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Energy and Nutrient Composition of Bambara Groundnut (*Vigna substarranea*) Enriched Pap

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ABSTRACT

Background: Complementary foods produced from cereals alone are usually deficient in some essential nutrients. Combining cereals and legumes to produce complementary foods has been shown to enhance their nutrient composition.
Objective: The study aims to evaluate the energy and nutrient composition of Vigna subterranea-enriched pap.
Methods: Maize grains, bambara groundnut, and granulated sugar were purchased at Ubani market in Umuahia, Abia State. The flours were produced using standard methods; blend formulation was based on protein content. The proximate compositions of the products were evaluated using AOAC methods. Minerals were determined using wet-acid digestion. The energy value of each nutrient was obtained by multiplying the nutrient value by its Atwater factor (4, 4, and 9 for protein, carbohydrate, and lipid, respectively). Energy density was calculated by dividing the total energy value by 100. The data generated were analyzed using Statistical Product for Service Solution version 20. Means were separated and compared with the Duncan multiple range test and Analysis of Variance. Significance was accepted at $p < 0.05$.
Results: Protein values ranged between 2.21% and 6.70%, with protein content in bambara groundnut-enriched maize pap samples significantly ($p < 0.05$) higher than the protein content of 100% maize pap (2.21%). Fat (1.00%–1.47%) and crude fiber (0.60%–1.83%), fat energy value (9.0–13.23 kcal/100g), protein energy value (15.20–26.8 kcal/100g), and total energy densities (177.28–186.91 kcal/100g) were also significantly higher in bambara groundnut-enriched maize pap. All the analyzed minerals increased with an increase in the quantity of the supplement.
Conclusion: Protein, calcium, iron, zinc, and nutrient density increased with an increase in bambara groundnut flour. Supplementing pap with 40% bambara groundnut was observed to meet over 100% of the protein Recommended Daily Intake (RDI) for children aged 6–12 months old.

Keywords: *Vigna substarranea*, *Zea mays*, energy density, complementary food, protein

INTRODUCTION

Complementary foods are foods other than breast milk that are gradually introduced to babies to complement the mother's breast milk which still forms part of the diet (1). They are used for gradual withdrawal of breast milk for total adoption of regular diet (2). In developing countries complementary foods are majorly produced from starchy staple foods, which due to their high viscosity are diluted with water before been administered to the infants. This practice results in reduced nutrients and energy in the already deficient food. In other to improve nutritional profile of locally produced complementary foods supplementation of cereal with legume has been advocated for.

Vigna substarranea commonly known as bambara groundnut is an indigenous African leguminous crop believed to have originated from Mail in West Africa (3). In Zimbabwe bambara groundnut is called "nyimo", Ghana (aboboi), South Africa (jugo) (4). In Nigeria the Igbos calls it "okpa", Hausa (gurgiya or kwaruru), Yoruba (epa-roro), Idoma (ikpei). Nutritionally, it contains between 54.5 – 69.3% of carbohydrate, 17 – 24.6% of protein, 5.3 – 7.8% of fat (3). Omoikhoje, (5) reported that the essential amino acids profile is comparable to that of soybean. In another study, it was reported that its methionine content was higher than that of groundnut (6). Other nutrients reported in substantial amounts are calcium, iron, zinc, vitamin C and the B-vitamins (7). In West Africa, the nuts are eaten as snack, roasted and salted or as meals boiled similar to other beans (8). In

addition to consuming the nuts as snack, in Nigeria the dried nuts are ground into flour used to produce steamed pudding known as "okpa". Though bambara nut is a good source of some key nutrients like protein and zinc (9), personal observation also shows that its hard nature when toasted limits its consumption in children and also the traditional method of preparing it into "okpa" is not very favourable because of peppery nature. Diversifying the usage of bambara groundnut by incorporating it in cereal based complementary food will increase its consumption and in the long run enhance the nutritional status of individual that will consume it due to its high protein and some of its other key micronutrient contents. In Nigeria the use of cereal is employed in the production of most complementary foods locally known as akamu or ogi. Being a product from cereal, ogi is usually deficient in lysine but rich in methionine (9). In order to obtain an adequate meal from cereal the latter is usually combined with legume which is known to be a good source of lysine (9). The objective of the work is to evaluate the energy and nutrient composition of *Vigna substarranea* enriched pap.

MATERIALS AND METHODS

Purchase and cleaning of raw materials

The maize (*Zea mays*) grains (yellow variety) and bambara groundnut (*Vigan subterranean* –Gaborone cream) and granulated sugar were purchased at Ubani market in Umuahia Abia State.

One thousand gram each of the maize grain and bambara groundnut were manually sorted to remove stones and other extraneous substances.

Production of maize flour

Sorted maize grains (800g) were steeped in 6000ml of tap water in a covered plastic bucket and left for 48h at room temperature to allow for fermentation. The fermented grains were washed and wet milled using a hammer milling machine. The slurry was mixed with 3000ml of tap water and sieved using a muslin cloth. The filtrate was allowed to stand for 24h to allow for proper sedimentation. The water was decanted and the sediment was collected and placed in a clean muslin clot and allowed to stand for another 12h. The drained sediment was oven dried using Uniscope oven at 65^{o}C for 8h. The dried maize sediment was milled into fine flour in a disc attrition mill, sieved through a mesh of aperture 500µm and packed in an air tight polythene bag.

Production of bambara groundnut flour

The cleaned bambara groundnut (800g) was soaked in tap water in a plastic bucket and covered 18h at room temperature after which the outer cover of the bambara groundnut was manually decorticated and oven dried at 65^{o}C for 8h. The dried bambara groundnut was milled into fine flour into a disc attrition mill and sieved through a mesh of aperture 500µm before it was packed into an air tight polythene bag.

Blend formulation

The blends were formulated on protein basis and coded as follows. Sample M100 (100% maize), sample M80:B20 (80% maize and 20% bambara groundnut), sample M60:B40 (60% maize and 40% bambara groundnut), and sample M50:B50 (50% maize and 20% bambara groundnut).

Production of the complementary foods

Slurry made from 300 g maize flour and 200ml of potable water was added to 600 ml of boiling water with continuous stirring (for about 10 min) until a thick paste was formed. The above method was also used to prepare pap from maize: bambara groundnut (80:20, 60:40 and 50:50) flour blends.

Chemical analyses of the samples

The proximate compositions of the biscuits were determined using standard AOAC (10) methods. Moisture content was determined gravimetrically. The crude protein content was determined using microKjeldahl method, 6.25 was used as the nitrogen conversion factor. The crude fat content was determined using Soxhlet extraction method. The ash content was determined by incinerating the samples at 600^{o}C in a muffle furnace. Carbohydrate was obtained by difference. Nutrient energy value was obtained by multiplying the energy giving food nutrient (carbohydrate, fat and, protein) value with its Atwater factor (4, 4, and 9, for protein, carbohydrate and lipid). Energy density was calculated by dividing Total Energy value by 100 (11). Mineral elements were determined using wet-acid digestion method for multiple nutrients determination as described by the method of AOAC (10). The digest was used for the determinations of calcium (Ca) and magnesium (Mg) using the ethylamine ditetra acetic acid (EDTA) Versanate complexiometric titration method. Microminerals (Zn, Fe) were by Atomic Absorption Spectrophotometer (Model 3030 Perkin Elmer, Norwalk USA).

Statistical analysis

All determinations were done in duplicates. The data generated were entered into the computer and analyzed using Statistical Package for Social Sciences (SPSS version 20) Means and standard deviation obtained from the chemical analysis were calculated. Level of significance was accepted at

p<0.05. Analysis of variance (ANOVA) was used to compare the values obtained for sensory evaluation.

RESULTS

The proximate composition of bambara groundnut enriched pap is presented on Table 1. The moisture (55.75 %) and carbohydrate (39.41%) contents of the pap produced with 100% maize were significantly (p>0.05) higher than values of moisture (52.61 – 54.71%) and carbohydrate (36.72 – 38.27%) obtained for pap produced from maize and bambara groundnut flour blends. The protein (3.80 - 6.70%), fat (1.00 – 1.47%), crude fibre (0.62 – 0.68%) and the ash (1.60 – 1.83%) contents of the pap produced from maize and bambara groundnut flour blends were however significantly (p>0.05) higher than values of protein (2.21%), fat (0.76%), crude fibre (0.56%) and ash (1.33%) obtained for 100% maize pap.

Table 1: Proximate composition of bambara groundnut enriched pap. as consumed (%)

Nutrient	M100	M80:B20	M60:B40	M50:B50
Moisture	55.75^{a}± 0.03	54.71^{b} ±0.02	53.38^{c}± 0.02	52.61^{d} ±0.01
Protein	2.21^{c} ±0.05	3.80^{c} ±0.02	5.10^{b}±0.02	6.70^{a} ±0.01
Fat	0.76^{d} ±0.01	1.00^{c} ±0.01	1.24^{b} ±0.01	1.47^{a} ±0.03
Crude fibre	0.56^{cd}±0.02	0.62^{c} ±0.03	0.68^{b} ±0.05	0.73^{a} ±0.04
Ash	1.33^{d} ±0.01	1.60^{c} ±0.01	1.73^{b} ±0.02	1.83^{a} ±0.02
Carbohydrate	39. 39^{a} ±0.01	38.27^{b}± 0.01	37.87^{c}± 0.02	36.66^{d}± 0.01

Values are mean ± standard deviation of 2 replicates. Mean within each row not.

followed by the same superscript are significantly different (P≤0.05) from each other.

Key: M100 – 100% maize; M80:B20 – 80% maize: 20% Bambara groundnut; M60:B40 – 60% maize: 40% Bambara groundnut; M50:B50 – 50% maize: 50% Bambara groundnut

The nutrient energy value and energy densities of the products is shown on Table 2. The fat energy value ranged between 6.84 – 13.23 kcal/100g with 100% maize pap having the lowest fat energy value (6.84 kcal/100g) and M50:B50 pap having the highest fat energy value (13.23 kcal/100g). The protein energy values (15.20 – 26.8 kcal/100g) of pap made from maize-bambara groundnut flour blends were significantly higher than the protein energy value (8.84 kcal/100g) of 100% maize pap. Carbohydrate energy value (146.88 – 153.08 kcal/100g) of pap made from maize-bambara groundnut flour blends were significantly (p<0.05) lower than the value (157.64 kcal/100g) obtained for 100% maize pap. The energy densities ranged between 1.73kcal/g in 100% maize ogi to 1.86kcal/g in M50:B50 pap.

Table 2: Nutrient Energy value and energy density of bambara groundnut enriched pap as consumed.

Nutrient	Fat energy value (kcal/100g)	Protein energy value(kcal/100g)	Carbohydrate energy value(kcal/100g)	Total energy value(kcal/100g)	Energy density(kcal/g)
M100	6.84 ± 0.05	8.84 ± 0.04	157.64±0.02	173.32±0.05	1.73
M80:B20	9.0±0.04	15.20±0.05	153.08±0.03	177.28±0.04	1.77
M60:B40	11.16±0.01	20.4±0.01	151.48±0.05	183.04±0.03	1.83
M50:B50	13.23±0.04	26.8±0.02	146.88±0.04	186.91±0.03	1.86
RDI Energy range for Children aged 6 – 12months/Energy density	*25-35	*20	*550	*472-844	**≥ 0.8

Values are mean ± standard deviation of 2 replicates. *Source: World Health Organization, 2003; ** CODEXSTAN, 2006

Key: M100 – 100% maize; M80:B20 – 80% maize: 20% Bambara groundnut; M60:B40 – 60% maize: 40% Bambara groundnut; M50:B50 – 50% maize: 50% Bambara groundnut

The mineral composition of bambara groundnut enriched pap is presented on Table 3. The calcium values of the products ranged between 4.72 – 10.60 mg/100g with calcium contents (6.88 – 10.60 mg/100g) of bambara groundnut enriched pap being significantly (p > 0.05) higher than the calcium content of 100% maize pap. The magnesium (5.91 – 11.40 mg/100g), iron (2.11 – 3.93 mg/100g) and zinc (1.7 -1.9 mg/100g) contents of bambara groundnut enriched pap appear to be also significantly higher than that of (magnesium 3.82 mg/100g), iron (1.62 mg/100g) and zinc (1.4 mg/100g) 100% maize pap.

Table 3: Mineral composition of bambara groundnut enriched pap (mg/100g) as consumed

Nutrient	M100	M80:B20	M60:B40	M50:B50
Calcium	4.72^{d} ±0.05	6.88^{c}± 0.04	9.10^{b}± 0.05	10.60^{a}±0.04
Magnesium	3.82^{d} ±0.04	5.91^{c} ±0.04	8.64^{b} ±0.05	11.40^{a}± 0.04
Iron	1.62^{d} ±0.05	2.11^{c} ±0.02	3.05^{b} ±0.02	3.93^{a}± 0.02
Zinc	1.4^{d} ±0.01	1.7^{c} ±0.01	1.8^{b} ±0.02	1.9^{a}± 0.01

Values are mean ± standard deviation of 2 replicates. Mean within each row not.

followed by the same superscript are significantly different ($P \leq 0.05$) from each other.

Key: M100 – 100% maize; M80:B20 – 80% maize: 20% Bambara groundnut; M60:B40 – 60% maize: 40% Bambara groundnut; M50:B50 – 50% maize: 50% Bambara groundnut

DISCUSSION

The moisture contents of all the products were relatively high with the moisture content of 100% maize pap being significantly higher than that of pap produced with maize and bambara groundnut flour blends. When compared to other studies the moisture values obtained in this study were lower than moisture values (72.29 – 74.50%) reported by Ukaegbu and Anyika (12) in a work they carried out on maize based complementary food but higher than values (6.84 7.03%) reported by Noah (13) in a similar work. The high values of moisture found in this study could be because the moisture content of the pap was determined as consumed. Moisture of ≤ 13% in food is said to make food susceptible to microbial infection (14), it is thus important to prepare only the quantity of food the child can consume at a time, in order to protect the child from microbial infection. The study showed that protein content of maize supplemented with 20% bambara groundnut flour was 1.71 – folds higher than the protein content of M100. The protein content of samples M60:M40 and M50:B50 40% was 2.31-fold and 3.03 -fold higher than that of sample M100, respectively. Increase of protein contents of bambara groundnut supplemented maize ogi with increase of bambara groundnut flour is an indication that bambara groundnut is a better source of protein than maize (14). The study revealed that enriching maize based complementary food of children within 1 - 2yrs with 20%, 40% and 50% bambara groundnut flour will meet about 17%, 29% and 39% of RDI protein need, respectively. Inasmuch as the fat and crude fibre values in the maize supplemented ogi increased with increase in bambara groundnut flour, the values of both fat and crude fibre were still low. The values of fat in bambara groundnut supplemented ogi were 83.67 – 88.89% lower than the recommended 9% fat value for complementary food in Nigeria (14). Incorporating external fat as part of the recipe in the current study may enhance the fat values of the products. The values of crude fibre obtained in this study were all below the 19 g/d recommended for children within 1 – 2 yrs (15). Consuming these products alongside other products rich in fibre may however increase cumulative intake. Adequate intake of fibre is associated with reduction of cholesterol level, acceleration of the transit time for chyme in the gut, increase of fecal weight as well as management of obesity (11). Higher carbohydrate found in 100% maize ogi relative to the carbohydrate values obtained in supplemented pap could be because maize is a better source of carbohydrate compared to bambara groundnut (16). Decrease in carbohydrate with increase in the addition of bambara groundnut flour was similar to the findings of Sefa – Dede *et al*. (17) who reported a decrease in carbohydrate values with increase in addition of legume flour in maize based complementary foods.

The fat and protein energy values of bambara groundnut enriched products were significantly higher than that of 100% maize ogi. The carbohydrate energy value of 100% maize ogi was however significantly higher than the carbohydrate energy value of bambara groundnut ogi. These observations were expected because maize is a better source carbohydrate than bambara groundnut (16). The daily recommended fat, protein and carbohydrate energy needs of children aged 6 – 12months are 25 – 35 kcal/100g, 20 kcal/100g and 550 kcal/100g (19). This implies that consumption of a 100g of maize ogi supplemented with 20g, 40g and 50g of bambara groundnut flour will supply fat (36 – 53%), protein (76 – 134%) and carbohydrate (27 – 28%) energy values of that age group. Based on this finding supplementing the diet of children aged 6 – 12 months with 40% bambara groundnut is highly recommended. All the products can be considered energy dense as their energy densities were > 0.8kcal/g (20). It is important to note that the energy densities of bambara groundnut enriched maize ogi could be a function of their protein and fat contents while the energy density of 100% maize ogi could be a function of its carbohydrate content.

Though the minerals (with exception of zinc) were low in all the samples, the samples supplemented with bambara grountnut flour still had significantly

higher mineral contents than 100% maize ogi. All the mineral contents of the bambara groundnut enriched ogi were observed to increase with increase in bamabara groundnut flour supplementation. Minerals particularly calcium, iron and zinc play significant roles in the physical and mental development of children.

CONCLUSION

Protein, fat, crude fibre and the mineral contents of bambara groundnut fortified maize ogi were significantly higher than those of 100% maize ogi and the afore mentioned parameters increased with increase in bambara ground nut flour. Energy densities (kcal/g) were also observed to increase with increase in bambara groundnut flour.

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