

Evaluation of Complementary Food Formulated from Local Staples and Fortified with Calcium, Iron and Zinc

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Abstract

Protein energy malnutrition among small children is arguably the most important public health problem in developing countries. In sub-Saharan Africa, particularly, Nigeria it has largely been due to poor infant feeding practices where complementary foods low in both macro and micronutrients are fed to at-risk infants. Home fortification of complementary foods using food-to-food supplementation has been shown to reduce micronutrients deficiency in many resource-poor communities. The study assessed the nutrient composition of formulated complementary foods based on sorghum; soybean and plantain flour fortified with foods rich in micronutrients. The raw materials were purchased from Ogige market Nsukka, Enugu State, Nigeria. Three complementary test gruels were developed by blending sorghum (fermented), soybean (boiled and dehulled) and moderately ripe plantain flour in different ratios (65:30:5, 60:30:10, 55:30:15). The traditional complementary food (TCF) (Akamu) from 100% sorghum served as the control. The flour and the complementary foods were analyzed for their nutrient and antinutrient composition using standard methods. The data obtained were analyzed statistically. The test gruels especially the 60:30:10 blends had both higher energy and nutrient contents than the control. There was significant difference in protein between the test gruels and the control ($p < 0.05$). The antinutrients content were within safe levels. The nutrient density particularly, the micronutrients of the test products were appreciable. The sensory and acceptability profile showed that the products were acceptable. As indicated by the results, food-to-food supplementation would be a suitable form of home fortification for the regions where protein energy malnutrition is prevalent.

Keywords: Complementary food; Micronutrients; Food-to-food fortification; Local staples; Fortificants; Infants

Introduction

Adequate nutrition during infancy and childhood is fundamental to development of a child to its full potential. Infancy period (0-2 years) is a "critical window" for promotion of optimal growth, health and behavioral development. After two years of the child's life, it is difficult to reverse stunting that has occurred earlier [1]. In sub-Saharan Africa as in other developing countries, protein deficiency in the diets is common and it is usually associated with deficiencies in calories and micronutrients leading to endemic protein energy malnutrition with its attendant health consequences particularly, in infancy. In Nigeria, the traditional complementary foods (gruel) are mainly porridges from either maize or sorghum or millet which do not satisfy the energy and other nutrient needs of infants [2,3]. The gruel is too watery (liquid gruel) and thus have a low energy density or too bulky (thick porridge), which cannot be consumed in sufficient quantity by infants [4]. Bulkiness of gruel is due to the effect of heat on the starch structure. On cooking the starch granules swell and bind large amount of water. This result in gruel of high viscosity which needs to be further diluted with water to give a consistency that is appropriate for child's feeding. The dilution decreases the energy and nutrient density of the gruel and makes it practically impossible for the child to meet his/her nutrient requirement due to limited gastric capacity of children (200-250 ml) [4]. Krebs and Hambidge [5] observed that improper feeding during the period of complementary feeding results in immediate consequences, including morbidity and mortality as well as delayed mental and motor development. In long term, nutrition deficit are linked to impairment in intellectual performance, work capacity, reproductive outcomes and overall poor health during adolescence and adulthood. Malnutrition and "Hidden hunger" are amongst the devastating problem worldwide especially in developing countries. Experience from industrialized

countries shows that one of the ways of providing essential nutrient in adequate amount is to use culturally acceptable food that are affordable and fortified with the nutrient that are commonly missing in traditional diets. As in most other developing countries, the high cost of fortified nutritious complementary foods is in most cases prohibitive and beyond the reach of most Nigerian families. Such families often depend on inadequately processed traditional foods consisting mainly of supplemented cereal porridges made from maize or sorghum or millet [6]. Sorghum is an important staple in many parts of Africa particularly, Nigeria [7]. Sorghum typically has protein level of about 9%, enabling dependent human population to subsist on it in times of famine [7]. Like every other cereal, it is ideal to combine them with legume as this will improve their nutritive value. Soybean (*Glycine max*) is produced extensively in Nigeria, with protein content of approximately 43% [8]. Like other legumes soy protein is rich in lysine and relatively low in methionine-sulphur containing amino acids.

Plantain (*Musa paradisiaca*) is a popular food, which is well accepted by both young and old. Ripe and unripe stages of plantain have a wide arrays of forms to which it could be processed [9]. Plantain has been

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shown to enhance the flavour of food products [10]. *Moringa oleifera* is the best known of the thirteen species of the genus Moringaceae. *Moringa* was highly valued in the ancient world. Nutritional analysis indicates that *Moringa* leaves contain a wealth of essential, disease preventing nutrients. The Roselle calyx is very rich in vitamin C and riboflavin with some major minerals present. In western Nigeria, roselle calyx is used in cooking vegetable soup and in the northern part of the country it is used to prepare zobo drink [11]. The primary cause of under nutrition during infancy is lack of suitable micronutrients dense complementary foods during complementary feeding period. So in order to combat malnutrition in infancy (6-24 months), there is need not only to develop nutritious and cheap complementary foods from our locally available foods, but also to increase the micronutrients in a cost- effective-manner by food- to-food fortification. The complementary foods should have required consistency, energy density and micronutrients. The study seeks to produce nutrient dense, acceptable, cheap and easy to prepare complementary food for infant (6-24 months), from sorghum, soybean and plantain, fortified with calcium, iron and zinc from *Moringa oleifera*, and Roselle calyces (*Hibiscus sabdariffa*) to meet Recommended Nutrient Intake (RNI) of infants (6-24 months), particularly that of calcium, iron and zinc, which is 400mg/ kg body weight/ day, 0.55 mg/ kg body weight/ day and 311 µg/kg body weight/ day, respectively. The objectives of the study were to: produce flours from sorghum, soybean and plantain and blend them into composite flour, formulate complementary food using the composite flour, fortify the formulated complementary food using *Moringa oleifera*, and Roselle calyces (*Hibiscus sabdariffa*), determine the nutrient density, viscosity and evaluate the sensory attributes of the complementary food.

Materials and Methods

Sorghum (*Sorghum bicolor*), Soybean (*Glycine max*), Plantain (*Musa paradisiaca*), Roselle calyces (*Hibiscus sabdariffa*) and *Moringa oleifera* were purchased from local retailer at Ogige market in Nsukka, Enugu State, Nigeria.

Sample preparation

Two kilogram of sorghum was cleaned by hand picking and steeped in tap water in the ratio of 1:3 (w/v) and allowed to ferment at $28 \pm 2^\circ\text{C}$ for 48 h. At the end of the fermentation, the grains were oven dried at $55 \pm 5^\circ\text{C}$, milled to fine flour and packaged as fermented sorghum flour. One kilogram of soybean was cleaned by hand picking, boiled in tap water in the ratio of 1:3(w/v) for one hour. The grains were dehulled manually and dried in a hot air oven (Gallenkamp BS oven 250 Model No 320) at $50 \pm 5^\circ\text{C}$. The dried sample was then milled to fine flour (70 mm mesh screen). One kilogram of plantain in its early climacteric ripening stage were dehandled, peeled in cold water, sliced thin and steeped in cold water to avoid browning. These slices were dried in a hot air oven as described earlier.

Composite flour formulation

The protein level of each flour was estimated by micro Kjeldahl procedure. The composite flours were formulated in the ratio of 65:30:5, 60:30:10, and 55:30:5 on protein basis.

The composites are shown below:

- SgSP (65:30:5): Fermented sorghum, soybean and plantain
- SgSP (60:30:10): Fermented sorghum, soybean and plantain
- SgSP (55:30:15): Fermented sorghum soybean and plantain

TCF (Akamu) : Traditional complementary food from 100% sorghum served as control.

Moringa oleifera and *Hibiscus sadariffa* (Roselle calyces) were used as fortificants.

Calculation of the quantity of composite that will furnish 3.25 g N per 100 g sample (20 g protein per day)

Based on the value of crude protein determination and ratios of food protein source, the total quantity required to furnish 3.25 g N per 100 g (20 g protein per day) for each composite was calculated.

Processing of *Moringa oleifer*: *Moringa oleifera* was plucked, shade dried and ground into fine flour. The moringa flour was then added to the composite flour for fortification. Since analysis showed that the leaves was high in some micronutrients.

Processing of Roselle calyces (*Hibiscus sabdariffa*): The roselle calyces (*Hibiscus sabdariffa*) were used to fortify the complementary food with zinc and iron. The roselle calyces were hand sorted to remove dirt and extraneous material, dried at $50 \pm 5^\circ\text{C}$ in (Gallenkamp oven Model IH - 150). The dried flower was milled and ashed to white powder at $550^\circ\text{C} \pm 5^\circ\text{C}$ in a furnace.

Quantity of *Moringa oleifera* and *Hibiscus sabdariffa* incorporated into the composite flours

Based on the value of calcium (2003 mg) contained per 100 g dried leaves of moringa. The quantity required to furnish 400 mg calcium was calculated by simple proportion to be 19.97 g in 100 g composite flour. Based on the value of iron (4.17 mg) contained per 100 g of *Hibiscus sabdariffa*. The quantity required to furnish 0.55 mg iron was calculated by simple proportion to be 13.19 g in 100 g composite flour. Based on the value of zinc (24.22 mg) contained per 100 g of *Hibiscus sabdariffa*. The quantity required to furnish 2.79 mg zinc was calculated by simple proportion to be 11.56 g in 100 g composite flour.

Chemical analysis of the flour and the complementary food

Crude protein (Kjeldahl, x 6.25), fat (Soxhlet extraction), ash, crude fibre and moisture contents were determined according to the methods of AOAC (2005). Carbohydrate was calculated by difference as $100 - (\% \text{ protein} + \% \text{ fat} + \% \text{ ash} + \% \text{ crude fibre} + \% \text{ moisture})$ and taking the sum. The average physiological fuel value of the energy nutrients was determined based on the digestibility of each of the nutrients using Atwater's conversion factors thus: 1 g of carbohydrate yields 4 Kcal of energy (17 KJ), 1g of protein yields 4 Kcal of energy (17 KJ), 1 g fat yields 9 Kcal of energy (37 KJ). Ascorbate and β -carotene was determined using variable wavelength spectrophotometer instrument. Minerals (calcium, iron, iodine, and zinc) were determined by Zeeman atomic absorption spectrophotometer. Tannin was determined using modified methanol procedure by Price and Phytate by photometric method of Latta. Bulk density was determined by the method described by Onwuka [12]. Emulsion, water Absorption capacity and reconstitution index were determined by the method of Beuchat [13].

Preparation of porridges

A standard recipe was developed and used to prepare porridges from the composite flours. 100 g of flours (from both composites and the control), 100 ml of cold water (to make paste) and 500 ml of boiled water (to cook the slurry). Akamu- a traditional complementary food (TCF) from 100% sorghum served as the control. *Moringa oleifera* and *Hibiscus sabdariffa* powder served as fortificants.

Source of protein	Soybean	Sorghum	Plantain
Blend ratio	30	65	5
SgSP ₁	13.54 g	126.19	35
Blend ratio	30	60	10
SgSP ₂	13.54	116.5	70.28
Blend ratio	30	55	15
SgSP ₃	13.54	106.8	105.4

SgSP=Sorghum/Soybean/Plantain

Table 1: Quantity of blend (g) to supply 3.25 g N/100 g.

Sample/Nutrient	S	Sg	P
Moisture	7.65 ± 0.01 ^a	8.30 ± 0.02 ^b	10.55 ± 0.02 ^c
Protein	43.00 ± 0.01 ^a	10.46 ± 0.9 ^a	2.89 ± 0.01 ^a
Fat	17.35 ± 0.02 ^a	3.50 ± 0.03 ^{ab}	15.35 ± 0.02 ^{ab}
Ash	3.10 ± 0.02 ^{ab}	1.75 ± 0.03 ^{ac}	2.45 ± 0.00 ^{ad}
Fibre	0.15 ± 0.01 ^b	1.15 ± 0.02 ^a	0.10 ± 0.01 ^c
Carbohydrate	23.75 ± 0.01 ^{ab}	75.74 ± 0.03 ^{ad}	68.06 ± 0.01 ^{ae}

Mean ± standard deviation

Row values of the same superscript are significantly different at p<0.05

S=Soybean, Sg=Sorghum, P=Plantain

Table 2: Proximate composition of sorghum, soybean and plantain flour per 100 g sample.

Methods

Bring water to boiling point, make paste with the composite flours, add it to the boiling water, and allow the slurry to be well cooked for about 10 minutes, stir occasionally until cooked. The flour to water ratio should be 1:3. Gruel (porridge) should be left to cool at room temperature to serving state (40°C), serve in a cup with a teaspoon to infants. For reconstitution purpose, it is ideal to know the quantity consumed/100g of prepared porridge, thus: Initial weight of sample + pot: 700 g + 150=850 g, Final weight of sample + pot (after cooking)=600 g, therefore, Initial weight – final weight of sample prepared + pot=850 – 600=250 g. Hence 250 ml of prepared porridge is consumed/100 g of sample.

Sensory evaluation

The sensory evaluation of the complementary food (gruel) was conducted at the Department of Home Science, Nutrition & Dietetics, and University of Nigeria Nsukka. A panel of forty nursing mothers were recruited to evaluate the likeness of the test products. The judges evaluated the samples using a five- point hedonic scale where 5 (like extremely) was the highest and 1 (dislike extremely) was the lowest score. The gruels were presented to each of the panellist as coded in the hedonic scale. Each panellist was given a serving plate, spoon and a cup of water to rinse their mouth after each tasting to avoid being biased. The samples were evaluated by the panellist for flavour, texture, colour and general acceptability.

Statistical analysis

The data generated were statistically analyzed for means and standard deviation and Analysis of Variance (ANOVA) was used to test the level of significance. Duncan's New multiple Range Test was used to compare and separate means. Significance was accepted at p<0.05.

Results

Table 2 shows the proximate composition of sorghum, soybean and plantain flours. The moisture content of the three flours varied. It ranged from 7.65-10.55%. The sample P had moisture (10.55%) which

was significantly (p<0.05) different from samples Sg (8.30%) and S (7.65%). The protein composition of the three flours differed. It ranged from 2.89-43.00%. The sample P had the least value (2.89%) which was significantly (p<0.05) different from the other samples (2.89 vs 10.46 and 45.00%) (p<0.05). Sample S had the highest protein value (43.00%). The fat values of the three flours ranged from 3.50 -17.35%. The sample S had the highest value (17.35%) which was significantly (p<0.05) different from the other samples (17.35 vs. 15.35 and 3.50%) (p<0.05). The sample Sg had the least fat (3.50%). The ash composition of the samples differed, the sample Sg and P had 1.75% and 2.45%, respectively. The sample S had the highest ash value (3.10%). The high ash content was indicative of high mineral content. The fibre composition of the three flours ranged from 0.10% - 1.15%, the sample Sg had the highest fibre value (1.15%) followed by sample S (0.15%). On the other hand, the sample P had the least fibre (0.10%). The carbohydrate composition of the three flours varied. The value ranged from 23.75 – 75.74%. The Sg value (75.74%) was significantly (p<0.05) higher than the others. Samples P and S have 68.06%, and 23.75%, respectively.

Table 3 presents the micronutrient composition of samples S, Sg and P (mg/100 g sample). The β-carotene composition of the three flours varied. The S had the highest β -carotene (2.20 mg/100 g) that was significantly (p<0.05) different from sample P (1.66 mg) and sample Sg that had the least (1.08 mg). The vitamin C content of the flours differed. The sample S had the highest value (7.68 mg), which had a slight edge over sample P (7.48). The sample Sg had the least value (6.60 mg). The iodine composition of the three flours ranged from 0.51-1.02 mg/100g. The samples S and P had similar value (1.02 mg) and sample Sg had the least value (0.51 mg). The iron composition of the three flours differed. It ranged from 0.17 – 0.87 mg/100 g. The sample P had the highest value (0.87 mg/100 g) while the samples S and Sg each had 0.17 mg, respectively.

The zinc composition varied from 0.02 -3.20 mg/100 g. The sample P had the highest zinc value (3.20 mg) which was significantly (p<0.05) different from the other flours (3.20 vs 0.05 and 0.02 mg/100 g) (p<0.05). The sample S had the least zinc value (0.02 mg). The calcium composition ranged from 0.16 - 0.40 mg/100 g sample. The sample Sg has the least calcium value (0.16 mg) followed by the sample P (0.24 mg). The sample S had the highest calcium value (0.40 mg).

Table 4 shows the antinutrients composition (mg/100 g sample) of the flours. The tannin composition varied from 0.53-0.08 mg/100

Nutrients (mg/100 g)	S	Sg	P
β-carotene	2.20 ± 0.02 ^a	1.08 ± 0.05 ^b	1.66 ± 0.03 ^c
Vitamin C	7.68 ± 0.01 ^a	6.60 ± 0.0 ^b	7.48 ± 0.01 ^c
Iodine	1.02 ± 0.03 ^a	0.51 ± 0.02 ^b	1.02 ± 0.03 ^c
Iron	0.17 ± 0.01 ^a	0.17 ± 0.01 ^b	0.87 ± 0.00 ^c
Zinc	0.02 ± 0.00 ^a	0.05 ± 0.00 ^a	3.20 ± 0.20 ^a
Calcium	0.40 ± 0.01 ^a	0.16 ± 0.01 ^b	0.24 ± 0.02 ^c

Mean ± standard deviation

Column means of the same superscript are significantly different at p<0.05

Keys: S=Soybean, Sg= Sorghum, P=Plantain

Table 3: Vitamin and mineral composition of sorghum, soybean and plantain flour.

Nutrient	S	Sg	P
Tannin	0.08 ± 0.01 ^a	0.35 ± 0.07 ^b	0.53 ± 0.02 ^c
Phytate	0.17 ± 0.00 ^{ab}	0.25 ± 0.01 ^{bc}	0.66 ± 0.03 ^{cd}

Mean ± Standard deviation

Column values of the same superscript are significantly different at P<0.05

Keys: S=Soybean, Sg=Sorghum, P=Plantain

Table 4: Antinutrient composition (mg/100 g) of the flour.

g sample. The sample P had the highest tannin value (0.53 mg) while the sample S had the least value (0.08 mg) followed by sample Sg (0.35 mg). The phytate composition varied from 0.17-0.66 mg. The sample S had the least phytate value (0.17 mg) followed by sample Sg (0.25 mg). However, sample P had the highest phytate value (0.66 mg) that differed significantly ($p < 0.05$) from the other flours.

The functional properties of the flours are given in Table 5. The test products had low bulk density that ranged from $(0.42 \pm 0.02$ to 0.45 ± 0.02 g/cm³) relative to the control (0.46 ± 0.02 g/cm³). The water absorption capacity of the SgSP₁ (74.34%) was significantly ($p < 0.05$) higher than the other formulated foods and the control (Table 3). The test products had high emulsion capacity that ranged from 4.00 to 8.20% which showed similar trend as water absorption capacity. The control had 3%. There was no significant difference ($p > 0.05$) in the reconstitution index among the samples and between them and the control. The values ranged from 80 to 87%.

Table 6 shows the proximate composition of a gruel formulated from sorghum, soybean and plantain flour blend at varying ratio and that of the control. The moisture content varied from 42.50-50.41%. The TCF (the control) had the least moisture value (42.50%) which was significantly different from the other samples at $p < 0.05$. The high and comparable values of samples SgSP₁, SgSP₂, and SgSP₃ were similar at $p = 0.05$. The fat composition varied. It ranged from 4.26 to 7.13%. The TCF (the control) had the least value which was significantly ($p < 0.05$) different from the other samples at $p < 0.05$ (4.26 vs 5.09, 7.13 and 5.14%).

The protein content of the samples varied from 11.17-14.21%. The TCF had the least value (8.46%) which was significantly ($p < 0.05$) different from the other samples (12.07, 14.21 and 11.17%). The sample SgSP₃ had the least protein value (11.17%).

Sample	Bulk density g/cm ³	Water absorption capacity (%)	Emulsion capacity (%)	Reconstitution Index (%)
SgSP ₁	0.45 ± 0.02 ^a	74.34 ± 2.40 ^a	8.20 ± 0.24 ^a	87 ± 1.20 ^a
SgSP ₂	0.42 ± 0.02 ^a	70.67 ± 3.35 ^a	6.00 ± 0.30 ^a	85 ± 1.00 ^a
SgSP ₃	0.43 ± 0.02 ^a	60.00 ± 2.50 ^a	4.00 ± 0.21 ^b	80 ± 1.00 ^a
TCF	0.46 ± 0.02 ^a	50.00 ± 0.02 ^a	3.00 ± 0.02 ^a	80 ± 0.02 ^a

Column means of the same superscript are significantly different at $p < 0.05$
 Sg SP₁ 65:30:5=Sorghum, soybean and plantain
 Sg SP₂ 60:30:10=Sorghum, soybean and plantain
 Sg SP₃ 55:30:15=Sorghum, soybean and plantain
 TCF (Akamu) (control)=Traditional complementary food from 100% sorghum

Table 5: Functional properties of the composite flour for complementary food production.

	Sg SP ₁ 65:30:5	Sg SP ₂ 60:30:10	Sg SP ₃ 55:30:15	TCF 100
Moisture (%)	46.36 ± 0.02 ^a	47.99 ± 0.00 ^a	50.41 ± 0.01 ^a	42.50 ± 0.00 ^b
Fat (%)	5.09 ± 0.01 ^a	7.13 ± 0.01 ^a	5.14 ± 0.01 ^a	4.26 ± 0.00 ^b
Protein	12.07 ± 0.01 ^a	14.21 ± 0.00 ^a	11.17 ± 0.01 ^a	8.46 ± 0.00 ^a
Ash	3.48 ± 0.01 ^a	3.30 ± 0.01 ^a	3.30 ± 0.01 ^a	0.08 ± 0.00 ^a
Fibre	2.23 ± 0.01 ^a	2.27 ± 0.02 ^a	2.27 ± 0.02 ^a	0.04 ± 0.00 ^b
Carbohydrate	32.87 ± 0.01 ^a	30.10 ± 0.01 ^a	30.10 ± 0.01 ^a	87.20 ± 0.01 ^b
Energy (Kcal)	225.57 ^a	241.41 ^a	211.34 ^a	420.98 ^b

Mean ± standard deviation

*Column values of different superscript are significantly different $P < 0.05$

Sg SP₁ 65:30:5=Sorghum, soybean and plantain gruel
 Sg SP₂ 60:30:10=Sorghum, soybean and plantain gruel
 Sg SP₃ 55:30:15=Sorghum, soybean and plantain gruel

Table 6: Proximate composition of the gruel formulated from sorghum, soybean and plantain composite flour at varying ratio and that of the control (TCF)/100 g sample.

Micronutrients (mg/100 g)	Sg SP ₁ 65:30:5	Sg SP ₂ 60:30:10	Sg SP ₃ 55:30:15	TCF 100
Vitamin C	3.43 ± 0.01 ^a	5.29 ± 0.01 ^a	5.27 ± 0.22 ^a	0.18 ± 0.05 ^b
β-carotene	0.39 ± 0.00 ^a	0.71 ± 0.01 ^a	0.59 ± 0.01 ^a	0.60 ± 0.0 ^b
Zinc	0.51 ± 0.00 ^a	0.76 ± 0.01 ^a	0.76 ± 0.00 ^a	0.31 ± 0.02 ^b
Iodine	0.51 ± 0.00 ^a	0.50 ± 0.01 ^a	0.50 ± 0.00 ^a	0.15 ± 0.01 ^b
Calcium	6.44 ± 0.03 ^a	12.14 ± 0.03 ^a	7.63 ± 0.03 ^a	0.04 ± 0.00 ^a
Iron	0.62 ± 0.01 ^a	0.77 ± 0.00 ^a	0.77 ± 0.00 ^a	0.13 ± 0.01 ^b

Mean ± standard deviation

Column values of different superscripts are significantly different $P < 0.05$

Sample A (Sg SP₁ 65:30:5)=Sorghum, soybean and plantain gruel

Sample B (Sg SP₂ 60:30:10)=Sorghum, soybean and plantain gruel

Sample C (Sg SP₃ 55:30:15)=Sorghum, soybean and plantain gruel

TCF 100% sorghum=traditional complementary food

Table 7: Micronutrient composition of the gruel formulated from sorghum, soybean and plantain flour at varying ratios and the control (TCF)mg /100 g sample.

Antinutrient	Sg SP ₁ 65:30:5	Sg SP ₂ 60:30:10	Sg SP ₃ 55:30:15
Tannin	2.38 ± 0.01 ^a	2.44 ± 0.01 ^a	2.40 ± 0.01 ^a
Phytate	2.67 ± 0.00 ^a	1.90 ± 0.00 ^a	1.84 ± 0.01 ^a

Mean ± standard deviation

Row values of different superscript are significantly different $P < 0.05$

Sg SP₁ 65:30:5=Sorghum, soybean and plantain gruel

Sg SP₂ 60:30:10=Sorghum, soybean and plantain gruel

Sg SP₃ 55:30:15=Sorghum, soybean and plantain gruel

Table 8: Antinutrient composition of the gruel formulated from sorghum, soybean and plantain composite flour at varying ratios per 100 g sample.

The ash composition of the gruels varied from 0.08-3.48%. The TCF had the least ash value which is lower than the other samples (0.08 vs 3.48, 3.30 and 3.30%). The comparable ash values of samples SgSP₂ and SgSP₃ (3.30%, 3.30%, respectively), were similar at $p > 0.05$. The fibre composition of the gruels differed. It varied from 0.04 -2.27%. The TCF had the least value which was significantly ($p < 0.05$) different from the test samples (0.04 vs 2.27, 2.23 and 2.22%). The samples SgSP₁, SgSP₂, and SgSP₃ had comparable values of 2.23%, 2.27% and 2.22%, respectively and were similar at $p > 0.05$. The carbohydrate composition varied from 30.10-87.20%. The samples SgSP₁, SgSP₂, and SgSP₃ had 32.87, 30.10 and 30.75%, respectively and were significantly different from the control (TCF) at $p < 0.05$.

The energy values varied from 211.34 – 420.98 Kcal. TCF had the highest value which was significantly ($p < 0.05$) different from samples SgSP₁, SgSP₂, and SgSP₃ (420.98 vs 225.57,241.41, 211.34Kcal, respectively).

Table 7 shows the micronutrient composition of the gruel and that of the control (TCF). The vitamin C content varied from 0.18 ± 0.05^b to 5.29 mg. The TCF had 0.18 ± 0.05^b . The samples SgSP₂, and SgSP₃ had comparable values of 5.29 and 5.27 mg respectively, which is similar at $p < 0.05$. The Sg SP₁ had value that was significantly ($p < 0.05$) different from the other test samples. The β-carotene content varied from 0.39 to 0.71 mg. The Sg SP₂ sample had the highest value which was similar to Sg SP₃ sample (0.71 vs 0.59 mg) but differed significantly ($p < 0.05$) from Sg SP₁ (0.39 mg). The zinc values of the samples were similar ($p < 0.05$). The TCF had the least zinc value which was significantly ($p < 0.05$) different from the other samples (0.31 vs 0.76, 0.76 and 0.51 mg).

The iodine content ranged from 0.15 to 0.51 mg. The samples SgSP₁, SgSP₂, and SgSP₃ had 0.51 and 0.50 and 0.50 mg, respectively which was significantly ($p < 0.05$) different from the control (0.15 mg). The calcium values varied from 0.04 to 12.14 mg. The TCF had the least value (12.14 mg) which was significantly ($p < 0.05$) different from the other samples.

Sample	Colour	Texture	Flavour	General acceptability
Sg SP ₁	4.2 ± 0.66 ^b	1.95 ± 0.44 ^{ab}	4.45 ± 0.47 ^a	4.00 ± 0.55 ^b
Sg SP ₂	4.45 ± 0.47 ^b	1.89 ± 0.42 ^{ab}	4.75 ± 0.36 ^a	4.22 ± 0.43 ^b
Sg SP ₃	3.90 ± 0.38 ^b	1.79 ± 0.40 ^{ab}	4.35 ± 0.44 ^a	4.25 ± 0.52 ^b
TCF	4.55 ± 0.76 ^a	2.06 ± 0.46 ^{ab}	3.00 ± 0.30 ^{bc}	4.75 ± 0.32 ^{ab}

Mean ± SEM

Keys: Sg SP₁ (65:30:5)=Sorghum, soybean and plantain gruel

Sg SP₂ (60:30:10)=Sorghum, soybean and plantain gruel

Sg SP₃ (55:30:15)=Sorghum, soybean and plantain gruel

TCF=Traditional complementary food

Table 9: Sensory evaluation of the test complementary foods and the control.

The sample SgSP₁ had the calcium value (6.44 mg) that was lower than other test samples. The iron composition varied from 0.13 to 0.77 mg. The TCF had the least (0.13 mg) which was significantly ($p < 0.05$) different from the other samples.

Table 8 shows the antinutrients content of the gruel formulated from sorghum, soybean and plantain flour blends at varying ratios. The tannin composition varied from 2.38–2.74 g. The Sg SP₂ sample had the highest value (2.44 mg) which was similar to the other samples at $p > 0.05$. The phytate composition varied. The SgSP₁ had the highest value (2.67 mg) which was significantly ($p < 0.05$) higher than the others (2.67 mg vs 1.90, 1.84 mg for SgSP₁, SgSP₂ and SgSP₃, respectively).

The sensory attributes of the products are presented in Table 9. The colour of TCF had the highest mean score 4.55 ± 0.76 which significantly ($p < 0.05$) differed from the colour of Sg SP₁, Sg SP₂ and SgSP₃. TCF had the highest mean score (2.06 ± 0.46) for texture relative to other samples ($p < 0.05$). The SgSP₂ had the highest flavour value (4.75 ± 0.32) which was not significantly different from SgSP₃ and SgSP₁ but differed from TCF at $p < 0.05$. The trend is the same for general acceptability. TCF had the highest mean value (4.75 ± 0.02) which was significantly different from the other samples (SgSP₁, Sg SP₂ and SgSP₃) at $p < 0.05$.

Discussion

The protein levels of the food samples agreed with other previous researchers [8,14,15]. Soybean has a high protein value of over 43.00% which would complement sorghum protein. Soybeans contain about 3% lecithins which are helpful for the brain development especially, of infants. Soybeans have in addition to lecithins essential minerals such as calcium, phosphorous and vitamins A, B, C and D [16]. Isoflavones in soybeans are effective in the prevention of osteoporosis via phytoestrogen effects that stop the neovascularisation in ocular conditions [16]. Supplementation of cereal-based foods with legume and plantain for the production of complementary foods to improve their nutrient density has been reported [2,17-19]. This is because legume proteins are high in lysine, an essential limiting amino acid in most cereals. Cereals on the other hand, are high in methionine and cystine which are deficient in legumes [7]. Therefore blending legume with cereal will provide desirable protein pattern that would enhance nutritional status of the population. Also the high mineral and vitamin contents of these food crops are responsible for the increased nutritive quality of the supplemented products [19]. The functional properties of composite flour made from sorghum, soybean and plantain have been found, to be suitable for the production of complementary foods [18]. Due to their high fibre content, cereals, legumes and plantain have been included within the group of functional foods due to their hypocholesterolemic and hypoglycemic effects [20,21].

Soybean had the highest fat content among the food samples. This could be attributed to the fact that soybean is an oil seed. The high fat level are in line with the value reported in literature [22]. Sorghum had

the highest carbohydrate value and this could be attributed to the fact that it is a cereal, a carbohydrate based food. The high carbohydrate levels for the products might be ascribed to either individual food materials or microflora enzyme hydrolysis via fermentation that led to the synthesis of complex carbohydrates from other nutrients carbon skeletons. The slightly lower values of carbohydrate for some blends could be attributed to its use as source of energy by the fermenting microflora or that the carbohydrate provided the required carbon skeleton for synthesis of other new nutrients particularly, protein [2]. The fibre value of the samples is small and this might be due to different processing techniques that were applied. The fairly high level of vitamin C, β -carotene, zinc and iron was due to the effects of food-to-food fortification [2]. The high carbohydrate in plantain could be attributed to the stage (climacteric stage) of ripening.

The flour blends had low bulk density and this has both nutritional and economic significance as more of the products thereof can be eaten resulting in high energy and nutrient density [4,15,18]. The water absorption capacity of the formulated food was higher than that of the control. This was due to higher absorption capacity of the soybean flour. This result is in agreement with the earlier report by Igyor et al. [23] that protein functions in binding water and fat while retaining them. Thus, the availability of soy protein has increased its ability to absorb water. The high emulsion capacity reported (Table 2) was the result of high concentration of protein in the food. Oyarekua and Adeyeye [24] reported that high value of emulsion capacity acts as flavour retainer and enhances the mouth feel and taste of food. Again, addition of plantain also served as a flavour enhancer [10]. The reconstitution index showed no significant difference probably because all the composites flour were passed through the same sieve (500 μ m mesh size) after milling [23].

The high moisture content of the product (gruel) could be attributed to the fact that the product is in fluidly form [6]. This will also have an adverse effect on its keeping quality though the product is not usually kept too long before consumption. The protein content of the gruel was appreciably high since the product is only a little below half of what the infant should consume per meal (250 ml) based on the requirement. This high protein level could be attributed to cereal-legume supplementation [17,25]. The fibre composition of the gruel is not significantly different probably because the products were made from the same type of base ingredient with the same processing method. The calcium composition of the test products was appreciable; this could be attributed to incorporation of *Moringa oleifera* in the product. Iron values of the test products were good (Table 7). This value is enough to meet the recommended iron intake of the infant which is 0.55 mg/day. This high iron value might be attributed to incorporation of *Hibiscus sabdariffa*. The phytate and tannin values of the test products were within safe levels.

The low colour rating was attributed to incorporation of *Moringa oleifera* powder which gave the product a greenish colour which the mothers were not familiar with. The same was applicable to texture, flavour and general acceptability.

Conclusions

The results showed that the formulated complementary foods are nutrient-dense with good functional and sensory properties. Food-to-food fortification thus appeared to be vital in upgrading the nutritional, functional and sensory properties of the complementary food produced and could help solve the problem of protein energy malnutrition in the regions that are devastated by this epidemic.

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