

Chemical Composition of Complementary Foods Formulated from Roasted Groundnut, Soybean, Millet and Crayfish

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Abstract[H1]

The study evaluated chemical composition of complementary foods formulated from blends of soybean (S), groundnut (G), millet (M) and crayfish (C) which were processed into flours using standard methods. Four samples (102= 30G: 25SB: 35M: 10%C; 103= 25G: 35SB: 30M: 10%G; 104= 20G: 40SB: 30M: 10%C and 105= 15G: 35SB: 40M: 10%C and 101 (Cerelac) served as control. Proximate, vitamins (pro-vitamin A, thiamin, niacin, folic acid and vitamin K) and minerals (calcium, magnesium, phosphorus, iron and zinc) were analyzed using standard methods. Statistical analysis was done using SPSS Version 20 at $P \leq 0.05$. [H2] Sample 103 had highest (31.83%) protein while control had least (15.91%). Fat ranged from 1.77% (101) -14.34% (104). Ash contents ranged from 3.15% (101)- 4.83% (103). There were significant differences ($P < 0.05$) in carbohydrate contents of samples with highest (73.74%) in control while sample 104 had least (34.27%) value. Dietary fiber ranged 2.17% (101)- 8.04% (102) and highest energy value of 1635.34KJ was in 104. Pro-vitamin A (ug/100g), thiamin, niacin, folic acid, vitamin K (mg/100g) ranged from 0.33 (105)-6.4 (101), 0.71 (101)-3.42 (102), 3.96 (101)-6.50(102), 0.52 (101)-0.57(102 and 103) and 0.97(105)- 68.12 (101), respectively. Calcium, magnesium, phosphorus, iron and zinc values were all significantly different ($P < 0.05$) from one another. Values in mg/100g ranged from 27.24 (102)-66.15 (101), 0.16 (101)-36.45 (102), 20.32 (105)-74.20 9101), 3.86 (102)-13.51 9101) and 2.50 (105)- 4.98 (101), respectively. Food materials used for the blends were good when formulated using the ratios of samples 102 and 103 as they yielded the highest nutrient.

Keywords: Complementary foods, complementary feeding, chemical composition

[H3]Introduction

Good nutrition affords children the opportunity to survive, grow, learn, play, participate and contribute meaningfully in life's endeavors. But malnutrition robs children of their futures and leaves lives hanging in the balance (United Nation's Children Fund/ World Health Organization/ International Bank for Reconstruction and Development/ World Bank (UNICEF/WHO/IBRD/WB) (2020). Good nutrition for young children aged 6 months and above involves adequate complementary feeding along with continued breast feeding up to 2 years and beyond (World Health Organization (WHO) (2023). This is because, breast milk only is no longer adequate to meet the nutritional needs of the infant, hence complementary foods should be added to the diets of children (WHO, 2017). Guidelines for the choice of complementary foods must consider time of introduction, types, order and amounts of foods given (Pearce *et al.*, 2013; Solomons and Vossenaar, 2013). World Health Organization (WHO) (2005) opined that complementary foods are those which are appropriately timed, nutritionally adequate and hygienically prepared, given to infants along with continued breast feeding from 6 months of age.

In Nigeria, traditional complementary foods are usually introduced to young children between 3 and 6 months depending on the locality, type of cereal grain and root crop available (Onofiok and Nnanyelugo, 2007). Onabanjo (2007) noted that the usual first complementary food is called pap, akamu, ogi or koko prepared from fermented cereals such as maize, millet or guinea corn. Thereafter, other staple foods like yam, rice, garri, cocoyam eaten with sauce or soup are introduced (Ikegwu, 2010). Such single mix complementary foods are inadequate to meet daily macro and micro nutrients plus energy requirements of an infant and may lead to malnutrition in infants and young children (WHO, 2005). Protein energy malnutrition among young children is 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 micro- nutrients are fed to at risk infants (UNICEF, 2009). Development Initiatives (2020) reported that globally, when it comes to solid foods, only 69.5% of infants aged 6-8 months ate any solid food at all. Of children aged 6-23 months, a little above half (53.1%) got the recommended minimum number of meals with less than one in three children (29.3%) receiving the minimum diet diversity and 18.9% ate a minimum acceptable diets (Development Initiatives, 2020).

The obvious consequences are the prevalence of stunting and wasting that are not abating globally. In 2019, globally, 21.3% of children under 5 years were stunted. Stunting is the devastating result of poor nutrition in utero and early childhood. Stunted children may never attain their full possible height and their brains may never develop to their full cognitive potential (UNICEF/WHO/IBRD/WB, 2020). Wasting results due to poor nutrient intake and/or disease. Wasted children have weakened immunity, are susceptible to long-term developmental delays and face an increased risk of death. Wasted children under 5 years were put at 6.9% globally (UNICEF/WHO/IBRD/WB, 2020). The report further revealed that Asia and Africa bear the highest burdens of stunting and wasting where 54%, 40% and 45%, 24% of children under 5 years were stunted and wasted, respectively. Stunting prevalence in West Africa and Nigeria were 27.7% and 62.8%, respectively (UNICEF/WHO/IBRD/WB, 2020). Globally, around 40% of all adults and 20% of children are now overweight or obese (WHO, 2021) Overweight and obesity have been shaped in part by industry marketing and greater access to processed foods along with lower levels of physical activity. Overweight/ obesity rate globally was put at 5.6% (UNICEF/WHO/IBRD/WB, 2020). Unarguably, sales of infant formulas and commercially produced complementary foods together with unwholesome snacks have contributed to the rising prevalence of overweight/obesity especially among children in rich households. Those commercial complementary foods have been shown to be energy-dense (UNICEF/WHO/IBRD/WB, 2020). But for children in poor

households, the use of cereal-based gruels as complementary foods which are energy-dense and poor in nutrients may contribute to excessive caloric intake.

Malnutrition in children can be prevented by feeding them adequate nutritious, diverse and safe foods (Food and Agriculture Organization (FAO), 2011; UNICEF/WHO/IBRD/WB, 2020). Good complementary feeding means feeding children enriched food every day in addition to nutritious snacks. Foods can be enriched with powders and Strengthening Partnerships, Results and Innovations in Nutrition Globally (SPRING) (2016) stated that enrichment powders are a blend of energy-dense foods that can be preserved in a flour form and sprinkled on a prepared meal such as ready-made pap, porridge, rice and other family foods to increase the energy and nutrient contents of such foods. Soybeans, groundnut, benniseed or sesame seeds and crayfish are different options that can be used.

A blend of millet, soybean, groundnut and crayfish could provide adequate nutrient and energy intakes for a child. Millet is rich in calcium, dietary fiber, polyphenols and protein. It is also rich in both essential and non-essential amino acids (Devi *et al.*, 2011; Bagdi *et al.*, 2011; FAO, 2009). Soybean is an important source of plant protein which competes with that of animal. The protein content per 100g is 36.49g with a well balance of amino acid mixture (United States Department of Agriculture (USDA) (2006). Groundnut is an important oil seed and is also grouped as legume because of its relatively high protein content of 25g/100g (USDA, 2006). Crayfish is one of the cheapest source of animal protein in Nigeria. It is a good source of iron, calcium, vitamin B12 and its protein content per 100g is 14.89g (Swahn, 2004).

Therefore, as part of effort to produce nutritionally adequate complementary foods from blends of Nigerian indigenous food materials, the study was designed to formulate composite flours from fermented millet, soybean, roasted groundnut and crayfish. Porridges were prepared from the flours and their chemical contents evaluated.

Materials and methods

Study design: Experimental design was employed in the study. The different samples were prepared in the laboratory and analyzed for chemical compositions. One of the samples served as the control without treatment while the rest had different proportions of the food materials.

Raw materials collection: Soybean, millet, groundnut seeds and crayfish used for the study were purchased from Ubani, main market, Umuahia. Analytical grade reagent that were used for the chemical analysis were obtained from the Biochemistry Laboratory of National Root Crops Research Institute Umudike, Abia State.

Sample preparation: Soybean flour was produced following the method described by Adelekan *et al.* (2013). The soybean seeds were sorted, steeped in water for 6 hours, boiled for 30 minutes, outer covering removed, oven dried at 60⁰C for 6hours, milled and sieved (Figure 1). Figure 2 shows the preparation of groundnut flour. The steps involved sorting of groundnut seeds, washing and draining, roasting in oven at 50⁰C for 20minutes, removal of outer coat and grinding (Reena and Arivuchudar, 2018). Millet flour was produced according to the method described by Kwaw and Sackey (2013). In Figure 3, the steps were sorting and washing of millet seeds, soaking for 24hours, oven drying at 60⁰C for 9 hours and milling. Finally, the method described by Okoye and Ene (2018) was followed in the production of crayfish flour as outlined in Figure 4. [H4]The crayfish was sorted, washed, drained, oven dried at 60⁰C for 10hours, milled and sieved.

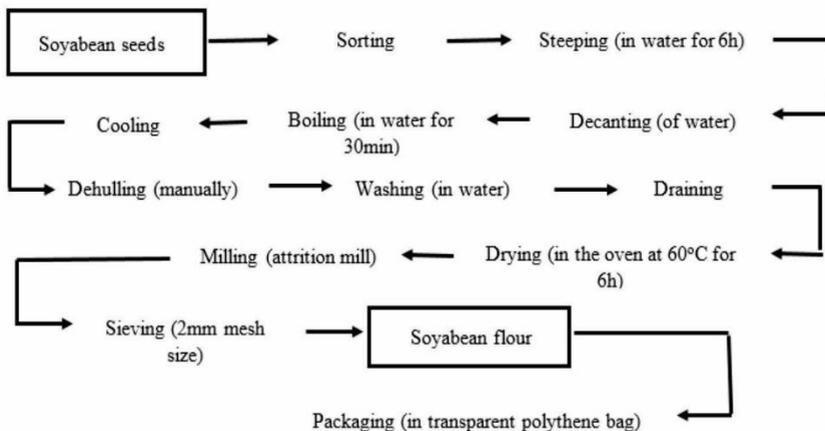


Figure 1: Flow chart for production of soybean flour
 Source: Adelekan *et al.* (2013).

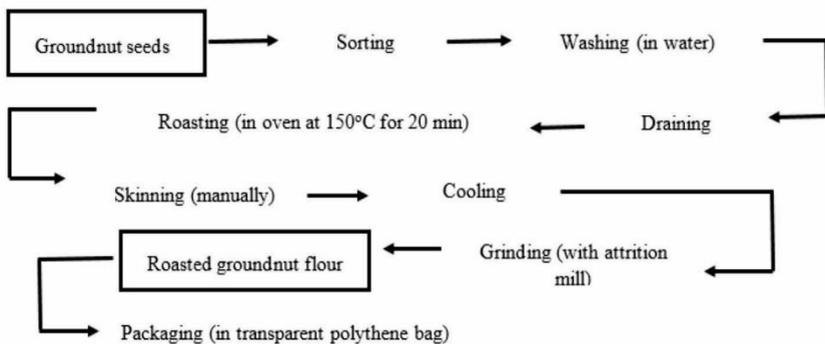


Figure 2: Flow chart for production of roasted groundnut flour
 Source: Reena and Arivuchudar (2018).

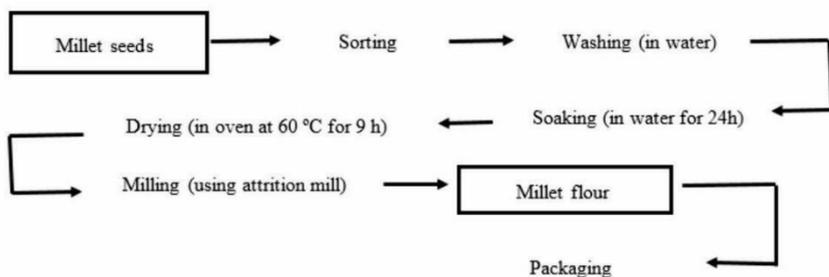


Figure 3: Preparation of millet flour
Source: Kwaw and Sackey (2013)

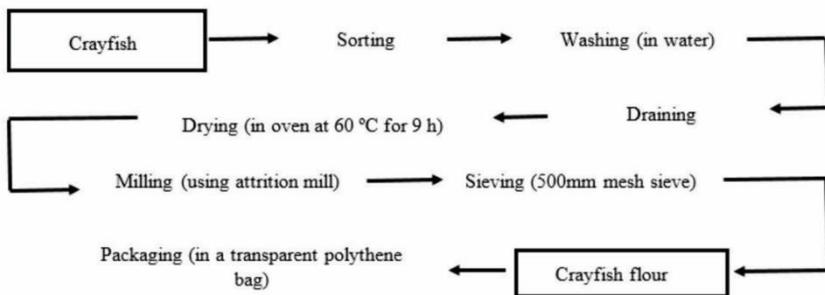


Figure 4: Flow chart for production of crayfish flour
Source: Okoye and Ene (2018)

Formulation/ preparation of complementary foods: Table 1 presents the flour blend formulations comprising groundnut, soybean, millet and crayfish flours in the ratios: 30: 25:35: 10; 25: 35: 30: 10; 20: 40: 30: 10 and 15: 35: 40: 10 for samples 102, 103, 104 and 105, respectively [H5]. Sample 101, cerelac, a commercial complementary food served as the control. The basis for the choice of the ratio was the fact that millet, a cereal is a starchy staple used in preparing children foods just like maize, hence it has higher proportion. Soybean, a legume complements it by supplying protein, which is of high quality. Groundnut will provide fats as well as protein, while crayfish provides animal source protein. Overall, the diet will be both energy and nutrient dense.

The experimental complementary foods were prepared according to the method described by Okoye and Ene (2018) and the ingredients as shown in Table 2. Gruels were prepared from both the formulated complementary foods and the control by mixing 100g of each blend with 200ml of boiled water. The mixtures were continuously stirred to obtain homogenous gruels and 4g of granulated sugar was added to each sample. The gruel samples as consumed were packaged in transparent plastic containers and stored till needed for analysis. [H6]

Table 1: Flour blends formulation (%) [H7]

Samples	Cerelac (control)	Roasted groundnut flour	Soybean flour	Millet Flour	Crayfish Flour
101	100	0	0	0	0
102	0	30	25	35	10
103	0	25	35	30	10
104	0	20	40	30	10
105	0	15	35	40	10

Table 2: Recipe for production of complementary foods

Ingredients	Quantity
Composite flour	100 g
Boiled water	200 ml
Granulated sugar	4 g

Source: Okoye and Ene (2018)

Chemical Analysis

The method described by the Association of Official Analytical Chemist (AOAC) (2010) was used to determine the proximate composition (moisture, ash, fat, crude protein and dietary fiber). The carbohydrate content was calculated using the formula: % carbohydrate = $100 - (\% \text{ protein} + \% \text{ fat} + \% \text{ dietary fiber} + \% \text{ ash} + \% \text{ moisture})$ contents. The energy values in kilocalorie were calculated by multiplying the proportion of protein, fat and carbohydrate by their respective physiological fuel values of 4, 9 and 4kcal/g, respectively and taking the sum of their products. Then energy values in kilocalories were multiplied by 4.18kilojoule to get the values in kilojoules. Minerals (phosphorus, calcium, magnesium, iron and zinc) were determined according to the method described by Onwuka (2019), AOAC (2010) and Onwuka (2019), respectively. The procedures detailed by Onwuka (2019) were employed in analyzing for vitamin B1 (thiamin), vitamin K, vitamin B3 (niacin) and Pro-vitamin A while folic acid was determined following the procedure described by Ibrahim and Yusuf (2015).

Statistical Analysis

Results were presented as means of triplicate analysis. One way analysis of variance (ANOVA) was done using statistical package for service solution version 23. Treatment means were separated

using Duncan Multiple Range Test and significance difference was judged at P equal to or less than 0.05.

Results

The results for the proximate composition of the complementary foods are shown in Table 3. The result revealed that the control (101) had the lowest (3.25%) moisture content, which significantly ($P < 0.05$) differed from the rest (8.10, 8.14, 8.36 and 9.02%) for samples 103, 102, 104 and 105, respectively. The control had the lowest (15.91%) crude protein content while the highest (31.83%) was noted in sample 103. Dietary fiber contents ranged from 2.17% (101)- 7.54% (103) and all the values differed significantly from one another. The fat contents of the samples showed that sample 103 had the highest (4.83%) but this did not differ significantly from 4.81% noted in sample 104. The lowest ash content of 3.15% was noted in sample 101 and the rest of the samples, 102 and 105 had 4.67 and 4.61%, respectively. The control recorded the highest (73.74%) carbohydrate content, however, for the experimental samples, 105 had the highest (38.45%) followed by 102 which recorded 37.34%. The energy values in kilojoules ranged from 1544.30 (102) - 1635.34 (104).

Table 3: Proximate composition

Proximate	101	102	103	104	105
Moisture content (%)	3.23 ^e ± 0.01	8.14 ^c ± 0.01	8.10 ^d ± 0.01	8.36 ^b ± 0.01	9.02 ^a ± 0.01
Crude protein (%)	15.91 ^e ± 0.01	31.20 ^c ± 0.01	31.83 ^a ± 0.01	31.24 ^b ± 0.01	28.31 ^d ± 0.01
Fat (%)	1.77 ^e ± 0.01	10.58 ^d ± 0.01	13.06 ^c ± 0.01	14.34 ^a ± 0.01	13.36 ^{eb} ± 0.01
Dietary fiber (%)	2.17 ^e ± 0.01	8.04 ^a ± 0.01	7.54 ^b ± 0.01	6.95 ^c ± 0.01	6.22 ^d ± 0.01
Ash (%)	3.15 ^c ± 0.01	4.67 ^b ± 0.01	4.83 ^a ± 0.01	4.81 ^a ± 0.01	4.61 ^b ± 0.01

Values are mean ± standard deviation of triplicate sample a-e= means with similar superscript in each row are not significantly different from one another.

101= Cerelac (100%)

102= Millet (35%) + Soybean (25%) + Groundnut (30%) + Crayfish (10%)

103= Millet (30%) + Soybean (35%) + Groundnut (25%) + Crayfish (10%)

104- Millet (30%) + Soybean (40%) + Groundnut (20%) + Crayfish (10%)

105- Millet (40%) + Soybean (35%) + Groundnut (15%) + Crayfish (10%)

Table 4 presents the vitamin contents of the complementary foods. Pro-vitamin A contents ranged from 0.33 (105)- 6.4ug/100g (101). Sample 102 had the highest (3.42mg/100g) thiamin content and the lowest (0.71mg/100g) was for the control. Niacin contents of the complementary foods significantly differed from one another and ranged from 3.96 (101)-6.50mg/100g (102). The folic acid contents in ug/100g ranged from 0.52 (101)- 0.57 (102 and 103).

Sample 101 had the highest (68.12ug/100g) vitamin K while 105 contained the lowest (0.97mg/100g).

Table 4: Vitamin compositions of the complementary foods

Vitamins	101	102	103	104	105
Pro-Vitamin A(μ g/100g)	6.4 ^a \pm 0.00	0.36 ^d \pm 0.01	0.38 ^b \pm 0.01	0.37 ^c \pm 0.01	0.33 ^e \pm 0.01
Thiamin(mg/100g)	0.71 ^d \pm 0.01	3.42 ^a \pm 0.01	3.40 ^a \pm 0.01	3.35 ^b \pm 0.01	3.21 ^c \pm 0.01
Niacin(mg/100g)	3.96 ^d \pm 0.01	6.50 ^a \pm 0.21	5.38 ^b \pm 0.01	4.65 ^c \pm 0.01	4.00 ^d \pm 0.01
Folic acid(mg/100g)	0.52 ^d \pm 0.02	0.57 ^a \pm 0.01	0.57 ^a \pm 0.01	0.55 ^b \pm 0.01	0.53 ^c \pm 0.01
Vitamin k(mg/100g)	68.12 ^a \pm 0.01	3.19 ^c \pm 0.00	3.11 ^c \pm 0.01	3.49 ^b \pm 0.10	0.97 ^d \pm 0.01

Values are mean \pm standard deviation of triplicate sample

^{a-e} means with similar super script in each rows are not significantly different (P>0.05)

The mineral contents of the samples are presented in Table 5. Calcium contents of the samples significantly differed from one another and the values increased from 27.24, 32.72, 35.08, 36.04 and 66.15mg/100g in samples 102, 103, 105, 104 and 101, respectively. The magnesium values in mg/100g ranged from 0.16 (101)- 36.45 (102) while the reverse was noted in the phosphorus contents which ranged from 20,32 (105)- 74.20mg/100g (101). The control had the highest (13.51mg/100g) iron content while the formulated foods' iron contents significantly differed from one another with values of 3.86, 4.70, 5.07 and 5.56mg/100g for samples 102, 103, 104 and 105, respectively. Zinc values recorded the highest values for the formulated foods in sample 102 with a value of 2.68mg/100g followed by 102 with a value of 2.62 and the least (2.50) was for 105.

Table 5: Mineral compositions of the complementary foods

Minerals	101	102	103	104	105
Calcium(mg/100g)	66.15 ^a ±0.01	27.24 ^e ±0.01	32.72 ^d ±0.01	36.04 ^b ±0.01	35.08 ^c ±0.01
Magnesium(mg/100g)	0.16 ^e ±0.01	36.45 ^a ±0.01	34.64 ^b ±0.01	30.42 ^c ±0.01	28.66 ^d ±0.01
Phosphorus(mg/100g)	74.20 ^a ±0.01	30.91 ^b ±0.01	26.67 ^c ±0.01	22.95 ^d ±0.01	20.32 ^e ±0.01
Iron(mg/100g)	13.51 ^a ±0.01	3.86 ^e ±0.01	4.70 ^d ±0.01	5.07 ^c ±0.01	5.56 ^b ±0.01
Zinc(mg/100g)	4.98 ^a ±0.01	2.68 ^b ±0.01	2.62 ^c ±0.01	2.56 ^d ±0.01	2.50 ^e ±0.01

Values are mean ± standard deviation of triplicate samples.

^{a-e} means with similar super script in each rows are not significantly different (P>0.05)

Discussion

Moisture content is a measure of shelf life which relates to the keeping quality or how long the prepared complementary foods will last before deterioration. The lower moisture content noted in the control may be attributable to the processing methods employed by the producers in producing the control. Since it is a commercial product, the producers might have used processing methods that drastically reduced the moisture content so that it can keep for a longer period. The moisture contents of the formulated complementary foods are quite low and can keep for a reasonable long time, but since they are home-made, it is recommended that smaller quantities be produced in order to retain the freshness. The moisture contents of the experimental samples were comparable to the 6-10% reported by Kent and Evers (2014). However, they were higher than the 4.96% reported by Nwokem *et al.* (2019). [H10] The higher protein contents of the experimental samples were due to the addition of soybean, groundnut and crayfish to them which contributed significantly to the protein contents of the foods. This has further proved that the use of multi mix of food materials in the production of complementary foods increases the protein content, which is an essential nutrient required for growth in children. The protein contents reported in this study were higher than the 12-17% (millet, soybean and crayfish) reported by Holland *et al.* (2008), 6.37-7.88% (guinea corn, millet and maize) by Anigo *et al.* (2010) and 25.76% (guinea corn/millet/yellow maize, soybean, groundnut, date and crayfish) by Nwokem *et al.* (2019). It was only in the last study under comparison that employed four mix like the present study even though the authors did not show the ratios for the blending of the food materials. [H11] The protein contents reported by the authors and the present study were all high and both met the 12.5, 14 and 15g/day for 0-6 months, 7-12 months and 1-3 years, respectively recommended by Food and Agriculture Organization/World Health Organization (FAO/WHO/UNU) (2002) [H12] for infants and young children.

The fat contents of the formulated complementary foods were all higher than the control and they increased with the addition of groundnut and soybean. They were also higher than the 1.05-2.06% reported by Anigo *et al.* (2010). The higher fat contents of the formulated blends may be due to the use of less millet and more of soybean and groundnut put together in the blends formulation. High fat contents reported in this study may also be due to soaking which probably led to leaching of soluble components, thus increasing the amount of fats in the flours. The increase in fat contents may also be attributable to the destruction of cell structure and the efficient release of oil reserve (Aguma *et al.*, 2017). Sade (2009) also reported an increase of fat after roasting of millet. The authors of the reference work used 60% of either millet or guinea corn and less of groundnut and soybean put together. That therefore may have reduced the fat contents of their blends. In contrast, Nwokem *et al.* (2019) reported fat content of 18.74% which was higher than that of the study under discussion. In addition to soybean and groundnut, the authors incorporated date palm and that might have increased the fat content of their sample. According to Institute of Medicine (IOM) (2005), percentage fat intakes for children 6-24months should be gradually reduced to 35%. The formulated complementary foods may not exceed that percentage when fed to children.

The European Commission (2008) defined dietary fibers as carbohydrate polymers with three or more monomeric units, which are neither digested nor absorbed in the human small intestine. The dietary fiber contents of the formulated blends were all higher than the control and 3.5% (Okhuze, 2016), 2.0-2.5% (Udensi *et al.*, 2012), 0.04-2.27% (Onoja and Obizoba, 2014), 0.87-1.74% (Anigo *et al.*, 2010) and 3.69% (Nwokem *et al.*, 2019) reported by the authors. The grains used in the formulation of the complementary foods could have contributed to the high contents of dietary fiber. This could help in meeting the 19-25g/day dietary fiber recommended for children 1-8years (IOM, 2005). The ash contents

of the complementary foods were higher than the control (cerelac produced from maize, milk fortified with calcium, iron, zinc and vitamins) probably due to the use of different grains which individually contributed together with the crayfish added to all of them.[H13] The values were higher than the 1.03- 2.69% and 3.59% reported by Anigo *et al.* (2010) and Nwokem *et al.* (2019), respectively. The differences noted could be attributed to the proportions of cereal and legumes used in the blends.

The carbohydrate contents of the experimental samples were comparable to the 30.10% reported by Unoja *et al.* (2014) but were lower than the 88.75-90,89% and 46.93% reported by Anigo *et al.* (2010) and Nwolem *et al.* (2019), respectively. It then appears that ratio of cereal to legume affected most of the proximate contents as earlier noted. The control which was a cereal based mix (maize, milk, fortified with calcium, iron, zinc, iodine, vitamins) recorded the highest carbohydrate content and this was in congruent with what Nwokem *et al.* (2019) with regards to their control (cerelac) recording a carbohydrate content of 64.43%. The energy values of the complementary foods as determined from their carbohydrate, protein and fat contents were all higher than the control except for sample 102[H14] (35%M: 25%S: 30%G: 10%c). The values were lower than the 459.50kcal reported by Nwokem *et al.* (2019). Human energy requirement for children 7-12months is 765kcal/day (FAO/WHO/UNU, 2004). This implies that the complementary food blends when fed a number of times daily along with breast milk can meet that requirement.

The formulated complementary foods are not good sources of pro-vitamin A, hence would contribute minimally in meeting the 400(μ)/d for children 7-12 months as stipulated by FAO/WHO (1988). This means that children fed the complementary foods must receive other sources of pro-vitamin A and preformed vitamin A such as mashed paw paw, watermelon juice, mashed mango, egg yolk, liver and so on. The values reported in this study were similar to the 0.30-0.35ug reported by Udensi *et al.* (2012). Thiamin

contents of the complementary foods increased with increase in groundnut substitution. The values can adequately meet the 0.3mg/d of thiamin recommended for children 7-12months by FAO/WHO (2004). Niacin contents of the complementary foods followed a similar trend to that of thiamin increasing as groundnut substitution increases. The values were similar to the 4.5-6.3mg reported by Fagbemi and Oshodi (2011) but higher than the 3.88mg reported by Nwokem *et al.* (2019). Folic acid contents of the complementary foods were higher than the control, but the values were far below the 80ug dietary folate equivalent per day recommended for children 7-12months (FAO/WHO, 2004). Vitamin K contents of the complementary foods were all lower than the control but can likely meet the 10ug/d recommended for all children 7-12months if the foods are fed 3-4 times daily. Soybean are good sources of vitamin K ranging from 50-200ug/100g while a range of 1-10ug/100g can be found in groundnut (FAO/WHO, 2004).

Calcium, iron and zinc are minerals of public health importance especially among infants and young children. Iron and zinc play crucial roles in cognitive development during early life while calcium is important for strong bones and teeth (Roohani *et al.*, 2013; Abbaspour *et al.*, 2014). [H15]The recommended nutrient intakes of children 7-12 months for calcium is 400mg/d, zinc are 0.8, 4.1 and 8.4mg/d for high, moderate and low zinc bio-availabilities, respectively, iron are 3.9, 4.8, 5.8 and 11.6mg/d for 15, 12, 10 and 5% bio-availabilities, respectively, magnesium is 54mg/d and phosphorus is 275mg/d (FAO/WHO, 1988; FAO/WHO, 2004). The calcium contents of the complementary foods were lower than that of the control but higher than the 6.44-12.14mg/100g reported by Onoja and Obizoba (2014). They were also lower than the 27.68-47.95mg and 328.44mg reported by Anigo *et al.* (2010) and Nwokem *et al.* (2019), respectively. The control was fortified with calcium carbonate and that increased the calcium content. Magnesium contents of the complementary foods

were higher than the control but lower than the 107.56-146.91mg reported by Anigo *et al.* (2010). The control was fortified with iron and that increased the iron content making it higher than the experimental samples. The iron contents of the samples were lower than the 17.71-47.66mg reported by Anigo *et al.* (2010). Phosphorus contents of the experimental samples were also lower than the control as well as the highest (219.98mg) value reported by Anigo *et al.* (2010). Zinc content of the control was higher than the rest of the samples because it was fortified with zinc sulphate. The use of malted guinea corn and millet at a proportion of 60% might have contributed to the higher zinc contents of 7.45-10.79mg reported by Anigo *et al.* (2010). The same explanation could also be alluded to the other mineral contents that were higher than the present study. Generally, for the experimental foods to meet the recommended nutrient intakes for those minerals, they will be fed 3-4 times and supplemented with animal sources of the minerals, particularly iron and zinc.

Conclusion and recommendations

The findings from this work indicated that acceptable nutrient-dense complementary foods can be produced from blends of cereal, legume and crayfish[H16]. It was noted that proportions as that of samples 102 (35%M: 25%S: 30%G: 10%C) and 103 (30%M: 35%S: 25%G: 10%C) [H17]yielded the most nutrients. Therefore, it is recommended that the complementary foods be fortified with animal source foods or fed along with those foods to increase the iron, zinc and vitamin A contents and intakes as well.

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