

**Replacement of soyabean meal with toasted Lima beans, (*Phaseolus lunatus*) on growth and nutrient utilization of clariid catfish (*Heterobranchus bidorsalis*) fingerlings**

**Abstract**

An experiment was designed and carried out to assess the survival, growth performance and feed utilization (weight gain, feed conversion ratio, protein efficiency ratio, specific growth rate, feed intake and survival) of *Heterobranchus bidorsalis* fingerlings fed graded levels of toasted Lima beans seed (*Phaseolus lunatus*) meal based diets with the aim of establishing the best inclusion level of Lima beans seed meal. One hundred (100) fingerlings with an initial mean weight of  $2.5 \pm 0.5$ g were allotted at random to five treatments in triplicate groups with each treatment tank having five fingerlings and were fed with the compounded diets. The toasted Lima beans seed meal was used to replace soybean meal in the diets in the following proportions: diet I (0%), diet II (25%), diet III (50%), diet IV (75%) and diet V (100%). At the end of the feeding trials that lasted for 70 days, At the end of the experiment, the Specific growth rate showed no significant difference ( $P > 0.05$ ) among all treatments. Treatment III (3.250) had the highest specific growth rate and Treatment II (2.083) had the lowest value. Relative weight gain was highest in treatment V (20.53) with 100% lima beans and lowest in treatment II (16.95) with 25% lima beans diet inclusion level. Treatment I and IV had no significant difference ( $P > 0.05$ ) but these treatments had a significant difference ( $P < 0.05$ ) with treatments II, III and V also treatment II, III, and V are significantly different ( $P < 0.05$ ) from each other. There was no significant different ( $p > 0.05$ ) in the feed conversion ratio of treatment II, III, IV. There was also no significant difference ( $p > 0.05$ ) in the feed conversion ratio of treatment I and V. Treatment II, III and IV showed a significant difference ( $P < 0.05$ ) in the feed conversion ratio with treatment I and V. FCR was highest in treatment II (1.383) and lowest in treatment IV (1.162). Treatment V had the highest feed intake with value 3.775. Treatment I, II, III, IV and V had no significant difference ( $P > 0.05$ ). Treatment I had the lowest feed intake with value (3.246). Protein efficiency ratio showed no significant differences among all treatment. PER was highest in treatment V (6.346) and lowest in treatment III (5.346). The survival rate was slightly different but not as a result of the feed consumed. Based on the findings in this study, it is therefore recommended that 75% inclusion level of Lima beans meal should be adopted in the formulation of feed for *Heterobranchus bidorsalis*.

**Keywords:** feed utilization, Soyabean, Lima beans, *Phaseolus lunatus* and fish nutrition

**Introduction**

Fish is very important to humans due to its very high quality protein as well as the essential amino acids required by the body for growth and maintenance of muscle tissue. Around the world fish protein makes up complete protein sources in many people's Diets. Proteins of high quality, as found in most fresh fish can be used to maintain an active metabolism (Ayoola, 2011). In 2007, fish accounted for 15.7% of global animal protein intake and 6.1% of all protein consumed (Delgado *et al*, 2003). No doubt, the increasing demand for fish protein can be met when capture fisheries is supplemented by aquaculture. The Nigerian aquaculture industry has grown considerably, contributing to the production of about 20,475 metric tonnes of fish per year in the 1990s to about 85,087 metric tonnes per year in 2007. (Olaniyi, 2005).

Once fish are removed from their natural environment to an artificial one, enough food must be supplied in order to enable them grow. This could be in the form of complete rations, where the

47 artificial diet furnishes all the nutrients required by the fish or supplementary diets, where part of  
 48 the nutritional needs of fish is supplied by the natural food in the aquatic environment (Eyo,  
 49 2003). Nutrient requirement for fish encompasses protein, lipids, carbohydrate, vitamins, and  
 50 minerals, protein being the major constituents in fish diet presumes that knowledge of its  
 51 requirement for fish species is essential for the formulation of a balance diet. The main source of  
 52 protein in fish feed is the animal and plant source origin. Animal proteins are of higher quality  
 53 than those of plant origin. Animal protein includes fishmeal, meat meal bone meal, and blood  
 54 meal of which the best protein source for fish feed is fishmeal. Plant protein materials commonly  
 55 used in fish feed are Soybean meal, groundnut cake and cottonseed cake and the most used and  
 56 well utilized of these is the soya bean. (Eyo, 2003).

57 Soya bean that serves as the most utilizable plant source of protein in feed formulation have  
 58 become expensive and has to be imported to meet local demands in sub Saharan countries like  
 59 Nigeria. (Fagbenro and Adebayo 2005). The fishmeal production has increased the total cost of  
 60 fish production. FAO (2000) reported that the fish used as fishmeal raw materials in year 2000  
 61 accounted for about 30 out of 130 tonnes. Inadequate supply of feedstuff, fishmeal in particular  
 62 which is scarce, expensive and not readily available has hampered aquaculture development  
 63 (Nwanna, 2003; Gabriel *et al.*, 2007), necessitating the need for the development of fish feed  
 64 from high quality yet inexpensive product.

65 Lima bean (*Phaseolus lunatus* L.) is a tropical and subtropical legume cultivated for its edible  
 66 seeds, a plant protein source and according to Aletor and Aladetimi (1989) . It has been classified  
 67 as one of the under-utilized legumes in Nigeria. Studies from Ologhobo (1980) and Aletor and  
 68 Aladetimi (1989) showed a resemblance to a common bean in amino acid profile. This class of  
 69 lesser legume is largely due to a seemingly lack of awareness on its nutritional potentials. Lima  
 70 bean is widely cultivated in the south-western, south-eastern and the middle belt regions of  
 71 Nigeria.

## 72 **Materials and Methods**

### 73 **Preparation of Lima beans and Soyabean Meal**

74 Lima beans (*Phaseolus lunatus*) seeds were purchased from a retail outlet. The matured seeds  
 75 where dark brown in colour, round, dry and hardy, a total weight of 10kg was purchased and  
 76 decoated. The whole seeds were toasted on a well heated pot for ten minutes in the school farm  
 77 to reduce the effect of toxins and inhibitors such as polyphenols and trypsin inhibitors, after  
 78 which they were brought down, allowed to cool then milled into fine form.

### 79 **Preparation of Experimental Diets**

80 Fishmeal, soybeans cake, corn meal, palm oil as fatty acid and bone meal that were used in the  
 81 production of the feed were purchased from Liz Enterprises, a private company at Murtala  
 82 Mohammed Way in Benin City. The vitamin E-gel was purchased from GPS Pharmacy, Third  
 83 Street, Benin City and the palm oil was obtained from New-Benin market in Benin City. Five  
 84 isonitrogenous and isocaloric diets were formulated. Diets 1 (control), 2, 3, 4, 5, had soybean  
 85 meal protein substituted with Lima beans seed meal at 0%, 25%, 50%, 75%, 100% respectively.  
 86 The composition of the experimental diets is shown in Table 1

87 **Table 1: Gross Composition of the Experimental Diets (%) on as fed basis**

88

<b>Ingredients</b>	<b>Diet 1 0% LBM</b>	<b>Diet 2 25% LBM</b>	<b>Diet 3 50% LBM</b>	<b>Diet 4 75% LBM</b>	<b>Diet 5 100% LBM</b>
Fishmeal (65.5% CP)	35.40	35.40	35.40	35.40	35.40
SBC (48.0% CP)	40.00	30.00	20.00	10.00	0.00

LBM (36.17% CP)	0.00	10.00	20.00	30.00	40.00
Yellow maize (9.5% CP)	20.00	20.00	20.00	20.00	20.00
Palm oil	8.00	8.00	8.00	8.00	8.00
Bone meal	4.00	4.00	4.00	4.00	4.00
Vitamin premix	0.04	0.04	0.04	0.04	0.04
Vitamin E gel	0.60	0.60	0.60	0.60	0.60
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

89 **LBM= Lima Bean meal, CP= Crude protein**

90 The various ingredients were measured accurately to their required quantity, after which they  
91 were homogenously mixed, finely pelleted and dried. The pelleted feed was stored in sealed  
92 containers throughout the duration of the experiment.

### 93 **Experimental Fish**

94 One hundred *Heterobranchus bidorsalis* fingerlings (mean weight  $2.5 \pm 0.5\text{g}$ ) were obtained  
95 from a hatchery unit of the department farm. They were acclimatized for five days during which  
96 they were fed commercial feed.

### 97 **Experimental Units**

98 The study was conducted in the wet laboratory, Department of Fisheries, University of Benin,  
99 Benin city, Nigeria. Fifteen (15) rectangular plastic tanks, (five (5) treatment in three (3)  
100 replicates) measuring (30cm×36cm×52cm) were used. Each tank was filled up to 2/3 of its  
101 volume with bore-hole water attached to the laboratory.

### 102 **Experimental Procedure**

103 As the period of acclimatization (5 days) came to an end the fishes were weighed in batches of 5  
104 into each of the experimental units replicated three for each treatment. They were fed twice daily  
105 to satiation to ensure maximum growth between 8:00 - 9:00hrs and 15:00 - 16:00hrs. Feeding  
106 was monitored for each unit to ensure that fishes were not underfed or overfed. The experimental  
107 units were cleaned by total changing of the water daily and sometimes once in two days. All  
108 fishes per replicate were weighed and counted weekly to determine growth and survival, also the  
109 weekly weighing of feed was also carried out.

### 110 **Parameters Monitored**

111 Data on feed consumed and weight gain were collected weekly for each unit from which the  
112 following performance parameters were evaluated.

113 1. Weight gain (WG) =  $W_2 - W_1$  (g)

114 Where;  $W_1$  = initial weight

115  $W_2$  = final weight

116 2. Feed intake = Initial weight of feed – Final weight of feed

117

118 3. Specific growth rate per day (SGR) % =  $\frac{\text{Loge } W_2 - \text{loge } W_1}{T_2 - T_1} \times 100$

119 Where:  $T_1$  and  $T_2$  are time of experiment in days.

120  $W_2$  = final weight at  $T_2$

121  $W_1$  = initial weight at  $T_1$

122 Loge = natural logarithm.

123 4. Relative weight gain (PWG) % =  $\frac{\text{Weight Gain}}{\text{Initial Weight}} \times 100$

124 5. Food conversion ratio (FCR) =  $\frac{\text{Feed Intake(g)}}{\text{Wet Weight Gain(g)}} \times 100$

125 6. Protein efficiency ratio (PER) =  $\frac{\text{Weight Gain (g)}}{\text{Protein Intake}} \times 100$

126 7. Survival rate % =  $\frac{\text{Initial stocked} - \text{mortality}}{\text{Initial stocked}} \times 100$

127 **Proximate Analysis of Diets and Fish**

128 A sample of 10 fishes of the initial stock was used for initial analysis, also at the end of the  
129 experimental trial some survivals from each treatment were sacrificed and analyzed. Diet  
130 samples from the five compounded diets were also collected and a sample of the toasted Lima  
131 beans for analysis. They were analyzed using standard methods of the Association of Official  
132 Analytical Chemists (AOAC 2000)

133 **Determination of Moisture Content**

134 This is a measure of the % moisture lost due to drying at a temperature of 105<sup>o</sup>c, 2g of the  
135 sample was weighed (W1) into pre-weighed beaker (W0) and placed into a hot drying oven at  
136 105c for 3hours. The crucible was removed, cooled in a desiccator and weighed. The process of  
137 drying, cooling and weighing were repeated until a constant weight (W2) was obtained. The  
138 weight loss due to moisture was obtained by the equation

139 % moisture =  $\frac{W1-W2}{W1-W0} \times 100$

140 **Determination of Ash Content**

141 This is a measure of the residue remaining after combustion of the dried sample in a furnace at  
142 temperature of 60<sup>o</sup>c for 3hours. According to James (1995), 1g of the sample was weighed (W1)  
143 into pre-weighed empty crucibles (W0) and placed into a Linton furnace at 60<sup>o</sup>c for 3 hours. The  
144 ash was cooled in a desiccator and weighed (W2). The weight of the ash was determined by the  
145 difference between the powdered leave sample, pre-weighed crucible and the ash in the crucible.  
146 Percentage ash was obtained by:

147 % Ash =  $\frac{W2-W1}{W1-W0} \times 100$

148 **Determination of Crude Protein Content**

149 The crude protein of the sample was determined using the micro Kjeldahl method described by  
150 AOAC (1990). The principle of this method is based on the transformation of protein and that if  
151 the other nitrogen containing organic compounds, other than nitrites and nitrates into ammonium  
152 sulphate by acid digestion. The sample (0.5g) was weighed into a micro Kjeldahl digestion flask  
153 of foss automatic digester block system. It was shaken and allowed to stand for some time. One  
154 tablet of selenium catalyst with a mixture of 2:1 copper sulphate and potassium sulphate was  
155 added followed by the addition of 20cm<sup>3</sup> concentrated sulphuric acid. The flask was heated on  
156 the digestion block at 450<sup>o</sup>c for 1hour until digest became clear. An aliquot of the digest  
157 (100cm<sup>3</sup>) as transferred into another micro Kjeldahl flask along with 20cm<sup>3</sup> of distilled water  
158 and placed in the distilling outlet of the micro Kjeldahl distillation unit. A conical flask  
159 containing 20cm<sup>3</sup> of boric acid indicator was placed under the condenser outlet. Sodium  
160 hydroxide solution (20cm<sup>3</sup>, 40%) was added to the content in the Kjeldahl flask by opening the  
161 funnel stop cock. The distillation start and the heat supplied were regulated to avoid sucking  
162 back. When all the available distillate was collected in 5cm<sup>3</sup> of boric acid mix indicator, the  
163 distillation was stopped. The nitrogen in the distillate was determined by titrating with 0.N of  
164 HCL; the end point was obtained when the colour of the distillate changed from green to pink.  
165 Crude protein is a measure of the nitrogen in the sample. It was calculated by multiplying the  
166 total nitrogen content by a constant, 6.60. This is based on the assumption that, protein contains

167 16.7%N which includes both true protein and non-protein N and does not make a distinction  
168 between available or unavailable protein.

### 169 **Determination of Lipid**

170 The lipid content was determined as described by AOAC (1980) using the Soxhlet apparatus for  
171 continuous extraction. A clean dry round bottom flask (500ml) containing anti-bumping granules  
172 was weighed and about 210cmof petroleum ether (B.P. 60-80°C) was poured into the flask fitted  
173 with soxhlet extraction unit. The weighed sample (5g) was transferred into the thimble which  
174 was already fixed into the soxhlet extraction unit. Cold water circulation and the heating mantle  
175 was switched on, the heating rate adjusted until the solvent was refluxing at a steady rate. The  
176 extraction process was carried out for 8hours. The solvent was recovered by evaporation and the  
177 thimble fitted to the central siphon portion of the extractor of the soxhlet apparatus. The flask  
178 and its content were placed in the oven at 70°C for one hour. The flask was cooled in a desiccator  
179 and weighed. The flask and the content were then replaced in the oven for 30minutes after which  
180 it was reweighed. This was repeated until the sample was dried to a constant weight. From the  
181 weight of the material residue in the receiver flask the percentage lipid content was determined  
182 as given below:

$$183 \text{ \% lipid content} = \frac{\text{Weight of lipid extracted}}{\text{Weight of Sample}} \times 100$$

### 184 185 **Statistical Analysis**

186 The data obtained from the feeding trials were tested for significant differences using Analysis of  
187 Variance (ANOVA) test and the means were separated using Duncan's Multiple Range Test, all  
188 at 5% level of significance.

### 189 **RESULTS**

190 Temperature of water ranged from 27-29°C and PH of 7.3- 7.6.

191 **Table 2: Proximate Composition (%) Of Experimental Diets**

	TREATMENT					
<b>Proximate Composition</b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>V</b>	<b>Lima beans</b>
Moisture content (%)	5.32	5.22	5.44	5.36	5.55	5.14
Protein content(%)	39.21	41.13	48.51	46.57	45.25	36.17
Ether extract(%)	17.99	18.01	20.14	18.20	16.61	15.28
Crude fibre (%)	4.12	3.49	3.88	3.57	3.54	3.14
Ash (%)	6.38	8.27	7.21	7.65	7.23	7.12
NFE (%)	26.98	23.88	14.82	18.65	21.82	33.15

192 (Source: Field Survey, 2018)

193 The proximate composition of experimental diet (Table 2) shows that crude fat is highest at  
 194 treatment III (20.14%) and lowest at treatment V (16.61%), crude fiber content was highest in  
 195 treatment I (4.12%) and lowest in treatment V (3.54%), moisture content was highest in  
 196 treatment V (5.55%) and lowest at treatment II (5.22%), Crude protein value was highest in  
 197 Treatment III (48.51%) and lowest in Treatment I (39.21%), Ash content value was recorded to  
 198 be highest in Treatment II having a value of (8.27%) and the lowest in Treatment I (6.38%).  
 199 Nitrogen Free Extract (NFE) was highest in Treatment I (26.98%) and lowest in Treatment III  
 200 (14.82%).

201 **Table 3: Carcass composition (%) of *Heterobranchus bidorsalis* fingerlings fed varying**  
 202 **levels of *Phaseolus lunatus*. seed meal based diets for 70 days**

	Initial carcass	TSF I	TSF II	TSF III	TSF IV	TSF V
Moisture content	5.17	5.31	5.37	5.43	5.16	5.32
Fat	15.23	15.41	16.00	17.23	16.67	15.75
ash	8.11	8.23	7.94	7.18	8.27	7.41
Crude protein	68.25	48.56	53.01	56.50	52.85	56.73
NFE	4.14	22.49	17.68	13.66	17.05	14.79

203 **TSF = Test fish carcass composition** (Source: Field Survey, 2018)

204 The proximate composition of test fish shows that crude protein was highest in test fish fed with  
 205 diet V having the value 56.73%CP and lowest in test fish fed with diet I (48.56% CP). When  
 206 compared to the initial carcass (68.25%CP), treatment I, II, III, IV, V had a lower crude protein  
 207 value. The fat content was highest in fish fed with diet III with the value (17.23%) and lowest in  
 208 fish fed with diet I (15.41%). Fish fed with diet IV had the highest ash content having the value  
 209 (8.27%) and lowest in fish fed with diet III having the value (7.18%). Test fish fed with diet I  
 210 had the highest Nitrogen Free Extract (NFE) value of 22.49% and the lowest value in test fish  
 211 fed with diet III 13.66%.

212 **Table 4: Growth response and nutrient utilization of *Heterobranchus bidorsalis* fingerling**  
 213 **fed *Phaseolus lunatus* seed meal-based diets**

PARAMETERS	TREATMENT					SEM
	I	II	III	IV	V	
	0%	25%	50%	75%	100%	
WEIGHT GAIN	2.404	2.317	2.604	2.800	2.921 <sup>NS</sup>	0.377
FEED CONVERSION RATIO	1.296 <sup>b</sup>	1.383 <sup>c</sup>	1.321 <sup>c</sup>	1.162 <sup>a</sup>	1.362 <sup>c</sup>	0.1465
FEED INTAKE	3.246	3.367	3.421	3.262	3.775 <sup>NS</sup>	0.344
RELATIVE WEIGHT GAIN	18.95 <sup>c</sup>	16.95 <sup>d</sup>	22.92 <sup>a</sup>	19.79 <sup>c</sup>	20.53 <sup>b</sup>	3.10
SPECIFIC GROWTH RATE (g)	2.500	2.083	3.250	2.833	2.625 <sup>NS</sup>	0.584
PROTEIN EFFICIENCY	6.098	5.596	5.376	5.996	6.346 <sup>NS</sup>	0.837

RATIO						
SURVIVAL	100	96.22	98.45	100	100 <sup>NS</sup>	1.20

214  
 215 Mean in each row with the same superscript are not significantly different ( $P > 0.05$ ) SEM = standard error of mean  
 216 NS= No Significant Difference (Source: Field Survey, 2018)

217 The growth response and nutrient utilization of test fish is presented at table 4. At all levels of  
 218 substitution, there was an increase in weight gain, the highest weight gain was 2.921g recorded  
 219 in fish fed with diet containing 100% inclusion level of lima beans meal. This treatment was not  
 220 significantly different ( $p > 0.05$ ) from all other treatment (I, II, III and IV). The lowest weight  
 221 gain was recorded in fish fed 25% inclusion level of lima beans diet

222 Relative weight gain was highest in treatment V (20.53) with 100% lima beans and lowest in  
 223 treatment II (16.95) with 25% lima beans diet inclusion level. Treatment I and IV had no  
 224 significant difference ( $P > 0.05$ ) but these treatments had a significant difference ( $P < 0.05$ ) with  
 225 treatments II, III and V also treatment II, III, and V are significantly different ( $P < 0.05$ ) from each  
 226 other. Treatment V had the highest feed intake with value 3.775. Treatment I, II, III, IV and V  
 227 had no significant difference ( $P > 0.05$ ). Treatment I had the lowest feed intake with value  
 228 (3.246). Specific growth rate in treatment II, III, IV and V showed significant no difference ( $P$   
 229  $< 0.05$ ) from treatment I. Treatment III (3.250) had the highest specific growth rate and treatment  
 230 II (2.083) have the lowest value. There was no significant different ( $p > 0.05$ ) in the feed  
 231 conversion ratio of treatment II, III, IV. There was also no significant difference ( $p > 0.05$ ) in the  
 232 feed conversion ratio of treatment I and V. Feed conversion ratio in Treatment II, III and IV was  
 233 significantly different ( $P < 0.05$ ) from the value of the feed conversion ratio in treatment I and V.  
 234 FCR was highest in treatment II (1.383) and lowest in treatment IV (1.162). Protein efficiency  
 235 ratio showed no significant difference ( $p > 0.5$ ) across all treatments (I, II, III, IV, V). PER was  
 236 highest in treatment V (6.346) and lowest in treatment III (5.346)

### 237 Discussion

#### 238 Proximate composition of Lima beans

239 The crude protein content and ether extract of toasted lima beans seed was recorded to be  
 240 36.17% CP and 15.28% respectively; these values are higher than the 31.27% CP and 10.12%  
 241 reported by Adeparusi and Ajayi (2004). This indicates that there are factors which affect the  
 242 crude protein and fat content such as the processing methods. Emenolom and Udedibie (2005)  
 243 reported that cooking of mucuna bean reduces the crude protein content of raw Nigeria and  
 244 Brazilian seeds by 5.3% and 6.5% respectively. Adeparusi (2001) also noted that raw lima bean  
 245 had a higher protein, lipid and ash content when compared with soaked, autoclaved and toasted  
 246 lima beans seed. The usual approach to formulating Diets for simple-stomach animals is to use  
 247 ingredients that will maintain Dietary fiber levels below acceptable maximum levels. These  
 248 levels would be in the range of 3- 6% crude fiber for catfish Diets (Robinson *et al.*, 2001). Lima  
 249 beans had 3.14% of crude fibre as shown in this study and this must have influence the value  
 250 obtained in the experimental diet to be in the appropriate range

#### 251 Growth

252 The experimental fish within all the treatments showed great increase in weight, which indicates  
 253 that the fishes were able to convert feed protein to extra muscles. Weight gain and specific  
 254 growth rate are usually considered as the most important measurement of productivity of Diets  
 255 (Adesina *et al.*, 2013). From this experimental study, the result showed that treatment III (50%  
 256 LBM) had a better specific growth rate when compared to other experimental diet including the  
 257 control (TRT I, 0% LBM). This is followed by treatment IV (75% LBM). This is slightly  
 258 correlating with the study carried out by Adeparusi and Olute (2001) of methionine

259 supplemented toasted lima beans fed to *Oreochromis niloticus* in which growth rate was found to  
260 be highest for diet containing the same inclusion level of Lima bean meal. The least growth was  
261 observed in treatment II (25% LBM). This is also in Harmony with the assertion of Adeparusi  
262 and Olute (2001) in their related study as stated above. The weight gain was highest with fish in  
263 treatment V (100% LBM) and lowest in treatment II (25% LBM). The low level of crude fibre in  
264 lima beans as shown in this study must have improve the palatability of the diet hence having a  
265 favourable effect on the digestibility which obviously had influenced the weight gain. The low  
266 weight gain experienced in treatment II could have been as a result of the imbalance in the plant  
267 protein source. It was documented by Ogunji et al. (2001) that some levels of amino acids in  
268 cracked soybean seed decreased after heat treatment. The study showed no significant difference  
269 ( $P < 0.05$ ) between the growth performance (percentage weight gain and specific growth rate) of  
270 the fingerlings fed the compounded Lima beans meal substituted diets (treatment II, III, IV and  
271 V) and those fed the conventional soyabean meal diet (treatment I). This can be attributed to  
272 proper utilization of the LBM, the suitability of the processing method used to adequately  
273 eliminate the anti-nutritional factors. This corroborates with the finding of Francis et al. (2001)  
274 who reported that reductions in anti-nutrients by different processing technique result in better  
275 palatability and growth in fish. Heat treatment has been shown to improve dietary utilization in  
276 legumes (Alonso *et al.*, 2000; Drew *et al.*, 2007).

### 277 **Nutrient Utilization**

278 Feed utilization expressed as FCR is known to be affected by body weight, ration and size and  
279 temperature (Keremah and Beregha, 2014). The lower the food conversion ratio indicates higher  
280 protein conversion efficiency thereby resulting in better growth. Olele *et al.* (2013). Adikwu  
281 (2003) documented that the lower the FCR, the better the feed utilization by the fish. From this  
282 study, the feed conversion ratio of (1.162) and (1.321) obtained by fingerlings fed diet containing  
283 Lima 75% (Trt IV) and Lima 50% (Trt II) respectively are lower compare to others except from  
284 the control diet (0% lima) which is yet higher than diet Treatment IV but lower than treatment  
285 III. The result was in contrast to the study carried by Nyadjeu et al (2018) in which the lowest  
286 value of FCR was reported in Treatment II (25% Lima) however in their experimental study,  
287 Lima beans was been substituted with fish meal.

288 Protein Efficiency Ratio (PER) is known to be regulated by the non-protein energy input of the  
289 Diet and is a good measure of the protein-sparing effect of lipid and/or carbohydrate (Tibbetset  
290 *et al.*, 2005). The PER of the experimental fish obtained in this study exhibited no significant  
291 differences  $P > 0.05$  in all treatments. The PER values increased among the experimental fish with  
292 the highest recorded in treatment V (Lima beans 100%). Similar observations were made by  
293 Sotolu (2008).

294 All the experimental diets were accepted by the experimental fish indicating that the  
295 incorporation of LBM in fish diets did not have adverse effect on the palatability of the  
296 experimental diets. It has been noted that cultured fish in artificial enclosures such as cages  
297 depend solely on the nutrient from the feed for growth with little or no contribution from natural  
298 food. This implies that the general increase in weight of trial fish was an indication that all the  
299 diets met a part or the whole nutrient requirement for growth in *Hetrobranchus bidorsalis*  
300 fingerlings.

### 301 **Conclusion**

302 The diet fed to *H. bidorsalis* had significant effect on their growth and nutrient utilization, the  
303 result obtained from this study showed that among the diet which contained Lima beans meal,  
304 diet IV (75% lima) had the best performance level in experimental fish although the highest

305 weight gain was observed in treatment V, but the value is slightly higher than what was observed  
306 in treatment IV which had a better Specific growth rate and feed conversion ratio.  
307 This study has demonstrated that Lima beans have the potential to replace soya beans; this would  
308 considerably reduce the expenditure on soya beans without compromising growth performance  
309 and feed utilization of the African catfish.

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