Evaluation of Nutrient Composition of Complementary Foods Made From Locally Available Cereals and Legumes

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ABSTRACT

Background: *Complementary foods play a very important role in the life of infants and young children, as they serve as a complement to breast milk after the first 6 months of exclusive breast feeding to meet nutritional requirement of infants and achieve optimal growth.*

Objective: *The study was carried out to evaluate the nutritional content of four complementary foods produced from locally available cereals and legumes.*

Methods: *Recipe of four complementary foods was formulated and prepared in the Laboratory, the samples were produced from blends of maize, soybean, sorghum, wheat, rice and groundnut at different ratios. The proximate, mineral and anti-nutritional properties of these complementary foods blend were determined using standard procedures. Analysis of variance (ANOVA) was employed to analyze the data, Duncan's multiple range test used to separate the means at P<0.05.*

Results: *The result obtained shows Moisture content of 6.09±0.08 – 2.40±0.06%, Protein of 24.97±0.18 – 12.27±0.08%, Fat content of 15.08±–8.39±0.13%, Carbohydrate content of 52.28±0.23 - 69.43±0.18. Tannin content of 98.46±0.22 –58.32±0.51 mg/100g, Phytate 5.79±0.03 - 3.56±0.30 mg/100g, and Trypsin Inhibitor 59.81±0.32 –24.32±0.53 mg/100g. The four complementary foods show no significant difference (p>0.05) in the nutrients except in Trypsin Inhibitors that is significantly different (p<0.05). The samples contain Calcium content of 44.89±0.52–11.83±1.19 mg/100g, Magnesium content of 310.59±0.05–168.33±0.64 mg/100g, and Potassium of 622.03±0.22–295.82±0.77 mg/100g.*

Conclusion: *The four complementary foods can meet the macro and micro nutritional needs of young infants.*

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INTRODUCTION

Complementary foods are solid or semi-solid foods given to infants in addition to breast milk or formula to provide essential nutrients for growth and development (1). Complementary food plays a vital role in infant nutrition, marking a significant milestone in a child's life. As breast milk or formula alone cannot meet the nutritional needs of infants beyond six months, complementary foods are introduced to support breastfeeding to provide essential nutrients for growth and development (2). The introduction of complementary foods is a critical period in an infant's life, as it marks the transition from exclusive breastfeeding to a mixed diet (3). However, this transition can be challenging, especially in developing countries where access to nutrient-dense foods is limited (4). Complementary foods should be continued until the child is two years old or beyond, gradually increasing variety and quantity as the child grows (5).

In Nigeria, like many other developing countries, complementary foods are often made from locally available cereals and legumes, which are rich in carbohydrates, proteins, and fiber (6). Despite the importance of complementary foods, challenges such as; limited access to nutrient-dense foods, especially in rural areas, inadequate knowledge about proper feeding practices, and cultural beliefs and taboos surrounding food introduction persist (7). Malnutrition is a significant public health problem in Nigeria therefore, ensuring that complementary foods are nutrient-dense is crucial for preventing malnutrition and promoting healthy growth and development in infants (8). Infants should be given complementary foods that are nutritionally adequate and safe, while continuing to breastfeed for up to two years or more (9).

Commercially available complementary foods are too expensive for the average and low-income families in Nigeria and many developing countries (10). Appropriate processing and blending of locally available food commodities have been found to improve nutrient density of the complementary food and improved nutrient intake, which resulted in the prevention of malnutrition problems (11). Complementary foods are being formulated and sold to mothers in our health facilities, hence need to evaluate the nutritional content of the foods produced at the Federal Medical Centre Abeokuta from locally available cereals and legumes. The nutrient content determination of produced complimentary for is necessary to ascertain the nutrient supply by the foods.

MATERIALS AND METHOD

Source of Material

The complimentary foods made from cereals and legumes are sold to mother to complement their children's foods at the Federal Medical Center Abeokuta. The recipe for the foods was collected at prepared in the laboratory to determine the nutrient content of the complimentary foods.

All ingredients that were used for the preparation of the complementary foods which includes, wheat (*Triticum*), Soy bean (*Glycine max*), Groundnut (*Arachis hypogaea)*, Maize (*Zea mays)*, Sorghum (*Sorghum bicolor)* and Rice (*Oryza sativa*) were purchased from Ado-Odo Ota market area of Ogun State.

Production of Composite Flours

Production of Maize Flour

Wholesome maize grains (*Zea mays* yellow, 0.50 kg) were sorted and weighed after which it was washed and soaked in water for 10 hours. It was drained and oven dried for 8 hours at 60°C in a cabinet dryer (DC500, Genlab, Cheshire, United Kingdom). The seeds were dry-milled and passed through 250 µm-mesh sieve. The maize flour was packaged in an airtight bag until required.

Production of Soybean Flour

Wholesome soybean seeds (0.5 kg) were sorted and dry-cleaned to remove impurities. The seeds were washed and steeped in water for 10 hours. The seeds were drained and precooked for 15 minutes, at temperature of 100 ºC after which, they were dehulled by rubbing in between palms and the hulls were removed by rinsing the seeds with clean water. The dehulled soybeans were dried in a cabinet dryer (DC500, Genlab, Cheshire, United Kingdom) at 100ºC for 5 hours. The seeds were dry-milled and passed through 250 µm-mesh sieve. The soybean flour was packaged in an airtight bag until required.

Production of Sorghum Flour

Red sorghum grains (*Sorghum bicolor,* 0.50 kg) were sorted and dry-cleaned to remove impurities. The seeds were washed and steeped in water for 10 hours. The seeds were drained and dried in a cabinet dryer (DC500, Genlab, Cheshire, United Kingdom) at 60 ºC for 8 hours. The seeds were dry-milled and passed through 250 µm-mesh sieve. The sorghum flour was packaged in an airtight bag until required.

Production of Wheat Flour

Wholesome wheat grains (0.50 kg) were sorted and dry-cleaned to remove impurities. The seeds were washed and steeped in water for 10 hours. The seeds were drained and dried in a cabinet dryer (DC500, Genlab, Cheshire, United Kingdom) at 60 ºC for 8 hours. The seeds were dry-milled and passed through 250µm-mesh sieve. The wheat flour was packaged in an airtight bag until required.

Production of Rice Flour

Commercial parboiled polished rice (*Oryza sativa,* Mama's Pride, Olams, Nigeria, 0.50kg) grains was dry-cleaned and sorted to remove impurities. The grains were milled into flour using a hammer mill and sieved through a 250μm-mesh sieve. The rice flour was packaged in an airtight bag until required.

Production of Groundnut flour

Wholesome raw dried groundnuts (*Arachis hypogaea*, 0.50 kg) seeds were dulled and dry-cleaned to get rid of stalks, stones and pebbles. The groundnuts were milled, sieved through a 250 μm-mesh sieve, packed into an airtight bag and stored in a cool dry place until required.

Proximate Analysis of Samples

The moisture, protein, crude fibre, ash, carbohydrate and fat content were determined using the method of Association of Official and Analytical Chemist (AOAC) (13). The moisture content was determined by gravimetric method described by AOAC (13). Samples protein content was determined using Kjedahl method described by AOAC (13). Soxhlet extraction technique as describe by AOAC., (13) was used for fat content determination. Ash content was determined by using incineration of 2g of each sample in a muffle furnace at 500°C for 2 hours as described by AOAC (13), crude fibre was also determined by AOAC method. The carbohydrate content was calculated by difference as the nitrogen free extraction (NFE), a method separately described by AOAC. The dry matter of the sample was calculated using the formula; % dry matter = 100% -% moisture content of the sample.

Determination of Minerals

Calcium, Iron, Magnesium, Copper, Zinc, Selenium were determined by atomic absorption spectrometer as described by AOAC (13). Potassium and Sodium were determined flame photometry. The sample solutions were aspirated into the flame and were analysed for the presence of sodium and potassium. The metals were introduced into the flame and the emitted light intensity was measured in the range 500nm to 800nm (14). Phosphorous was determined calorimetrically (13).

Determination of Antinutrient content

The alkaloids were determined using the gravimetric technique (15). The sample's tannin concentration was determined spectrophotometrically, as described by Kirk and Sawyer (16). Phenol was measured using the folin-ciocatean spectrophotometry method (13). The trypsin inhibitor and oxalate determination methods ware adapted from Moussa *et al*. (17) and Margaret *et al* (18) respectively.

Statistical Analysis

The data was collected, recorded, checked, cleaned, validated, stored and analyzed using the Statistical Package for Social Sciences (SPSS) Windows software for standard deviation and mean separation. Analysis of variance (ANOVA) was used to analyze the data; Duncan's multiple range test was used to separate the mean at $p<0.05$.

RESULTS

Proximate Composition of the Complementary Foods

The moisture content ranges from 6.09±0.08 g/100g in sample RGT to 2.40±0.06 g/100g in sample AMF. There was no significant difference ($p<0.05$) in carbohydrate content between sample GCG (69.43±0.16 g/100g) and RGT (69.42±0.16 g/100g). Sample AWT (52.28±0.23 g/100g) have the lowest value of carbohydrate content. There is significant difference ($p>0.05$) between the crude protein content of the samples. Sample AWT (24.97±0.18 g/100g) have the highest value of crude protein content while sample RGT (12.27±0.08 g/100g) have the lowest value of protein content. The fat content of the complementary food samples ranges from 15.08±0.45 g/100g in sample AMF to 8.39±0.13 g/100g in sample RGT. There is a significant difference ($p>0.05$) between the fat content of the samples. The crude fiber content of the samples ranges from 2.03±0.84 g/100g in sample AMF to 1.47±0.06 g/100g in sample AWT. There is significant different ($p<0.05$) between the crude fibre content of samples. The total ash content of the complementary food samples ranges from 2.05±0.04 g/100g in sample RGT to 1.32±0.00 g/100g in sample AMF.

Sample Formulation and Recipe

	AWT	AMF	GCG	RGT
Wheat flour	60g			
Soya bean flour	30g	30g		
Groundnut flour	10g	10g	20g	20g
Yellow maize flour		60g		
Rice flour				80g
Sorghum flour			80g	

Table 1:Proximate Composition of Complementary Foods Made from Locally Available Cereals and Legumes (g/100g)

PARAMETERS	AMF	GCG	AWT	RGT
Moisture (g/100g)	2.40±0.06[d]	3.72±0.08[c]	4.89±0.08[b]	6.09±0.08[a]
Carbohydrate (g/100g)	55.25 ±0.29[b]	69.43±0.18[a]	52.28±0.23[c]	69.42±0.16[a]
Crude Protein (g/100g)	23.93± 0.06[b]	13.19±0.06[c]	24.97±0.18[a]	12.27±0.08[d]
Crude Fat (g/100g)	15.08± 0.45[a]	10.61±0.28[c]	14.45±0.14[b]	8.39±0.13[d]
Crude Fibre (g/100g)	2.03± 0.84[a]	1.61±0.01[c]	1.47±0.06[d]	1.78 ± 0.01[b]
Total Ash (g/100g)	1.32± 0.00[c]	1.71±0.05[b]	1.94± 0.12a	2.05±0.04[a]
Gross Energy Kcal	510.5	461.61	497.33	437.46

Mean ± standard deviation of duplicate determination. Mean values in the same row with different superscript are significantly different (p<0.05).
KEYS
AMF = (Yellow maize, Soybeans, Groundnut)
AWT = (Wheat, soybeans, Groundnut)
GCG = (Guineacorn, Groundnut)
RGT = (Rice, Groundnut)

Anti-Nutrient content in the Complementary foods produced

The tannin content which ranges from 98.46±0.22 mg/100g in sample GCG to 58.32±0.51 mg/100g in sample RGT showing no significant difference (P>0.05). The oxalate content of the samples ranges from 38.82±0.41 mg/100g in sample GCG to 30.22±0.05 mg/100g in sample RGT and there is no significant difference (p>0.05) in the values of the oxalate content. The phytate content ranges from 5.79±0.03 mg/100g in sample AWT to 3.56±0.30 mg/100g in sample RGT showing no significant difference (p>0.05). The Trypsin inhibitor content ranged from 59.81±0.32 mg/100g in sample AWT to 24.32±0.53 mg/100g in samples RGT. The alkaloid content ranges from 5.04±0.01 mg/100g in sample GCG to 3.00±0.85 mg/100g in samples RGT.

Mineral Composition of the Complementary Foods Produced

The calcium content ranges from 44.89±0.52 mg/100g in sample AMF to 11.86±1.24 mg/100g in sample GCG showing no significant (p>0.05). The magnesium content of the complementary food samples ranges from 310.59±0.05 mg/100g in sample AMF to 168.33±0.64 mg/100g in sample RGT. The magnesium content of the samples shows significant difference (p<0.05) in all the samples. The result of the potassium content shows significant

Table 2: Anti-nutrient content in Complementary Foods produced from locally available Cereals and Legumes (mg/100g)

PARAMETERS	AMF	GCG	AWT	RGT
Tannin	86.11±0.07[b]	98.46±0.22[a]	85.45±0.48[b]	58.32±0.51[c]
Oxalate	33.29±0.17[b]	38.82±0.41[a]	34.15±0.57[b]	30.22±0.05[c]
Phytate	4.85±0.27[b]	5.18±0.05[b]	5.79±0.03[a]	3.56±0.30[c]
Trypsin Inhibitor	47.86±0.01[b]	35.52±0.46[c]	59.81±0.32[a]	24.32±0.53[d]
Alkaloid	4.28 ±0.18[b]	5.04±0.01[a]	5.03±0.08[a]	3.00±0.85[c]

KEY

AMF= Yellow maize, Soybeans, Groundnut)

AWT= (Wheat, Soybeans, Groundnut)

GCG= (Sorghum, Groundnut)

RGT= (Rice, Groundnut)

differences ($p<0.05$) among the samples with sample RGT (295.82±0.77 mg/100g) having significantly the lowest value. There was significant difference in the phosphorus content of the complementary foods which ranges from 311.20±0.59 mg/100g in sample AWT to 164±0.52 mg/100g in sample RGT. The sodium content of the complementary food ranges from 145.50±0.18 mg/100g in sample RGT to 22.57±0.06 mg/100g in sample AMF. There was no significant difference ($p>0.05$) between samples GCG (22.92±0.27 mg/100g) and sample AMF (22.57±0.06 mg/100g). The iron content of the complementary food samples increased significantly($p<0.05$) from the range of 15.53±0.52 mg/100g in sample AMF to 6.90±0.08 mg/100g in sample RGT. The values of the copper content also show significant difference ($p<0.05$) from the range of 0.99±0.50 in sample GCG to 0.39±0.03 mg/100g in sample RGT. The Zinc content of the samples ranges from 3.85±0.23 mg/100g in samples AMF to 1.30±0.04 mg/100g in sample RGT. There was no significant difference ($p>0.05$) between samples AWT (2.87±0.11 mg/100g) and sample GCG (2.81±0.05 mg/100g). The iodine content of the complementary food samples ranges from 8.90±0.33 mg/100g in sample AMF to 3.19±0.04 mg/100g in sample RGT. There is a significant difference ($p<0.05$) in the increase among the samples with sample RGT (3.19±0.04 mg/100g) having the lowest iodine content.

DISCUSSION

The study provides valuable information of complementary foods sold to mothers at Federal Medical Centre, Abeokuta. The result from this study demonstrated that, in terms of nutrient composition, the complimentary foods prepared using locally available cereals and legumes are nutrient dense. The result of moisture content obtained is lower compared to the result obtained by Ajilore *et al*., (19) on formulation and proximate evaluation of complementary diets from locally available foods in southwestern Nigeria. Adeola *et al.,* (20) on their study on evaluation of nutrient composition, functional and sensory attributes of sorghum, pigeon pea and soybean flour blends as complementary food in Nigeria obtained higher moisture content on analysis on complementary foods. The moisture content in the samples falls within the range of the codex standard which is 0-5% except for sample RGT which is higher. The relatively high amount of moisture in sample RGT could be a disadvantage as moisture content of food products determines their shelf life and storage potentials and thus, high moisture content of food have been proved to cause low shelf life of foods because it encourages microbial attack and spoilage which will in turn spoil the food (21).The result of the carbohydrate is in line with the result obtained by Adeola *et al.,* (20) and Joel *et al.,* (12) but lower than the result obtained by Anigo *et al*., (2) on their study on nutrient composition of commonly used complementary foods in North Western Nigeria. The crude protein result obtained is in line with the result

Table 3: Mineral Composition of Complementary Foods Made from Locally Available Cereals and Legumes (mg/100g)

PARAMETERS	AMF	GCG	AWT	RGT
Calcium (mg/100g)	44.89±0.52[a]	11.86±1.24[c]	31.83±1.19[b]	11.89±0.34[c]
Magnesium (mg/100g)	310.59±0.05[a]	214.86±0.40[c]	236.13±0.07[b]	168.33±0.64[d]
Potassium (mg/100g)	597.61±1.28[b]	394.32±1.36[c]	622.03±0.22[a]	295.82 ±0.77[d]
Phosphorus (mg/100g)	267.68±0.89[b]	253.06±1.19[c]	311.20±0.59[a]	164±0.52[d]
(Sodium mg/100g)	22.57±0.06[c]	22.92±0.27[c]	28.76±0.94[b]	145.50±0.18[a]
Iron (mg/100g)	15.53±0.52[a]	13.30±0.74[b]	8.50±0.32[c]	6.90±0.08[d]
Copper (mg/100g)	0.50±0.07[c]	0.99±0.50[a]	0.86±0.28[b]	0.39± 0.03[d]
Zinc (mg/100g)	3.85±0.23[a]	2.81±0.05[b]	2.87±0.11[b]	1.30±0.04
Iodine (mg/100g)	8.90±0.33[a]	8.34±0.02[b]	4.02±0.21[c]	3.19±0.04[d]

Mean ± standard deviation of duplicate determination. Mean values in the same row with different superscript are significantly different ($p<0.05$).

KEYS

AMF = (Yellow maize, Soybeans, Groundnut)

AWT = (Wheat, -Soybeans, Groundnut)

GCG = (Sorghum, Groundnut)

RGT = (Rice, Groundnut)

obtained by Adeola *et al.*, (20) when compared with sample AMF and AWT but higher than crude protein content in sample RGT and GCG. Joel *et al.,* (12) obtained a higher protein content on analysis of complementary foods while Ajilore *et al.*, (19) and Anigo *et al.*, (22) obtained a low protein content in their analysis respectively. This result is adequate when compared with the standard recommendation given by Codex that the protein content of complementary foods should be between 13.8g to 23.08g, except for sample RGT which have the lowest value of protein content. The result of fat content of food samples is similar the result of Joel *et al.*, (12) obtained a result in line with sample GCG, higher than sample RGT but lower when compared to sample AMF and AWT. The fat content obtained is also higher when compared with the result of Ajilore *et al.*, (19) and that of Anigo *et al.*, (22). The Fat contents of sample AMF, AWT and GCG meets the required dietary allowance (RDA) value of 10-25 g/day for infants and young children (22), while sample RGT did not meet the daily RDA value. High fat content can increase the energy density of the complimentary food and also increase the intake of fat-soluble vitamins. Dietary fat also helps to improve the palatability of foods by absorbing and retaining flavors (23). The result of crude fiber is in line with the report of Anigo *et al.*, (22) but lower than that obtained by Adeola *et al.*, (20) and Joel *et al.*, (12) respectively.

Antinutrient content showed that tannin content the values were significantly higher in sample GCG and significantly ($p>0.05$) lower in sample. The result obtained is in line with that obtained by Anigo *et al.*, (22) but higher than the results recorded by Joel *et al.,* (12) and Adeola *et al.*, (20).Concentration of tannins in the complementary foods were higher than the 20 mg/100 g tannins reported by Joel *et* *al*., (12), this will bring about the unpleasant, dry and bitter mouth feeling that is caused by tannins, which usually leads to reduced food intake by the child and this might lead to impaired growth and development (12, 24). The oxalate content of the samples is higher than the result recorded by Adeola *et al*., (20). Oxalates at higher concentration are considered poisonous, but are harmless when present in smaller amount (25). Also, phytate content is higher than that reported by Joel *et al*., (12) and Adeola *et al*., (20). Studies have shown that the absorption of Zinc is compromised by regular intake of diets high in phytate, such as diets that are based on unrefined cereal (22).

The calcium content is low when compared with the result obtained by Joel *et al.,* (12) and Adeoti *et al.,* (26). Magnesium contents of samples were higher than the results reported by Adeoti *et al.,* (26) and Okoye and Ene (27). Also, iron content of the complementary food samples was high, Adeoti *et al.,* (26) obtained a higher iron content while Joel *et al.,* (12) and Okoye and Ene (27) reported a lower iron content when compared with this study. The Iodine result obtained is in line with the result obtained by Adeoti *et al*., (26) but higher than the result reported by Okoye and Ene (27). There is a significant difference ($p<0.05$) in the increase among the samples with sample RGT having the lowest iodine content. Iodine plays an important role in the normal development of the central nervous system which is a vital part of the human body (28, 29).

CONCLUSION

The study has provided information on the nutrient composition of complementary foods made from locally available cereals and legumes that are sold at Federal Medical Centre, Abeokuta. The complementary foods contained adequate amounts of essential nutrients which are important in supporting the optimum growth of children that are being introduced to complementary foods.

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