

CHEMICAL COMPOSITION AND SENSORY EVALUATION OF COMPLEMENTARY FOODS PRODUCED FROM GUINEA CORN (*Sorghum bicolor*), SOYBEAN (*Glycine max*) AND BANANA (*Musa spp.*) BLENDS.

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ABSTRACT

Background: Cereal grains are the main ingredients of complementary foods in Nigeria. These complementary foods are deficient in protein and micronutrients hence there is a need to improve the nutrient density of these complementary foods.

Objectives: This study was designed to determine the chemical composition and sensory attributes of complementary food produced from soybean, guinea corn and banana.

Methods: The grains and banana were purchased from the market and farm in Umuahia, Abia State. The guinea corn and soybean were sorted and soaked in water for 8hrs respectively. The soybeans were blanched in boiling water at 100°C for 10minutes. The guinea corn and soybean were dried in a locally fabricated cabinet dryer at 100°C for 5hours respectively. They were milled into flour using hammer milling machine (Fritsch, D-55743, Idar-Oberstein-Germany). The milled samples were sieved through a 250 micron sieve to obtain fine flour. The bananas were washed and cleaned, peeled, sliced and dried in Forced- Air Moisture Extraction Plus II Oven, Sanyo Gellenkamp at 65°C for 48hours and milled. The products were analyzed using standard analytical methods. The mean, standard deviation and ANOVA was done using statistical package for service solution (SPSS) version 20. Means were separated using Duncan's new multiple range test and significance was accepted at $P < 0.05$.

Results: Sample C0 (control) had the highest moisture (74.04%) and protein contents (10.11%). Sample GSB3 (50% guinea corn: 30% soybean: 20% banana) recorded the highest value for pro-vitamin A (62.33µg/100g), while vitamin C content was highest in the control (41.22mg/100g). The control (cerelac) recorded the highest values for calcium (324.17mg/100g), sodium (191.12mg/100g), potassium (516.92mg/100g), iron (10.05mg/100g) and zinc (6.17mg/100g) contents. Sample GSB3 recorded the highest phosphorous (36.71mg/100g) and magnesium (26.72mg/100g) contents. Sample C0 recorded the lowest values for flavonoid (0.12mg/100g), alkaloid (0.42mg/100g), tannin (0.26mg/100g) and phytate 0.11mg/100g. Sample C0 (control) was the most preferred for all sensory attributes followed by sample GS1 (60% guinea corn: 40% soybean).

Conclusion: The complementary food produced is nutritious and can serve as a healthy weaning food for children in Nigerian households.

Key Words: Nutrient composition, complementary food, guinea corn, soybeans, banana, blends.

INTRODUCTION

Complementary feeding is the introduction of other foods and liquids to infants when the breast milk alone is no longer sufficient to meet their nutritional requirements (World Health Organization, 2000). In order to provide infants with additional nutrients, complementary foods should consequently be introduced to the infants between the age of 6 and 23 months with continued breastfeeding (Motuma *et al.*, 2016). In Nigeria, complementary feeding practices continue to pose a challenge to good nutrition in children (Motuma *et al.*, 2016). These challenges are characterized by poor feeding practices and poor dietary quality of homemade complementary foods. The poor quality and lack of diversity in the

complementary foods affects children's growth and nutritional status (Motuma *et al.*, 2016). Improving the quality of complementary foods has been cited as one of the cost-effective strategies for improving health and reducing morbidity and mortality in young children (Nancy and Michael, 2007).

Soybean (*Glycine max*) is among the species of legume and widely grown edible beans which has numerous uses. In Nigeria, it grows majorly in the middle belt (Food and Agriculture Organization, 2004). Guinea corn (*Sorghum bicolor*) is an important food crop in Nigeria with multifarious usages (FAO, 2004). Guinea corn is rich in carbohydrates, magnesium, phosphorus and potassium and low in protein and fat content.

Bananas (*Musa acuminata*) are cultivated in nearly all tropical regions of the World. Banana is an important staple food in Nigeria. Banana is a rich source of carbohydrates and several vitamins and minerals, especially potassium, vitamin B6 and vitamin C (Atil, 2014). There is a need to improve the feeding practices of infants and young children in Nigeria. Some of the complementary foods in Nigeria are over the counter processed foods which are inadequate in nutrients and may cause poor growth in children. There is need to improve the nutrient composition of complementary foods through the addition of foods from various food groups. This addition of variety of foods will help increase the energy and nutrient content of complementary foods. This work is designed to produce adequate complementary foods from soybean, guinea corn and banana and evaluate the sensory and nutrient content of the complementary foods produced.

MATERIALS AND METHODS

Sample collection

Guinea corn (*Sorghum bicolor*) and soybean (*Glycine max*) were purchased from Umuahia main market, Abia State. Banana was purchased from a farm in Umuariaga, Ikwuano in Abia State.

Sample preparation

Preparation of guinea corn flour (*Sorghum bicolor*)

The guinea corn flour was produced using the method described by Nwakalor and Obi. (2014). The guinea corn grains were sorted to remove stones and other particles, the grains were soaked in clean water for 8hours. The grains were dried in a locally fabricated cabinet dryer at 100°C for 5hours to moisture content of less than 10%. The dried guinea corn was roasted and milled into flour using hammer milling machine (Fritsch, D-55743, Idar-Oberstein-Germany). The milled sample was sieved through a 250 micron sieve to obtain the flour. The guinea corn flour was packed and sealed in polythene bags at ambient temperature until analysis.

Preparation of soybean flour (*Glycine max*)

The method as described by Nwakalor and Obi. (2014) was adopted. Soybean seeds were sorted to remove dirt. The sorted soybean was soaked in

water for 8hours. The beans were drained of water and blanched in boiling water at 100°C for 10minutes to free seed coat. Furthermore, the beans were de-hulled. The soybeans were dried in a locally fabricated cabinet dryer at 100°C for 5hours. The dried soybeans were milled into flour using hammer milling machine (Fritsch, D-55743, Idar-Oberstein-Germany). The milled sample was sieved through a 250 micron sieve to obtain the flour. The soybean was packed and sealed in polyethylene bags at ambient temperature until further analysis.

Preparation of banana flour (*Musa acuminata*)

As described by Adeniji *et al.* (2010), harvested green bunches of banana were detached from the peduncle. The banana fruits were removed from the bunch into a bowl containing water and washed to remove dirt and possible chemical residue and latex. The fruits were peeled manually with the aid of stainless kitchen knife and it was kept in a bowl containing water until the peeling process was complete to prevent browning of resultant flour. The pulps were sliced longitudinally to about 15mm thickness with stainless steel knife to prevent discoloration and to enhance dehydration. The sliced bananas were dried in Forced- Air Moisture Extraction Plus II Oven, Sanyo Gellenkamp at 65°C for 48hours. The dried pulp slices were milled using a Retch Muhle, 2850 RPM Hammer Mill to obtain a fine powder.

Formulation of Guinea Corn, Soybeans and Banana Blends.

Using the method of Amankwah *et al.* (2009) with a little modification, the samples were formulated. The ratios of the composite are 60:40:0, 70:20:10 and 50:30:20; these ratios represent the incorporation of guinea corn, soybean and banana respectively. Key: C0- Control (100% cerelac), GS1- (60% guinea corn: 40% soybean), GSB2- (70% guinea corn: 20% soybean: 10% banana), GSB3- (50% guinea corn: 30% soybean: 20% banana). The formulated blends were thoroughly blended using a hand mixer to obtain a homogenous mixture. The formulated blends were suitable for use as complementary foods as they provide additional nutrients to compliment foods in the family as recommend by the codex standard for processed cereals for young children (Codex Alimentarius Commission 2006).

Table 1: Recipe for preparation of the control and formulated complementary food.

Control

Ingredients	Quantity
Cerelac	100g
Water	300ml
Yield	400g

Formulated complementary food

Ingredients	Quantity
Composite flour	100g
Water	350ml
Sugar	1 teaspoon
Yield	450g

Method of preparation of the complementary food

The composite flours as well as the control were prepared using the above recipe. One hundred grams of the control was properly dissolved and mixed thoroughly in 300ml of boiled and cooled water which was then used to conduct the sensory evaluation after which the remaining was taken for chemical analyses. One hundred grams of the formulated composite flours was poured in a bowl and dissolved with 50ml of water, the formula was transferred into 350ml of boiling water (100°C) in a pot and stirred for 5 minutes to avoid forming of lump until a fine texture was gotten. One teaspoon of sugar was added for taste and allowed to cool to a serving temperature of 40°C. The sample was used to conduct sensory evaluation and the remaining was packaged in air tight containers and taken to the laboratory for chemical analysis.

Proximate Analysis

The proximate composition of the samples was determined by AOAC. (2006). The moisture content of the blends was determined by drying in a moisture extraction oven at 105°C until a constant weight was obtained. Crude protein was determined by micro-kjeldahl method, using 6.25 as the nitrogen conversion factor. Crude fat was determined by Soxhlet extraction method using petroleum ether. Ash was determined by incinerating the sample at 600°C in a muffle furnace. Carbohydrate for each sample was obtained by subtracting the summed up percentage composition of moisture, protein, fat, fibre and ash contents from 100g of the sample (Otitoju, 2009). Energy was calculated using Atwater's conversion factor from fat, carbohydrate and protein content using the Atwater conversion factors in Kcal and KJ (4.0kcal/g, 17kj; for protein, 4.0kcal/g, 17kj; for carbohydrate, and 9.0kcal/g, 37kj for lipid) (Iombor *et al.*, 2009).

Determination of minerals

The minerals (iron, calcium and zinc) were determined using wet acid digestion method for multiple nutrient determinations (AOAC, 2006). Potassium (K) and sodium (Na) were determined by the flame photometry method (AOAC, 2006). Phosphorus was determined by the vanadomolybdate yellow method using spectrophotometer as described by AOAC. (2006). Magnesium was determined by the EDTA versante complexometric titration method (AOAC, 2006).

Determination of vitamins

Vitamin A was determined by using spectrophotometric method as described by AOAC. (2006), while ascorbic acid (vitamin C) was determined using titration method as described by AOAC. (2006).

Determination of anti-nutrients

Alkaloids and flavonoids were determined by gravimetric oven drying method as described by Harborne. (1973). Tannin was determined as described by Pearson. (2001) using a spectrophotometer. Phytate was determined using the method described by Obeitease *et al.* (1998).

Sensory evaluation

Sensory evaluation of the complementary foods formulated was carried out for colour, texture, taste and general acceptability. The evaluation of the blends was conducted using a 30 semi-trained panelist randomly selected among nursing mothers from Ikwuano Health Centre and Federal Medical Center Umuahia. The food samples were evaluated for colour, flavor, texture, taste and general acceptability using a nine-point hedonic scale (Ihekoronye and Ngoddy, 1985). A table was set with the reconstituted samples and control (cerelac) in coded plates. Water was used for rinsing of mouth in-between evaluations on each tasting session.

Statistical analysis

The result obtained from the chemical analysis and sensory evaluation was subjected to Analysis of Variance (ANOVA) to compare the means of the samples. The mean, standard deviation and ANOVA was done using statistical package for service solution (SPSS) version 20. Means were separated using Duncan's new multiple range test and significance was accepted at $P < 0.05$.

RESULTS

Table 2 shows the energy and proximate composition of the complementary foods produced. The moisture content of the samples ranged from 59.19 to 74.04%. Sample C0 (control) had the highest moisture value (74.04%), while sample GSB2 (70% Guinea corn: 20% soybean: 10% Banana) had the lowest (59.19%) moisture. The moisture content of the gruel samples were significantly ($P < 0.05$) lower than the control sample. The value for protein ranged from 6.21 to 10.11%. Sample C0 (control) had the highest value for protein (10.11%), while sample GS1 (60% Guinea corn: 40% soybean) recorded the least value (6.21%). Crude fat content of the gruels ranged from 1.29 to 2.46%. Sample C0 (control) had the highest crude fat (2.46%), while sample GS1 had the least value (1.29%). Sample C0 (control) had the highest crude fiber (1.18%), while sample GSB3 (50% Guinea corn: 30% soybean: 20% Banana) had the lowest crude fiber (0.72%). A significant difference ($P < 0.05$) was observed in the crude fibre content of the blends. The ash content of the blends ranged from 1.45 to 2.63%. Sample GS1 had the least ash value (1.45%), while sample C0 (control) recorded the highest value (2.63%). The carbohydrate content of the products ranged from 10.78 to 22.12%.

Sample GS1 had the highest carbohydrate value (22.21%), while sample C0 (control) had the least value (10.78%). The energy value of the complementary foods ranged from 105.57 to

129.20%. Sample GSB2 had the highest energy value (129.20%), while sample C0 had the least energy value (105.57%).

Table 2: Energy and proximate composition (%) of complementary food from guinea corn- soybean-banana flour blends.

Samples	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate	Energy (Kcal)
C0	74.04 ^a ± 0.02	10.11 ^a ± 0.01	2.46 ^a ± 0.01	1.18 ^a ± 0.02	2.63 ^a ± 0.00	10.78 ^d ± 0.00	105.57 ^d ± 0.19
GS1	68.92 ^d ± 0.01	6.21 ^d ± 0.01	1.29 ^d ± 0.00	0.81 ^{bc} ± 0.01	1.45 ^d ± 0.02	22.12 ^a ± 0.01	124.86 ^b ± 0.06
GSB2	68.19 ^c ± 0.03	6.62 ^c ± 0.01	1.81 ^c ± 0.02	0.79 ^{bc} ± 0.01	1.85 ^c ± 0.01	21.54 ^b ± 0.01	129.2 ^a ± 0.04
GSB3	69.24 ^b ± 0.01	6.80 ^b ± 0.01	2.01 ^b ± 0.01	0.72 ^d ± 0.01	2.05 ^b ± 0.02	19.9 ^c ± 0.02	124.89 ^b ± 0.03
RV		10	30	<5	<5	95	345

Values are mean ± standard deviation of duplicate samples.

^{a-d} means with different superscripts in the same column are significantly different (P < 0.005)

Key: C0- (100% cerelac)

GS1- (60% Guinea corn: 40% soybean)

GSB2 (70: 20: 10) = 70% Guinea corn: 20% soybean: 10% Banana)

GSB3 (50: 30: 20) = 50% Guinea corn: 30% soybean: 20% Banana

RV: Recommended values (WHO, 2009).

Table 3 presents the vitamin composition of the complementary gruels produced. The gruel samples recorded values ranging from 61.82 to 360.17µg/100g for its pro-vitamin A content. Sample C0 (control) recorded the highest value (360.17µg/100g) for pro-vitamin A, while sample GS1 (60% Guinea corn: 40% soybean) had the lowest pro-vitamin A, value (61.82µg/100g). There were significant differences (P<0.05) from each of

the samples. The vitamin C in the complementary foods produced ranged from 17.17 to 41.22 mg/100g. Sample C0 (control) had the highest vitamin C value (41.22µg/100g), while sample GS1 (60% Guinea corn: 40% soybean) had the lowest vitamin C value (17.17µg/100g). The value of vitamin C content in all the samples varied significantly (P<0.05) from each other.

Table 3: Vitamin composition of complementary food from guinea corn- soybean-banana flour blends.

Samples	Pro- Vitamin A (µg/100g)	Vitamin C (mg/100g)
C0	360.17 ^a ± 0.01	41.22 ^a ± 0.01
GS1	61.82 ^d ± 0.02	17.17 ^d ± 0.01
GSB2	62.16 ^c ± 0.03	18.35 ^c ± 0.02
GSB3	62.33 ^b ± 0.01	18.72 ^b ± 0.02
RV	400	30

Values are mean ± standard deviation of duplicate samples.

^{a-d} means with different superscripts in the same column are significantly different (P < 0.005)

Key: C0- (100% cerelac)

GS1- (60% Guinea corn: 40% soybean)

GSB2 (70: 20: 10) = 70% Guinea corn: 20% soybean: 10% Banana)

GSB3 (50: 30: 20) = 50% Guinea corn: 30% soybean: 20% Banana

RV: Recommended values (WHO, 2009).

Table 4 presents the mineral composition of the complementary foods. The calcium content of the gruels ranged from 41.51 to 324.17mg/100g. Sample C0 (control) had the highest calcium content (324.17mg/100g), while GS1 (60% Guinea corn:

40% soybean) had least calcium (41.51mg/100g). There was a significant difference (p< 0.05) between calcium content of the complementary food samples. The sodium content of the gruels ranged from 60.67 to 191.12mg/100g. The control (cerelac) recorded the

highest value for sodium (191.12mg/100g), while sample GS1 recorded the least value (60.67mg/100g). There was a significant difference ($p < 0.05$) between sodium content of the complementary food samples. The phosphorus content of the gruel samples ranged from 13.12 to 36.71mg/100g. Sample GSB3 (50% Guinea corn: 30% soybean: 20% Banana) had the highest phosphorus value (36.71mg/100g), while sample C0 (control) had the least phosphorus value (13.12mg/100g). There was a significant difference ($p < 0.05$) between phosphorus content of the complementary food samples. The magnesium in the gruels ranged from 0.81 to 26.72mg/100g. Sample GSB3 recorded the highest magnesium value (26.72mg/100g), while the control (cerelac) recorded

the least value (0.81mg/100g) of magnesium. There was a significant difference ($p < 0.05$) between magnesium content of the complementary food samples. The potassium content of the gruels ranged from 126.51 to 516.92mg/100g. Sample C0 recorded the highest value for potassium (516.92mg/100g), while sample GS1 recorded the least value (126.51mg/100g). The value for iron ranged from 3.96 to 10.05mg/100g. There was a significant difference ($p < 0.05$) between iron content of the complementary food samples. Zinc content in the gruel samples ranged from 2.58 to 6.17mg/100g. The control recorded the highest value (6.17mg/100g) for zinc, while sample GS1 recorded the least value (2.58mg/100g).

Samples	Calcium (mg/100g)	Sodium (mg/100g)	Phosphorus (mg/100g)	Magnesium (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
C0	324.17 ^a ± 0.01	191.12 ^a ± 0.02	13.12 ^d ± 0.01	0.81 ^d ± 0.01	516.92 ^a ± 0.02	10.05 ^a ± 0.01	6.17 ^a ± 0.01
GS1	41.51 ^d ± 0.01	60.67 ^d ± 0.01	29.47 ^c ± 0.01	18.06 ^c ± 0.01	126.51 ^d ± 0.00	3.96 ^d ± 0.01	2.58 ^d ± 0.01
GSB2	56.86 ^c ± 0.03	60.83 ^c ± 0.01	33.14 ^b ± 0.02	22.16 ^b ± 0.00	229.03 ^c ± 0.01	4.15 ^c ± 0.01	2.87 ^c ± 0.04
GSB3	76.92 ^b ± 0.01	97.89 ^b ± 0.01	36.71 ^a ± 0.01	26.72 ^a ± 0.02	331.35 ^b ± 0.01	4.32 ^b ± 0.02	2.92 ^b ± 0.03
RV	500	-	400	60	1100	4-12	5

Table 4: Mineral composition of complementary food from guinea corn- soybean-banana flour blends.

Values are mean ± standard deviation of duplicate samples.

^{a-d} means with different superscripts in the same column are significantly different ($P < 0.005$).

Key: C0- (100% cerelac)

GS1- (60% Guinea corn: 40% soybean)

GSB2 (70: 20: 10) = 70% Guinea corn: 20% soybean: 10% Banana)

GSB3 (50: 30: 20) = 50% Guinea corn: 30% soybean: 20% Banana

RV: Recommended values (WHO, 2009).

Table 5 shows the anti-nutrient composition of the gruel samples. The flavonoid composition in the gruel samples varied from 0.12 to 0.24mg/100g. Sample GS1 (60% Guinea corn: 40% soybean) had the highest value (0.24mg/100g) for flavonoid, while sample C0 (control) had the lowest value (0.12mg/100g). There was no significant difference ($P > 0.05$) observed in the flavonoid content of the samples. The alkaloid content ranged from 0.42 to 0.98mg/100g. Sample C0 (control) had the least alkaloid value (0.42mg/100g), while sample GS1 had the highest alkaloid value (0.98mg/100g). There was

no significant difference ($P > 0.05$) observed in the alkaloid content of the samples. Sample GSB3 (50% Guinea corn: 30% soybean: 20% Banana) had the highest tannin value (1.84mg/100g), while sample C0 recorded the least tannin value (0.26mg/100g). A significant difference ($P < 0.05$) was observed in the tannin content of the samples. The phytate values of the samples ranged from 0.11 to 1.18mg/100g. Sample C0 (control) had the least pyhtate value (0.11mg/100g), while sample GSB3 had the highest phytate value (1.18mg/100g).

Table 5: Anti-nutrient composition of complementary food from guinea corn- soybean-banana flour blends.

Samples	Flavonoid (mg/100g)	Alkaloid (mg/100g)	Tannin (mg/100g)	Phytate (mg/100g)
C0	0.12 ^d ± 0.01	0.42 ^d ± 0.01	0.26 ^d ± 0.01	0.11 ^d ± 0.01
GS1	0.24 ^{ab} ± 0.02	0.98 ^a ± 0.01	1.61 ^c ± 0.01	1.14 ^c ± 0.01
GSB2	0.21 ^{ab} ± 0.01	0.83 ^{bc} ± 0.01	1.78 ^b ± 0.01	1.17 ^{ab} ± 0.01

GSB3	0.17 ^c ± 0.01	0.80 ^{bc} ± 0.01	1.84 ^a ± 0.01	1.18 ^{ab} ± 0.02
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Values are mean ± standard deviation of duplicate samples.

^{a-d} means with different superscripts in the same column are significantly different (P < 0.005).

Key: C0- (100% cerelac)

GS1- (60% Guinea corn: 40% soybean)

GSB2 (70: 20: 10) = 70% Guinea corn: 20% soybean: 10% Banana)

GSB3 (50: 30: 20) = 50% Guinea corn: 30% soybean: 20% Banana

Table 6 presents the sensory attributes of the gruel samples. The mean scores for color of the gruel samples ranged from 7.27 to 8.77. Sample C0 (control) had the highest mean value for colour (8.77), while sample GSB2 (70% Guinea corn: 20% soybean: 10% Banana) had the lowest mean value (7.27). A significant difference (P<0.05) was observed in the colour of the blends. The mean scores for flavour of the complementary food produced ranged from 6.77 to 8.43. Sample C0 had the highest mean value (8.43) for flavor, while sample GSB2 had the lowest mean value (6.77). There was no significant difference (P>0.05) between the flavour of the samples. The mean values

for texture ranged from 6.80 to 8.16. Sample C0 had the highest mean value (8.16) for texture. There was no significant difference (P>0.05) between the texture of the samples. The mean scores for taste of the complementary foods ranged from 6.73 to 8.66. Sample C0 had the highest mean value (8.66) for taste. There was no significant difference (P>0.05) between the taste of the samples. The mean scores for general acceptability of the complementary foods ranged from 6.92 to 8.50. Sample C0 had the highest general acceptability value (8.23), while sample GSB2 had lowest general acceptability value (6.92). A significant difference (P<0.05) was observed in the general acceptability of the blends.

Table 6: Sensory attributes of complementary food from guinea corn- soybean-banana flour blends.

Samples	Colour	Flavor	Texture	Taste	General Acceptability
C0	8.77 ^a ± 0.04	8.43 ^a ± 0.06	8.16 ^a ± 0.06	8.66 ^a ± 0.03	8.50 ^a ± 0.12
GS1	7.67 ^b ± 0.06	7.10 ^{bc} ± 0.20	7.03 ^b ± 0.05	6.83 ^{bc} ± 0.01	7.15 ^b ± 0.08 55
GSB2	7.27 ^d ± 0.03	6.77 ^d ± 0.08	6.80 ^{cd} ± 0.03	6.83 ^{bc} ± 0.01	6.92 ^d ± 0.11
GSB3	7.40 ^c ± 0.01	7.10 ^{bc} ± 0.13	6.80 ^{cd} ± 0.04	6.73 ^d ± 0.01	7.01 ^c ± 0.10

Values are mean ± standard deviation of duplicate samples.

^{a-d} means with different superscripts in the same column are significantly different (P < 0.005).

Key: C0- (100% cerelac)

GS1- (60% Guinea corn: 40% soybean)

GSB2 (70: 20: 10) = 70% Guinea corn: 20% soybean: 10% Banana)

GSB3 (50: 30: 20) = 50% Guinea corn: 30% soybean: 20% Banana

DISCUSSION

The moisture content of the samples obtained in this study was higher than the moisture content (42.50 to 50.41%) of the complementary food reported by Onoja *et al.* (2014). The protein content in the blends produced was lower than the control (cerelac) and this could be due to soaking and cooking treatment. These processing treatments results in slight reduction of nutrients such as protein (Huma *et al.*, 2008). The increased protein content in sample GS1 could be as a result of the supplementation with soybean which is a rich source of protein. The crude protein values obtained in the formulated complementary foods were lower than that obtained by Ezeokeke and Onuoha. (2016). The fat content in the blends was lower than the control (cerelac). The reduction of fat content of the blends could be due to leaching of fat into water during soaking. Akinjayeya

and Francis. (2007) attributes fat reduction during soaking to hydrolysis of fat to fatty acids and glycerol by lypolytic enzymes. The crude fat values obtained in the formulated complementary foods were lower than that obtained by Ezeokeke and Onuoha. (2016). The ash content obtained in this study was comparable with the ash content (1.91 – 3.18%) of the complementary food reported by Okoye and Egbujie. (2018). The carbohydrate content of all the blends was higher than the control and this could be attributed to the dehulling and milling process of the blends. Oghbaei and Prakash. (2013) reported that the process of dehulling and milling improves the starch content of grains. The value of carbohydrate content in this study was lower than the values reported by Ezeokeke and Onuoha. (2016). The amount of pro-vitamin A content increased with the addition of banana flour to the

gruel samples. The pro-vitamin A content of the complementary food produced in this study was higher than that reported by Oche *et al.* (2017). The values of calcium and vitamin C obtained in this research were lower than that reported by Ezeokeke and Onuoha. (2016) on maize-soybean-banana blends. The level of sodium, phosphorus and potassium obtained in the gruels increased with addition or increase in banana flour and this could be because banana is high in sodium, phosphorus and potassium. The value of magnesium obtained in this study was higher than that reported by Ezeokeke and Onuoha. (2016). The values of iron obtained in this study were higher than the values reported by Onoja *et al.* (2014). The alkaloid content of the complementary food produced in this study is not in conformity with the values (0.02-0.03mg/100g) reported by Okudu *et al.* 2017. The value of tannins recorded in this study was lower than that (2.22 to 2.40mg/100g) reported by Ezeokeke and Onuoha. (2016) on maize-soybean-banana blends. The levels of phytate and zinc in the complementary food produced were similar when compared to the report by Ezeokeke and Onuoha. (2016) on maize-soybean and banana blends. The levels of the phytate present in the gruel samples were within the safe limit (Codex Alimentarius Commission, 2006). The highest mean scores for colour, flavor, texture, taste and general acceptability was recorded for sample C0 (cerelac) and this could be because milk and flavours were added to the cerelac during processing and production, giving it a more creamy and appealing appearance. Among the formulated blends, sample GS1 (guinea corn 60: soybean 40) was the most preferred. The mean scores of the sensory attributes of complementary food produced in this study were higher than the mean scores reported by Ezeokeke and Onuoha. (2016) on maize-soybean-banana blends.

CONCLUSION

This study shows that complementary food of acceptable level of nutrient quality can be produced from composite flours of guinea corn, soybean and banana. The analysis of proximate, vitamins, minerals, anti-nutrient and sensory evaluation of complementary food produced from guinea corn, soybean and banana blend samples showed recommended level of iron and also low fibre content for easy digestibility and absorption of nutrients and these are desirable for health. The vitamin C values in all the blends can help improve immune systems in infants. The supplementation up to 20% banana flour recorded the best in terms of minerals and vitamin contents and can be compared favorably with the control. The sensory evaluation provided general acceptability even though sample GS1 (guinea corn 60: soybean 40) was more preferred. This complementary food produced can serve as a healthy replacement for commercial processed

complementary foods for families in Nigeria. The raw materials used for the gruels were locally sourced and affordable. It is therefore important that complementary food formulated with guinea corn, soybean and banana flours be fed as weaning foods to infants for maintenance of a healthy nutritional status.

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