



## **Nutritional Study of Processed *Amygdalus communis* L. *Sesamum indicum* and *Bertholletia excelsa* Nuts on Two Weeks Old Wistar Rats**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The study evaluated the nutritional benefits of processed Almond nuts, Sesame seeds and Brazil nut on two weeks old Wistar rats. The rats were weighed and arranged into seven groups and feed for 4 weeks. Group one (control) was fed with commercial rat feed and distilled water. Group two was fed with a diet formulated from Brazil nuts and distilled water. Group three was fed with a diet formulated from almond seeds and distilled water only while Group four was fed with a diet formulated from sesame seeds. Group five was fed with diet from sesame + almond seeds while Group six was fed with a diet formulated from Brazil +almond nuts. Group seven was fed with a diet formulated from Brazil + Almond nuts +Sesame seeds. Biochemical and haematological analyses were carried out applying standard methods and procedures. Results for proximate analysis indicated that Brazil nut contains 4.03% Ash, 7.61% crude moisture, 43.74% crude lipid, 12.82% crude protein, 8.7% crude fibre and 28.1% carbohydrate. Plasma enzyme activities of rats fed with Brazil nuts were: ALT (22.96±1.95U/l), AST (66.49±3.33 U/l), ALP (64.18±2.76 (U/l) and GGT (6.89±1.69 (U/l). Total protein, albumin, and total bilirubin concentrations were 53.56±2.03 g/dl, 32.13±1.21 g/dl and 3.82±0.20 g/dl respectively. Total cholesterol, triglyceride, LDL and HDL concentrations were 2.83±0.42 mmol/l, 1.35±0.02 mmol/l, 4.10±0.19 mmol/l, 4.72±0.13 mmol/l

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respectively. The PCV, Hb, WBC, RBC, Platelet and MCV concentrations of rats fed with Brazil nuts only were  $48.20 \pm 1.79\%$ ,  $15.02 \pm 0.65$  g/dl,  $7.06 \pm 0.44 \times 10^3/\text{mm}^3$ ,  $7.28 \pm 0.23 \times 10^6/\text{mm}^3$ ,  $195.00 \pm 5.79 \times 10^3/\text{ml}$ , and  $6.63 \pm 0.43 \times 10^{-7}$  fl respectively which were significantly ( $p < 0.05$ ) different from the control values. The result is suggestive that they can be incorporated as a supplementary diet for Wistar rats. However, the results obtained from rats feed with almond and Brazil nuts were more significant when compared with sesame seeds.

**Keywords:** Brazil nuts; almond nuts; sesame seeds; nutritional benefits; wistar rats.

## 1. INTRODUCTION

Approach to infants' nutrition has significantly transformed over the last decade but typically involved spoon-feeding pureed food from around 4–5 months of age [1]. Poor infant feeding practices, as well as childhood and maternal under-nutrition, are the main risk factors of infant and early childhood mortality and morbidity. Malnutrition is one of the major problems facing infants and young children in developing countries. The unavailability of nutritious food and the high cost of commercial complementary foods and animal protein are the main causes of Protein-energy malnutrition in children in developing countries. Commercial formulated and processed weaning food is quite exorbitant and not easily accessed by rural dwellers while indigent parents cannot afford such weaning food. This has led to poor nutritional life of most infants in Africa including Nigeria which may be responsible for the increased mortality and morbidity rate in Nigeria. According to the Protein Advisory Group, guidelines for weaning food is 20% of proteins, fat levels of up to 10%, moisture content 5% to 10% and total ash content 5% [2]. Several studies, however, have reported that most of the weaning foods consumed by children in many parts of developing countries are deficient in essential macronutrients and micronutrients [3]. The unavailability of nutritious food and the high cost of commercial complementary foods are the causes of protein-energy malnutrition in children [4].

Almond (*Amygdalus communis* L.) is a perennial plant growing in inner Anatolia, the Mediterranean and the Marmara regions of Turkey. The kernel nut forms a significant source of protein in nutrition. Almond contains low saturated fat and whole wheat muffin as a daily snack. Almond contains high potassium and magnesium content with other mineral composition and several physical properties of almond nut and kernel were evaluated as functions of moisture content [5]. Brazil nuts are

shown to be rich in oil (60-79%) and 17% protein with abundant. The lipids, minerals, and phytochemicals composition, and their health functions in Brazil nuts are critically reviewed. The nuts have high nutritive food value containing 60–70% oil and 17% protein. Brazil nuts have dietary antioxidants, including selenium (Se). One single Brazil nut provides 160% of the US Recommended Daily Allowance (RDA) of selenium. Brazil nuts possess phenolics and flavonoids in both free and bound forms and are rich in tocopherol, phytosterols, and squalene [6]. Therefore, developing nutrient-dense, safe, affordable and accessible complimentary food from locally produced ingredients using household or small to medium scale production technologies is approved as a sustainable approach to address the problem of malnutrition [7] Due to the availability and high cost of commercial complementary foods to residents in rural areas in weaning babies, the need to study and formulate other nutritive sources or nut-based weaning food sources that are rich in lipid, carbohydrate, protein and minerals with low cost, easily available, accessible and affordable become imperative. In this research, nut-based weaning (almond, Brazil nuts, and sesame seed) to ensure that low-cost weaning food is accessible, to reduce malnutrition and mortality rate in infants to the beeriest minimum will be carried out. It will also include a comparison of the nutritive value of the formulated weaning diet with imported commercial weaning food in Africa and the United States of America.

## 2. MATERIALS AND METHODS

Sesame seeds, Brazil and almond nuts were purchased from Mile One market Port Harcourt. They were sundried for eight weeks. The dried samples were then ground into powder each weighing 3000 g. Exactly, 20 g of each of the feed was served morning and evening while the combined feed was served in 10:10 grams for two months.

## 2.1 Sample Preparation (Almond and Brazil Nuts, Sesame Seeds) For Atomic Absorption Spectroscopy

The method, as explained by Bhupander, et al. [8], was adopted for this study. Standard solutions of amino acids purchased from Sigma-Aldrich and containing 2.5  $\mu\text{mol/mL}$  in 0.1 M HCl of each amino acid, alanine (Ala), glycine (Gly), valine (Val), leucine (Leu), isoleucine (Ile), proline (Pro), hydroxyproline (Hyp), serine (Ser), threonine (Thr), tyrosine (Tyr), methionine (Met), cysteine (Cys), arginine (Arg), phenylalanine (Phe), histidine (His), aspartic acid (Asp), and glutamic acid (Glu) was used as an internal standard.

## 2.2 Digestion of Sample and Analysis of the Proximate Composition of Sesame Seeds, Almond and Brazil Nuts

The digestion of the sample was carried out according to the method as explained by Mohammed, et al. [9]. Moisture content analysis of Sesame seed, almond and Brazil nuts were carried using moisture content analyser, following the modified methods as described by Luciano, et al. [10]. The crude protein content of the seeds and nuts were determined following the method as described by Hanne, et al. [11]. The ash content was determined using the method as described by Hanne, et al. [11]. The crude fibre content of the seeds and nuts was determined according to the method as described by Kiyoshi, et al. [12]. Crude lipid contents of the seeds and nuts were determined using the method as described by Kiyoshi, et al. [12].

## 2.3 Experimental Design

Two weeks old Wistar albino rats weighing between 25 and 30 g were used for this study. They were obtained from the Biochemistry Animal House Choba University of Port Harcourt, Rivers State. The weight of rats was determined and recorded and immediately separated from their mother and was grouped into seven (7) of five rats per cage and was fed for four weeks as follows:

**Group One:** (normal control): fed with normal rat feed and distilled water only.

**Group Two:** fed with powdered Brazil nuts and distilled water.

**Group Three:** fed with powdered almond seeds and distilled water.

**Group Four:** fed with powdered sesame seeds and distilled water.

**Group Five:** fed with powdered sesame + almond seeds and distilled water.

**Group Six:** fed with powdered Brazil nut +almond seeds only.

**Group Seven:** fed with powdered Brazil nut + almond +sesame seeds and distilled water.

The weight of the rats in each of the groups was determined and recorded every week throughout the study. After 4 weeks, the animals to be sacrificed were first anaesthetized with chloroform (inhalational anaesthesia) followed by cervical dislocation. Each animal was then placed on a dissecting slab and then cut along the thorax down the abdominal region; blood was collected via cardiac puncture and dispensed into the EDTA bottle for haematology indices and Heparin bottle for biochemical assays.

## 2.4 Determination of Haematology Indices

The determinations of haematological parameters (haemoglobin concentration, packed cell volume, total white blood cell count, platelet count, neutrophils and lymphocytes) were carried out according to the method of Dacie and Lewis [13].

## 2.5 Determination of Biochemical Parameters

Total bilirubin concentration, urea, and creatinine levels were determined by the method of Tietz [14]. Total Cholesterol, triglycerides, LDL, HDL, Protein, Albumin, Creatinine and Urea, as well as the activity of ALT, AST and ALP were analysed using methods as outlined in Randox assay kits (Randox Laboratories, Crumlin, County Antrim, England) and absorbance of parameters were measured using a double-beam spectrophotometer. The determination of  $\text{Na}^+$  and  $\text{K}^+$  was by flame photometer method described by Chuang, et al. [15]. Chloride was assayed as described by Cheesbrough [16].

## 2.6 Determination of Magnesium Ion ( $\text{Mg}^{2+}$ ) Concentration

Magnesium ion was determined by the colorimetric method described by Reitman and Frankel [17].

### 2.7 Determination of Oil Absorption Capacity (OAC) of Sesame Seed, Almond and Brazil Nuts

The oil absorption capacity of a sesame seed, almond and Brazil nuts were determined using AAS, following the methods as described by Kain and Chen [18].

### 2.8 Determination of Water Absorption Capacity (WAC) of Sesame Seed, Almond and Brazil Nuts

The water absorption capacity of a sesame seed, almond and Brazil nuts were determined using AAS, adopting the modified method as explained by Suresh [19].

### 2.9 Determination of Bulk Density of Sesame Seed, Almond and Brazil Nuts

The bulk density of sesame seed, almond, and Brazil nuts were determined using AAS following the method as described by Kain and Chen [18].

### 2.10 Determination of Swelling Capacity (SC) of Sesame Seed, Almond and Brazil Nuts

The swelling capacity of a sesame seed, almond and Brazil nuts was determined following the

method as explained by Kain and Chen [18], using AAS.

### 2.11 Statistical Analysis

Statistical analysis was performed using statistical package for social science (SPSS) version 20.0 (IBM, U.S.A). The data were analysed using a one-way analysis of variance (ANOVA) and significant differences were determined using Bonferri for the Post Hoe test of multiple comparisons at  $p \leq 0.05$ . Values were reported as mean  $\pm$  standard deviation (M  $\pm$  SD).

## 3. RESULTS AND DISCUSSION

### 3.1 Amino Acid Composition of Almond Nuts, Sesame Seeds and Brazil Nuts

Table 1 shows the amino acid composition of Almond nuts Sesame Seeds and Brazil Nuts. Analysis of the amino acid composition revealed the presence of eighteen amino in the almond nut, twenty amino acids in sesame seeds acids and twenty amino acids in Brazil nuts expressed in g/100 g. The amino acid composition in sesame seeds, almond and Brazil nuts which gave a total of fifty-six amino acid showed that these seeds and nuts are good sources of nutrients and nourishment. These data are in line with the report of Fernandez, et al. [20] on amino acids, fatty acids and trace element composition of five weaning food in Jos, Plateau State.

**Table 1. Amino acid composition of almond nuts, sesame seeds and Brazil nuts**

Amino acids	Almond nuts (g/100 g)	sesame seeds (g/100 g)	Brazil nuts (g/100 g)
Alanine	3.41	1.34	4.58
Glycine	4.94	1.73	6.02
Valine	3.26	1.48	3.43
Leucine	4.75	2.31	5.1
Isoleucine	1.68	1.56	2.03
Proline	2.71	1.83	3.18
Methionine	0.53	1.05	1.25
Serine	3.61	1.48	4.26
Threonine	2.25	0.92	2.94
Phenylalanine	3.92	1.24	2.51
Aspartic acid	9.44	7.13	7.13
Cysteine	0.64	0.05	0.47
Glutamic acid	23.74	6.83	12.36
Lysine	1.58	0.62	1.27
Arginine	8.9	3.57	8.55
Tyrosine	1.8	1.42	1.89
Tryptophan	0.52	0.02	0.03
Histidine	1.26	1.16	0.82
Hydroxyproline	-	0.36	1.05
Asparagine	-	0.01	-

### 3.2 Proximate Composition of Sesame Seeds, Almond and Brazil Nuts

Table 2 shows the proximate composition of sesame seeds, almond and Brazil nuts. The proximate parameters determined include ash, moisture content, lipid, crude protein, crude fibre and carbohydrate concentrations which were expressed in percentages (%). The ash content of Brazil nuts was highest in concentration followed by almond and the least was sesame while the moisture content of almond was highest in concentration followed by Brazil nuts and the lowest was sesame seeds. The crude lipid of Brazil nut was higher than that of almond while sesame seeds showed the lowest crude lipid concentration. Crude protein concentration Brazil nuts were higher in concentrations followed by sesame seeds and then almond while the crude fibre content of almond nuts > sesame seeds > and Brazil nuts while the decreasing order of carbohydrate content of the seeds and nuts were Brazil nuts < sesame seeds < almond nuts.

composition. Potassium mineral composition determined was higher in Brazil nuts followed by that of almond while the lowest composition of potassium was found in sesame seeds. The magnesium and calcium mineral composition determined were higher in sesame seeds followed by those of Brazil nuts with lowest compositions in almond nuts. The manganese composition was higher in Brazil nuts followed by sesame seeds and the lowest was observed in almond seeds while the zinc and iron compositions were higher in Brazil nuts followed by almond and lowest compositions were observed in sesame seeds. It also showed the functional properties of sesame seeds, almond and Brazil nuts. The WAC of sesame seeds is greater than those of Brazil and almond nuts while the least was that of almond. More so, almond nuts have greater OAC followed by Brazil nuts and the least was sesame seeds while a higher bulk density was observed with Brazil nuts followed by sesame seeds and the least was almond nuts.

### 3.3 Mineral Concentration and Functional Properties of Sesame Seeds, Almond and Brazil Nuts

Table 3 shows the mineral composition of sesame seeds, almond and Brazil nuts. The sodium mineral composition was higher in sesame seeds followed by Brazil nut while almond nuts have the lowest sodium

### 3.4 Effect of Diet Formulated from Sesame Seeds, Almond and Brazil Nuts on the Plasma Liver Biomarkers in Wistar Albino Rats

Table 4 shows the effect of diet formulated from sesame seeds, almond and Brazil Nuts on the plasma liver biomarkers of Wistar albino rats. A significantly decreased plasma ALT, AST, ALP

**Table 2. Proximate composition of sesame seeds, almond and Brazil nuts**

Sample	Ash (%)	Moisture content (%)	Crude lipid (%)	Crude protein (%)	Crude fibre (%)	Carbohydrate (%)
Sesame Seed	2.96	5.84	31.43	19.32	8.63	31.82
Almond Nut	3.84	8.72	38.26	15.43	26.95	20.16
Brazil Nuts	4.03	7.61	43.74	12.82	8.7	28.1

**Table 3. Mineral composition and functional properties of sesame seeds, almond and Brazil nuts**

Mineral (mg/100 g)	Sesame seeds	Almond nuts	Brazil nuts
Na	26.314	4.58	15.184
K	294.274	175.34	365.412
Mg	102.48	18.46	57.642
Ca	135.602	28.172	84.392
Mn	135.602	1.683	3.748
Zn	5.212	6.947	11.26
Fe	40.836	13.46	19.157
Functional properties of Sesame seeds, Almond and Brazil nuts			
WAC (ml/g)	3.48	1.15	1.33
OAC (ml/g)	0.88	1.02	0.94
Bulk density (g/cm <sup>3</sup> )	0.73	0.68	0.83

and GGT activities were observed in the group of rats fed with a diet formulated from Brazil nuts and sesame seeds when compared to the control group and similar trends also occurred in rats fed with diet from sesame seeds and almond nuts. While more improved effects were noted with rats fed with sesame seeds + almond, Brazil + almond as well as with sesame seeds+ almond +Brazil nuts when compared to the control values. More so, a significantly increased concentrations of the plasma total protein and albumin were observed following feeding with a diet formulated from sesame seeds, Brazil and almond nuts and the more improved effect was produced with rat fed with the combinations of the three diets (sesame +almond, Brazil +almond, sesame + almond + Brazil nuts) when compared to the control values.

### **3.5 Effect of Diets Formulated from Sesame Seeds, Almond and Brazil Nuts on Plasma Lipid Profile of Wistar Albino Rats**

Table 5 shows the effect of diets formulated from sesame seeds, almond and Brazil nuts on the plasma lipid profile of Wistar albino rats. The plasma total cholesterol triglyceride and HDL concentrations of rats fed with Brazil nuts were significantly increased when compared to the Control values and were significantly different at  $p \leq 0.05$  from those fed with diet from sesame and almond nuts only. More so, rats fed with a diet formulated from sesame seed + Brazil + almond nuts were significantly different at  $p \leq 0.05$  from the control values followed by those fed with Brazil nuts + almond and were also different from the groups fed with sesame seed only, almond only and Brazil nuts only.

### **3.6 Effect of Diets formulated From Sesame Seeds, Almond and Brazil Nuts on the Plasma Kidney Biomarkers of Wistar Albino Rats**

Table 6 presents the effect of diets formulated from sesame seeds, almond and Brazil nuts on the plasma concentrations of the kidney biomarkers of Wistar albino rats. The plasma concentrations of  $\text{Na}^+$ ,  $\text{Cl}^-$  and blood urea nitrogen fed with the various formulated diet were significantly increased when compared with control values and while plasma concentrations of  $\text{K}^+$ ,  $\text{Mg}^{2+}$  and creatinine were significantly

decreased at  $p \leq 0.05$  when compared with the control values. The plasma concentrations of rats fed with a diet formulated from sesame + almond and Brazil +sesame +almond were significantly different at  $p \leq 0.05$  from the control values and those fed with sesame only, almond only and Brazil only with significant decreases at  $p \leq 0.05$  in plasma  $\text{K}^+$ ,  $\text{Mg}^{2+}$  and creatinine concentrations.

### **3.7 Effect of Diets Formulated from Sesame Seeds, Almond and Brazil nuts on the Plasma Haematological Parameters of Wistar Albino Rats**

Table 7 shows the effect of diets formulated from sesame seeds, almond and Brazil nuts on the plasma PCV, Hb, WBC, RBC, Platelet and MCV concentrations of Wistar albino rats. The plasma PCV, Hb, WBC, RBC, Platelet and MCV concentrations of rats fed with Brazil only, almond and sesame seeds only were significantly increased at  $p \leq 0.05$  when compared to the control values and were. The plasma PCV, Hb, WBC, RBC, Platelet and MCV concentrations of rats fed with sesame +almond, Brazil + almond, and Brazil +sesame +almond were significantly increased at  $p \leq 0.05$  when compared to the control values and were also significantly different from the those fed with sesame seeds only, almond nuts only and Brazil nuts.

### **3.8 Effect of Diets Formulated from Sesame Seeds, Almond and Brazil Nuts on the Plasma Haematological Parameters of Wistar Albino Rats**

Table 8 shows the effect of diets formulated from sesame seeds, almond and Brazil nuts on the plasma MCH, MCHC, neutrophils, lymphocytes, eosinophils, monocytes and basophils concentrations of Wistar albino rats. The plasma MCH, MCHC, neutrophils, lymphocytes, eosinophils and monocytes concentrations of rats fed with diets formulated from sesame seeds, almond and Brazil nuts only were significantly increased at  $p \leq 0.05$  when compared to the control values. More so, the plasma MCH, MCHC, neutrophils, lymphocytes, eosinophils and monocytes concentrations of rats fed with diets formulated from Brazil nut +almond, and Brazil + sesame +almond were also significantly increased  $p \leq 0.05$  when compared to the control values.

**Table 4. Effect of diet formulated from sesame seeds, almond and Brazil nuts on the plasma liver biomarkers in wistar albino rats**

Group	ALT (U/I)	AST (U/I)	ALP (U/I)	GGT (U/I)	Total Protein (g/dl)	Albumin (g/dl)	T. Bilirubin (g/dl)
Control	26.15±0.06 <sup>a</sup>	74.19±1.18 <sup>a</sup>	71.23±2.41 <sup>a</sup>	28.21.29 <sup>a</sup>	37.90±1.86 <sup>a</sup>	22.74±1.12 <sup>a</sup>	4.42±0.12 <sup>a</sup>
B.N	22.96±1.95 <sup>bc</sup>	66.49±3.33 <sup>bc</sup>	64.18±2.76 <sup>bc</sup>	6.89±1.69 <sup>bc</sup>	53.56±2.03 <sup>bc</sup>	32.13±1.21 <sup>bc</sup>	3.82±0.20 <sup>bc</sup>
A.N	23.66±1.22 <sup>bc</sup>	70.40±1.87 <sup>bc</sup>	63.88±1.28 <sup>bc</sup>	23.09±1.60 <sup>bc</sup>	60.73±1.72 <sup>bc</sup>	36.34±10.88 <sup>bc</sup>	2.51±0.11 <sup>bc</sup>
S.S	21.82±1.16 <sup>bc</sup>	63.88±1.28 <sup>bc</sup>	55.31±3.36 <sup>bc</sup>	16.24±2.56 <sup>bc</sup>	50.98±2.09 <sup>bc</sup>	30.58±1.25 <sup>bc</sup>	2.24±0.05 <sup>bc</sup>
S.S.+A	19.44±0.60 <sup>bc</sup>	55.14±2.21 <sup>bc</sup>	48.32±1.45 <sup>bc</sup>	13.55±1.74 <sup>bc</sup>	65.98±1.78 <sup>bc</sup>	39.58±1.07 <sup>bc</sup>	2.23±0.09 <sup>bc</sup>
BN +AN	18.30±0.28 <sup>bc</sup>	50.30±1.52 <sup>bc</sup>	43.26±0.76 <sup>bc</sup>	11.19±1.02 <sup>bc</sup>	69.03±2.34 <sup>bc</sup>	41.42±1.41 <sup>bc</sup>	2.23±0.09 <sup>bc</sup>
B+S+A	18.17±0.30 <sup>bc</sup>	47.19±2.18 <sup>bc</sup>	35.38±1.27 <sup>bc</sup>	10.93±1.58 <sup>bc</sup>	84.21±3.47 <sup>bc</sup>	50.52±2.09 <sup>bc</sup>	1.37±0.11 <sup>bc</sup>

BN- Brazil nut, A- Almond nut, S.S- Sesame seeds; Data are reported as mean ± Standard Deviation. n= 5. Values with similar superscripts (<sup>bc</sup>) indicate significantly different at  $p \leq 0.05$  from the control (<sup>a</sup>)

**Table 5. Effect of the formulated diet from sesame seeds, almond and brazil nuts on plasma lipid profile concentrations of wistar albino rats**

Group	Total cholesterol (mmol/l)	Triglyceride (mmol/l)	LDL (mmol/l)	HDL (mmol/l)	VLDL (mmol/l)
Control	2.69±0.05 <sup>a</sup>	1.18±0.50 <sup>b</sup>	4.41±0.95 <sup>c</sup>	1.19±0.95 <sup>d</sup>	0.53±0.23 <sup>e</sup>
B.N	2.48±0.14 <sup>a</sup>	0.94±0.02 <sup>b</sup>	4.10±0.19	1.21±0.13	0.42±0.01 <sup>e</sup>
A.N	2.09±0.12 <sup>a</sup>	0.78±0.03 <sup>b</sup>	3.82±0.09 <sup>c</sup>	1.39±0.03	0.35±0.01 <sup>e</sup>
S.S	2.43±0.13 <sup>a</sup>	1.12±0.09	3.99±0.14	1.07±0.05	0.50±0.03
S.S + A	1.90±0.04 <sup>a</sup>	0.65±0.03 <sup>b</sup>	3.82±0.11 <sup>c</sup>	1.64±0.09 <sup>d</sup>	0.29±0.01 <sup>e</sup>
B.N + A	1.95±0.03 <sup>a</sup>	0.74±0.05 <sup>b</sup>	3.72±0.14 <sup>c</sup>	1.44±0.12	0.33±0.02 <sup>e</sup>
B+S+A	1.62±0.06 <sup>a</sup>	0.46±0.03 <sup>b</sup>	3.49±0.47 <sup>c</sup>	1.67±0.44 <sup>d</sup>	0.20±0.02 <sup>e</sup>

BN- Brazil nut, A- Almond nut, S.S- Sesame seeds; Data are reported as mean ± Standard Deviation. n= 5. Values with similar superscripts (<sup>ab</sup>) indicate significantly different at  $p \leq 0.05$  from the control (<sup>a</sup>)

**Table 6. Effect of diet formulated from sesame seeds, almond, and Brazil nuts on the plasma kidney biomarker concentrations in wistar albino rats**

Group	Na <sup>+</sup> (mmol/l)	K <sup>+</sup> (mmol/l)	Cl <sup>-</sup> (mmol/l)	Mg <sup>2+</sup> (mmol/l)	Creatinine (mmol/l)	BUN (mmol/l)
Control	108±2.59 <sup>b</sup>	4.52±0.29 <sup>b</sup>	69.20±1.99 <sup>b</sup>	22.54±1.17 <sup>b</sup>	99.59±3.94 <sup>b</sup>	1.19±0.09 <sup>b</sup>
B.N	119.81±3.99 <sup>bx</sup>	4.48±0.14 <sup>bx</sup>	73.27±2.09 <sup>bx</sup>	16.20±0.72 <sup>bx</sup>	83.73±2.07 <sup>bx</sup>	1.21±0.13 <sup>bx</sup>
A.N	127.32±2.01 <sup>bx</sup>	3.86±0.11 <sup>bx</sup>	66.30±2.186 <sup>bx</sup>	14.34±0.85 <sup>bx</sup>	81.64±2.47 <sup>bx</sup>	1.21±0.03 <sup>bx</sup>
S.S	122.26±1.01 <sup>bx</sup>	4.22±0.07 <sup>bx</sup>	73.00±2.29 <sup>bx</sup>	18.41±1.41 <sup>bx</sup>	90.51±1.46 <sup>bx</sup>	1.07±0.05 <sup>bx</sup>
S.S+A	134.26±1.69 <sup>bx</sup>	3.44±0.20 <sup>bx</sup>	83.12±2.44 <sup>bx</sup>	21.89±0.80 <sup>bx</sup>	67.69±1.96 <sup>bx</sup>	1.64±0.09 <sup>bx</sup>
B+S+A	135.73±2.18 <sup>bx</sup>	2.27±0.38 <sup>bx</sup>	84.24±4.38 <sup>bx</sup>	18.68±0.28 <sup>bx</sup>	52.27±1.14 <sup>bx</sup>	1.67±0.44 <sup>bx</sup>

BN- Brazil nut, A- Almond nut, S.S- Sesame seeds; Data are reported as mean ± Standard Deviation. n= 5. Values with similar superscripts (<sup>bx</sup>) indicate significantly different at  $p \leq 0.05$  from the control (<sup>b</sup>)

**Table 7. Effect of diet formulated from sesame seed, almond and Brazil nuts on the plasma haematological parameters in wistar albino rats**

Group	PCV (%)	Hb (g/dl)	WBC (X10 <sup>3</sup> /mm <sup>3</sup> )	RBC (X10 <sup>6</sup> /mm <sup>3</sup> )	Platelet (X10 <sup>3</sup> /ml)	MCV (X10 <sup>-7</sup> fl)
Control	37.00±2.00 <sup>a</sup>	11.35±0.62 <sup>a</sup>	6.46±0.32 <sup>a</sup>	6.75±0.10 <sup>a</sup>	169.80±8.01 <sup>a</sup>	5.48±0.27 <sup>a</sup>
B.N	48.20±1.79 <sup>ab</sup>	15.02±0.65 <sup>ab</sup>	7.06±0.44 <sup>ab</sup>	7.28±0.23 <sup>ab</sup>	195.00±5.79 <sup>ab</sup>	6.63±0.43 <sup>ab</sup>
A.N	45.20±3.11 <sup>ab</sup>	13.98±1.12 <sup>ab</sup>	8.52±0.25 <sup>ab</sup>	7.04±0.09 <sup>ab</sup>	233.80±18.27 <sup>ab</sup>	6.42±0.39 <sup>ab</sup>
S.S	45.20±3.83 <sup>ab</sup>	13.98±1.31 <sup>ab</sup>	7.62±0.33 <sup>ab</sup>	7.65±0.22 <sup>ab</sup>	137.65±0.22 <sup>ab</sup>	5.89±0.57 <sup>ab</sup>
S.S+A	45.80±1.92 <sup>ab</sup>	14.16±0.73 <sup>ab</sup>	10.36±0.46 <sup>ab</sup>	7.80±0.39 <sup>ab</sup>	276.40±9.96 <sup>ab</sup>	5.88±0.49 <sup>ab</sup>
S.S+A	45.80±1.92 <sup>ab</sup>	14.16±0.73 <sup>ab</sup>	10.36±0.46 <sup>ab</sup>	7.80±0.39 <sup>ab</sup>	276.40±9.96 <sup>ab</sup>	5.88±0.49 <sup>ab</sup>
B+S+A	43.60±2.88 <sup>ab</sup>	13.43±0.98 <sup>ab</sup>	11.62±0.24 <sup>ab</sup>	8.99±0.18 <sup>ab</sup>	317.80±10.80 <sup>ab</sup>	4.85±0.42 <sup>ab</sup>

BN- Brazil nut, A- Almond nut, S.S- Sesame seeds; Data are reported as mean ± Standard Deviation. n= 5. Values with similar superscripts (<sup>ab</sup>) indicate significantly different at p ≤ 0.05 from the control (<sup>a</sup>)

**Table 8. Effect of diet formulated from sesame seed, almond and Brazil nuts on the plasma concentration of haematological parameters in wistar albino rats**

Group	MCH (X10 <sup>-5</sup> pg)	MCHC (g/dl)	Neutrophils (X10 <sup>3</sup> /mm <sup>3</sup> )	Lymphocytes (X10 <sup>3</sup> /mm <sup>3</sup> )	Eosinophils (X10 <sup>3</sup> /mm <sup>3</sup> )	Monocyte (X10 <sup>3</sup> /mm <sup>3</sup> )	Basophils (X10 <sup>3</sup> /mm <sup>3</sup> )
Control	1.67±0.91 <sup>a</sup>	0.31±0.00 <sup>a</sup>	1.77±0.07 <sup>a</sup>	5.34±0.22 <sup>a</sup>	0.02±0.11 <sup>a</sup>	0.02±0.05 <sup>a</sup>	0.01±0.01 <sup>a</sup>
B.N	2.06±0.14 <sup>ab</sup>	0.41±0.00 <sup>ab</sup>	1.92±0.06 <sup>a</sup>	5.52±0.26 <sup>ab</sup>	0.04±0.01 <sup>ab</sup>	0.08±0.05 <sup>ab</sup>	0.01±0.01 <sup>a</sup>
A.N	2.25±0.15 <sup>ab</sup>	0.44±0.00 <sup>ab</sup>	2.26±0.12 <sup>ab</sup>	6.12±0.30 <sup>ab</sup>	0.03±0.01 <sup>ab</sup>	0.10±0.01 <sup>ab</sup>	0.01±0.01 <sup>a</sup>
S.S	2.48±0.14 <sup>ab</sup>	0.41±0.00 <sup>ab</sup>	2.04±0.09 <sup>ab</sup>	5.90±0.30 <sup>ab</sup>	0.05±0.01 <sup>ab</sup>	0.18±0.01 <sup>ab</sup>	0.01±0.01 <sup>a</sup>
B.N+A	2.78±0.14 <sup>ab</sup>	0.66±0.00 <sup>ab</sup>	2.39±0.11 <sup>ab</sup>	7.08±0.22 <sup>ab</sup>	0.05±0.02 <sup>ab</sup>	0.20±0.01 <sup>ab</sup>	0.01±0.01 <sup>a</sup>
B.+S+A	1.92±0.18 <sup>ab</sup>	0.61±0.00 <sup>ab</sup>	2.89±0.07 <sup>ab</sup>	7.64±0.32 <sup>ab</sup>	0.06±0.01 <sup>ab</sup>	0.23±0.01 <sup>ab</sup>	0.02±0.01 <sup>a</sup>

BN- Brazil nut, A- Almond nut, S.S- Sesame seeds; Data are reported as mean ± Standard Deviation. n= 5. Values with similar superscripts (<sup>ab</sup>) indicate significantly different at p ≤ 0.05 from the control (<sup>a</sup>)

**Table 9. Effects of the diet formulated from sesame seeds, almond and Brazil nuts on the body weight, liver and kidney of wistar albino rats**

Group	Week 1 (g)	Week 2 (g)	Week 3 (g)	Week 4 (g)	Liver weight (g)	Kidney weight (g)
Control	34.26±10.79 <sup>a</sup>	36.20±10.38 <sup>a</sup>	40.46±11.87 <sup>a</sup>	77.66±20.69 <sup>a</sup>	3.28±0.78 <sup>a</sup>	0.70±0.71 <sup>b</sup>
B.N	31.12±6.17 <sup>a</sup>	35.74±6.03 <sup>ab</sup>	39.20±8.90 <sup>ab</sup>	84.54±17.24 <sup>ab</sup>	3.90±0.90	0.68±0.19
A.N	33.22±5.01 <sup>a</sup>	38.22±5.40 <sup>a</sup>	48.32±7.21 <sup>ab</sup>	89.52±14.84 <sup>ab</sup>	4.42±0.65	0.80±0.19
S.S	28.48±9.93 <sup>a</sup>	38.08±4.80 <sup>ab</sup>	45.92±11.83 <sup>ab</sup>	66.30±14.01 <sup>ab</sup>	2.80±0.52	0.42±0.16
S.S.+A	29.42±3.15 <sup>a</sup>	38.86±4.03 <sup>ab</sup>	45.92±11.83 <sup>ab</sup>	66.30±14.01 <sup>ab</sup>	1.62±0.49	0.38±0.13
B.N+A	33.06±2.19 <sup>a</sup>	42.60±5.48 <sup>ab</sup>	40.80±6.37 <sup>ab</sup>	74.78±8.87 <sup>ab</sup>	3.02±0.69 <sup>a</sup>	0.66±0.11 <sup>b</sup>
B+S+A	36.94±7.85 <sup>ab</sup>	47.62±8.38 <sup>ab</sup>	40.50±11.44 <sup>ab</sup>	76.66±17.56 <sup>ab</sup>	3.50±0.54	0.76±0.05

BN- Brazil nut, A- Almond nut, S.S- Sesame seeds; Data are reported as mean ± Standard Deviation. n= 5. Values with similar superscripts (<sup>ab</sup>) indicate significantly different at p ≤ 0.05 from the control (<sup>a</sup>)



### 3.9 Effects of Diets Formulated from Sesame Seeds, Almond and Brazil Nuts on the Bodyweight of Wistar Albino Rats

Table 9 shows the effect of diets formulated from sesame seeds, almond and Brazil nuts on the bodyweight of Wistar albino rats from week 1-4. The bodyweight of the rats fed with the formulated diet for Brazil nuts only, sesame seeds only, almond, sesame +almond, and Brazil +almond were not significantly different from the control values for week 1 except for those fed with diet from Brazil + sesame + almond. However, rats fed with almond, sesame seeds, sesame +almond, Brazil +almond, and Brazil +sesame+ almond showed a significantly increased body weight for week 2 and similar trends occurred for week 3 and 4. Similarly, the weight of the livers and kidneys of rats fed with Brazil nuts only and sesame seeds only were significantly different from the control values while those fed with almond were not different from the control values. More so, rats fed with sesame +almond, Brazil +almond, and Brazil +sesame + almond gained weights in livers and kidneys which were significantly different from the control values.

Oilseeds and nuts are vital sources of nutrients including proteins, carbohydrate, and fat which nourishes infants, serve as a high-quality source of to meet nutritional needs of infants and they are very much less expensive [21]. Consumption and utilization of local indigenous edible seeds and nuts especially oilseeds and legumes which are rich in protein [22]. The use of local indigenous food commodities to formulate local and home-based complementary foods is being practised in many developing countries in weaning children and for sustainable livestock production which is highly dependent on the availability of various sources of nutrients that are required for the formulation of animal feed. In this study, analysis for the amino acid composition of almond showed the presence of eighteen (18) amino acids, sesame seeds showed the presence of twenty (20) amino acids while that of Brazil nuts also indicated the presence of twenty (20) amino acids as indicated in Tables 1, 2 and 3. The amino acid composition in sesame seeds, almond and Brazil nuts which gave a total of fifty-six amino acid showed that these seeds and nuts are good sources of nutrients and nourishment. These data agree with the report of Fernandez, et al. [20] on amino acids, fatty acids and trace

element composition of five weaning food in Jos, Plateau State.

The proximate composition of foods includes which include; moisture, ash, lipid, protein and carbohydrate contents which are estimated in vegetables, seeds, and nuts and are a good approximation of the contents of packaged comestible goods and services as a cost-effective and easy verification of nutritional panels [23]. In this study, the proximate composition of sesame seeds, almond, and Brazil nuts indicated moisture content, crude protein, crude lipid, crude fibre, and carbohydrate. The high crude lipid, protein, fibre and carbohydrate composition observed is reflective of high emerging containing the capacity of sesame seeds, almond, and Brazil nuts and could serve as sources of nourishment during weaning in infants. This result is in agreement with the report of Francisca, et al. [24] on the foundation and nutritional evaluation of weaning food processed from cooking banana, supplementation with cowpea and peanuts.

In developing countries, one of the biggest problems affecting children especially infants is the lack of adequate protein intake in terms of quality and quantity during weaning. Cereals are generally low in protein, supplementation of cereals with a locally available legume that is high in protein increase the protein content of cereal-legume blends. Several traditional fermentations have been upgraded to high technology production systems and this has undoubtedly improved the general well-being of weaning infants [25]. Efforts have therefore been made to improve on the nutritional quality of the traditional weaning foods and these include the incorporation of protein-rich legumes, fermentation of the cereal component and incorporation of malt in the weaning foods [26]. The general acceptability of weaning foods by infants is greatly influenced by the functionality of the ingredients used for their production. Functional properties such as gelation, water holding capacity, viscosity, and pasting properties are very important for ensuring the appropriateness of the diet to the growing child [27]. In this research, the result of the functional properties of sesame seeds, almond and Brazil nuts WAC, OAC and bulk density were similar to the values reported by Mohammed, et al. [27] on functional properties of weaning food blends from selected sorghum *Sorghum bicolor* varieties and soybean (Glycine max).

Complementary feeding is the provision of foods or fluids rich in minerals to infants in addition to breast milk [28]. In this study, the analysis for the mineral composition of sesame seeds, almond and Brazil nuts showed the presence of Ca, K, Mg, Zn, Na, and Mn. The mineral composition of sesame seeds, Brazil and almond nuts as shown in this study is reflective that diet formulated from these seeds and nuts could help in proper bone formation and body function.

The liver as the main visceral organ metabolizes dietary nutrients from the portal vein and thus impacts nutrient-derived signalling in the central nervous system [29]. Many diets including those that are formulated may impact negatively on liver metabolism and to this end, it is imperative to investigate the impact of diets of various kinds on liver metabolism [30]. In this study, diet formulated from sesame seeds only, almond nuts only and Brazil nuts significantly decreased ALT, AST, ALP, and GGT activities at  $p \leq 0.05$  when compared to the control values and most significant decreased were observed with rats fed with diet formulated from sesame+ almond, Brazil + almond, and Brazil +sesame +almond. The significantly decreased plasma ALT, AST, ALP and GGT activities observed in the rats fed with formulated diet from sesame seeds, almond and Brazil nuts were indicative of the capacity of the diet in the enhancement of liver metabolism. This result agrees with the report of Ighosotu and Tonukari [31] on the effect of high diet on food intake and liver metabolism during pregnancy, lactation and after weaning in mice. More so, a significantly increased plasma total protein and albumin concentrations were observed following feeding with formulated diets from sesame seeds, almond and Brazil nuts when compared to the control values. This is suggestive that sesame seeds, almond and Brazil nuts were rich in protein, enhancing the functional capacity of the liver in the metabolism of bilirubin due to its decreasing concentrations observed in the rats fed with the diet. These results are also in line with the report of Ighosotu and Tonukari [31] stated above.

There is a connection between dietary fat especially edible oil and health [32]. In this study, the plasma total cholesterol and triglyceride concentrations of rats fed with the formulated diet was significantly increased when compared to the control values which are reflective that the diet is rich in cholesterol and triglycerides. However, a significantly increased and

decreased plasma concentrations of HDL-cholesterol and LDL-cholesterol were observed in the rats fed with diets from the seeds and nuts when compared to the control. The significantly increased HDL-cholesterol and decreased LDL-cholesterol observed the following feeding with the formulated diet is suggestive that diet formulated from sesame seeds, almond and Brazil nuts were rich in good cholesterol which could be responsible for the decreased LDL concentration. This data agrees with the report of Friedman [33] on the serum profile of rats fed with palm oil and kernel oil-containing diet.

A significantly increased plasma  $\text{Na}^+$ ,  $\text{Mg}^{2+}$  and  $\text{Cl}^-$  concentrations were observed in the rats fed with sesame seeds, almond, and Brazil nuts while creatinine and urea concentration was significantly decreased. The significantly increased plasma  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ , and  $\text{Cl}^-$  observed suggest that the diets enhanced the secretion and release of intestinal and renal electrolytes which are required for the enhancement of renal function [34].

Several studies on haematological parameters indicated that different diets could exert diverse effects on haematological indices of animals [35,36]. In this study, a significantly increased ( $p \leq 0.05$ ) plasma PCV, Hb, WBC, RBC, and platelet count were observed following feeding with diets formulated from sesame seeds only, almond nuts only and Brazil nuts only when compared to the control values and more improved levels occurred in rats fed with sesame +almond, Brazil +almond, and Brazil +sesame +almond as and similar trends occurred in the plasma MCH, MCHC, lymphocytes, basophils, neutrophils, eosinophils, and monocytes. This suggests that the diets were not toxic to the rats and that they enhanced haematopoiesis in the rats. These data concur with the report of Margaret, et al. [37] on the assessment of the haematological indices of albino rats fed diets supplemented with jackfruit bulb, seed or a blend of bulbs, and seeds.

Protein is a source of essential amino acids needed mostly for tissue synthesis, maintenance and repair, and seeds, vegetables and nuts are good sources of proteins and minerals [38]. In this study, only rats fed with Brazil +sesame +almond diet have significantly increased body weight for week 1 when compared with the control values. However, significant increases in

body weights were observed for week 2-4 following feeding with the different formulated diet across all the groups when compared with the control values. The significantly increased body, liver and kidney weight noticed in the rats fed with the diets from week 2-4 showed that diets formulated from sesame seeds, almond and Brazil nuts are rich in lipid and essential protein capable of fluid production, cell growth, hormone, and enzyme synthesis. These results are in line with the publication of Kalyani, et al. [39] on food consumption patterns and the weight gain of albino rats fed with irradiated and non-irradiated diets.

#### 4. CONCLUSION

The use of local indigenous food commodities to formulate local and home-based complementary foods are being practised in many developing countries in weaning. This study provides evidence that an instant weaning diet which is not expensive can be formulated from sesame seeds, almond and Brazil nuts. The significant improvements in the plasma enzyme activities, liver and kidney biomarkers, lipid profile, haematological parameters and increases in body and organ weight were suggestive that diets formulated from sesame seeds, almond, and Brazil nuts are good sources of instant weaning food for infants. Results obtained from rats feed with almond and Brazil nuts were more significant when compared with sesame seeds.

#### ETHICAL APPROVAL

As per international standard guideline was written ethical approval has been collected and preserved by the author(s).

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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