

ORIGINAL RESEARCH ARTICLE

PRODUCTION, ASSESSMENT, AND SAFETY ASPECT OF WEANING FOOD FROM SORGHUM, CRAYFISH AND GARDEN EGGS

ABSTRACT

Aim: This study examined the production, assessment, and safety aspects of weaning food from sorghum, crayfish, and garden eggs.

Methodology: Sorghum was fermented, garden egg and crayfish were cleaned and processed into flours and further formulated into blends. Five formulations were produced through random sampling method. Laboratory analyses were carried out, lipid and hematological studies of thirty five Wistar rat fed with commercial and formulated diets were done, other parameters include; growth rate, feed intake and bodyweight. Data were subjected to one-way analysis of Variance (ANOVA) in randomized block to test significant variations ($P < 0.05$) among mean values obtained.

Results: The results showed that moisture content observed in the diets was very low. The lowest moisture content was observed in diet O (10.41%), the highest protein was from diet L (26.35%). The highest ash content was observed in diet L (5.35 %). Diet L (8.82 %) had the highest fat content. The highest calcium content was found in diet L (26591.10mg/kg). Next were A (26158.86 mg/kg), M (23405.84 mg/kg), I (16291.12 mg/kg), O (13298.34 mg/kg), and F (6011.12 mg/kg). Diet A (103.40 mg/kg) had the highest iron content. Next were M (91.69 mg/kg), L (89.74 mg/kg), O (77.66 mg/kg), I (77.07 mg/kg), and X (28.19 mg/kg). The lowest low density lipoprotein (LDL) was observed in rats fed diet M (14.0 mg/dl). Next were rats fed diets L (16.0 mg/dl), S (17.50 mg/dl) and O (24.0 mg/dl). The bodyweight of the rats at day 0 ranges between 32.10-33.85g, at day 4 (39.60-47.90 g), at day 8 (38.85 – 52.75 g), at day 12 (38.70 -54.35 g), at day 16 (41.80-74.25 g), at day 20 (46.30 -84.85 g), at day 24 (47.85 -86.35 g), and at day 28 (50.15 -90.35 g). The highest white blood cell (WBC) counts were diets M, and O with the same values ($10.0 \times 10^9/L$), next was A and S with the same values ($9.0 \times 10^8/L$), L ($8.0 \times 10^8/L$), I ($7.0 \times 10^8/L$) and X ($4.0 \times 10^8/L$) in that same decreasing order. The highest PCV count was diet I (43%). Next were A (42 %), O (41 %), M (40 %), L (39 %), X (38 %), and S (37 %).

Conclusion: This study showed that the use of sorghum, crayfish, and garden eggs (vegetable) at a combination of 60: 30:10 respectively, could improve optimal health and growth in children between 6-23 months in Nigeria.

Key words: Weaning, Proximate, Lipid, Sorghum, Safety

INTRODUCTION

Breast milk is a perfect food for the infant for the first six months of life. It has all the nutrients needed by an infant to maintain optimal health and growth. In addition, breast milk protects infants against the two leading causes of infant mortality i.e. upper respiratory infections

and diarrhea [1]. At the age of six months and above, the child's birth weight is expected to have doubled, and then breast milk is no longer enough to meet the nutritional needs of the growing infant. Nutritious complementary foods are introduced at the end of 6 months, it is also known as weaning foods, which typically starts from six to twenty four months of age in developing countries [2].

Guinea corn also known as sorghum is a cereal grain that originated in Africa and is consumed in the world because of its resistance to drought. Guinea corn contains important nutrient (such as protein, ash, crude fiber etc) that is often milled into flour to make bread, porridge, pancakes and Kunun drink. This product offers a number of nutritional and therapeutic benefits, fiber helps fill you up without a lot of calories and may help lower your risk of cancer, constipation, high blood sugar and high cholesterol (www.livestrong.com). Guinea corn contain the same and some times more protein than other grains. It is use as food, fodder for animals, and for the production of alcoholic beverages. It can resist drought and heat, and is important in arid regions. It is an important food crop in Africa, Central America, and South Asia, and fifth most important cereal crop in the world. Guinea corn is one of the nutritional high light foods, its mineral content in ¼ cup serving contains 13mg calcium, 2.1mg iron, 13.8mg phosphorus, and these are essential minerals needed for bone health and strength (www.livestrong.com) .

Garden egg (Solanum), a widespread plant of the family Solanaceae, it has more than 1000 species with at least 100 indigenous species in Africa; these include a number of valuable crop plants and some toxic ones. Garden egg is represented by 25 species in Nigeria, including the domesticated with their leaves, fruits, or both, they eaten as vegetables or used for traditional medicine. Both consumed as vegetables or used for traditional medicine. Among them are two African eggplants, *S. aethiopicum* L. and *S. macrocarpon* L., which are widely cultivated in Nigeria and across the African continent [3][4].

Eggplants/garden eggs (Hausa: Dauta; Igbo: afufa or añara; Yoruba: igbagba), are highly valued constituents of the Nigerian foods and indigenous medicines; they are commonly consumed almost on daily basis by both rural and urban families.

Seafood contains fat-soluble (A, D, E, and K) and water-soluble examples like C and the B complex. [5]. Retinol and vitamin D are found in fish liver oils and in small amounts in the fatty tissues of fish. Some fish oils, example cod liver oil, are high in vitamin D, providing more than 200% of the recommended (www.sciencedirect.com). Crayfish is among the cheapest animal protein sources in Nigeria. The composition of Fish composition are mainly water, protein and fat with traces of carbohydrates, amino acids and other non-protein nitrogenous extracts, various minerals and vitamins [6]. The production of composite flours from Guinea corn, crayfish and garden egg could help to improve the nutritional status of the infants. Fermentation of plant foods (sorghum) provide means through which their nutritional worth can be improved upon.

The objectives of this study was to develop, evaluate and determine the safety aspect of some quality attributes of sorghum, crayfish and garden egg flour blends as a complementary food for children between 6-23months in Nigeria.

MATERIALS AND METHODS

Source of Materials:

Guinea corn (*Sorghum bicolor*), crayfish (*Cambarus sp*) and garden egg (*Solanum melongena*) used in this experiment were purchased from Auchi, Edo State, Nigeria.

Preparation of materials:

Four kilograms of sorted sorghum grains were cleaned and soaked in clean tap water in a covered container. The soaked grains were allowed to ferment at room temperature (37°C) for 24 h. After fermentation, the water was drained and grains milled and later dried at 60°C for 3hrs. Four kilograms of sorted and cleaned crayfish was sun dried. Three kilogram of garden eggs were sorted, cleaned, sliced thinly and dried. All the dried samples ie guinea corn, garden egg and crayfish were separately milled (Figure 1, 2 and 3).

Formulation of composite flours:

These composites were formulated using Response Surface Methodology (RSM) in the ratio showed below (Table 1) with Design expert, version 6. The controlled experiment were 100% sorghum (X) and a commercial diet (S) cerellac.

Table 1: Formulation of fermented sorghum, crayfish and garden egg

Samples ID	Level of subscription		
	Fermented sorghum	Crayfish	Garden egg
A	100.00	20.00	5.00
I	113.64	25.00	7.50
L	60.00	30.00	10.00
M	80.00	25.00	11.70
O	80.00	25.00	7.50
X	100.00	0.00	0.00
S	100.00	0.00	0.00

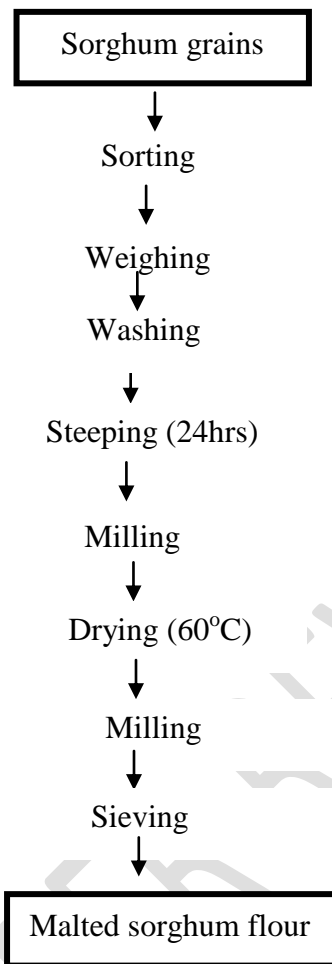


Fig 1: Flow chart for the processing of sorghum flour

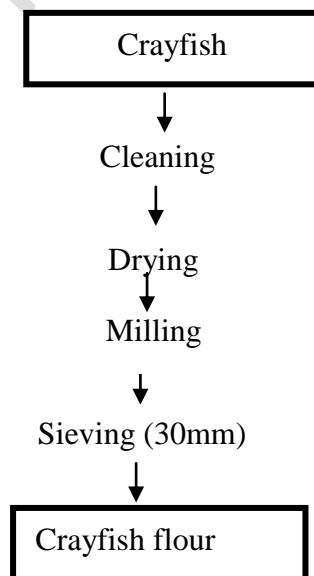


Fig. 2: Flow chart for the production of crayfish flour

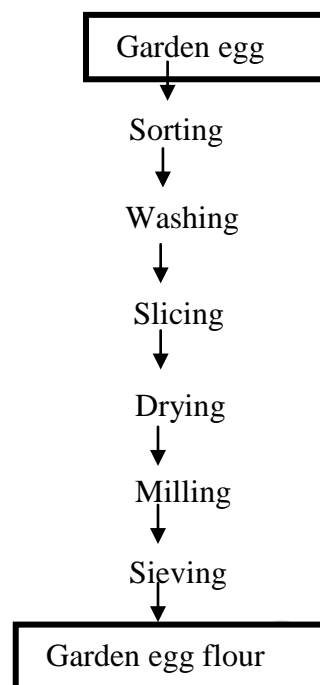


Fig. 3: Flow chart for the production of garden egg flour

Proximate analysis:

Composition of the flour blends was calculated according to standard assay [7]. Moisture using Thermo Scientific-UT 6200, Germany. Crude protein was calculated by Micro kjeldah method using Kjeldahl apparatus. Fat was determined by Soxhlet extraction (Gerhardt Soxtherm SE- 416, Germany) and Ash determined gravimetrically after incineration in muffle furnace (Carbolite AAF-11/18, UK) for 24 h at 550°C. Carbohydrate was determined by difference while gross energy was also calculated. All assays were performed in triplicate.

Mineral analysis:

The mineral contents of the products were determined as described by [8]. Two grams (2g) oven-dried sample were ashed at 600°C using a muffle furnace. The ash formed was transferred into 250ml glass beaker and 120ml conc. HNO₃ and 10ml H₂O₂ added. The component was heated at 90 °C for a duration of 1 hr, allowed to cool, and filtered, with the filtrate transferred into a 250 ml volumetric flask, which was later made up to the mark with deionized water. After gentle shaking to mix, 2ml was transferred into 250ml using a pipette and diluted to the mark with deionised water. Stock solution of 1000mg/kg of elements was prepared using deionised water. Dilution comprising of each element was made with deionised water and together with the test sample were analyzed using an atomic absorption spectrophotometer.

Experimental Design

Thirty five healthy Wistar rats with mean weight of 32.10-33.85g were obtained from an animal farm attached to Federal University of Technology Akure, Nigeria. The rats were allowed to acclimatize with the laboratory condition for 2days in well ventilated cages.

The rats were divided into seven groups of 5 animals each. Each rat was given an identification mark on the tail, head and back. Rats for each group were fed either formulated or commercial diet (Cerelac). The formulated diets are seen in Table 1. Samples X and S were used as control (Sorghum and Cerelac). The rats were acclimatized on a commercial diet (rat pellet) and water *ad libitum* for 2 days prior to commencement of the experiment which lasted for 28 days.

Growth performance study: The growth Performance was studied by the method described [9].

Feed Intake (FI)

This was measured daily and determined as the difference between the amount of feed offered and refusal for 28 days.

Collection and Analysis of Blood Sample

Rats were anaesthetized using chloroform vapour twelve hours (12 h) after feed administration, and blood samples were collected through cardiac puncture into set of plain and fluoride oxalate sample bottles for haematological and lipid studies [10]

The Red Blood Cells Count was determined by Hemocytometry Method

Procedure: Blood was drawn up to 0.5 mark of RBC pipette and RBC diluting fluid was added to make up 101 marks. The fluid was mixed with the blood and the first few drops of blood were discarded by holding the pipette vertically. The counting chamber was charged with drop of blood that mixed with diluting fluid and the chamber left

settled for few minutes then the corners of the chamber viewed with low power (10x) objective and cells were counted.

$$\text{Total RBC/L} = \frac{\text{Number of cells counted} \times \text{diluting factor}}{\text{Area counted} \times \text{depth of fluid}}$$

White Blood Cells (WBC) or Total Leucocytes Count (TLC)

Total Leucocyte count was determined by haemocytometer method. Blood was at to 0.5 mark of the WBC pipette while WBC diluting fluid was added up to 11 mark. The fluid and blood were thoroughly mixed while the first few drops of blood was thrown away by holding the pipette vertically. The counting chamber was charged by holding the pipette vertically and was charged with a drop of blood that has mixed with diluting fluid and the chamber was left settled for few minutes, the four corners of the chamber and the middle visualized with low power (10x) objective and cells counted in all the four marked squares [10]

$$\text{Total WBC/L} = \frac{\text{Number of cells} \times \text{diluting factor}}{\text{Area counted} \times \text{depth of fluid}}$$

Packed Cell Volume (PCV)

Blood sample was filled up to 75% of capillary tube, one end was sealed with plasticine and put in micro- haematocrit centrifuge set at 12 rpm (revolution per minute) for 5 minutes. Thereafter, the centrifuge was spun and the tubes were removed and the percentage packed volume was read using micro-haematocrit reader according to the method [10]

Determination of platelets: The platelets were determined by diluting the blood in one percent (1%) ammonium oxalate which hemolysed the red blood cells. The platelets counted using the rulings of an improved Neubauer counting chamber.

Determination of hemoglobin: Sahli's haemoglobinometer was employed for the estimation of hemoglobin (Hb) content of the blood, using the Sahli haemoglobinometer. The colour of test solution filled to 20ml mark with 10N hydrochloric acid, 0.02ml of blood was added, the content of the test tube was mixed with the use of glass rod. It was allowed for 5 min (haemoglobin changed into acid haematin). More acid was added and mixture stirred until colour of the test solution matched that of the colored glass standard. The level of the fluid in the tube was read and the haemoglobin content was expressed in percentage.

Determination of Leucocytes: The differential white blood cell count (Neutrophils, Lymphocytes, monocytes, Eosinophils and Basophils) was carried out by making a thin film of blood on a smooth edged slide. Dry was allowed on a bench free from dust, ants, flies, and other insects. Blood film was fixed by a covered staining jar of methyl alcohol for 3 minutes. Ten (10) ml of May Grunwald Stain (mixture of 5g of May Grunwald powder and 1 liter of methanol) and 10ml of buffered water (pH 6.8) was mixed and smear covered with dilute May Grunwald stain for 3 minutes. The stain was off and replaced with diluted Giemsa's stain (5%) for 9 minutes. The stain was washed using buffered water (pH 6.8) and pure water was allowed on the slide which lasted for 30 seconds. The water was tipped off and the slide was allowed to dry and examined microscopically (McArthur microscope) for Neutrophils, Eosinophils, Basophils, Monocytes and lymphocytes.

Statistical Analysis

Data generated were subjected to one-way analysis of Variance (ANOVA) in randomized block to test significant variations ($p < 0.05$) among mean values obtained. The values were in triplicate, and where significant differences existed Duncan's multiple range test was applied to indicate the differences, using Genstat statistical package 2005, 8TH edition (Genstat Procedure Library Release PL16). Also, data were represented by simple descriptive bar chart.

RESULTS AND DISCUSSION

Table 2: Proximate composition of raw materials (flour)

Proximate (%)	Samples			SEM
	X	Y	Z	
Moisture	9.55 ^b	12.30 ^a	9.31 ^b	0.06
Ash	2.48 ^c	3.19 ^b	5.13 ^a	0.06
Protein	7.49 ^c	17.40 ^a	12.69 ^b	0.04
Fat	1.59 ^b	6.72 ^a	6.80 ^a	0.15
Fiber	0.49 ^b	1.05 ^b	3.14 ^a	0.21
Carbohydrate	78.41 ^a	59.34 ^c	62.94 ^b	0.28

Means with the same superscript along the rows are significantly not different ($p > 0.05$)

Sample X= sorghum

Sample Y= Crayfish

Sample Z= Garden egg

SEM= Standard error of mean

The analysis of variance showed significant differences ($p < 0.05$) in the proximate composition of the raw plant materials (Table 2).

The moisture content of all the raw samples was significantly ($p < 0.05$) low. However, sample Y had the highest (12.30%) moisture content and it was significantly higher ($p < 0.05$) than the other samples (raw samples X and Z). The high moisture content of sample Y could be attributed to the fact that it is an animal product. The relative increase in the moisture content of the sample may be attributed to a variation in the treatment during the drying process of the diets and the storage conditions. This was followed by the moisture content of sample X (9.55%), which was not significantly different ($p > 0.05$) from sample Z (9.31%). The low moisture content of the various samples reflects their shelf stability. [11] reported that low moisture content within the range of 9.31-12.30% suggest a moderate moisture level needed for long term storage of processed flour and plant raw material. High moisture content makes food prone to deterioration and microbial infestation. The high moisture content of the local diets may affect the storage quality of the foods. High moisture content in foods has been shown to encourage microbial growth [12].

Sample Z had the highest (5.13%) ash content and was significantly different ($p < 0.05$) from samples Y (3.19%) and Sample X (2.48%) in decreasing order. According to [13] No standard for ash concentration has been specified for weaning/follow-up foods in the Codex Alimentarius Standards (FAO/WHO, 1994). The highest protein content was observed in sample Y (17.40%), followed by sample Z (12.69%), and the least was in Sample X (7.49%). The highest protein content observed in sample Y suggests its source (animal source). Animal foods are the highest quality protein sources, with complete protein, and it contains all the essential amino acids in the correct proportion. For the rapid growth and development of a child, proteins are important both in quantity and quality.

Growth faltering in particular is often widespread as soon as CFs are introduced because of the low nutrient density of most traditional complementary diets (www.ajol.info). The use of this

formulation could serve as a practical means of upgrading the protein levels of the traditional sorghum and maize-based complementary foods.

The crude fiber in all the samples was very low, the lowest was Sample X (0.49%), followed by Sample Y (1.05%) and the highest was Sample Z (3.14%) in that increasing order. The low crude fiber found in these raw materials is of importance because feeds that are high in fiber are less digestible than those low in fiber.

The fat content in these diets was low and the lowest was Sample X (1.59%), which was significantly different ($p < 0.05$) from samples Y (6.72%) and Z (6.80%). However, there was no significant difference ($p > 0.05$) between Samples Y and Z. Fat in food increases the energy density. Fat can also provide essential fatty acids like those of n-3 and n-6 Polyunsaturated Fatty Acids (PUFA's) needed to ensure proper neural development. Even though the fatty acid composition of these local diets was not determined, research carried out by [14] and his colleagues on the fatty acid composition of some Nigerian weaning foods, revealed that weaning foods are devoid of arachidonic and docosahexaenoic acids, but high in linoleic and linolenic acids.

The low crude fiber content in all these samples is nutritionally appreciated except for Sample Z (3.14%), which had the highest. Next was Sample Y (1.05%) while the least was X (0.49%). The crude fiber content of infant foods is expected to be low [13], as foods with high fiber content tend to cause indigestion in infants. Hence, samples with low fiber content were rated as good as potential complementary foods. The highest carbohydrate was reported in Sample X (78.41%). This was followed by Sample Y (62.94%) and the least was Sample Y (59.34%), in decreasing order. Carbohydrates foods are important part of a healthy diet. Carbohydrate supplies the body with glucose, which can be converted to energy to support bodily functions and physical activity.

Table 3: Proximate composition of the diets

Proximate Composition (%)	Samples					
	A	I	L	M	O	SEM
Moisture	10.71 ^b	11.73 ^a	10.42 ^c	10.72 ^b	10.41 ^c	0.02
Protein	18.10 ^d	19.35 ^c	26.35 ^a	23.09 ^b	23.06 ^b	0.02
Ash	3.30 ^d	3.01 ^e	5.35 ^a	4.26 ^b	3.60 ^c	0.04
Fat	7.89 ^c	5.67 ^e	8.82 ^a	7.05 ^d	8.10 ^b	0.03
Fiber	1.40 ^c	1.34 ^{cd}	2.32 ^a	1.64 ^b	1.29 ^d	0.02
Carbohydrate	58.61 ^b	58.92 ^a	46.76 ^e	53.26 ^d	53.56 ^c	0.04

Means having same superscript along the rows are not significantly different ($p > 0.05$)

Sample A=100.0 sorghum, 20.0 crayfish, 5.0 garden egg

Sample I=113.64 sorghum, 25.0 crayfish, 7.50 garden egg

Sample L= 60.0 sorghum, 30.0 crayfish, 10.0 garden egg

Sample M= 80.0 sorghum, 25.0 crayfish, 11.70 garden egg

Sample O= 80.0 sorghum, 25.0 crayfish, 7.50 garden egg

SEM= Standard error of mean

The analysis of variance has showed significant difference ($p < 0.05$) in the proximate composition of the different diets.

The moisture content observed in the diets was very low. The lowest moisture content was observed in diet O (10.41%), it was not significantly different ($p > 0.05$) from diet L (10.42%), next was diet A (10.71%) which was not significantly different from diet M (10.72%) while the highest was diet I (11.73%).

The highest protein was from diet L (26.35%) and was significantly different from other diets, this was followed by diet M (23.09%) and was not significantly different ($p > 0.05$) from diet O (23.06%), next was diet I (19.35%) while the least protein was diet A (18.10%). Protein is essential for normal growth and development of children since they help the body to synthesize new tissues and repair worn out tissues. They are also components of hormones, enzymes and other vital processes in the body. The protein obtained in these formulated diets was high. Diets composed of cereals/legumes mixed with some animal protein source (10 – 20 %), have been reported to be sufficiently high in amino acids to meet recommended nutrient intakes (Fernandez *et al.*, 2002). There was significant difference ($p < 0.05$) in the ash content of the various diet.

The highest ash content was observed in diet L (5.35%) and was significantly different ($p < 0.05$) from other diets, this was followed by diet M (4.26%), diet O (3.60%), diet A (3.30%) and diet I (3.01%). The high level of ash in the blends may indicate high amount of mineral in these blends.

There was significant difference ($p < 0.05$) in the fat content of the diets. Diet L (8.82%) had the highest fat content and was significantly different ($p < 0.05$) from other diets, next was diet O (8.10%), diet A (7.89%), M (7.05%) and diet I (5.67%) in that decreasing order. Fat provide essential fatty acids like that of n-3 and n-6 Polyunsaturated Fatty Acids (PUFA's) needed to ensure proper neural development. Even though the fatty acid composition of the formulated diets were not determined, research carried out by [14] on the fatty acid composition of some Nigerian weaning foods, revealed that the foods were devoid of arachidonic and decosahexanoic acids, but high in linoleic and linolenic acids.

Diet L (2.32%) had the highest fiber content, next was diet M (1.64%), A (1.40%), I (1.34%) and the least diet O (1.29%). Crude fiber adds bulk to food to facilitate bowel movements (peristalsis) and prevent many gastrointestinal diseases

There was significant difference ($p < 0.05$) in the carbohydrate content of the diets. The highest was found in diet I (58.92%) and was significantly different ($p < 0.05$) from other diets, next was diet A (58.61%), O (53.56%), M (53.26%) and least L (46.76%) in that decreasing order.

Table 4: Mineral composition of the different diets

Minerals (mg/kg)	Samples						SEM
	A	I	L	M	O	X	
Potassium	6304.35 ^e	5827.06 ^f	9068.31 ^b	7915.66 ^c	7606.39 ^d	10159.49 ^a	0.404
Calcium	26158.86 ^b	16291.12 ^d	26591.10 ^a	23405.84 ^c	13298.34 ^e	6011.12 ^f	0.403
Sodium	6957.02 ^b	6704.73 ^c	8024.70 ^a	6321.70 ^e	6543.06 ^d	957.94 ^f	0.201
Iron	103.40 ^a	77.07 ^d	89.74 ^c	91.69 ^b	77.66 ^d	28.19 ^e	0.204

Means with the same superscript along the rows are not significantly different ($p > 0.05$)

Sample A=100.0 sorghum, 20.0 crayfish, 5.0 garden egg

Sample I=113.64 sorghum, 25.0 crayfish, 7.50 garden egg

Sample L= 60.0 sorghum, 30.0 crayfish, 10.0 garden egg

Sample M= 80.0 sorghum, 25.0 crayfish, 11.70 garden egg

Sample O= 80.0 sorghum, 25.0 crayfish, 7.50 garden egg

SEM= Standard error of mean

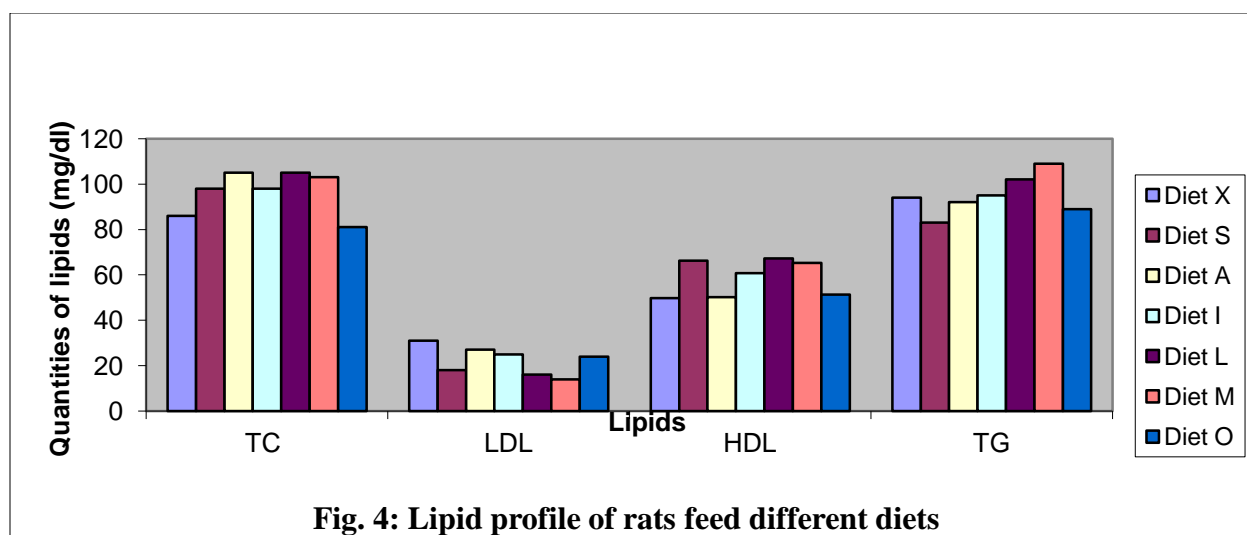
There was significant difference ($p < 0.05$) in the mineral composition of the diets. Minerals are vital to the functioning of many body processes and are critical players in nervous system functioning, other cellular processes, water balance, and structural (e.g. skeletal) systems [15].

The highest potassium was recorded in diet X (10159.49mg/kg), next was diet L (9068.31mg/kg), M (7915.66mg/kg), O (7606.39mg/kg), A (6304.35mg/kg) and I (5827.06mg/kg) in that decreasing order. Potassium is needed for regulating the water balance of cells, the use of carbohydrates and the building of proteins. It acts against disturbances of the cardiac rhythm and intervenes in the regulation of the osmotic pressure of the cell.

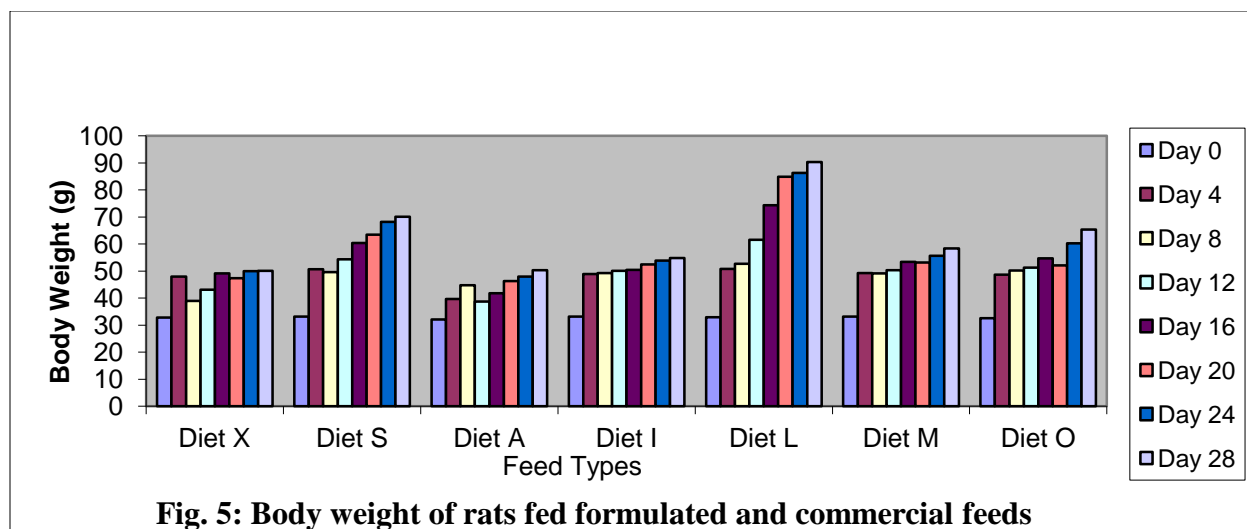
The highest calcium content was found in diet L (26591.10mg/kg), next was A (26158.86mg/kg), M (23405.84mg/kg), I (16291.12mg/kg), O (13298.34mg/kg), and F (6011.12mg/kg). Calcium plays a major role in the constitution of the skeleton, and also in various metabolic functions such as muscle activity, nerve stimuli, enzymatic and hormonal activities and oxygen transport [16].

Diet L (8024.70mg/kg) had the highest sodium content, next was B (6957.02mg/kg), I (6704.73mg/kg), O (6543.06mg/kg), M (6321.70mg/kg) and X (957.94mg/kg). Sodium helps the acid-base balance and water balance of the body. It promotes nerve function and muscle contraction.

Diet A (103.40mg/kg) had the highest iron content, next was M (91.69mg/kg), L (89.74mg/kg) and O (77.66mg/kg), I (77.07mg/kg), and X (28.19mg/kg). Iron (Fe) is essential nutrient in diets particularly in neonate diets. It is for the development of baby's brain; it helps neurological and cognitive development. It is important babies consume steady supply of iron at every stage of growth. Iron deficiency hinders development of central nervous system. Iron is also involved in the formation of hemoglobin, myoglobin and enzymes play a key role in many metabolic reactions [17].



The analysis of variance showed significant differences ($p < 0.05$) in the lipid status of the various rats fed different diets (Figure 4). There was significant difference ($p < 0.05$) in the total cholesterol (TC) of rat fed different diets. Rat fed with diet A had the highest (105.50mg/dl) TC but was not significantly different ($p > 0.05$) from TC of rats fed with diet L (104.50mg/dl), M (103.50mg/dl), S (infant formula) 98.0mg/dl and X (infant formula) had 86.50mg/dl. The rat fed with different diets had low value of low density lipoprotein (LDL). However, the lowest LDL was observed in rats fed diet M (14.0mg/dl), next was rats fed diet L (16.0mg/dl), S (17.50mg/dl), O (24.0mg/dl) while the highest LDL was seen in the control diet X (31.0mg/dl) in increasing order. Rats fed diet L had a significant ($p < 0.05$) increase in high density lipoprotein (HDL) (67.25mg/dl), followed by diet S (66.30mg/dl), M (65.30mg/dl), and the least HDL was observed in diet X (49.80mg/dl) (control). There was also significant difference ($p < 0.05$) in the Triglyceride (TG) of the various rats fed with different diets. The rat fed with diet L had the highest TG (67.25mg/dl), followed by rats fed diet S (66.30mg/dl), M (65.30mg/dl), I (60.70mg/dl), O (51.30mg/dl), A (50.20mg/dl), and X (49.80mg/dl) in decreasing order.



The analysis of variance has showed significant differences ($p < 0.05$) in the body weight of the rats fed with formulated and commercial diets (Figure 5). The body weight of the rat at day 0 ranges between 32.10-33.85g, at day 4 (39.60-47.90g), at day 8 (38.85 – 52.75g), at day 12 (38.70 -54.35g), at day 16 (41.80-74.25g), at day 20 (46.30 -84.85g) at day 24 (47.85 -86.35g), and at day 28 (50.15 -90.35). At day 0, there was no significant difference ($p > 0.05$) in the body weight of the rat fed different diets; diet A (32.10g), I (33.10g), L(32.85g), M (33.15g), O (32.65g), S (33.20G), and X(32.75g). However, there was significant ($p < 0.05$) progressive increased in the body weight of the rats from 4 to 28 days. At 4 days, rats fed with diet L (50.85g) had the highest body weight, this was followed by diet S (50.75g), M (49.30g), I (48.90g), O (48.75g), and the least was seen in diet A (39.60g). This trend was observed at 8 days but with diet X (38.85g) as the least. Throughout the period, rat fed with diet L compete favorably with rats fed diet S (infant formula) and had significant ($p < 0.05$) body weight at day 8(52.75g while S= 49.60g), day 12 (61.70 while S=54.35g) day 16 (74.25g while S= 60.35g), day 20 (84.85g while S= 63.49g), day 24 (86.35 while S= 68.25g) and day 28 (90.35g while S= 70.10).

There was significant difference ($p < 0.05$) in the feed intake based on the diets fed to the rats (Table 6). At 4 days, rats fed with diet I had the highest feed intake (53.50g), however, it was not significantly different from diets L (45.10g) and M (45.63g), next was diet S (43.20) and this was not significantly different from diet A (43,20g), the least feed intake was observed in diet X (35.60g). At 8 -28 days, the feed intake increased for diet L (62.83g - 72.90g), S (63.10-70.20g), M (62.56 -69.70g), A (56.20-60.40) and O (46.60-60.30g). Although, the feed intake increased for diet X from 8-24 days but with a decreased in the feed intake at 28 days (51.40g). It was obvious that the formulated diet and S control diet had increased in the feed intake throughout the feeding period while the control, diet X (sorghum) had reduction in the feed intake at 28 days. The reduction in the feed intake at 28 days is an obvious indication of gradual dislike of the feed (sorghum).

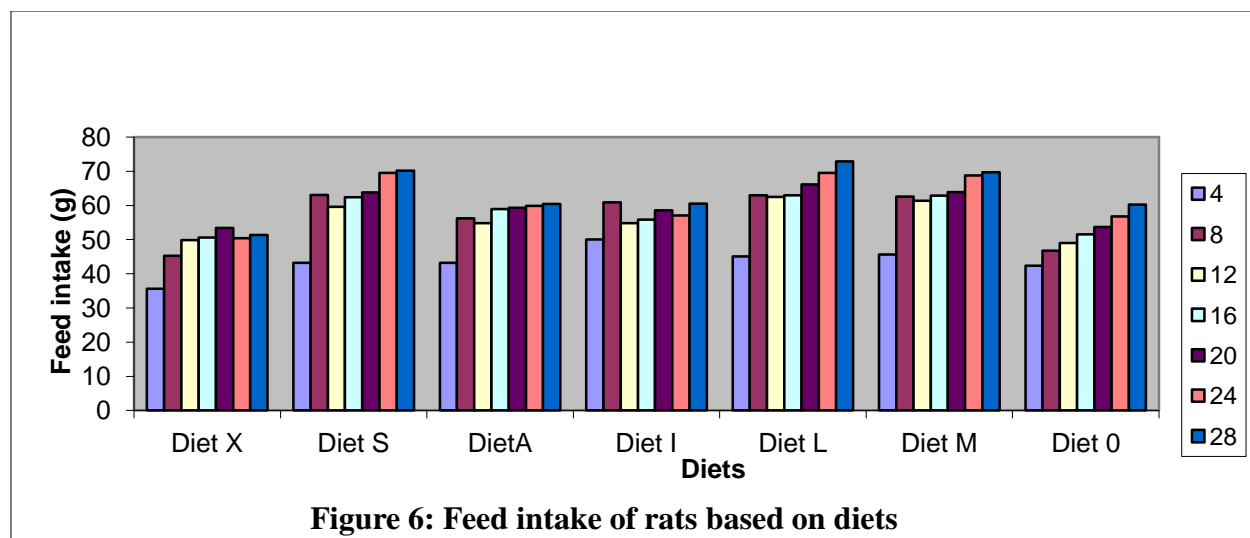


Table 5: Hematological studies of rats fed different diets

Haematology	Formulated and commercial diets fed to rats							SEM
	A	I	L	M	O	S	X	
WBC($10^8/L$)	9.0×10^{8a}	7.0×10^{8a}	8.0×10^{8a}	10.0×10^{9a}	10.0×10^{9a}	9.0×10^{8a}	4.0×10^{8a}	3.2×10^8
Neutrophils(%)	28.00 ^b	32.50 ^a	19.50 ^d	27.00 ^b	21.50 ^{cd}	23.50 ^c	32.50 ^a	0.945
Lymphocytes(%)	72.50 ^{ab}	77.50 ^a	72.50 ^{ab}	61.00 ^d	76.00 ^a	66.50 ^{bc}	51.00 ^e	2.041
Monocytes(%)	6.00 ^{ab}	8.00 ^a	5.50 ^{abc}	3.00 ^{cd}	2.50 ^d	4.50 ^{bcd}	5.00 ^{bcd}	0.756
Basophils(%)	0.50 ^a	1.00 ^a	1.00 ^a	1.00 ^a	1.00 ^a	0.50 ^a	1.00 ^a	0.24
Eosinophils(%)	2.50 ^a	3.50 ^a	2.50 ^a	2.50 ^a	2.50 ^a	1.50 ^a	2.50 ^a	0.756
Haemoglobin(g/dl)	14.21 ^{ab}	13.34 ^{ab}	13.56 ^{ab}	13.27 ^{ab}	14.77 ^a	12.92 ^{ab}	12.81 ^b	0.527
PCV	42.00 ^a	43.00 ^a	38.00 ^a	40.00 ^a	41.00 ^a	37.00 ^a	38.00 ^a	1.704
Platelet($10^9/L$)	3.0×10^{9ab}	2.0×10^{9ab}	5.0×10^{9a}	4.0×10^{9ab}	3.0×10^{9ab}	4.0×10^{9a}	5.1×10^{8b}	8.8×10^8
RBC($10^{12}/L$)	4.0×10^{12bc}	6.0×10^{12ab}	5.0×10^{12ab}	6.0×10^{12a}	6.0×10^{12ab}	5.0×10^{12abc}	4.0×10^{12c}	3.1×10^{11}

Means with the same superscript along the rows are not significantly different ($p > 0.05$)

SEM=Standard error of mean

The analysis of variance has showed that there are significant differences ($p < 0.05$) in the hematological status of rat fed with different diets. Hematological parameters are important indices of the physiological and pathological status for both animals and humans

There was no significant difference ($p > 0.05$) in the WBC of rats fed with different diets. The white blood cell count however cannot give a definite or specific information about infections, toxicity, allergy, immuno-suppression and poisoning but the result of a differential white blood cell count (Neutrophils, eosinophils, Monocyte, lymphocytes and Basophiles) narrows down to give specific information [18].

However, the highest WBC counts were diets M and O with the same values ($10.0 \times 10^9/L$), next was A and S with the same values ($9.0 \times 10^8/L$), L ($8.0 \times 10^8/L$), I ($7.0 \times 10^8/L$) and X ($4.0 \times 10^8/L$) in that decreasing order.

Significant differences were observed ($p < 0.05$) in the neutrophils of the rat fed with different diets. The highest neutrophils were in diets I and X with the same count (32.50%), next was A (28.0%), M (27.0%), S (23.50%), O (21.50%) and L (19.50%) in decreasing order. Neutrophils is mainly responsible for phagocytosis of pathogenic micro organism during the first few hours after their entry into tissues

For Lymphocytes, Diet I had the highest count (77.50%) and was not significantly different ($p > 0.05$) from diet O (76%), L (72.50%) and A (72.50%). Lymphocytes are involved in immunological functions, such as immunoglobulin production and modulation of immune defense [19]. They are type of white blood cell. Lymphocytes at excess levels suggest an infection or other inflammatory condition.

Significant difference ($p > 0.05$) was not observed in the monocytes of diet A (6%), I (8%), L (5.50%) and the least monocytes was sample O (2.60%). Monocytes defend the tissues against microbial agents, increases with bacterial infection but decreases with stress.

The basophils and Eosinophils counts in the different diets fed to rats were not significantly different ($p > 0.05$). The low basophiles could be as a result of some residual anti-nutrients present in the diet which must have affected these parameters. Basophils are chiefly responsible for allergic and antigen response by releasing the chemical histamine causing vasodilation [20].

The hemoglobin count was not significantly different ($p > 0.05$) in the rats fed with different diets except for diet X (12.81g/dl). Hemoglobin plays the important role of carrying oxygen and carbon dioxide through the blood.

Significant difference ($p > 0.05$) was not recorded in the PCV results of the rats fed different diets Packed cell volume (PCV) is important in the diagnosis of anemic condition. The highest PCV count was diet I (43%) next was A (42%), O (41%), M (40%), L (39%), X (38%) and S (37%).

Significant difference ($p > 0.05$) existed in the platelets count of the diets fed to rats except for diet X ($5.1 \times 10^8/L$). Platelets are blood cells responsible for clots to stop bleeding.

Significant difference ($p>0.05$) was not recorded in the PCV results of the rats fed different diets. Packed cell volume (PCV) is important in the diagnosis of anemic condition. The highest PCV count was diet I (43%) next was A (42%), O (41%), M (40%), L (39%), X (38%) and S (37%).

Significant difference ($p>0.05$) existed in the platelets count of the diets fed to rats except for diet X ($5.1 \times 10^{8b}/L$). Platelets are blood cells responsible for clots to stop bleeding.

Significant difference ($p>0.05$) was not recorded in the RBC count of the diets fed to the rats except for diet X ($4.0 \times 10^{12}/L$). Red blood cells (RBC) are useful to diagnose anemic condition. The red blood cell count in this study was higher compared to the RBC obtained by [20].

Conclusion

This study has shown that affordable, available, and acceptable complementary foods can be produced from sorghum, crayfish, and garden eggs. The formulated diets were able to compete favorably with the commercial diets. The results from this study showed that the formulated diets had low LDL, high HDL, and high nutritional content, which enhanced the growth rate, body weight, feed intake, and better hematological properties. All these would influence the growth of children and are aimed at combating the problem of malnutrition among infants and children in Nigeria and other developing countries.

Competing interests

The authors declared no competing interests exist.

Ethical Approval

This study was given full ethical approval by the Health Research Ethics Committee (NHREC) with registration number NHREC/12/06/2013 and assigned number 079/21

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