

1 Original Research Article

2 **NUTRITIONAL QUALITY OF WEANING FOODS**
3 **FORMULATED FROM MAIZE GRUEL 'OGI' AND**
4 **CRAYFISH USING COMBINED TRADITIONAL**
5 **PROCESSING TECHNOLOGY.**

6
7
8
9 **ABSTRACT**
10

Aims: To investigate the nutritional quality of weaning foods produced from maize gruel 'ogi' and crayfish using combined traditional processing techniques (germination, fermentation and toasting).

Study design: Randomized block design

Place and Duration of Study: Department of Food Science and Technology, Federal University of Technology, Akure, Ondo State, Nigeria, between January 2013 and November 2014.

Methodology: Maize grains were germinated at room temperature for three days after which they were fermented for 24 h. the maize grains were milled into slurry and divided into two portions. The first portion was oven-dried at 50°C and milled into flour while the second portion was toasted at 80°C and milled into flour. The two flours were separately mixed with crayfish powder to obtain oven-dried crayfish-ogi blend and toasted crayfish-ogi blend. The microbiological quality of the blends was determined. The nutritional qualities of the crayfish enriched ogi blends were assessed biologically using animal feeding experiment to determine the growth rate, feed intake, protein quality parameters and haematological properties. A commercial weaning food (Crelac) and traditional weaning food, ordinary ogi (Maize gruel), were used as control diets

Results: The total mesophilic bacteria count of the ogi blends ranged from 1.2 to 2.5x 10³ cfu/g. Mold (1.0 x 10³) were found in both oven-dried and toasted crayfish enriched ogi blends. Yeasts were found only in oven-dried enriched ogi blend (1.0 x 10³cfu/g). Coliform, staphylococcus and salmonella were not detected in all the formulated diets. The growth rate of animals fed with crayfish enriched-ogi blends were lower than those fed with the cerelac, but higher than those fed with ordinary ogi. The protein efficiency ratio of animals fed with crayfish enriched ogi blends was was similar (p= 0.05) to those fed with cerelac diet. The net protein ratio, True digestibility, Biological value and Net protein utilization of animals fed with crayfish enriched ogi diet were significantly lower (p<0.05) than those fed with cerelac diet. The weight of the heart, liver, spleen and kidney of animals fed with crayfish-enriched ogi blends were significantly higher (p=0.05) than those fed with ordinary ogi but similar to the rats fed with casein and cerelac diets. The haematological variables of animals fed with crayfish enriched ogi diets, commercial weaning food (cerelac) and casein diet were not significantly (p>0.05) influenced by the dietary treatment .

Conclusion: Crayfish enriched ogi has potential as a functional weaning food with adaptable production technology (toasting) especially among rural dwellers.

11
12 *Keywords: Quality evaluation, crayfish, enrichment, Ogi, germination, fermentation, toasting*
13

14 1. INTRODUCTION

15 When breast milk is no longer enough to meet the nutritional needs of the infant at
16 the age of four or six months and above, complementary foods (i.e., traditional or
17 commercial weaning foods) should be added to the diet of the child. Several commercial
18 weaning foods are marketed in Nigeria, but they are too expensive for people of low socio-
19 economic status, especially those in the rural areas [1]. The most popular traditional weaning
20 food in Nigeria which is fermented maize gruel known as 'ogi' has been implicated in the
21 etiology of protein – energy malnutrition (PEM) in children during weaning period due to the
22 low nutritive value characterized by low protein, low energy density and high bulk [2]. There
23 is therefore a need to develop weaning foods with adequate protein that will promote growth
24 in children from low cost local food sources using methods that are suitable at village level or
25 at home.

26 Food processing techniques such as roasting, germination, milling, cooking, drying,
27 fermentation and extrusion have the potential to enhance the nutrient bioavailability, nutrient
28 density, food safety, storage stability, palatability, and convenience of supplementary foods
29 suitable for infant mixtures [3]. Germination, fermentation and toasting of cereals are
30 affordable and widely practiced processing techniques in Africa [4]. Fermentation enhances
31 the nutrient of foods through biosynthesis and bioavailability of vitamins, essential amino
32 acids, reducing the antinutrients and improving the protein quality and fibre digestibility [5, 6].
33 Germination unlocks many nutrients which are in bound forms in the food and thereby
34 increases nutrient bio-availability, energy density and acceptability of the food [7, 8].
35 Toasting reduces anti-nutrients, improves the taste and nutrient quality of the food product
36 and lowers the moisture content of such food product thereby increasing its shelf life [9]. An
37 integrated approach that combines a variety of the traditional food processing techniques in
38 the preparation of weaning food, including the addition of small amount of animal-source
39 foods has been reported to be the best strategy to improve the nutrient content and
40 bioavailability of micro- nutrients in plant-based diets in resource-poor settings [10]. The
41 combination of two or more food processing techniques is more effective in removing
42 antinutritional factors in cereal and thereby producing high nutrient dense weaning food [11]

43 Crayfish which is classified as an animal polypeptide is a freshwater crustacean resembling
44 small lobster and it is commonly found in Nigerian coastal water. Crayfish is relatively cheap,
45 affordable and readily available throughout the year. A review of nutritional value of crayfish
46 showed that it is a good source of protein (36 -45%) with a superior biological value, true
47 digestibility, net protein utilization, high content of essential amino acid, and protein
48 efficiency is favourable compared to casein [12,13]. It is very low in carbohydrate but rich in
49 vitamin D, A and mineral elements such as calcium, potassium, copper, zinc and iodine, [14,
50 15].

51 In the effort to cube problem of protein-energy malnutrition (PEM) among the infants in
52 Nigeria, a number of weaning foods have been formulated from locally available food
53 materials [2,16,17,18]. Most of these formulated complementary foods are still not
54 accessible to many nursing mothers, as a result of the high cost of food materials and
55 production processes [19]. The present study is therefore aimed at producing weaning foods
56 from ogi flour and crayfish flour mixes using a combination of traditional processing
57 techniques and evaluates the microbiological and nutritional quality of the formulated diets.

2. MATERIALS AND METHODS

2.1 Materials

White maize (*Zea mays*), white crayfish (*euastacus spp*) and commercial weaning food (cerelac) were purchased from Oba market in Akure Ondo state Nigeria.

2.2 Preparation of crayfish enriched ogi blends

The maize grains were soaked overnight after which they were germinated for 3 days. The germinated grains were dried at 60 °C for 14 hours and the radicles were removed. The germinated grains were steeped in water for 24 hours for fermentation to take place. The germinated - fermented grains were wet-milled, sieved and the slurry obtained was allowed to settle after which it was dewatered using muslin cloth. Ogi cake obtained was pulverized, sieved and divided into two portions. The first portion was oven dried at 50 °C for 24 hours while the second portion was toasted at 70 °C to 80°C using open cast iron. The crayfish were cleaned and milled into flour. The two ogi flours were separately mixed with crayfish powder in ratio of 80:15 respectively to obtain oven-dried crayfish-ogi blend and toasted crayfish-ogi blend. The choice of these mixing ratios was based on the target protein which is 18%. This mixing ratio was determined by using Quarto pro 8 software programme.

2.3 Microbiological analysis

The formulated weaning diets were examined microbiologically using the procedure of Olutiola *et al.*, [20] after serial dilution. The total microbial load was determined using nutrient agar in a plate count while molds and yeasts were examined using potato dextro agar. Staphylococcus aureus, coliform and salmonella were determined using manitol salt agar, macconkey agar and deoxycholate citrate agar respectively.

2.4 Experimental Diets

The experimental diets which consist of formulated diets (crayfish enriched-ogi diets), commercial weaning food (cerelac) and casein were prepared at 10% protein level (iso-nitrogenous diets). A Basal diet (ordinary ogi) was also prepared. Composition of experimental diets is shown in Table 1. Diet 1 is the basal diet (ordinary ogi), diet 2 is the control (casein diet) while diets 3, 4 and 5 are cerelac, oven dried crayfish enriched ogi and toasted crayfish enriched ogi respectively.

Table 1: Composition of experimental diet (g/100g)

Ingredients	N-free diet	Casein diet	Cerelac diet	Oven-dried enriched ogi diet	Toasted enriched ogi diet
Ordinary ogi	71.80	60.30	5.63	16.24	16.24
Casein	-	11.50	-	-	-
Cerelac	-	-	66.67	-	-
Oven-dried enriched ogi	-	-	-	55.56	-

Toasted enriched ogi	-	-	-	-	55.56
Glucose	5.00	5.00	5.00	5.00	5.00
Sucrose	10.00	10.00	10.00	10.00	10.00
Non-nutritive cellulose	5.00	5.00	5.00	5.00	5.00
Vegetable oil	5.00	5.00	5.00	5.00	5.00
Mineral mixture	2.00	2.00	2.00	2.00	2.00
Vitamin mixture	1.00	1.00	1.00	1.00	1.00
NaCl	0.2	0.2	0.2	0.2	0.2
Total	100.00	100.00	100.00	100.00	100.00

90

91 2.5 Animal Experiment

92 In this study, thirty weanling albino rats of the Wistar strain weighing between 30 – 65g at the
93 beginning of experiment were obtained from the Department of Biochemistry, University of
94 Ilorin, Kwara state, Nigeria. The rats were weighed and divided into five groups. They were
95 randomly distributed in metabolic cages and fed on normal (pellet) diets for a period of 7
96 days for proper acclimatisation to the environment before commencement of the
97 experiments. After the acclimatisation period, the animals were then re-weighed and
98 grouped into five groups of six rats each per group such that the differences in their mean
99 weights were $\pm 2g$. Two groups of animals were administered with the formulated diets
100 (oven-dried crayfish enriched ogi and toasted crayfish enriched ogi). The remaining three
101 groups of animals were administered with cerelac (a commercial weaning food), ordinary ogi
102 and casein. Food and water were provided *ad libitum* to the rats for 28days. During this
103 period dietary intake per day and weight of the animals were recorded. Five days before the
104 end of feeding experiment, the faeces and urine were collected separately from each rat and
105 pooled together at the end of the experiment. Pooled samples of faeces were dried in an
106 oven at 80°C for 12 hours, cooled and weighed. A few drops of dilute sulphuric acid
107 (H₂SO₄) were added to the urine, which was kept under frozen conditions. Nitrogen in the
108 urine and faeces was determined by micro-Kjeldahl method [21]. The biological value (BV),
109 true digestibility (TD), net protein utilization (NPU), protein efficiency ratio (PER), feed
110 efficiency ratio (FER) and net protein ratio (NPR) were calculated.

111 2.6 Haematological Evaluations

112 At the end of the experiment, all the rats were starved for 3 hours and weighed after which
113 each rat was anaesthetised and sacrificed. Blood samples from each rat were collected into
114 sample bottles containing a few milligram of EDTA prior to haematological analysis. The
115 packed cell volume (PCV) was estimated by spinning about 75 μ l of each blood sample in
116 heparinised capillary tubes in a haematocrit microcentrifuge for 5 minutes, and the total red
117 blood cell (RBC) and white blood cell (WBC) counts were determined. The haemoglobin
118 concentration (Hb) was estimated using the cyano-methaemoglobin concentration method,
119 while the lymphocyte, neutrophil, monocyte, basophil and eosinophil were determined [22,

120 23]. The heart, lungs, spleen, kidneys and liver were removed, blotted free of blood and
121 weighed [22]. The values were subsequently expressed in g/kg of body weight

122 2.7 Statistical analysis

123 All analyses were carried out in triplicates. Means were tested for differences using Analysis
124 of Variance (ANOVA) using Statistical Analysis System Software (SAS version 9.2, SAS
125 institute, Cary, NC). Significant differences between mean values were determined by
126 Duncan's Multiple Range Test and accepted at $P \leq 0.05$. Data are reported as mean \pm
127 standard deviation from the mean.

128 3. RESULTS AND DISCUSSION

129 3.1 Microbial analysis

130 The result of *coliform*, *staphylococcus*, *salmonella*, mould, yeast and total viable count of the
131 formulated diets are shown in Table 2. *Coliform*, *Staphylococcus* and *Salmonella* spp were
132 absent in the formulated diets. This shows that the food will be fit for human consumption.
133 The total viable count in all the formulated diets are below the maximum level of 1.0×10^5
134 recommend by PAG [24]. However, all the formulated weaning diets would require cooking
135 before feeding to children during which most of these microorganisms would be destroyed.
136 The reduction in the total viable count of toasted enriched ogi diets may be due to toasting
137 which was done at high temperature. (70-80°C) and might have destroyed all the pathogenic
138 microorganisms.

139

140

141 Table 2: Microbiological quality of enriched ogi (cfu/g)

counts		
Micro-organism	Ovendried	Toasted
Coliform	0	0
Staphylococcus	0	0
Salmonella	0	0
Molds (sfu/g)	1×10^3	1×10^3

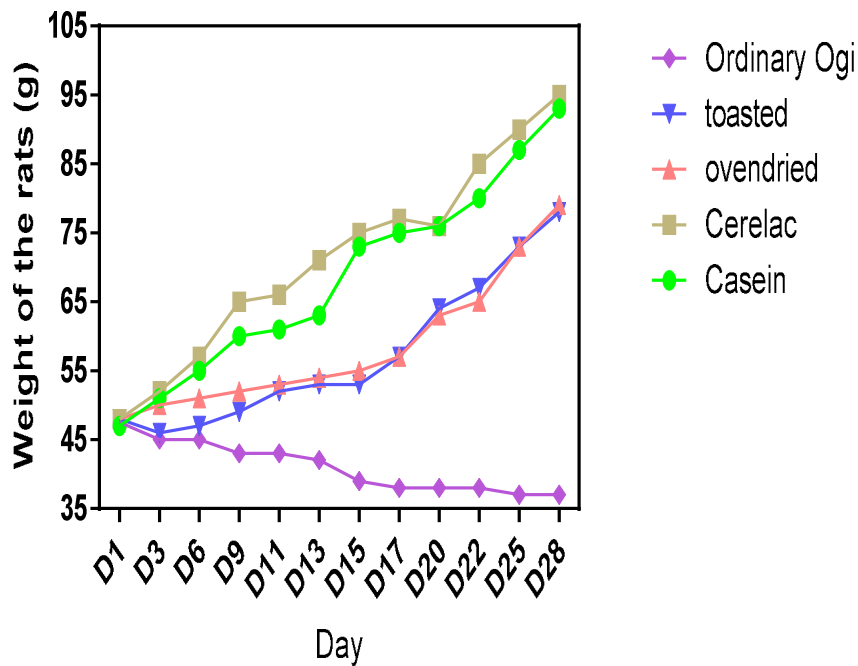
Yeast	1×10^3	0
Total viable count	1.8×10^3	1.2×10^3

142

143

144 3.2 Growth Performance and nutrient utilization of the experimental animals

145 The food intake of rats fed on the formulated diets, cerelac and casein ranged from 148.5g (oven-dried
 146 enriched ogi) to 182.2g (cerelac diet) (Table 3). Food intake of animals fed with casein and cerelac diet was
 147 significantly ($p=0.05$) higher than that of animals fed with oven-dried and toasted enriched ogi. A similar
 148 trend was observed in the protein intake of the experimental animals (Table3). The growth performance and
 149 weight gain /loss of the experimental animals are presented in Figure 1. The weight gain of the experimental
 150 animals ranged from 33.0 g to 46.8 g. It was observed that the weight gains of animals placed on
 151 experimental diets (oven-dried crayfish-ogi and toasted crayfish-ogi) were lower than those of animals fed
 152 with cerelac and casein diets but were higher than those of animal fed with ordinary ogi. Weight gain of
 153 animals fed with oven-dried crayfish-ogi was similar to that of animals fed with toasted crayfish-ogi. Weight
 154 gain of animals fed with cerelac and casein diet agreed with their food intake. Similar observation was
 155 reported by Ibironke, [25]. Ibironke et al. [15] reported that the diet formulated from maize flour and crayfish
 156 (10% and 15%) promoted growth more than the milk based commercial diet. Animals fed with ordinary ogi
 157 diet did not show any appreciable growth. This may be due to the fact that the diet lacked adequate nutrient
 158 such as protein with balanced amino acids. This agrees with the previous results that cereals are deficient in
 159 essential amino acid, such as lysine and tryptophan, hence, was not nutritionally adequate to promote
 160 growth [3,8,9].



161

162 D.....1042010 = Days of feeding

163 Fig. 1: Growth rate of rats fed with formulated weaning diets, cerelac and casein

164 Table 3: Nutrient utilization of rats fed with enriched ogi, casein and Cerelac

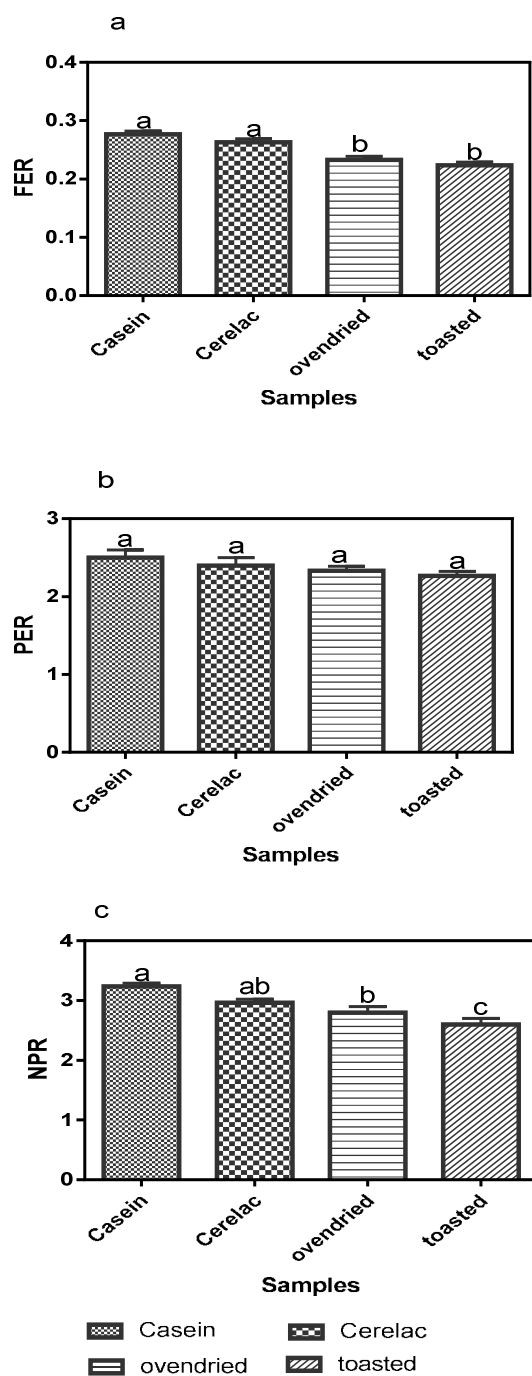
Parameters	casein	cerelac	Oven-dried enriched ogi	Toasted enriched ogi
Food intake (g)	164.6 ^a	182.2 ^a	148.5 ^b	149.6 ^b
Protein intake (g)	17.8 ^a	18.5 ^a	14.5 ^b	15.0 ^b
Nitrogen consumed	0.61	0.62	0.47	0.56
Feecal nitrogen	0.15	0.20	0.20	0.23
Urinary nitrogen	0.09	0.13	0.14	0.17
Nitrogen retained	0.37	0.28	0.13	0.16

165 Values followed by different superscript on the same row are significantly different (p=0.5)

166 The results of Feed efficiency ratio (FER), protein efficiency ratio (PER) and net protein ratio (NPR) of the
 167 experimental animals are shown in Figure 2. The feed efficiency ratio (FER) of different diets varied from
 168 0.22g (toasted enriched ogi diet) to 0.26g (casein diet). The FER of rats fed with casein and cerelac were
 169 not significantly different (P=0.05) but were higher than those of rats fed with toasted crayfish enriched ogi
 170 and oven-dried crayfish enriched ogi diets. The corrected PERs of the different diets varied from 2.3 (toasted
 171 crayfish enriched ogi) to 2.5 (Casein diet). The corrected PERs of the formulated diets were similar to those
 172 of cerelac and casein diets. The PAG (Protein Advisory Group) and U.S. Department of Agriculture
 173 guidelines recommend a PER of not less than 2.1 and preferably greater than 2.3 for weaning food and
 174 corn-based blends [18,26,27]. The net protein ratio (NPR) of the diets ranged from 2.6 (toasted enriched ogi)

175 to 3.25 (Casein diets). NPR is a more accurate measure of protein quality than PER as it allows for the
176 evaluation of maintenance requirement and results are independent of feed intake. The NPR of the
177 formulated diets was lower than those of casein and cerelac diets. Similar report was obtained by Fashakin,
178 [28].

179

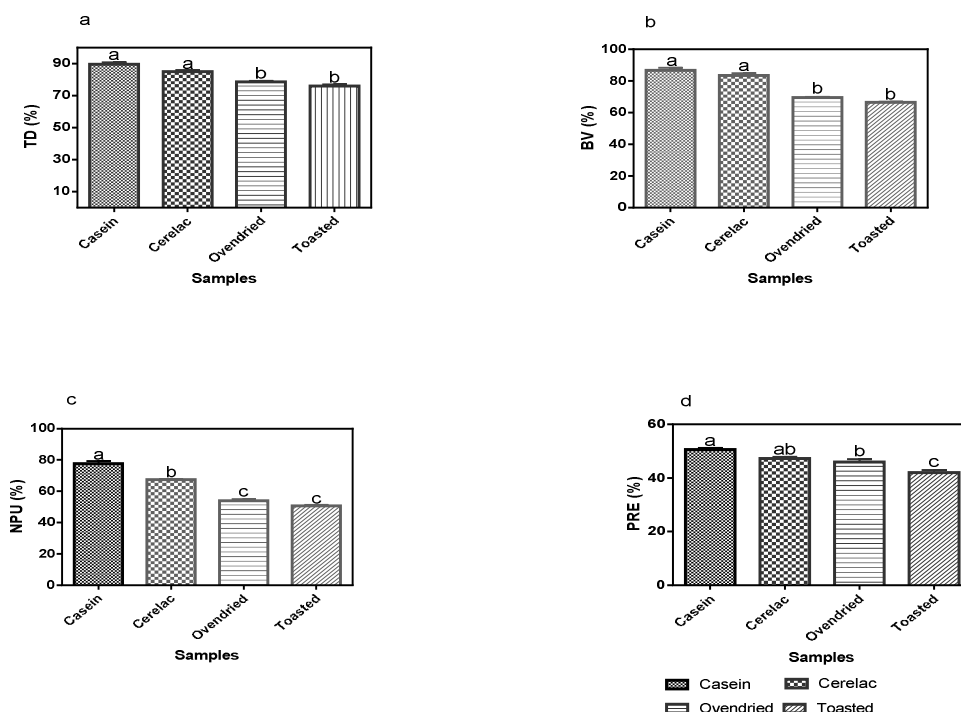


180

181 Fig. 2: (a) The Feed Efficiency Ratio (FER), (b) Protein Efficiency Ratio (PER) and (c) Net Protein Ratio
182 (NPR) of rats fed on different weaning diets and casein

183 The results of true digestibility (TD), biological value (BV), net protein utilization (NPU) and protein retention
184 efficiency (PRE) are illustrated in (Fig 3). TD, BV, NPU and PRE ranged from 76.0 to 89.8%, 66.5 to 87.6%,

185 50.5 to 77.4% and 42 to 51 respectively. The TD, BV and NPU of casein and cerelac were higher ($p \leq 0.05$)
 186 than those of oven-dried *and* toasted crayfish enriched *ogi*. The results obtained in the present study are
 187 similar to those observed by Obizoba [29], who reported BV values of 67.6 to 75.9% and NPU values of 51.8
 188 to 62.3% for the weaning food prepared from malted corn plus crayfish. The lower values of TD, BV and
 189 NPU in the toasted diet may be due to roasting as it affects the availability of some amino acids. Similar
 190 report was obtained by Dahiya and Kapoor, [9] who showed that PER, TD, BV and NPU decreased on
 191 roasting. The effect of roasting on availability of amino acid can be minimized by roasting at a reduced
 192 temperature. Since protein retention efficiency (PRE) was obtained by multiplying NPR by 16, the trend of
 193 the result obtained for PRE is similar to that of NPR (Fig. 2.).



194

195 Fig. 3: (a) The True Digestibility (TD), (b) Biological Value (BV), (c) Net protein Utilization (NPU) and (d)
 196 Protein Retention Efficiency of rats fed with different weaning diets and casein

197 3.3 Organ weights and haematological parameters of animals fed with cerelac, casein, 198 formulated diets and ordinary *ogi*

199 The weight of some vital organs of animals fed with cerelac, casein, formulated diets and ordinary *ogi* are
 200 shown in Table 4. The heart weight, the liver weight, the spleen weight and kidney weight ranged from 0.20
 201 to 0.37g, 2.19 to 4.4g, 0.13 to 0.42 g and 0.35 to 0.78g respectively. The weights of the heart, the kidney, the
 202 spleen and liver of animals fed with oven dried and toasted crayfish enriched *ogi* compared favorably with
 203 those of standard diet (Casein and Cerelac). This indicates that the formulated diets may not result in
 204 abnormal development of the vital organs.

205 The results of haematological parameters of animals fed with cerelac, casein, formulated diets and ordinary
 206 *ogi* are shown in Table 5. The blood indices varied: packed cell volume (PCV) 30.25 to 33.0 %, haemoglobin

concentration (Hb) 10.03 to 11.28%, red blood cell (RBC) 64.45 to 73.08 x10⁵, white blood cell (WBC) 52.0 to 101.5 x 10⁵, erythrocyte sedimentation rate 1.23 to 1.65, lymphocyte 50.18 to 53.15%, basophil 2.0 to 11.25%, neutrophil 30.5 to 37.35% and monocytes 7.75 to 10.0%. PCV measures the ratio of the volume occupied by red blood cell to the volume of whole blood cell. It is a convenient and rapid measure of the degree of anaemia [18]. Low PCV, Hb and serum protein have been associated with protein deficiency [25]. The PCV, Hb and RBC of rats fed with basal diet were lower than those fed with casein, cerelac and formulated diets. Similar results were reported by Osundahunsi and Aworh [30]. The values obtained for PCV, RBC, WBC and Hb of the rats fed with formulated diets were similar to those fed with casein and cerelac. The results show the adequacy of the formulated diets in blood formation. This suggests that the feeding of formulated diets will support haematopoietic activities of the body.

Table 4: Organ weights (g) of rats fed with crayfish enriched-ogi, casein, cerelac and ordinary 'ogi'

Dietary group	Heart (g)	liver (g)	Spleen (g)	Kidney (g)
Cerelac	0.28 ^b	4.02 ^{ab}	0.31 ^{ab}	0.72 ^{ab}
Casein	0.37 ^a	4.49 ^a	0.42 ^a	0.78 ^a
Oven-dried	0.29 ^b	3.79 ^b	0.29 ^b	0.55 ^{ab}
Enriched 'ogi'				
Toasted	0.31 ^{ab}	3.80 ^b	0.29 ^b	0.53 ^{ab}
Enriched 'ogi'				
Ordinary'Ogi'	0.20 ^c	2.19 ^c	0.13 ^c	0.35 ^b
diet				

218

219 Values with different superscript on the same column are significantly different (p=0.5)

220

221

222

223

224

225

226

227

228

229 **Table 5: Haematological parameters of rats fed with formulated diets, casein and cerelac**

Parameters	Toasted enriched ogi	Oven-dried enriched ogi	Casein	Cerelac	Ogi
Packed cell volume (%)	30.50	30.75	32.00	33.00	30.25
Haemaglobin (g/100ml)	10.38	10.25	10.73	11.28	10.03
Red blood cell ($\times 10^5$)	67.55	67.30	70.98	73.08	64.45
White blood cell ($\times 10^2$)	76.63 ^b	52.01 ^c	66.51 ^{bc}	68.01 ^{bc}	101.5 ^a
Erythrocyte sedimentation rate	1.23 ^b	1.35 ^{ab}	1.38 ^{ab}	1.35 ^{ab}	1.65 ^a
Lymphocytes (%)	53.15	51.00	50.18	51.00	54.25
Monocytes (%)	9.00	8.00	7.75	9.00	10.00
Eosinophil (%)	2.50	2.75	2.00	2.00	3.50
Basophil (%)	1.25 ^{ab}	1.75 ^a	1.25 ^{ab}	1.50 ^a	2.01 ^a
Neutrophil (%)	36.75 ^a	30.51 ^b	37.25 ^a	36.01 ^a	31.25 ^b

230

231 **Conclusion**

232 The study showed that the formulated diets promote growth better than ordinary ogi. The haematological
 233 indices and organ weight measurement of the rats fed the formulated diets were better than that of ordinary
 234 ogi and compared favourably with that of rats fed with standard casein and Cerelac. The study indicated that
 235 oven dried enriched ogi and toasted enriched ogi may support growth in children than ordinary ogi which is
 236 currently in use as traditional weaning foods in Nigeria. The implications of these findings are far reaching
 237 since all the components used in the formulation are obtained from local market and toasting is a processing
 238 method that can easily be practiced at home. Adoption of toasted enriched ogi may make the product a
 239 potentially more functional and more accessible weaning food.

240

241 **COMPETING INTERESTS**

242 We declared no competing interests exist

243

244 **ETHICAL APPROVAL**

245 This study was approved by the ethical review committee of the Federal University of
246 Technology, Akure, Ondo State, Nigeria

247

248 **REFERENCES**

- 249 1. Fetuga GO (2001) Nutritional Evaluation of maize-soyabens based weaning food
250 fortified with some local raw food materials. Proceedings of 15th Annual NIFST
251 conference. November, 5-9 . (Lagos).
- 252 2. Fashakin J B, Ogunsola F (1982) The utilization of local foods in the formulation of
253 weaning foods. Journal of Tropical Pediatrics 28:93-96.
- 254 3. Mila'n -Carrillo J, Valde'z-Alarco'n C, Gutie'rrez-Dorado R, Ca'rdenas-Valenzuela
255 OG, Mora-Escobedo R, Garzo'nN-Tiznado JA, & Reyes-Moreno C (2007) Nutritional
256 properties of quality protein Maize and chickpea extruded based weaning food. Plant
257 foods for Human Nutrition. 62:31-37
- 258 4. Ongol MP Niyonzima E, Gisanura I, Vasanthakaalam H (2013) Effect of
259 germination and fermentation on nutrients in maize flour. Pak J Food Sci 23:183-
260 188
- 261 5. Gabriel RAO, Akharaiyi FC (2007) Effect of spontaneous fermentation on the
262 chemical composition of thermally treated jack beans (*Canavalia ensiformis* L.). Int J
263 Biol Chem 1:91-97.
- 264 6. Ijarotimi OS (2012) Influence of germination and fermentation on chemical
265 composition, protein quality and physical properties of wheat flour (*Triticum*
266 *aestivum*). Journal of Cereals and Oil seeds 3:35-47.
- 267 7. Sangronis E, Machado CJ (2007) Influence of germination on nutritional
268 quality of *Phaseous vulgaris* and *Cajanus cajan*. J Sci Tech 40:116-120.
- 269 8. Obizoba IC, Egbuna HI (1992) Effect of germination and fermentation on the
270 nutritional quality of bambara groundnut (*Vaandzenia subterranea* L. Thauars) and
271 its product (milk). Plant Foods for Human Nutrition 42: 13-23.
- 272 9. Dahiya S, Kapoor AC (1993). Nutritional evaluation of home processed weaning
273 foods based on low cost locally available foods. Journal of Food Chemistry 48: 179-
274 182
- 275 10. Hotz C, Gibson RS (2007) Traditional food-processing and preparation practices to
276 enhance the bioavailability of micronutrients in plant-based diets. J. Nutr. 137:
277 1097–1100.
- 278 11. Hassan EE, Babiker AH, Tinay EI (2007) Content of antinutritional factors and HCl-
279 extractability of minerals from white bean (*Phaseolus vulgaris*) cultivars: Influence of
280 soaking and/or cooking. Food Chem100: 362-368
- 281 12. FAO/WHO/UNU (1985, 1998, 2002) Preparation and use of food-based dietary
282 guidelines. Report of a Joint.FAO/WHO Consultation. WHO Technical Report series
283 880. Geneva.
- 284 13. Ibironke SI, Fashakin JB, Badmus OA (2012) "Nutritional evaluation of
285 complementary food developed from plant and animal protein sources." Nutrition &
286 Food Science 42: 111-120.
- 287 14. Zaglol NF, Eltadawy F (2009) Study on chemical quality and nutrition value of fresh
288 water cray fish (*Procambarus clarkii*). Journal of the Arabian Aquaculture Society 4:
289 1-18.

- 290 15. Ibironke SI, Fashakin J B, IGE MM (2014) Nutritional quality of animal polypeptide
291 (Crayfish) formulated into complementary foods. American Journal of Food and
292 Nutrition 2: 39-42.
- 293 16. Ikujenlola VA & Fashakin JB (2005). The physicochemical properties of a
294 complementary diet prepared from vegetable proteins. Journal of Food Agriculture
295 and Environment 3:23-26.
- 296 17. Ijarotimi OS (2006). Evaluation of nutritional quality and sensory attributes of home-
297 made processed complementary diet from locally available food materials (*Sorghum*
298 *bicolor* and *Sphenostylis stenocarpa*). Journal of Food Technology 4:334-338.
- 299 18. Abiose SH, Ikujenlola AV, Abioderin FI (2015). Nutritional Quality Assessment of
300 Complementary Foods Produced from Fermented and Malted Quality Protein Maize
301 Fortified with Soybean Flour. Pol. J. Food Nutr. Sci. 65 (1): 49–56.
- 302 19. Ijarotimi OS (2008). Protein and haematological evaluations of infant formulated
303 from cooking banana fruits (*Musa* spp, ABB genome) and fermented bambara
304 groundnut (*Vigna subterranean* L. Verdc) seeds. Nutrition Research and Practice.
305 2(3):165-170
- 306 20. Olutiola PO, Famurewa O, Sontag HG(1991) An Introduction to General
307 Microbiology. Heidelberger Veringsinstall and Druekeriegmbll Heidelberg
308 Germanybll Heidelberg Germany.
- 309 21. AOAC (1995). Association of official analytical Chemists Official Methods of Analysis
310 16th ed. Washington D.C.
- 311 22. Agbede JO, Aletor VA (2003) Comparative evaluation of weaning foods from
312 *Glyricidia* and *Leucaena* leaf protein concentrates and some commercial brands in
313 Nigeria. Journal of the Science of Food and Agriculture 84: 21- 30.
- 314 23. Lamb G.N (1981) Mammal of Veterinary Laboratory Technique. CIBA-GEIGY.
315 Kenya Pp96-97.
- 316 24. PAG (1995) PAG Ad Hoc working group meeting on clinical evaluation and
317 acceptable nucleic acid-levels of SOP for human composition. Geneva
- 318 25. Ibironke SI (2014) Formulation of Infant Weaning Foods from Vegetable
319 Proteins and Cereal. American Journal of Food Technology 9: 104-110.
- 320 26. PAG, Protein Advisory Group of the United Nations. Guideline no. 8: Protein rich
321 mixtures for use as weaning foods. New York: Food and Agriculture Organization of
322 the United Nations/World Health Organization/United Nations Children's Funds,
323 1971, pp. 1–7.
- 324 27. Annan NT, Plahar WA (195). Development and quality evaluation of a soy fortified
325 Ghanaian weaning food. Food Nutr. Bull. 16(3):263–267.
- 326 28. Fashakin JB (2006). Bioassay and Physico-chemical properties of complementary
327 food prepared from cowpea (*Vigna unguiculata*) and melon seeds as man source of
328 proteins Proceeding of Annual Conf. School of Agric and Agric Technology. Federal
329 University of Technology Akure, Nigeria, 24th May 2006.
- 330 29. Obizoba IC (1988) Nutritive value of malted, dry or wet milled sorghum and corn.
331 cereal Chem 65: 447-449.
- 332 30. Osundahunsi OF, Aworh OC (2003) Nutritional evaluation with emphasis on protein
333 quality of maize – based complementary food enriched with soybean and cowpea
334 tempe. International Journal of Food Science and Technology 38: 809 – 813.