	0.30	0.29	0.50	0.000
SBF 2	4.1	0.010	0.59	0.59	1.01	0.000
SBF 3	6.7	0.014	0.91	0.89	1.51	0.000
SBF 4	7.9	0.020	1.20	1.19	2.02	0.000
SPS 5	11.2	0.023	1.47	1.49	2.52	0.000

ND = Not Detected

flour to six parts of breadfruit flour) could be used for soy--breadfruit weaning diet formulation.

In respect to sample SBF 4 (40% soy flour and 60% breadfruit flour), the amount of soy-breadfruit flour that could adequately meet the RDAs of children (1–3 years) was calculated (Table 4) and ranged from 1.6 to 310.2 g. The cost of producing the soybreadfruit-supplemented diet ($1.92) was less than that of the commercial weaning foods, *i.e.* between $5.42 and $12.08 (Table 5). Based on this fact, the low-income family cannot afford to purchase these commercial weaning foods and for such people an alternative low-cost weaning formula is warranted.

TABLE 4. Amount of soy-breadfruit needed to meet RDA for infants with reference to SPS 3 (40% soy flour and 60% breadfruit flour).

Nutrient	Infant's RDA (1–3 years)	SBF 4 (40:60)%	Amount needed to meet RDA (g)
Energy (MJ)	5.5	1.8	305.6
Protein (g)	16	18.35	87.2
Magnesium (mg)	70.0	82.1	85.3
Zinc (mg)	5.0	64.6	7.7
Calcium (mg)	540	174.1	310.2
Phosphorous (mg)	360	1068.0	33.7
Iron (mg)	15	91.9	16.3
Copper (mg)	0.5	29.7	1.6
Manganese (mg)	2.0	15.8	12.6
Sodium (mg)	NR	635.1	-
Potassium (mg)	NR	659.4	-

TABLE 5. Comparative cost of developed supplement and some commercial formulae.

Product's name	Cost			
	=N=		K	
Developed product (500 g)	230	:	00	($1.92)
Nutrend (400 g)	650	:	00	($5.42)
Cerelac (450 g)	850	:	00	($7.08)
SMA Gold (450 g)	1450	:	00	($12.08)
SMA (450 g)	800	:	00	($6.67)

=N= Naira, K = Kobo (US Dollar $1 = =N= 120)

Physical properties

Bulk density generally decreases with increasing SB supplementation. SBF 1 had the lowest (0.361 g/mL) while SBF 5 had the highest (0.425 g/mL) values of that parameter (Table 6). An increase in bulk density is desirable since it offers a greater packaging advantage as greater quantity may be packed within a constant volume [Fagbemi, 1999].

SBF 1 had the highest water absorption capacity (WAC) (490 mL/g) and SBF 5 had the lowest value (310 mL/g) of that parameter. This trend shows that increasing SB supplementation reduces WAC and that the presence of proteins interferes with the ability of breadfruit starch to absorb water. The ability to absorb water is particularly important during reconstitution into the dough form before consumption. The WAC is a measure of the ability of the flour to associate with water, particularly in products where hydration is required to enhance handling characteristics, such as dough and pastes [Giami & Alu, 1994].

TABLE 6. Physical properties: bulk density and water absorption capacity.

Sample	Bulk density (g/mL)	WAC (%mL/g)
BF 0	0.402	570
SB 0	0.557	200
SBF 1	0.361	490
SBF 2	0.379	470
SBF 3	0.382	450
SBF 4	0.389	410
SBF 5	0.425	310
CS	0.496	470

CONCLUSIONS

This work has shown that the nutritional status of breadfruit can be improved through soy flour supplementation and that the developed soy-breadfruit diets were nutritious, inexpensive and can easily be prepared from locally available raw food materials by using simple domestic processing techniques. The developed weaning diet can be incorporated into the diet for children to prevent protein energy malnutrition in the community.

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