

Effect of feeding complementary diet blends formulated from Zeamaysl. (maize), Vigna unguiculatal.Walp(cowpea), Voandzeiasubterranean (l.) verdc(bambaranut) and Arachishypogeeal. (groundnut) on weaning rats

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ABSTRACT

Cereal / legume complementary weaning food blends were formulated from yellow maize, cowpea, bambaranut and groundnut to enhance their protein quality. 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 yellow maize (Improved variety), cowpea, bambara nut and groundnut were obtained from Lake Chad Research Institute (LCRI) Maiduguri. Protein quality was evaluated by animal feeding experiment using 50 Weanling albino rats of approximately 21 days weighing 35 – 40kg, commercial weaning food Cerelac® was used as control. Data obtained were subjected to analysis of variance (ANOVA) and Duncan's multiple range test was used to separate the means. The lysine and methionine content of the MCBG met the RDA of infant 0–1 year, while that of MCB and MCG were close to the RDA of infants 0-1year and MBG was below the RDA. Food intake protein intake and weight gain of MCBG was almost close to the commercial weaning food Cerelac® and higher than that of MCB, MCG and MBG. The Protein Efficiency Ratio (PER) of MCBG (2.22±0.01), MCB (2.99±0.02), MCG (2.72±0.02), MBG (2.29±0.28) and Cerelac® (2.37±0.02) did not show any significant ($p>0.05$) difference while the FE of MCBG (0.23±0.01) and cerelac® (0.26±0.01) did not show any significant difference. The FE of MCB (0.16±0.01), MCG (0.12±0.02) and MBG (0.08±0.01) were lower than MCBG and not comparable to Cereal®. True protein digestibility (TPD) of MCBG (79.9±0.01) was lower compared to that of Cerelac® (92.18±0.02) and higher than MCB (67.70±0.06), MCG (59.60±0.01) and MBG (57.01±0.03). The Biological value (BV) of MCBG (75.50±0.02%) was significantly lower than Cerelac® (82.20±0.03%). The Biological BV of MCB (63.20±0.08), MCG (56.72±0.06) and MBG (54.10±0.02%) were significantly ($p<0.05$) lower than MCBG and not comparable to Cerelac®. The net protein utilization NPU of MCB (75.00±0.06%), MCG (71.80±0.03%) and MBG (69.50±0.19%) and MCBG (85.80±0.01%) were lower than that of Cerelac®. It can be concluded that MCBG has adequate protein quality and can be used infant food particularly for under privileged children.

Key words: Cereal/Legume blend, weaning, Biological value

INTRODUCTION

Complementary foods are any nutrient containing foods or liquids other than breast milk given to young children during the period (4-24months) of complementary

feeding (Muhimbula *et al.*, 2011). The growth of an infant in the first two (2) years is very rapid and breast milk alone will not meet the child's nutritional

requirements. The ability of breast milk to meet the requirements for macronutrients and micronutrients becomes limited with the increasing age of infants (Magda *et al.*, 2013). Thus, timely introduction of complementary weaning foods during infancy is necessary for both nutritional and developmental reasons (Igyor *et al.*, 2011).

In Africa, weaning is a period of transition for the infant during which its diet changes in terms of consistency and source. From a liquid milk-based diet, the child is gradually introduced to semi-solid food, such semi-solid or generally called weaning food should ideally be easily digestible, have high energy density and low bulk (Onweluzo and Nwabugwu, 2009). The weaning period is a very critical period in promoting child nutrition and survival (Akeredolu *et al.*, 2005, Kebebu *et al.*, 2013).

The weaning process may be gradual, lasting for months until the infant is finally introduced straight into the family diet (Ijarotimi and Keshinro, 2013). In the weaning process there is always a need to introduce soft easily swallowed foods to supplement the infants feeding early in life (Ezeji and Ojmelukwe, 1993). On the other hand, in abrupt weaning, the infant is introduced straight into the family menu. This latter option creates a problem, as the child may not be able to eat enough of the adult diet to meet his or her nutritional needs (Cameron and Hofvander 1983, Walker, 1990, Solomon 2005).

Protein-energy malnutrition is a range of pathological conditions arising from coincident lack in varying proportions of proteins and or calories, which occur most frequently in infants and young children and is commonly associated with infections (Kayode *et al.*, 2009, Mbaeyi and Onweluzo, 2010). Protein-energy malnutrition is a major health problem in developing countries and contributes to infant mortality, poor physical and intellectual development of infants as well as lowered resistance to disease and consequently stifles development (Jimoh *et al.* 2005). Protein-energy malnutrition generally occurs during the crucial transitional phase when children are weaned from liquid to semi-solid or fully adult foods (Amankwah *et al.*, 2009). This is as a result of inflation ignorance and exorbitant cost of animal source of protein thereby making it out of reach for the common man (Ijarotimi, 2012). Therefore, poverty and poor feeding practices have been attributed as the major factors responsible for this nutritional problem (Oluwole, 2008).

Traditional weaning foods in Nigeria consist of monocereal grains prepared from either maize, millet or sorghum referred to as "Ogi or Kamu", which is of poor nutritional value (deficient in most of the essential amino acids e.g. lysine and tryptophan) Adebayo-Oyetero *et al.*, 2012. Our locally available cereals when subjected to some processing techniques will result to enhance their quality as such can be supplemented with legumes (rich in essential amino acids) which are a good source of quality protein, that will give rise to a

weaning food which is easily digestible and acceptable to children (Modu *et al.*, 2010). Germination has been reported as ways of improving cereal protein quality (Ikpemeet *et al.*, 2012). Fermentation has been used by various workers to both remove the antinutritional factors as well as improve the nutritional level (Edema and Sanni, 2006).

Zea mays (Maize) is one of the cereals produced extensively in Nigeria. According to FAO (2002), *Zea mays* (Maize) grains are used in the production of several traditional foods. *Vigna unguiculata* (Cowpea), belong to the class of foods known as legumes. Cowpea is an important source of protein, particularly for those nursing mothers who cannot afford to purchase commercial complementary food for their children (Ijarotimi, 2012). The nutritional value of cowpea lies in their high protein content, which is higher than that of cereals. The utilization of cowpea as weaning diet is widespread in Nigeria and other developing countries either alone or in combination with cereals or other food materials (Nagai *et al.*, 2009).

Bambaranut is essentially grown for human consumption. The seed makes a complete food, as it contains sufficient quantities of protein, carbohydrate and fat. *Arachishypogea* Groundnut is food which belongs to the class of legumes as is one of the most important protein rich food (MuneMune *et al.*, 2011). Groundnut is high in protein and amino acids such as lysine, leucine, phenylalanine and methionine (Anigo *et al.*, 2010).

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.* (1981). One hundred (100g) of maize (cereal) was cleaned and steeped into

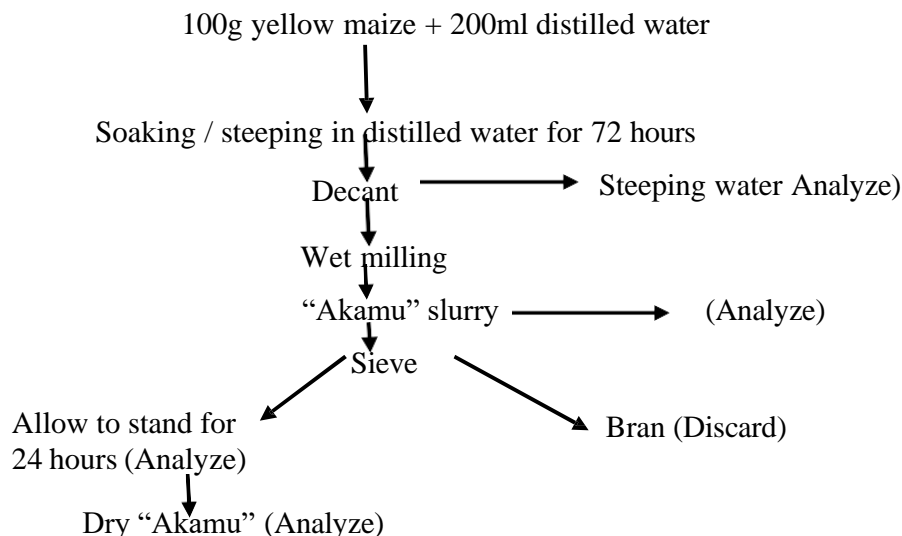


Figure 1. Flow Diagram for the Laboratory Preparation of "Akamu"

200ml of distilled water in a 1:2 ratio for 72 hours. At the end of the 72 hours, the top water was decanted and 200ml 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°C 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.*, (2007).

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.*, (2007)

Preparation of groundnut

One hundred (100g) of groundnut was cleaned of dirt, roasted and dehulled. The dehulled groundnut was milled as described by Davies, (2009).

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 amino acid profile

The amino acid profile in the sample was determined using methods as described by Sparkman *et al.*, (1958). The sample was drafted, hydrolysed, evaporated in a rotary evaporator and then loaded into the technicon sequential multi Amino acid analyzer (TSM).

Drafting of sample

A known weight of the dried sample was put into extraction thimble and the fat was extracted with chloroform / methanol (2:1 mixture) using soxhlet extraction apparatus. The extraction lasted for 15 hours.

Hydrolysis of sample

A known weight of the sample was put in glass ampoule. 7ml of 6N HCl will be added and nitrogen was passed into the ampoule to expel oxygen. This is to avoid possible oxidation of some amino acids (Methionine and cysteine) during hydrolysis the glass

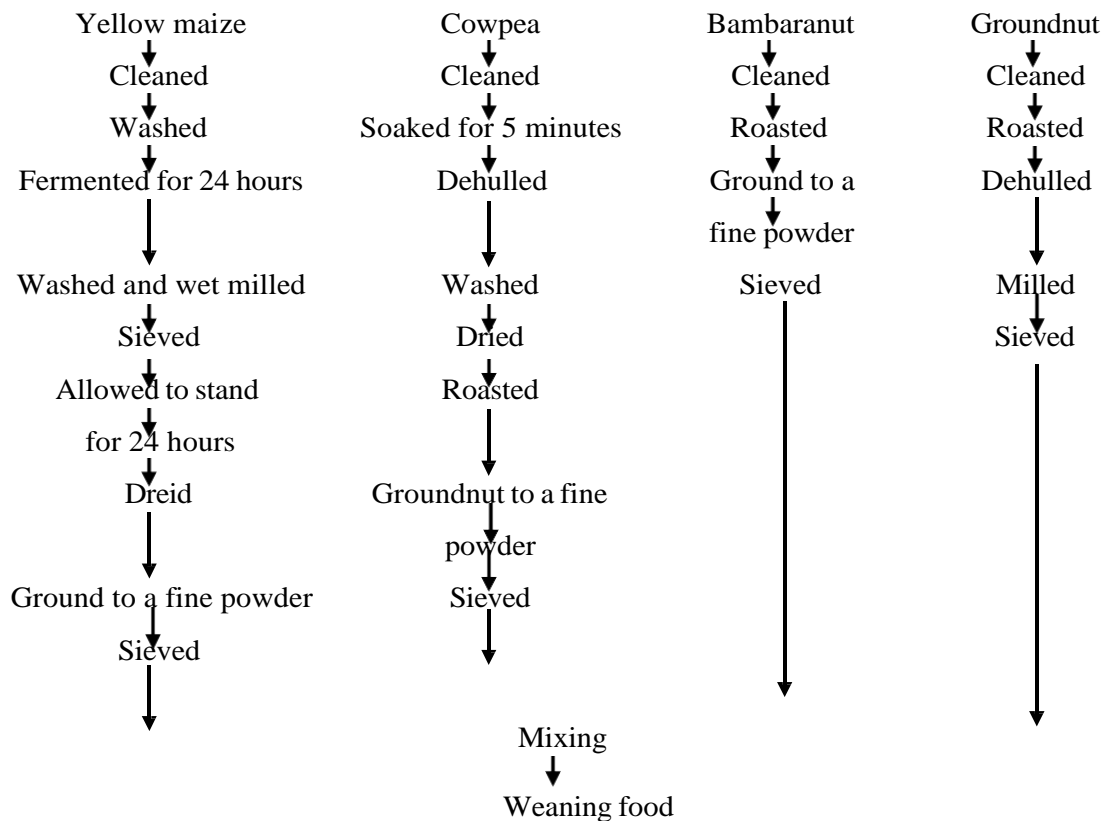


Figure 2. Flow Diagram for the preparation of the weaning food blends

ampoule was sealed with Bunsen burner flame and put in an oven preset at $105^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 22 hours. The ampoule was allowed to cool before breaking it, opened at the tip and the content was filtered.

The filtrate was then evaporated to dryness at 40°C under vacuum in a rotary evaporator. The residue was dissolved with 5ml of acetate buffer. (pH2.0) and stored in plastic specimen bottles which was kept in the freezer.

Loading of the hydrolysate into the TSM analyzer.

The amount loaded will be between 5 to 10 microlitre. This was dispensed into the cartridge of the analyzer. The TSM analyzer is designed to separate and analyze free, acidic, neutral and basic amino acids of the hydrolysate. Each analysis lasted for 76 minutes.

Animal feeding experiment

Fifty weanling strain rats of approximately 21 days old with an average initial weight of 35 – 40kg obtained from the Animal House of the Department of Biochemistry, University of Maiduguri were used. The

rats were divided into five groups consisting of 10 rats each.

- 1). Group one were fed the weaning food blend Test diet MCBG (60% fermented yellow maize, 20% roasted cowpea 10% roasted Bambaranut and 10% roasted groundnut).
- 2). Group two were fed the weaning food blend MCB (60% fermented yellow maize, 20% roasted cowpea and 20% roasted bambaranut).
- 3). Group three were fed the weaning food blend MCG (60% fermented yellow maize, 20% roasted cowpea and 20% roasted groundnut).
- 4). Group four were fed the weaning food blend MBG (60% fermented yellow maize, 20% roasted bambaranut and 20% roasted groundnut).
- 5). Group five were fed the commercial weaning food cerelac®

Protein Efficiency ratio (PER) and Food Efficiency (FE) were determined using the method of (Chapman, 1959). The period of study for PER and FE was 28 days. The wistar strain albino rats were weighed weekly. A weighed diet was given daily and unconsumed food was collected dried and weighed. Body weight gain, food and protein intake were recorded and calculated. PER and FE was calculated using the following.

Table 4.13. Amino Acid Composition of the Weaning Food Blend (g/100g)

Amino acids	Weaning food blend				
	MCBG	MCB	MCG	MBG	RDA
Aspartic acid	1.15	1.12	1.21	1.14	-
Threonine	2.10	2.90	1.96	1.92	3.40
Serine	1.00	0.65	0.72	0.61	-
Glutamine acid	2.71	2.58	2.47	2.18	-
Glycine	0.89	0.72	0.90	1.10	-
Alanine	1.09	1.13	1.17	1.19	-
Cystine	2.38	2.20	2.18	2.14	2.50
Valine	2.04	2.81	2.68	2.79	3.50
Methionine	2.10	1.96	1.88	1.39	2.20
Isoleucine	1.97	1.90	1.86	1.42	2.80
Leucine	3.99	3.57	3.40	3.32	6.60
Tyrosine	0.78	0.76	0.43	0.21	6.30
Phenylalanine	4.76	4.54	4.48	4.68	6.30
Histidine	0.56	0.47	0.42	0.29	1.90
Lysine	5.32	4.21	4.15	3.89	5.80
Arginine	1.70	1.15	0.84	0.71	2.00
Proline	0.76	0.78	0.81	0.82	-

RDA – Recommended dietary allowance of infants 0 – 1 years (1985)

Table 4.14. Average Weekly Food Intake (g) of Rats Fed Weaning Food Blends and Cerelac®

Weeks	Weaning food blends				
	MCBG	MCB	MCG	MBG	Cerelac®
1	39.20±6.37 ^a	39.80±2.27 ^a	39.50±1.18 ^a	47.70±1.95 ^b	55.14±2.03 ^c
2	77.30±5.01 ^a	70.30±8.24 ^b	69.3±6.60 ^c	60.30±6.16 ^d	86.30±2.87 ^e
3	79.10±3.31 ^a	77.8±8.33 ^b	74.5±9.61 ^c	71.50±9.01 ^d	80.60±6.06 ^e
4	85.40±3.85 ^a	76.5±4.37 ^b	76.00±2.45 ^c	80.00±3.49 ^d	87.90±1.95 ^e
Group mean*	70.27±3.54 ^a	68.15±8.23 ^b	67.06±4.21 ^c	66.15±7.35 ^d	77.50±5.32 ^e

Values are recorded as mean ± SD of seven days feed intake. 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 Bambara nut 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

* Values are mean ± SD of four weeks feed intake

$$\text{PER} = \frac{\text{change in body weight}}{\text{Protein intake}}$$

$$\text{FE} = \frac{\text{Change in body weight}}{\text{Total food consumed}}$$

After 28 days growth study, the nitrogen balance study was conducted. The experiment was conducted for 7 days. Another group of rats of the same weight and age were fed on a nitrogen free diet to calculate the endogenous urinary nitrogen and metabolic nitrogen losses. At the end of the 7 days, urine and fecal samples were collected. The urine was collected into a container containing 0.1N HCl. The feces collected was dried, weighed and ground into a fine powder for determination of nitrogen. Daily food consumption was recorded for the 7 days period. Unconsumed and spilled foods were collected, dried and weighed, then deducted from the food offered. The nitrogen content in

the urine and feces were determined by micro-kjedahl method. The data from this experiment was used to calculate Biological value (BV) True protein digestibility (TPD) and Net protein utilization (NPU). (Mitchell, 1923)

$$\text{TPD} = \frac{\text{Nintake (FN - MFN)}}{\text{Nintake}} \times 100$$

$$\text{BV} = \frac{\text{Nintake} - (\text{FN} - \text{MFN}) - (\text{UN} - \text{EUN})}{\text{Nintake} - (\text{FN} - \text{MFN})} \times 100$$

$$\text{NPU} = \frac{\text{BV} \times \text{TPD}}{100}$$

Where

FN = faecal nitrogen

UN = urinary nitrogen

MFN = metabolic faecal nitrogen

EUN = Endogeneous urinary nitrogen

Table 4.15 . Average Weekly Weight Gain (g) of Rats Fed Weaning Food Blends

Weeks	Weaning food blends				
	MCBG	MCB	MCG	MBG	Cerelac®
1	12.00±0.021 ^a	3.08±0.02 ^b	1.11±0.04 ^c	3.91±0.06 ^b	16.01±0.01 ^d
2	15.12±0.01 ^a	7.12±0.01 ^b	2.10±0.01 ^c	6.00±0.01 ^d	18.10±0.02 ^e
3	18.16±0.01 ^a	9.10±0.02 ^b	7.03±0.61 ^c	9.01±0.02 ^d	22.20±0.01 ^e
4	21.18±0.02 ^a	12.31±0.01 ^b	13.04±0.01 ^c	10.42±0.02 ^d	25.21±0.01 ^e
Group mean*	16.50±0.06 ^a	10.91±0.05 ^b	8.51±0.06 ^c	6.81±0.04 ^d	20.25±0.01 ^e

Values are recorded as mean ± SD of 10 rats. Means in the same raw with different superscripts are significantly (p<0.05) different.

* Values are mean ± SD of four weeks weight gain of rats fed.

MCBG – 60 parts of yellow maize, 20 parts of cowpea 10 parts of Bambara nut 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 Protein Efficiency Ratio (PER) and Food Efficiency (FE)

Table 4.16. Protein Efficiency Ratio (PER) and Food Efficiency (FE) of Rats Fed Weaning Food Blends and Cerelac®

Weeks	Weaning food blends				
	MCBG	MCB	MCG	MBG	Cerelac®
Food intake (g)	70.27±3.54 ^a	68.15±8.23 ^b	67.06±4.21 ^c	66.15±7.35 ^d	77.50±5.32 ^e
Protein intake (g)	7.43±0.01 ^a	3.77±0.04 ^b	3.12±0.02 ^c	2.40±0.02 ^c	8.53±0.01 ^d
Weight gain (g)	16.50±0.06 ^a	10.91±0.05 ^b	8.51±0.06 ^b	6.81±0.28 ^c	20.25±0.01 ^d
PER	2.22±0.01 ^a	2.89±0.02 ^b	2.72±0.03 ^c	2.29±0.01 ^d	2.37±0.02 ^a
FE	0.23±0.01 ^a	0.16±0.01 ^b	0.12±0.02 ^c	0.08±0.01 ^b	0.26±0.01 ^a

Values are recorded as mean ± SD of 10 rats. Means in the same raw with different superscripts are significantly (p<0.05) different.

MCBG – 60 parts of yellow maize, 20 parts of cowpea 10 parts of Bambara nut 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

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≤0.05.

Amino acid composition

The amino acid profile of the weaning food blends is presented in Table 4.13. The levels of the essential amino acids lysine and methionine in the weaning food blend MCBG met the RDA of infants 0 – 1 years. The lysine and methionine in the weaning food blends MCB and MCG were close to the RDA of infants 0-1 year while that of MBG was below MCBG, MCB, MCG and the RDA of infants 0-1 year. The levels of Isoleucine, leucine, arginine, tyrosine, phenylalanine and histidine of MCBG, MCB, MCG and MBG were below the RDA of infants 0-1 year.

Food intake and weight gain of the experimental rats

Table 4.14 shows the average weekly food intake of the rats fed the complementary weaning food blends

MCBG, MCB, MCG and MBG and the commercial weaning food Cerelac®. Increases were observed for the weaning food blends MCBG, MCB, MCG, MBG and Cerelac® from week 1 through week 4. Significant differences (p<0.05) were observed in the weekly food intake of the weaning food blends and Cerelac®. MCB had the highest mean food intake (68.15g) as compared to MCG (67.06g) and MBG (66.11g). MCB, MCG and MBG had a mean food intake that were lower than that of the weaning food blend MCBG (70.27g). Cerelac® had the highest mean food intake (77.50g) followed by MCBG, MCB, MCG and then MBG.

The average weekly weight gain of the rat fed the complementary weaning foods MCBG, MCB, MCG and MBG and the commercial weaning food Cerelac® are presented in Table 4.15. Significant (p<0.05) increases in weight gain were observed from week 1 through week 4 in the rat fed the weaning foods, MCBG (16.50g), MCB (8.91g), MCG (8.51g), MBG (6.81g) and the commercial weaning food Cerelac (20.25g).

The weaning food blend MCBG had the highest mean weight gain as compared to MCB, MCG and MBG. The highest mean weight gain was recorded in the rats fed Cerelac, which was followed by MCBG, MCB and then MCG. The lowest weight gain was recorded in the rats fed MBG.

The food intake protein intake, weight gain, protein

Table 4.17. Nitrogen Balance of Rats Fed Weaning Food Blend and Cerelac®

Weeks	Weaning food blends				
	MCBG	MCB	MCG	MBG	Cerelac®
Nitrogen intake (g)	1.49±0.02 ^a	1.38±0.17 ^b	0.53±0.13 ^c	0.46±0.02 ^d	2.14±0.03 ^e
Faecal nitrogen (g)	0.19±0.01 ^a	0.20±0.01 ^b	0.22±0.03 ^c	0.26±0.01 ^d	0.15±0.01 ^e
Urinary nitrogen (g)	0.22±0.01 ^a	0.25±0.02 ^b	0.27±0.01 ^c	0.32±0.03 ^d	0.18±0.01 ^e
Retained nitrogen (g)	1.06±0.01 ^a	0.77±0.02 ^b	0.44±0.09 ^c	0.35±0.01 ^d	1.96±0.01 ^e
Absorbed nitrogen (g)	1.99±0.02 ^a	0.69±0.01 ^b	0.50±0.02 ^c	0.30±0.01 ^d	2.01±0.01 ^e
TPD (%)	79.90±0.01 ^a	67.70±0.06 ^b	59.6±0.01 ^c	57.01±0.03 ^d	92.18±0.01 ^e
BV (%)	74.50±0.02 ^a	63.20±0.08 ^b	56.72±0.06 ^c	54.10±0.02 ^d	82.20±0.03 ^e
NPU (%)	85.8±0.01 ^a	75.00±0.06 ^b	71.80±0.03 ^c	69.50±0.19 ^d	90.5±0.01 ^e

Values are recorded as mean ± SD of 10 rats. 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

efficiency ratio (PER) and food efficiency (FE) of the weaning food blends and Cerelac® are presented in table 4.16. Rats fed with the commercial weaning food blend MCG Cerelac® had the highest food intake and weight gain which closely followed by MCBG, MCB, and MBG. The lowest food intake and weight gain were observed in the rats fed MCB. The PER of the four weaning food blends MCBG, MCB, MCG, MBG and Cerelac® did not show any significant difference. The FE of the weaning food blend MCBG and Cerelac® did not show any significant difference. MCB, MCG and MBG had FE values lower than cerelac® and MCBG.

Biological value

The nitrogen balance of the weaning food blends and Cerelac® are presented in Table 4.17. Significant differences were observed in the nitrogen intake, faecal nitrogen and urinary nitrogen of MCBG, MCB, MCG, MBG and Cerelac®. The group of rats fed with Cerelac® recorded the highest nitrogen intake, faecal nitrogen, urinary nitrogen, TPD, BV and NPU which was followed by MCBG, MCG, MCB and then MBG. Cerelac® group had higher retained and absorbed nitrogen followed by MCBG, MCB, MCG and then MBG. The group of rats fed MBG had higher faecal and urinary nitrogen and cerelac® group recorded the least.

DISCUSSION

Amino acid composition

The levels of the essential amino acids lysine and methionine in the weaning food blend MCBG met the RDA of infants 0 – 1 year. This indicates that the multiple protein sources (Co-supplementation) provided complementary supplies of essential amino acids in the weaning food blend in adequate quantities required for growth and development of infants 0 – 1 years, MCBG

and MCG were close to the RDA of infants this agrees with the work of Ijarotimi, (2013). Lysine, tryptophan and methionine are the essential amino acids of major importance in blend formulation with cereals and legumes. Due consideration is given to the right proportions of the blend components for maximum protein quality through the mutual complementation of the limiting amino acids (Nkama et al., 2001). The level of arginine, tryptophan and histidine, leucine, isoleucine, tyrosine and phenylalanine in the weaning food blends MCBG, MCB, MCG and MBG were below the RDA of infants 0 – 1 year this is in agreement with the report of (Laminu et al., 2014). The limiting essential amino acid in cereals (lysine and the limiting essential acid in legumes (Methionine) met the RDA of infants 0 – 1 years in the weaning food blend MCBG (Nkama et al., 2001). Robert et al., (2013) reported a significant increase in lysine content of rice, corn and sorghum during fermentation.

Food intake and weight gain of experimental rats

The rats fed the weaning food blends MCBG, MCB, MCG and MBG and the rats fed the commercial weaning food cerelac® had increase in their weight gains. This is in agreement with the report of Akeredolu et al (2005), who reported that growth rate in experimental rats was influenced by their food intake. The increase in body weight might be influenced by the source of nitrogen and this is in accordance with Odumodu et al., (2010), Modu et al., (2012), Collins (2003) and Falmata et al., (2014) with subsequent increase in body weight.

Protein Efficiency Ratio (PER) and Food Efficiency (FE)

The PER of a food reflects its biological value because the weight gain measured in PER are dependent on the incorporation of food protein into body tissue. FE is measured as a function of gain in body weight and food

consumed (Ikpeeme and Igile, 2010). Foods with high PER tend to add weight gain while low FE are prone to be used as energy rather than stored as body weight (Laminu *et al.*, 2014). The high PER and FE exhibited by the weaning food blends indicates that the improved pattern of amino acid was utilized by the rats for the synthesis of tissue protein. There was no significant difference in the FE content of the weaning food blend MCBG and Cerelac®, this is consistent with earlier observations of Gazhimet *et al.*, (2015).

Biological utilization

The cerelac® group had the highest retained nitrogen, true protein digestibility (TPD), biological value (BV) and net protein utilization (NPU) when compared to the MCBG, MCB, MCG and MBG though that of MCBG was close to the cerelac® group. This could be as a result of higher protein content of the weaning food blend MCBG and cerelac®. More nitrogen is retained when a food's amino acid pattern closely matches the body's demand for various amino acids (Bryrd-Brdbenner *et al.*, 2009). MBG group recorded higher faecal and urinary nitrogen than other groups. Faecal nitrogen affects digestibility. High faecal nitrogen losses indicate low nitrogen digestibility and utilization (Onwaluzo and Nwabugwu, 2009). The close BV for the weaning food blend MCBG to cerelac® indicates adequate complementation of amino acids in the weaning food blend MCBG supplemented with cowpea, bambarabutand groundnut. This is in consistent with the work reported by Modu *et al.*, (2010) and Gazhimet *et al.*, (2015), Laminu *et al.*, (2014). The close proximity of the weaning food blend MCBG to cerelac® could be due to complementation with legumes Falmata *et al.*, (2014) reported similar findings.

CONCLUSION

The findings showed that supplementation of cereal with more than two legumes improved the lysine and methionine content of MCBG, while that of MCB, MCG and MBG were below the RDA of infants 0-1 year. The PER of the weaning food blends MCBG, MCB, MCG and MBG were comparable to cerelac®. The FE of MCBG was comparable to cerelac®. The TPD, BV, NPU of MCB, MCG and MBG were below that of cerelac®. MCBG was close to cerelac® in terms of TPD, BV and NPU. Indicating that MCBG can support growth of infants during the critical period in developing countries like Nigeria.

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