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Studies on the Nutritive Value, Antinutritional Factors and *In Vitro* Protein Digestibility of Maize Based Food Blend Fortified with Cowpea Bambaranut

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Abstract

The complementary weaning food blends were formulated using cereal- legume combination using yellow maize, cowpea, bambaranut and groundnut. Yellow maize was fermented to produce "Akamu", cowpea, bambaranut and groundnut were roasted. The weaning food blends were formulated as follows: MCBG: 60 (g) yellow maize: 20 (g) cowpea: 10 (g) bambaranut: 10 (g) groundnut, MCB; 60 (g) yellow maize: 20 (g) cowpea: 20 (g) bambaranut, MCG: 60 (g) yellow maize: 20 (g) bambaranut: 20 (g) groundnut and MBG: 60 (g) yellow maize: 20 (g) bambaranut: 20 (g) groundnut. The parameters assayed include proximate composition, mineral element, vitamin content, *in vitro* protein digestibility, anti-nutritional content, function properties, amino acid composition and sensory evaluation using standard laboratory methods. The yellow maize (Improved variety),cowpea, bambaranut and groundnut were obtained from Lake Chad Research Institute (LCRI) Maiduguri. The weaning food blends exhibited a low moisture content MCBG (3.37 ± 0.11%), MCB (3.38 ± 0.57%), MCG (3.43 ± 0.17%) and MBG (3.60 ± 0.20%). Protein content of MCBG (12.35 ± 0.06%) was close to the commercial weaning foods Cerelac® and Frisogold® and met the RDA of infants 0 - 1 year while the protein content of MCB (9.87 ± 0.06%), MCG (4.20 ± 0.04%) and MBG (3.61 ± 0.18%) were not comparable to commercial weaning foods Cerelac® and Frisogold® and have not met the RDA of infants 0 - 1 year, MCB was close to MCBG in the level of protein. The fat content of MCBG (9.58 ± 0.02%) met the RDA (10.25%) of infants 0 - 1 year and was comparable to the commercial weaning foods Cerelac® (10.00%) and Frisogold® (7.30%), but that of MBG (6.80 ± 0.26%) was below the RDA and Cerelac®. MCB (2.94 ± 0.01%) and MCG (5.87 ± 0.32%) were below the RDA of infants 0 - 1 year and the commercial weaning foods Cerelac® and Frisogold®. The energy content of MCBG (403.00 ± 0.58 kcal) was comparable to the weaning foods Cerelac® (410.00 ± kcal/100g) and Frisogold® (415.00 kcal/100g) and met the RDA (400.00 kcal/100g) of infants 0 - 1 year. The levels of sodium, potassium, calcium and phosphorus of the weaning food blends MCBG, MCB, MCG and MBG were below the RDA of infants 0 - 1 year and were below the commercial weaning foods Cerelac® and Frisogold® while the levels of magnesium, iron and zinc of the four weaning food blends met the RDA of infants and were comparable to the commercial weaning foods Cerelac® and Frisogold®. Increases were observed in the thiamine, Riboflavin, pyridoxine, cobalamine of the weaning food blends MCBG, MCB, MCG and MBG met the RDA of infants 0 - 1 year while the Vitamin A and C content of the four weaning food blends were below the RDA and also below the commercial weaning foods Cerelac® and Frisogold®. Processing of the grains resulted in significant percentage reduction in phytic acid, yellow maize (74.4%) cowpea (62.5%), bambaranut (50.2%), groundnut (70.0%) and reduction the tannin content yellow maize (60.7%), cowpea (71.2%), bambaranut (57.5%) and groundnut (69.07%) reduction in the phytic acid and tannin content improved the *in vitro* protein digestibility of the weaning food blends MCBG (86.30 ± 0.53), MCB (77.10 ± 0.2) MCG (73.90 ± 0.04) and MBG (70.80 ± 0.16).

Keywords: *Maize; Cowpea; Bambaranut; Groundnut*

Introduction

Breast milk is the ideal food for infants during the first six months of life. Inspite of superiority milk cannot provide all of the nutrients that allow infants to thrive after 6 months of life [1]. The critical period for an infant's growth and development is between the weaning periods (6 – 24 months). During this period transition in administration of diet occurs from a liquid milk based diet to another diet which is usually semi-solid to a more solid diet [2]. Weaning is a period of transition for the infant during which its diet changes in term of consistency and source from a mother's milk diet to another diet which should be digestible, have high energy density and low bulk [3].

Protein energy malnutrition is a dispense resulting from coincident lack of protein and calories in different proportions and occurs in children primarily at weaning stage in infancy and often associated with infections [4]. Poor feeding practices and poverty have been attributed as the major factors responsible for this nutritional problem.

Traditional weaning foods are low in protein content because they are cereal based. This weaning foods formulated from Nigeria are from maize, millet or sorghum. Supplementation of cereals with locally available legumes that are high in protein increases the protein content of cereal legume blends [5].

Anti-nutritional factors and method of food processing of diet components affect the nutritional efficiency of traditional weaning foods [6]. Fermentation of maize and heat treatment of cowpea, bambaranut and groundnut used in traditional weaning foods have been found to improve the nutrient and protein quality of weaning food blends [7].

The present study is aimed at evaluating the proximate composition, mineral element composition, vitamin content, *in vitro* protein digestibility and anti-nutritional factors of a weaning food blends from maize, cowpea, bambaranut and groundnut. Nutritive value, anti-nutritional and *in vitro* protein digestibility of maize based foods fortified with cowpea, bambaranut and groundnut.

Materials and Methods

Materials

Sources of Yellow Maize, Cowpea, Bambaranut and Groundnut).

The yellow maize (Improved variety), cowpea, bambaranut and groundnut were obtained and authenticated by a seed breeder/plant taxonomist in the Lake Chad Research institute, and Department of Biological Science, University of Maiduguri respectively.

Source of Commercial Weaning Foods

The commercial weaning foods maize based Cerelac and wheat based Frisogold were purchased from a supermarket in Maiduguru, Borno State. It is recommended for infants of 6 months and above and it is a product of Nestle Nigeria plc.

Methods

Preparation of "Akamu"

The Akamu (ogi) was prepared by the method described by Akingbala., *et al* [8]. One hundred (100g) of maize (cereal) was cleaned and steeped into 200 ml of distilled water in a 1:2 ratio for 72 hours. At the end of the 72 hours, the top water was decanted and 200 ml of distilled water was added and milled into a slurry. The slurry was then sieved through a nylon cloth to separate the bran. The filtrate was then allowed to settle for 24 hours and the top water decanted. The akamu was sun-dried to a constant weight and was packed into airtight container and stored at 4^oC until used for weaning food formulation and analysis.

Preparation of Cowpea

One hundred (100g) of the cowpea was cleaned and soaked in distilled water for 5 minutes. The cowpea was dehulled (using a mortar and pestle) and washed to remove the husk. It was then sun-dried to a constant weight. roasted and ground into a fine powder as described by Theodore., *et al* [9].

Preparation of Bambaranut

One hundred (100g) of dry bambaranut was cleaned, roasted and milled into a fine powder after which it was sieved using a sieve as described by Theodore., *et al* [9].

Preparation of Groundnut

One hundred (100g) of groundnut was cleaned of dirt, roasted and dehulled. The dehulled groundnut was milled as described by Davies [10].

Formulation of the Weaning Diets

Cereal/legume diets were formulated using yellow maize, cowpea, bambaranut and groundnut in the following ratios:

1. 60 parts of Yellow Maize, 20 parts of Cowpea, 10 parts of Bambaranut and 10 parts of groundnut. i.e. 60:20:10:10-MCBG.
2. 60 parts of Yellow Maize, 20 parts of Cowpea, 20 parts of Bambaranut. i.e. 60:20:20-MCB.
3. 60 parts of Yellow Maize, 20 parts of Cowpea, 20 parts of Groundnut. i.e. 60:20:20-MCG.
4. 60 parts of Yellow Maize, 20 parts of Bambaranut, 20 parts of Groundnut. i.e. 60:20:20-MBG.

Determination of Proximate Composition

Proximate analysis was carried out on the yellow maize, cowpea, bambaranut, groundnut and the blend according to the methods of AOAC [11,12] to determine their proximate composition i.e. their moisture, ash, crude protein, crude fat, crude fibre and carbohydrate content.

Determination of Mineral Element

Atomic Absorption Spectrophotometer (AAS) AA 6800 series Shimazo Corp was used for the determination of Ca, P, K, Fe, Zn and Mg. Two grams (2g) of sample was weighed into a crucible and incinerated at 6000C for 2 hours. The ashed sample was transferred into 100 ml volumetric flask and 100 ml of distilled water was added into it and readings taken on the AAS. The appropriate lamps and correct wave length for each element as specified in the instruction manual are:

P = 213.6 nm, K = 766.5 nm, Ca = 422.7 nm, Mg = 285.2 nm, Zn = 213.9 nm, fe = 248.3 nm, Na = 589 nm

Determination of Vitamins (AOAC, 2000)

Samples was treated with potassium permanganate ($KMnO_4$) and hydrogen peroxide (H_2O_2) to remove background fluorescence. Interfering substances was removed using a 0.01M phosphate buffer.

Determination of *In Vitro* Protein Digestibility

In vitro protein digestibility was determined according to the method described by Nills (1979). In each of the three test tubes one milliliter (1 ml) of 11% trypsin was introduced and 1 ml of 0.1 NaCl added and allowed to stand to equilibrate; 1 ml of kamu or composite mixture was added to all the test tubes (labeled as digestibility at 1 hour and 6 hours). The reaction in each of the test tube was stopped with 5 ml of neutralized formalin at 60 minutes and 6 hours.

Determination of Anti Nutrients

Tannin Content Determination

Tannin content of the raw and processed pearl millet and wheat was determined by the method described by Price and Butler [13]. 0.2g of sample was weight into Erlenmeyer flask, and 10 ml of 4% HCl in methanol was pippeted into the flask. The flask was closed with parapilus and shaken for 20 minutes on a wrist actron shaker. 1 ml of extract will be pippeted and 1 ml of 1% vanillin and 0.5 ml of conc, HCl was added.

Five test tubes was labelled I, II, II, IV and V to prepare the standard solutions. Into the five test tubes, 0.1, 0.3, 0.5, 0.7 and 1.0 ml of phenol reagent was added respectively. The test tubes was made up to 1 ml with methanol (8% HCI in methanol). 1.0 ml of 1% vanillin and 0.5 ml conc. HCl was added to the tubes and made up to 5.5 ml with 4% HCl in methanol. Blank sample was prepared by using 5 ml of 4% HCI in methanol. The absorbance of the standard solutions, sample extract and blank sample was read using a spectrophotometer at 500 nm 20 minutes after incubation.

Calculation

Au = Astd

Cu Cstd.

Cu = Au x Cstd = mg/g

Astd

Where

Au = Absorbance of unknown.

Astd =Absorbance of standard.

Cu = Concentration of unknown.

Cstd Concentration of standard.

Determination of Phytic Acid

Phytic acid content of the raw and processed pearl millet and wheat samples was determined according to the method described by Davies and Reid [14]. One gram (1g) of sample was extracted by taking 40 ml of 0.3M nitric acid in a conical flask and shake for 1 hour on a shaker at 30°C and 80 revolutions per minute. The sample was then filtered and 5 ml of 0.08M ferric chloride was added and boiled for 20 minutes and filtered. The free iron (Fe^{3+}) remaining in the solution was determined colorimetrically by adding 2 ml of 0.005M ammonium thiocynate and the iron binding capacities of the extract was determined by difference. The results was expressed in terms of Mg, Fe bound per gran, of sample.

Statistical Analysis

All determinations were carried out in triplicates. All data collected were subjected to analysis of variance and Duncan multiple range test was used to compare the means using SPSS 11.0 software. Significance was accepted at $p \leq 0.05$.

Results

Proximate Composition

The proximate composition of the raw and processed yellow maize, cowpea, bambaranut and groundnut are presented in table 1. A significant ($p < 0.05$) decrease in the moisture content of raw and processed maize, bambaranut and cowpea was observed. The moisture content of raw and roasted groundnut did not show any significant difference ($p > 0.05$). The ash content of fermented maize, roasted cowpea, bambaranut and groundnut showed significant ($p < 0.05$) differences. Significant decrease was observed in the fibre content of fermented maize and roasted cowpea, bambaranut and groundnut compared to their unprocessed samples. There was a significant ($p < 0.05$) decrease in the fat content of roasted cowpea, bambaranut and groundnut compared to their unprocessed samples, while that of fermented maize did not show any significant ($p > 0.05$) difference as compared raw maize. Significant ($p < 0.05$) decreases were observed in the protein, contents of fermented maize, roasted cowpea, bambaranut and groundnut compared to raw maize, cowpea, bambaranut and groundnut. A significant ($p < 0.05$) decrease was observed in the carbohydrate and metabolizable energy content of fermented maize and roasted groundnut as compared to their unprocessed counterparts while increases were observed in roasted cowpea and bambaranut as compared to raw cowpea and bambaranut.

Parameters	Samples							
	Maize		Cowpea		Bambara-nut		Groundnut	
	Raw	Fermented	Raw	Roasted	Raw	Roasted	Raw	Roasted
Moisture (%)	3.27 ± 0.42[d]	2.37 ± 0.11[e]	4.23 ± 0.23[b]	3.53 ± 0.06[c]	5.37 ± 0.25[a]	3.60 ± 0.02[c]	1.63 ± 0.58[f]	1.77 ± 0.2[f]
Ash (%)	2.00 ± 0.01[b]	1.00 ± 0.01[e]	2.95 ± 0.01[a]	1.37 ± 0.01[d]	3.00 ± 0.01[a]	1.33 ± 0.01[d]	4.00 ± 0.01[b]	1.81 ± 0.01[c]
Fibre (%)	6.80 ± 0.26[f]	3.37 ± 0.25[g]	7.78 ± 0.29[e]	4.80 ± 0.26[f]	21.60 ± 0.57[b]	17.66 ± 1.00[d]	25.30 ± 0.81[a]	19.00 ± 1.00[c]
Fat (%)	2.80 ± 0.29[d]	2.08 ± 0.06[d]	4.78 ± 0.26[c]	1.17 ± 0.29[e]	2.83 ± 0.23[d]	1.83 ± 0.28[e]	28.30 ± 0.81[a]	24.70 ± 21.05[b]
Protein (%)	3.82 ± 0.02[g]	2.62 ± 0.70[h]	13.53 ± 0.01[c]	12.12 ± 0.06[d]	9.27 ± 0.04[e]	8.59 ± 0.03[f]	16.93 ± 0.05[a]	14.52 ± 0.05[b]
Soluble carbohydrate(%)	84.41 ± 1.61[a]	80.23 ± 0.46[a]	60.24 ± 0.53[b]	61.26 ± 0.10[b]	48.16 ± 3.25[d]	59.71 ± 0.16[c]	47.89 ± 2.20[d]	45.50 ± 1.17[d]
Metabolizable energy (kcal/100g)	161.30 ± 0.03[c]	158.40 ± 0.14[d]	136.60 ± 0.59[g]	138.6 ± 0.50[f]	152.6 ± 1.16[e]	157.2 ± 2.78[c]	238.1 ± 1.75[a]	209.0 ± 3.79[b]

Table 1: *Proximate Composition of Raw and Processed Maize, Cowpea, Bambaranut and Groundnut.*

Values are recorded as mean ± SD of three determinations. Mean in the same row with different superscripts are significantly (p < 0.05) different.

The proximate composition of the weaning food blends are presented in table 2. No significant differences (p > 0.05) were observed in the moisture contents of the complementary weaning food blends (MCBG, MCB, MCG and MBG). The moisture content of the weaning food blends MCBG (3.37%), MCB (3.33%), MCG (3.91%) and MBG (3.87%) are within the moisture content of weaning food blends and were comparable to the commercial weaning food Frisogold®. Significant differences were observed in the fibre content (3.81 - 4.96%) of the weaning food blends. The fibre value of MCBG was comparable to the commercial weaning food blends Cerelac® (4.30%) and higher than Frisogold® (1.70%), while the fibre content of MCB, MCG and MBG were lower compared to Cerelac® but comparable to Frisogold®. The fat content of MCBG (9.58%) met the RDA of infants from 0 - to 1 year (10 - 25%) and was comparable to the commercial weaning foods Cerelac® (10.00%) and Frisogold® (7.30%), while the fat content of the weaning food blends MCB (3.01%) and MCG (5.87%) were below the commercial standard as well as the RDA of infants 0 - 1 year but the fat content of MBG (6.80%) was comparable to Frisogold®. The weaning food blend MCBG had a protein content of 12.95% which was higher than MCB (10.61%), MCG (9.30%) and MBG (7.87%) and was close to the commercial weaning foods Cerelac® (15.00%) and Frisogold® (15.50%) and met the RDA value of 13.44 for infants (0 - 1 year). The levels of protein in MCB, MCG and MBG were lower than the commercial weaning foods, Cerelac® and Frisogold® and did not meet the RDA of infants (0 - 1 year). However the protein of MCB was close to MCBG.

Nutrients (%)	Weaning Food Blends						
	MCBG	MCB	MCG	MBG	Cerelac® (Maize)	Frisogold® (Wheat)	RDA
Moisture (%)	3.37 ± 0.11[a]	3.33 ± 0.37[a]	3.91 ± 0.17[a]	3.87 ± 0.20[a]	ND	2.00	-
Ash (%)	1.00 ± 0.01[b]	1.01 ± 0.02[b]	2.10 ± 0.07[a]	1.10 ± 0.06[b]	3.00	ND	-
Fibre (%)	4.96 ± 0.28[b]	3.83 ± 0.28[c]	7.81 ± 0.26[a]	3.94 ± 0.21[c]	4.30	1.70	-
Fat (%)	9.58 ± 0.02[a]	2.94 ± 0.06[b]	5.87 ± 0.32[c]	6.80 ± 0.26[d]	10.00	7.30	10.25
Protein (%)	12.95 ± 0.06[a]	10.87 ± 0.06[b]	9.30 ± 0.04[c]	7.61 ± 0.18[d]	15.00	15.50	12.44
Soluble carbohydrate (%)	63.26 ± 0.22[b]	72.9 ± 0.17[a]	62.9 ± 0.06[b]	52.9 ± 0.06[c]	65.00	71.00	-
Metabolisable energy (kcal/100g)	403.0 ± 0.58[a]	317.0 ± 1.18[d]	325.8 ± 0.61[c]	362.6 ± 0.38[b]	410.00	415.00	400 - 425

Table 2: *Proximate Composition of Weaning-Food Blends.*

Values are recorded as mean ± SD of three determinations. Means in the same row with different superscripts are significantly (P,0.05) different.

MCBG: 60 parts of yellow maize, 20 parts of cowpea, 10 parts of Bambaranut and 10 parts of groundnut

MCB: 60 parts of yellow maize, 20 parts of cowpea, 20 parts of Bambaranut

MCG: 60 parts of yellow maize, 20 parts of cowpea, 20 parts of Groundnut

MBG: 60 parts of yellow maize, 20 parts of Bambaranut, 20 parts of Groundnut

Cerelac®: Nestle Nigeria plc

Frisogold®: Nestle Nigeria plc

RDA: Recommended dietary allowance of infants (0 - 1 year) (1989)

ND: Not determined

The carbohydrate (NFE) levels of the MCBG (63.26%) was close to that of Cerelac® (65.00%) and below the carbohydrate content of Frisogold® (71.00%), while the other weaning foods blends had a carbohydrate content of MCB (72.9%), MCG (62.9%) and MBG (52.9%). MCB compared favourably with Cerelac® and Frisogold®. The metabolizable energy content of MCBG (430.00 kcal/kg) was higher than MCB (317.00 kcal/100), MCG (325.8 kcal/100g) and MBG (362.6 kcal/100g) and compared favourably with Cerelac® (410.00 kcal/100g) and met the RDA infants from 0 to 1 year (400 - 425 kcal/100g).

Mineral Element Composition

The mineral element composition of the raw and processed maize, cowpea, bambaranut and groundnut are presented in table 3. There were significant ($p < 0.05$) decreases in the levels of sodium in fermented maize when compared to raw maize and there were significant ($p < 0.05$) increases in the sodium content of roasted cowpea, bambaranut and groundnut when compared to raw cowpea, bambaranut and groundnut. A significant increase was observed in the potassium content of roasted cowpea and bambaranut when compared to raw cowpea and bambaranut while a decrease was observed in fermented maize and roasted groundnut when compared with raw maize and groundnut. A significant increase was also observed in the level of calcium of the fermented maize as compared to raw maize while significant ($P < 0.05$) decreases were observed in calcium content of roasted cowpea, bambaranut and groundnut when compared to raw cowpea, bambaranut and groundnut.

Parameters	Samples							
	Maize		Cowpea		Bambara-nut		Groundnut	
	Raw	Fermented	Raw	Roasted	Raw	Roasted	Raw	Roasted
Sodium	73.70 ± 0.50^c	35.70 ± 0.19^f	23.40 ± 0.18^g	37.53 ± 0.03^e	73.00 ± 0.08^c	85.35 ± 0.10^a	60.50 ± 0.12^d	77.90 ± 0.15^b
Potassium	806.00 ± 6.35^b	535.60 ± 6.41^c	238.40 ± 5.15^e	485.10 ± 1.20^d	853.40 ± 1.53^b	953.9 ± 3.02^a	883.8 ± 2.78^b	256.3 ± 5.40^e
Calcium	25.63 ± 0.41^g	62.50 ± 0.19^c	66.40 ± 1.75^b	58.80 ± 0.95^d	75.30 ± 1.76^a	65.40 ± 0.88^b	44.00 ± 0.27^e	30.90 ± 0.32^f
Magnesium	235.0 ± 3.70^a	121.20 ± 1.71^e	69.80 ± 0.79^f	153.40 ± 4.59^b	44.70 ± 1.90^g	29.60 ± 1.34^h	135.1 ± 1.03^d	138.7 ± 1.01^c
Phosphorus	60.22 ± 1.65^b	54.54 ± 0.45c	31.37 ± 0.76^f	54.26 ± 0.86^c	22.24 ± 0.26^g	37.32 ± 0.70^e	44.86 ± 0.20^d	74.75 ± 0.81^a
Iron	12.53 ± 0.42^a	9.69 ± 0.07^b	2.86 ± 0.02^e	2.84 ± 0.08^e	3.37 ± 0.17^d	3.57 ± 0.03^d	4.37 ± 0.22^c	4.57 ± 0.36^c
Zinc	6.25 ± 0.52^a	4.55 ± 0.30^b	3.08 ± 0.17^c	3.63 ± 0.56^c	1.55 ± 0.09^d	1.55 ± 0.12^d	4.35 ± 0.31^b	6.42 ± 0.15^a

Table 3: *Mineral Element Composition of Raw and Processed Maize, Cowpea, Bambaranut and Groundnut.*

Values are recorded as mean ± SD of three determinations. Means in the same row with different superscripts are significantly ($p < 0.05$) different

There was a significant ($p < 0.05$) decrease in the magnesium content of fermented maize. The phosphorus content of processed maize showed significant decrease while roasted cowpea, bambaranut and groundnut showed significant increase as compared to raw samples. No significant difference ($p > 0.05$) was observed in the iron content of both raw and roasted cowpea, bambaranut and groundnut while a significant decrease ($p < 0.05$) was observed in fermented maize when compared to raw maize. The zinc levels of raw and roasted cowpea and Bambaranut did not show any significant ($p < 0.05$) difference, while that of roasted groundnut showed an increase and that of fermented maize showed a decrease as compared to raw groundnut and maize.

The mineral element composition of the weaning food blends are presented in table 4. The sodium content of the weaning food blend MCB (1175 mg/100g) was higher in value than MCBG (83.90 mg/100g), MCG (100.2 mg/100g) but MBG (34.10 mg/100g) had lower sodium content compared to MCBG and MCB. The weaning food blends MCBG, MCG and MBG were not comparable to the commercial weaning foods, Cerelac® (145 mg/100g) and Frisogold® (120 mg/100g) and were below the RDA of infants (120 mg/100g) between 0 and 1 year old but however, the sodium content of the weaning food blend, MCB was close to the commercial weaning food Frisogold® (120 mg/100g) and the RDA of infants (120 mg/100g) within the same age bracket.

Nutrient	Weaning Food Blends						
	MCBG	MCB	MCG	MBG	Cerelac® (Maize)	Frisogold® (Wheat)	RDA
Sodium	83.90 ± 0.09[c]	117.5 ± 3.26[a]	100.2 ± 0.54[b]	34.10 ± 0.18[d]	145	120	120
Potassium	164.5 ± 3.16[d]	286.1 ± 2.36[a]	216.4 ± 0.39[b]	183.0 ± 4.05[c]	635	495	500
Calcium	112.7 ± 11.5[c]	123.9 ± 2.38[b]	157.6 ± 0.25[a]	85.69 ± 2.69[d]	600	350	400
Magnesium	227.3 ± 2.52[a]	165.9 ± 0.79[c]	179.9 ± 4.95[b]	59.8 ± 5.25[d]	ND	39	40.00
Phosphorus	27.66 ± 0.44[d]	183.3 ± 6.04[a]	86.65 ± 1.25[c]	35.79 ± 0.77[d]	400	330	350
Iron	6.58 ± 0.20[a]	5.73 ± 0.18[b]	5.96 ± 0.08[b]	3.29 ± 0.10[c]	7.50	ND	6.00
Zinc	5.42 ± 0.17[b]	5.58 ± 0.09[b]	6.43 ± 0.03[a]	2.97 ± 0.07[c]	6.00	1.70	5.00

Table 4: *Mineral Element Composition of Weaning Food Blends (mg/100g).*

Values are recorded as mean ± SD of three determinations. Means in the same row with different superscripts are significantly (P < 0.05) different.

MCBG: 60 parts of yellow maize, 20 parts of cowpea, 10 parts of Bambaranut and 10 parts of groundnut

MCB: 60 parts of yellow maize, 20 parts of cowpea, 20 parts of Bambaranut

MCG: 60 parts of yellow maize, 20 parts of cowpea, 20 parts of Groundnut

MBG: 60 parts of yellow maize, 20 parts of Bambaranut, 20 parts of Groundnut

Cerelac®: Nestle Nigeria plc

Frisogold®: Nestle Nigeria plc

RDA: Recommended dietary allowance of infants (0 - 1 year) (1989)

ND: Not determined

The level of potassium in the weaning food blends, MCB (286.10 mg/100g), MCG (216.40 mg/100g), MBG (185.00 mg/100g) and MCBG (164.50 mg/100g) were not comparable to the commercial weaning foods Cerelac® (635 mg/100g) and Frisogold® (495 mg/100g) and were below the RDA (500 mg/100g) of infants (0 - 1 year). The calcium content of MCG (157.60 mg/100g), MCB (123.90 mg/100g), MBG (85.69 mg/100g) and MCBG (112.70 mg/100g) were below the RDA of infants 0 to 1 year (400 mg/100g) and were not comparable to the commercial weaning foods Cerelac® (600 mg/100g) and Frisogold® (350 mg/100g). The magnesium content of weaning food blends MCBG (227.30 mg/100g), MCB (165.90 mg/100g), MCG (179.90 mg/100g) and MBG (59.8 mg/100g), were higher than the commercial weaning food Frisogold® (39 mg/100g) and the RDA of infants (40 mg/100g) between 0 and 1 year. The phosphorus level of MCB (183.30 mg/100g), MCBG (27.66 mg/100g), MCG (86.65 mg/100g) and MBG (35.79 mg/100g) were not comparable to the commercial weaning foods Cerelac® (40 mg/100g) and Frisogold® (380 mg/100g) and were below the RDA of infants 0 - 1 year. (350 mg/100g). No significant differences (p > 0.05) were observed in the iron content of MCB (5.73 mg/100g) and MCG (5.96 ± 0.1) but significant differences (p < 0.05) were observed in the iron content of MCBG (6.58 ± 0.20 mg/100g) MCB, MCG and MBG. The iron content of MCBG was close to the commercial weaning food Cerelac® (7.00 mg/100g) and met the RDA of infants (6.00 mg/100g) from 0 to 1 year. The weaning food blend MCG (6.43 mg/100g) recorded highest level of zinc when compared to MCBG (5.42 mg/100g), MCB (5.58 mg/100g) and MBG (2.97 mg/100g). The weaning food blends MCBG, MCB and MCG met the RDA of infants (5.00 mg/100g) between 0 and 1 year. MBG was below the RDA of infants 0 - 1 year and was not comparable to the commercial weaning food, Cerelac® but was comparable to the commercial weaning food Frisogold®.

Vitamin Composition

The vitamin composition of raw and processed maize, cowpea, Bambaranut and groundnut is presented in table 5. There was a significant decrease in thiamine content of roasted cowpea and bambaranut. A significant (p < 0.05) decrease was observed in the thiamine level of fermented maize when compared to raw maize while that of raw groundnut was not detected. The riboflavin, pyridoxine and cobalamine levels of the raw and processed maize, cowpea, bambaranut and groundnut showed a significant (P < 0.05) difference. There were significant (p < 0.05) differences in the ascorbic acid, and vitamin A content of raw and processed maize, cowpea, bambaranut and groundnut.

Parameters	Samples							
	Maize		Cowpea		Bambara-nut		Groundnut	
	Raw	Fermented	Raw	Roasted	Raw	Roasted	Raw	Roasted
Thiamine	3.87 ± 0.01^{a}	2.94 ± 0.01^{c}	3.21 ± 0.01^{b}	2.73 ± 0.01^{e}	2.90 ± 7.08^{d}	1.31 ± 0.31^{f}	ND	2.60 ± 0.03^{c}
Riboflavin	2.18 ± 0.02^{c}	1.38 ± 0.02^{b}	2.01 ± 0.03^{d}	1.82 ± 0.02^{e}	4.98 ± 0.03^{a}	3.60 ± 0.05^{b}	ND	1.50 ± 0.01^{c}
Pyridoxine	2.62 ± 0.01^{a}	0.88 ± 0.66^{b}	3.47 ± 0.01^{c}	1.70 ± 0.06^{d}	ND	1.45 ± 0.04^{d}	ND	2.86 ± 0.01^{e}
Cobalamine	1.34 ± 0.02^{f}	0.51 ± 0.01^{g}	5.33 ± 0.6^{a}	3.91 ± 0.54^{b}	3.13 ± 0.18^{d}	2.40 ± 0.01^{e}	5.19 ± 0.03^{d}	3.47 ± 0.02^{c}
Ascorbic acid	0.49 ± 0.01^{a}	0.06 ± 0.01^{g}	0.48 ± 0.02^{b}	0.33 ± 0.02^{c}	0.33 ± 0.01^{c}	0.26 ± 0.03^{e}	0.29 ± 0.02^{d}	0.09 ± 0.01^{f}
Vitamin A	5.95 ± 0.05^{a}	1.29 ± 0.05^{b}	1.75 ± 0.02^{c}	0.79 ± 0.07^{b}	0.87 ± 0.01^{c}	0.52 ± 0.01^{d}	1.49 ± 0.36^{d}	0.42 ± 0.01^{b}

Table 5: *Vitamin Composition of Raw and Processed Maize, Bambaranut and Groundnut (μg/g).*

Values are recorded as mean ± SD of three determinations. Mean in the same row with different superscripts are significantly ($p < 0.05$) different

ND: Not detected.

The vitamin composition of the weaning food blends are presented in table 6. The weaning food blend, MCBG (3.0 μg/g) recorded the highest level of thiamine which was closely followed by the weaning food blends MBG (2.9 μg/g), MCG (2.7 μg/g) and MCB (2.3 μg/g). The thiamine content of MCBG, MCB, MCG and MBG were higher than the commercial weaning foods Cerelac® (0.60μg/g), Frisogold® (1.23 μg/g) and the RDA of infants 0 - 1 year (0.30 - 0.50 μg/g). The riboflavin content of MCBG (1.7 μg/g), MCB (2.0 μg/g), MCG (2.4 μg/g) and MBG (2.47 μg/g) showed higher values than the RDA of infants (0.40 - 0.60 μg/g) and the commercial weaning foods Cerelac® (0.40 μg/g) and Frisogold® (0.78 μg/g). The pyridoxine content of MBG (5.81 μg/g), MCG (3.63 μg/g), MCB (5.59 μg/g) and MCBG (3.88 μg/g) were higher than the commercial weaning foods, Cerelac® (0.30 μg/g) and Frisogold® (0.43 μg/g). The cobalamine contents of the weaning food blends MCBG (1.62 μg/g), MCB (1.97 μg/g), MCG (1. 60 μg/g) and MBG (1.45μg/g) were comparable to the commercial weaning foods, Cerelac® (1.10 μg/g) and Frisogold® (1.70 μg/g) and higher than the RDA of infants (0 - 1 year).

Vitamin	Weaning Food Blends						
	MCBG	MCB	MCG	MBG	Cerelac® (Maize)	Frisogold® (Wheat)	RDA
Thiamine	3.0 ± 0.02^{a}	2.3 ± 0.02^{d}	2.7 ± 0.01^{c}	2.92 ± 0.01^{b}	0.60	1.23	0.30 – 0.50
Riboflavin	1.7 ± 0.01^{d}	2.0 ± 0.01^{c}	2.4 ± 0.01^{b}	2.47 ± 0.01^{a}	0.45	0.78	0.40 – 0.60
Pyridoxine	3.88 ± 0.06^{c}	5.59 ± 0.04^{b}	3.63 ± 0.01^{d}	5.81 ± 0.02^{a}	0.30	0.43	2.00 – 3.00
Cobalamine	1.62 ± 0.01^{b}	1.97 ± 0.01^{a}	1.60 ± 0.20^{c}	1.45 ± 0.03^{d}	1.10	1.07	0.20 – 0.20
Ascorbic acid	0.24 ± 0.01^{a}	0.17 ± 0.01^{c}	0.21 ± 0.01^{b}	0.08 ± 0.01^{d}	50.00	44.89	20 – 25
Vitamin A	0.77 ± 0.05^{d}	1.24 ± 0.08^{a}	1.20 ± 0.01^{b}	1.11 ± 0.04^{c}	1300	1350	300 – 420

Table 6: *Vitamin Composition of the Weaning Food Blends (μg/g).*

Values are recorded as mean ± SD of three determinations. Means in the same row with different superscripts are significantly ($P < 0.05$) different.

MCBG: 60 parts of yellow maize, 20 parts of cowpea, 10 parts of Bambaranut and 10 parts of groundnut

MCB: 60 parts of yellow maize, 20 parts of cowpea, 20 parts of Bambaranut

MCG: 60 parts of yellow maize, 20 parts of cowpea, 20 parts of Groundnut

MBG: 60 parts of yellow maize, 20 parts of Bambaranut, 20 parts of Groundnut

Cerelac®: Nestle Nigeria plc

Frisogold®: Nestle Nigeria plc

RDA: Recommended dietary allowance of infants, (0 – 1 year) (1989)

The weaning food blends MCBG, MCB, MCG and MBG had vitamin A and vitamin C content which were lower than the RDA of infants, 0 - 1 year and not comparable to the commercial weaning foods, Cerelac® and Frisogold®.

In Vitro Protein Digestibility

The i*n vitro* protein digestibility of the raw and processed yellow maize, cowpea, bambaranut groundnut and the commercial weaning food blend are presented in table 7. There were significant ($P < 0.05$) differences between the raw and processed maize, cowpea, bambaranut and groundnut at one hour digestibility with the processed cowpea and groundnut showing higher values. A significant ($P < 0.05$) difference was observed in the raw, processed maize, cowpea, bambaranut and groundnut at 6 hours digestibility with roasted groundnut showing highest digestibility (83.90%). The *in vitro* protein digestibility of raw and processed maize, cowpea, bambaranut and groundnut were found to significantly ($p < 0.05$) increase with time.

Digestibility	Samples							
	Maize		Cowpea		Bambara-nut		Groundnut	
	Raw	Fermented	Raw	Roasted	Raw	Roasted	Raw	Roasted
Digestibility at 1 hour (%)	11.40 ± 0.01^h	41.60 ± 0.53^f	47.30 ± 0.01^e	69.60 ± 0.01^b	32.20 ± 0.51^g	50.30 ± 6.31^d	62.90 ± 0.18^c	77.10 ± 1.01^a
Digestibility at 6 hour (%)	59.60 ± 0.58^e	65.50 ± 0.05^d	56.10 ± 0.29^g	76.60 ± 0.59^b	44.60 ± 0.75^h	57.30 ± 0.35^f	74.10 ± 0.33^c	83.90 ± 0.11^a

Table 7: *In Vitro Protein Digestibility of the Raw and Processed Maize, Cowpea, Bambaranut and Groundnut.*

Values are recorded as mean ± SD of three determinations. Mean in the same row with different superscripts are significantly (p < 0.05) different

The *in vitro* protein digestibility of the weaning food blends are presented in table 8. Significant ($p < 0.05$) differences were observed in the weaning food blends MCBG, MCB, MCG and MBG at one hour and 6 hours digestibility, with MCBG showing highest digestibility at one hour and 6 hours.

Digestibility(%)	Weaning food blends			
	MCBG	MCB	MCG	MBG
Digestibility at one (1) hour	66.70 ± 0.38^a	58.4 ± 0.60^c	61.30 ± 0.56^b	53.2 ± 0.21^d
Digestibility at six (6) hours	86.30 ± 0.53^a	77.1 ± 0.26^b	73.90 ± 0.04^c	70.80 ± 0.16^d

Table 8: *In Vitro Protein Digestibility of the Weaning Food Blends.*

Values are recorded as mean ± SD of three determinations.

MCBG: 60 parts of yellow maize, 20 parts of cowpea, 10 parts of Bambaranut and 10 parts of groundnut

MCB: 60 parts of yellow maize, 20 parts of cowpea, 20 parts of Bambaranut

MCG: 60 parts of yellow maize, 20 parts of cowpea, 20 parts of Groundnut

MBG: 60 parts of yellow maize, 20 parts of Bambaranut, 20 parts of Groundnut

Anti-nutritional Factor of Raw and Processed Maize, Cowpea, Bambara Nut and Groundnut

The results of the antinutritional content of the raw and processed yellow maize, cowpea, Bambaranut and groundnut is showed in table 9. Significant ($p < 0.05$) decrease in phytic acid were observed in the fermented maize, roasted cowpea, Bambaranut and groundnut. A reduction of 71.4%, 62.5%, 50.2% and 70.0% were observed in the phytic acid content of fermented maize, roasted cowpea, bambaranut and groundnut, respectively.

Parameters	Samples							
	Maize		Cowpea		Bambara-nut		Groundnut	
	Raw	Fermented	Raw	Roasted	Raw	Roasted	Raw	Roasted
Phytic acid (mg/g)	0.70 ± 0.06^c	0.20 ± 0.05^g	0.80 ± 0.01^a	0.30 ± 0.01^f	0.50 ± 0.05^d	0.10 ± 0.01^h	0.73 ± 0.05^b	0.41 ± 0.01^e
Percentage decrease (%)	71.4%		62.5%		50.2%		70.0%	
Tannin (mg/g)	1.12 ± 0.5^c	0.44 ± 0.01g	0.94 ± 0.02^d	0.27 ± 0.02^h	1.77 ± 0.05^a	0.76 ± 0.02^e	1.52 ± 0.01^b	0.47 ± 0.01^f
Percentage decrease (%)	60.7%		71.2%		57.6%		69.07%	

Table 9: *Antinutritional Factor Content of Raw and Processed Maize, Cowpea, Bambaranut and Groundnut.*

Values are recorded as mean ± SD of three determinations. Mean in the same row with different superscripts are significantly (p < 0.05) different

Significant ($p < 0.05$) reduction in the tannin content of fermented maize was observed, with a reduction of 60.7%. The roasted cowpea, bambaranut and groundnut also showed significant ($p < 0.05$) reduction of 71.2%, 57.6% and 69.07 in the tannin contents, respectively.

Discussion

The low moisture content observed in the fermented maize, roasted cowpea, bambaranut and groundnut indicates that the weaning food blend will have a good shelf- life, by Modu., *et al*. [15] reported that low moisture levels of weaning food blends can support a longer shelf- life. This is because food spoilage micro-organisms thrives, where the moisture content of a food is very high.

The decrease in ash content of fermented maize, roasted cowpea, bambaranut and groundnut might be due to processing. However the percentage ash content falls within the range reported by Modu., *et al* [15]. Anigo., *et al.* [16] reported ash content of maize in the range of 1.4 - 3.3%. The ash content of maize bran is however lower. Mbata., *et al.* [17] reported ash content of maize bran as 5.1%. The fibre values of fermented maize and roasted cowpea bambaranut and groundnut were significantly reduced compared with their unprocessed counterparts; this is similar to the reports of [18], who reported that the reduction could be due to retrogradation of starch during processing, Nout [19], reported similar findings. No significant difference in the fat content of raw and fermented maize, this finding agrees with that of Oyarekua [20]. The decrease in fat of roasted cowpea, bambaranut and groundnut may be due to loss of volatile oil in open dry heat method (Falmata., *et al.* 2014). The significant decrease in the protein content of fermented maize, could be as a result of possible increase in the number of microorganisms that use protein for metabolism. During fermentation micro-organisms hydrolyse protein and its complexes to release free amino acid for synthesis of new proteins. This is in agreement with the findings of Gerneh., *et al.* (2011) and Malleshi., *et al.* [21], while a decrease in roasted cowpea, bambaranut and groundnut may be due to high temperature of roasting, being a dry heat processing method, which causes the protein to be denatured. Onilude., *et al*. [22] reported that fermentation of blends increase the protein quality of weaning food blends. Chavan and Kadam (1989) reported that fermentation did not change the protein content but the protein quality of cereals.

The weaning food blends MCBG, MCB, MCG and MBG, had moisture content within the normal moisture content of flour blends (3.7). Low moisture content observed indicates that the weaning food blends will have a good shelf life because high moisture content of food encourages microbial growth [16]. The low moisture content of the weaning food blends were close to the commercial weaning food Frisogold®, this is in line with the work of Saleh., *et al* [23].

The ash content of the weaning food blends (1.0 to 2.10) were below the commercial weaning food Cerelac®. The decrease in ash content observed in this study could be due to general activities of the fermenting micro-organisms which by enzymatic activity could break down most of these components into their absorbable forms (Wakil and Kazem, 2012). The low ash content observed is in line with the work of Solomon (2005) and Egounlety (2002).

The fibre content of MCBG (4.96%), MCB (3.84%) and MBG (3.94%) compared favourably with the commercial weaning foods, Cerelac® (4.3%) but higher than Frisogold® (1.70%). This is in line with the findings of Oyerukua [20], the reduction in fibre contents of the weaning food blends might be due to enzyme degradation of the fibre during fermentation [18]. Fibre is an important dietary component in preventing overweight, constipation, cardiovascular disease, diabetes and colon cancer (Misha., *et al.* 2012). High dietary fiber content has been reported to impair protein and mineral digestion and absorption in human subjects [3]. The fat content of the weaning food blends MCB (3.01%) and MCG (3.87%), were not comparable to the commercial weaning food blends, Cerelac® (10.00%) and Frisogold® (7.30%) and have not met the RDA (10 - 25) of infants (0 - 1 year) while the fat content of MBG was close to Frisogold®. The fat content of MCBG (9.58%) was significantly higher than MCB, MCG, MBG and compared favourably with the commercial weaning foods Cerelac® and Frisogold®, and met the RDA of infants (0 - 1 year). This could be attributed to the use of groundnut in the weaning food blend MCBG, because groundnut is higher in fat than cowpea and bambaranut. This is in line the work of (Inyang and Zakari, 2008). The increase in fat content due to the addition of groundnut to the weaning food blend MCBG provided a more concentrated caloric source and can serve as a transport vehicle for fat- soluble vitamins (Anyabor., *et al*. 2009).

The protein content (12.35%) of the weaning food blend, MCBG, was close to the protein content (15.00%) of the commercial weaning foods, Cerelac® and Frisogold® and met the RDA of infants (0 - 1 year). The protein content of MCB and MCG were close to MCBG. The improvement in the protein content of the weaning food blends may be due to combined processing effects, that is, fermentation of the maize and roasting of the legumes and this is in line with earlier reports of [18].

The use of legumes as a fortifying agent has been reported to improve the protein content of the Cereal-based diet. Some workers (Wakil and Kazeem, 2012 and Sanni., *et al.* 1999) also reported an increase in the protein content of cereal – soyabean blends fermented with mixed culture of *Lactobacillus plantarum* and *Saccharomyces cerevisiae*. Ikujenlola and Adurotoye (2014) reported that protein quality is synergistically improved in cereal-legume blends due to the contribution of lysine by legumes and methionine by cereal. The protein content of MBG was lower than that of the MCBG and the commercial weaning foods, Cerelac® and Frisogold® and have not met the RDA of infants (0 - 1 year). This is in consonance with the work of Ajanaku., *et al.* (2012) and Mbaeyi and Onweluzo [18]. The carbohydrate content of the weaning food blends, MCB compare favourably with the commercial weaning foods Cerelac® and Frisogold® while that of MCBG was lower than Frisogold®, but close to Cerelac®. This is in agreement with the reports of Modu., *et al.* [15] in the production of Ogi from pearl millet and cowpea. MCG and MBG did not compare with the commercial weaning foods, Cerelac® and Frisogold®, this is similar to work of Obasi., *et al.* (2009), who observed a decrease in carbohydrate content of sorghum grains for production of legume fortified weaning food. The metabolizable energy value of (MCBG) was comparable to the commercial weaning foods Cerelac® and Frisogold® and met the RDA of infants (0 - 1 year). Madukwe., *et al.* (2013) reported that legumes store more energy in form of fat than cereals. Similar result was reported by Ikujenlola and Adurotoye, (2014) in the evaluation of quality characteristics of high nutrient dense complementary food from mixtures of malted quality maize and steamed cowpea. The energy values of the weaning food blends, MCB, MCG and MBG, were below the RDA of infant and did not compare with the commercial weaning food blends Cerelac® and Frisogold®, this is similar to the work of Mbaeyi and Onweluzo [18].

Mineral Element Composition

The loss in the levels of essential minerals such as sodium in the fermented maize and roasted cowpea and a loss in potassium in the fermented maize and calcium of roasted cowpea, bambaranut and groundnut could be attributed to loss of ash during processing. Oyerekua [20] reported that about 50% of the ash in cereals was leached out into the steep water and washed away. This is in line with the report of Brou., *et al*. (2008) and Ikram., *et al*. 2010.

The levels of sodium, potassium and calcium in the weaning food blends, MCBG, MCB, MCG and MBG did not agree with the commercial weaning foods and are below the RDA of infants (0 - 1 year). The low concentration of calcium, sodium and potassium recorded in this study tallies with the findings of Sule., et al. (2014) who found that cereals are poor in these minerals. The magnesium content of the weaning food blends MCBG, MCB, MCG and MBG were higher than the RDA of infants (0 - 1 years) and the commercial weaning foods, Frisogold®. Saleh., *et al*. [23] reported similar findings in the effect of fortification of rice with banjara bean and sesame. Magnesium is needed for more than 300 different enzymes systems in the body. It is important in formation of Adenosine triphosphate, storage of carbohydrates and proteins in nerve and muscle activity (Kumkum., *et al*. 2010). This observation is consistent with earlier reports of Solomon and Owolawashe (2007).

The iron and zinc contents of raw and processed maize and groundnut showed significant differences which is in agreement with the findings of Oshode., *et al*. (1999) who reported an increase in the iron content of a weaning food from maize flour. The significant increase in the level of iron and zinc in the weaning food blend could be due to the reduction of phytic acid during fermentation, since lactic fermentation changes a diet of low iron bioavailability into a diet of intermediate to high iron bioavailability which can be enhanced by degradation of phytate (Svanberg and Sandberg, 1988). The level of iron and zinc in the weaning food blends, MCBG, MCB and MCG met the RDA of infants (0 - 1 year). Some workers, Modu., *et al*. [15]; Whitney., *et al*. (1990), Oyarekua [20] reported similar findings in the production of weaning food blends from cereals and legumes. Iron is an essential micronutrient for the synthesis of haemoglobin, myoglobin and enzymes/coenzymes. Iron also enhances the body's immune system thus reducing infections and fostering proper functioning of other organs of the body (Adeyeye and Faleye, 2004). Zinc plays a role in gene expression, cell regulation, normal growth and development of immunity (Gibson., *et al*. 2006). There is a low level of phosphorus in the weaning food blends MCBG, MCB, MCG and MBG when compared with cerelac® and frisogold® and did not meet the RDA of infants (0 - 1 year). This is contrary to the finding of Idowu., *et al.* (1993) who reported that fermentation releases phosphorus bound to phytate in fermented cereal feeds.

Vitamin Composition

There are increases and decreases in the B- group vitamins of fermented cereal and roasted legumes. This observation is in agreement with earlier reports of Agunbiade., *et al.* (2013). The increase in the thiamine, pyridoxine and riboflavin content of the weaning food blends MCBG, MCB, MCG and MBG goes in line with the findings of Saleh., *et al*. [23] who reported an increase in the B- group vitamins. The level of the B group vitamins of the weaning food blends, MCBG, MCB, MCG and MBG were higher than the commercial weaning foods and the RDA of infants 0 - 1 year.

Elemo., *et al*. (2011), reported the increase in concentration of niacin, thiamine, riboflavin and other vitamins in sorghum after fermentation. The decrease in vitamin A and vitamin C of the formulated weaning food blends MCBG,MCB,MCG and MBG varied with the nature of raw material micro flora temperature and method of determination for these vitamins. Falmata., *et al*. (2014) reported similar findings.

***In vitro* Protein Digestibility**

Fermentation of yellow maize and heat treatment of the cowpea, bambaranut and groundnut helps in increasing the digestibility of the weaning food blends MCBG, MCB, MCG and MBG which lead to the reduction in anti-nutritional factors during processing ([7]; Laminu., *et al*. 2011) Activities of proteolytic enzymes during fermentation degrades protein into simple protein, polypeptides and amino acids thus enhancing digestibility of food samples (Falmata., *et al*. 2014; Singh., *et al*. 2012). Supplementation of the maize with legumes may improve the protein content of the weaning food blends, in line with the findings of Gazhim., *et al* (2015).

Antinutritional Factor Content

There was a significant decrease in the level of antinutritional factors phytate and tannins in the fermented maize, roasted cowpea, bambaranut and groundnut which is similar to the finding of Ijarotimi and Esho, (2009). The reduced phytic acid and tannins in the processed, cereal and legumes could be as a result of the leaching effect of the soaking and dehulling employed on samples before milling (Madukwe., *et al.* 2013). The observed reduction in the phytic acid and tannin content could also be as a result of processing which has been reported to reduce the discoloration imparted by tannin to maize [24]. Tobacco [25], reported that among the processing techniques fermentation and roasting are the most effective methods in reducing the tannin content of cereal and legumes. The result agreed with the report of Modu., *et al.* [24] who reported 35% reduction in tannin content of sprouted fermented sorghum flour while 45% reduction was reported by Hibberd., *et al.* [26] in the fermentation of sorghum and corn grains. Fermentation has been reported to reduce tannin content of cereals, legumes and tubers. Reduction in tannin content due to processing might have been caused by the activity of polyphenol oxidase or fermented microflora on tannins which hydrolysed tannin acids into inositol and orthophosphate [27]. Reduced level of phytic acid in cereals signifies a better nutritional value. Acidic pH (low) of the fermented product and temperature provide favourable conditions for phytase activity (Laminu., *et al.* 2011). Fermentation reduces the phytate content and the inherent phytase activity on cereals is believed to be activated during fermentation [7]. Neelma and Chauhan [28] reported similar findings. Onilude., *et al.* [22] also observed reduction in both polyphenol and tannin content of cereal – soybean blends as a result of malting and roasting.

This reduction is in accordance with the observation of Muahamad., *et al*. (2010) who reported that fermentation reduced phytate content of cereals. Lactic acid fermentation was also found to decrease tannin content in maize [29]. Usha and Chandra [30] observed that fermentation of finger millet with starter from previously fermented finger millet achieved a desirable goal of reduced phytate and tannin when compared to uncontrolled fermentation [31].

Conclusion

The present study established the nutritional qualities of weaning food blends formulated from yellow maize, cowpea, bambaranut and groundnut. The protein content of the weaning food blend met the RDA of infants 0-1year and was close to cerelac® and Frisogold®, while the protein content of MCB,MCG and MBG were below the RDA and the commercial weaning food blends cerelac® and Frisogold®. The energy content of MCBG was comparable to cerelac® and Frisogold® and met the RDA of infants while that of MCB,MCG and MBG were below the RDA and commercial weaning foods cerelac® and Frisogold®. Reduction in the levels of antinutrients improved the *in vitro* digestibility of the weaning food blends and also increased the availability of minerals such as zinc, magnesium and iron.

Recommendations

It is suggested that more efforts must be directed towards increasing the concentration of minerals like calcium, sodium, phosphorus and potassium in the weaning food blends through fortification with food rich in minerals like, crayfish, plantain, carrot and milk.

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Volume 10 Issue 5 September 2017