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Research Article

Growth Performance and Feed Utilization of *Heterobranchus bidorsalis* Fed with Flamboyant Seed Meal Substituted for Wheat Offal

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Abstract

Background and Objective: Sustainability of the consistent expansion of aquacultural industry depends on development of fish culture techniques in order to obtain the most efficient, safe and cost effective methods for producing aqua products. The study evaluated the growth performance and feed utilization of African catfish *Heterobranchus bidorsalis* fed varying levels of flamboyant (*Delonix regia*) seed meal as replacement for wheat offal for 14 weeks. **Materials and Methods:** The experiment was conducted for 14 weeks (98 days) from May 6th to August 12th, 2017. Four experimental feeds (Diets 1, 2, 3 and 4) each with about 40% crude protein content were formulated at diet 1 = 0%, diet 2 = 15%, diet 3 = 20% and diet 4 = 25% inclusion levels of fermented and boiled *Delonix regia* seed meal (FSM). Post 2 weeks of acclimation, 15 fish were stocked in a happa pen sized 0.432 m^2 for each feed with 3 replicates. The initial mean weight of fish was (33.70±0.78 g). Fish were fed at 3% body weight daily and adjusted accordingly every fortnight. Water quality parameters were noted morning and evening weekly. **Results:** Survival rate ranged from 79.99-86.66% randomly without significant difference. Treatments which contained 15% FSM gave the highest nominal performance with respect to mean weight gain, percentage mean weight gain, mean growth rate, specific growth rate and performance index, though there was no clear superiority over other feeds ($p>0.05$). The feed utilization indices were generally fair across all treatments, with best nominal performance in the treatment containing 25% FSM. **Conclusion:** The results revealed that the fish were able to utilize all the feed types well for growth, particularly at 15% inclusion level of flamboyant seed meal as basal feed stuff.

Key words: Growth performance, feed utilization, *Heterobranchus bidorsalis*, *Delonix regia*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Fish is the cheapest source of animal protein and account for about 40% of the total protein intake by the average Nigerian[1]. The dynamics of Nigeria's demographic figure is in favour of perpetual increase with the attendant challenge on food security vis-à-vis increasing demand for dietary protein. This is evident in the rising consumption of fish which aquaculture now provides a substantial quantity of the fish protein consumed[2]. Sustainability of the consistent expansion of aquacultural industry depends on development of fish culture techniques in order to obtain the most efficient, safe and cost effective methods for producing aqua products[3]. The current global economic depression has great implications on Nigeria's economy[4], thus provoking astronomic surge in the cost of fish feed which challenges fish production. Feed accounts for about 50-80% of fish production cost[5]. The implications of high cost of feed are universal to both the fish culturists whose concerns are the production levels, operational costs and sustainability of their ventures and the consumers whose consideration is meeting their fish protein per capita within their convenient budgets. Dietary protein[6] and energy[7] are responsible for the high cost of feed for both fish and livestock. These have prompted researches into possible reduction of feed cost through utilization of cheaper alternative sources of dietary protein[8], reduction in the dietary protein levels[9] and utilizing the available dietary protein and energy efficiently[10] with assured improvement in the desired performance of the cultured fish. Efficient use of protein implies minimizing the quantity of protein utilized for energy[11] and sparing it for normal body maintenance and growth[9] by incorporating other energy sources in the diets. Maize and wheat are the most widely used basal feed stuff in livestock feeds, as well as manage the energy cost in fish feeds formulation. Government regulations on wheat importation and its low production level in the country[12] cause wheat and its by-products (such as wheat offal) to be scarce and very expensive. The necessity for screening possible readily available low cost alternative ingredients that could be used to spare protein can therefore not be over emphasized. To this end, flamboyant (*D. regia*) seed meal is considered.

Delonix regia, a wild plant otherwise called flame of the forest, is a leguminous ornamental plant, which yields tones of seeded pods in the fruiting season[13]. These seeds are scarcely or not utilized for livestock feed, human food or medicine[14] hence, readily available for use as a cheap ingredient in aqua feed. Bake *et al.*[14-17] attempted the possible utilization of these seeds meal as protein supplement. The use of non-conventional plant feed ingredients to replace conventional feed stuffs in diets of cultured species had been explored widely by various researchers including[18-25].

The Clariid catfishes constitute an excellent food fish of high commercial value in Nigeria and some other tropical countries of the world[26]. *Heterobranchus bidorsalis* belongs to the genus *Heterobranchus* of the African mud catfish, Clariid that are widely cultured in Africa, Asia and Europe[27] due to their outstanding culture characteristics already noted by Owodeinde and Ndimele[28]. Teugels *et al.*[29] reported *H. bidorsalis* to be fairly abundant, able to attain 30 kg maximum weight and length of over 1 m.

Conventional feed stuff for feeding this fish are scarce and expensive, hence this effort to explore the suitability of the cheaper flamboyant seed as basal dietary ingredient to boost its production.

This study was carried out to evaluate the effect of dietary substitution of flamboyant seed meal for wheat offal meal on growth performance and feed utilization of *H. bidorsalis*.

MATERIALS AND METHODS

Experimental site: The experiment was conducted for 14 weeks (98 days) from May 6th-August 12th, 2017 at Safe Food MPCS Ltd., Fish Farm, located at 6 APhenson Street, Federal Housing Estate, Abak Road, Uyo, Nigeria in 12 hapa pens set in a concrete tank of 2×8 m. Each hapa measured 0.6×1.2×0.6 m.

Procurement and processing of flamboyant (*Delonix regia*) seeds: The seeds of a flamboyant tree were obtained along Abak Road by Federal Secretariat, Uyo, AkwaIbom state directly from the mature dried pods. The collected seeds were soaked in water for 24 h, then boiled for 1 h 30 min and thereafter, sundried in the open place for 3 days. These dried seeds were ground into a homogenous powder. The various treatments on the seeds before grinding aimed at reducing the anti-nutritional factors present.

Experimental fish: A group of 180 juveniles of *H. bidorsalis* where obtained from Heritage Farm Sapele, Delta state, Nigeria. The fish were acclimatized for 2 weeks in a 2×4 m concrete tank and were fed with 2 mm fish commercial feed (Coppens) twice daily (7:00-8:00 h and 17:00-18:00 h) at 3% total body weight divided into two rations per day. Post acclimatization, 15 fish were introduced into each experimental hapa pen.

Table 1: Percentage composition of test feed fed to the juveniles of *Heterobranchus bidorsalis* for 14 weeks

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4
Fish meal	25.00	25.00	25.00	25.00
Flamboyant seed meal	0.00	15.00	20.00	25.00
Soybean meal	13.63	13.63	13.63	13.63
Groundnut cake	20.00	20.00	20.00	20.00
Blood meal	10.00	10.00	10.00	10.00
Lysine	1.00	1.00	1.00	1.00
Methionine	0.50	0.50	0.50	0.50
Vitamin premix	0.25	0.25	0.25	0.25
Vitamin C	0.02	0.02	0.02	0.02
Bone ash	2.10	2.10	2.10	2.10
Palm oil	0.50	0.50	0.50	0.50
Composite wheat flour	1.50	1.50	1.50	1.50
Wheat offal	25.00	10.00	5.00	0.00
Salt	0.50	0.50	0.50	0.50
Total percentage	100.00	100.00	100.00	100.00
Wheat offal replacement (%)	0.00	60.00	80.00	100.00

Formulation and preparation of experimental diets: Four experimental diets 1, 2, 3 and 4 were formulated to contain 0, 15, 20 and 25% flamboyant seed meal (FSM), respectively. The crude protein (CP) value of *D. regia* seeds derived from the proximate analysis conducted were used to formulate the test feeds as shown in Table 1 based on 40% crude protein content. Each experimental diet was constituted according to its formula, homogenized, gelatinized with hot water, pelletized, sundried, there after packaged in a labelled polyethylene bag and stored till feeding time.

Experimental design and procedure: Completely randomized design (CRD) was employed in this research. The 12 hapa pens used were divided into 4 sets of 3. Each random set was assigned to a given feed treatment and the three hapas formed replicates. These gave 4 treatments and 3 replicates per treatment. The fish in each tank were weighed at the beginning of the experiment to determine the initial mean weight (33.70±0.78 g). Subsequent weighing and measurement were done bi-weekly. Fish in each replicate were fed daily at 3% of their total body weight split equally into morning and evening rations. The quantity was adjusted to 3% of the new weight after each periodic measurement. The water in the experimental tanks was changed weekly and the tanks thoroughly washed.

Proximate analysis: The proximate compositions of the raw and cooked seeds, experimental diets and carcasses of the fish before and after the experiment were determined using the standard methods of the Association of Official Analytical Chemists (AOAC)[30]. Anti-nutritional factors (total oxalate, tannin, saponin, trypsin) were also analyzed[31] while phytic acid and phytate were determined by modified method of Latta and Eskin[32]. The analyses were carried out at the Laboratory of Biochemistry Department, University of Uyo, Nigeria.

Measurement of physico-chemical parameters: Water temperature, pH and dissolved oxygen concentration were measured weekly. Water temperature and dissolved oxygen were measured with Oxygen meter (Hanna multi parameter kit-model 19828), while pH was measured with pH pen meter (Hanna-model HI 98107).

Determination of growth and feed utilization parameters:

$$\text{Mean weight gain (MWG)} = W_2\text{-}W_1$$

Where:

W_1 = Initial mean weight
W_2 = Final mean weight

Percentage mean weight gain (PMWG)[33] is given as:

$$\text{MWG (\%)} = \frac{\text{MWG} \times 100}{\text{MW}}$$

Where:

MW = Initial mean weight of fish

Mean growth rate (MGR)[34] is as follows:

$$\text{MGR} = \frac{W_2 - W_1}{0.5(W_1 + W_2)} \times \frac{100/t}{1}$$

Where:

W_2 = Final mean weight
W_1 = Initial mean weight
t = Feeding period in days

Specific growth rate (SGR)[35]:

$$\text{SGR} = \frac{100 \times \text{In}W_2 - \text{In}W_1}{\text{Rearing period in days}}$$

Where:

In W_2 = Natural Logarithm of final mean weight
In W_1 = Natural Logarithm of initial mean weight

Survival rate (SR):

$$\text{SR} = \frac{\text{Total No. of fish harvested}}{\text{Total No. of fish stocked}} \times 100$$

Performance index (PI)[36]:

$$PI = \frac{SR \times (W2 - W1)}{\text{Rearing period (in days)}}$$

$$\text{Protein index} = \frac{\text{Protein consumed}}{100}$$

Where:

$$\text{Protein consumed} = \frac{\text{Protein in feed (\%)} \times \text{Total diet consumed}}{100}$$

Protein efficiency ratio (PER)[37]:

$$PER = \frac{\text{Weight gained (g)}}{\text{Protein consumed (g)}}$$

Feed consumed (FC):

$$FC = \frac{\text{Weight of fish} \times 100}{\text{Feeding rate}}$$

Feed conversion ratio (FCR)[38]:

$$FCR = \frac{\text{Feed intake (g)}}{\text{Weight gain (g)}}$$

Feed conversion efficiency (FCE)[39]:

$$FCE = \frac{\text{Weight gain}}{\text{Feed intake}} \times \frac{100}{1}$$

Net protein utilization (NPU)[40]:

$$NPU = \frac{\text{Protein gained} \times 100}{\text{Protein consumed}}$$

Where:

$$\text{Protein gained} = \text{Final total body protein-initial total body protein}$$

and:

$$\text{Protein consumed} = \frac{\text{Protein in feed (\%)} \times \text{Total diet consumed}}{100}$$

Statistical analysis: The growth and feed utilization results obtained were subjected to one-way Analysis of Variance (ANOVA) for significant differences at 0.05 level of probability and the treatment means separated with Duncan Multiple Range test. Statistical Package for Social Sciences (SPSS) Version 20 was used for the analysis.

RESULTS

Water quality parameters: The means of water quality parameters recorded during the period of 14 weeks of the experiment are presented in Table 2.

Profile of the flamboyant (*Delonix regia*) seeds used in the experiment: Table 3 shows proximate nutrient composition and anti-nutritional factors present in raw and cooked flamboyant seeds. The results of chemical analyses revealed that the flamboyant seeds used in this research contained less than 20% crude protein. Also, the levels of anti-nutritional factors were significantly reduced in the cooked seeds while those of protein, fiber and lipids were enhanced.

Table 2: Quality indices of the culture water

Parameters	Mean value
Dissolved oxygen (mg L^{-1})	6.81
Temperature (°C)	27.95
pH	6.93

Table 3: Proximate and anti-nutrient composition of raw and cooked flamboyant seeds

	Proximate Composition		Anti-nutrient Composition		
Parameters	raw seed (%)	cooked seed (%)	raw seed (mg/100 g)	cooked seed mg/100 g)	Reduction (%)
Moisture	11.65	8.67			
Ash	4.06	1.41			
Fiber	10.58	11.06			
Protein	11.90	16.80			
Lipid	6.85	7.18			
NFE	66.61	63.55			
Kcal /100 g	394.31	389.47			
HCN			12.87	1.61	87.49
Tannin			98.93	20.94	78.88
Phytate			45.06	6.52	85.53
Total oxalate			243.45	76.00	68.78

NFE: Nitrogen free extract, HCN: Hydrocyanide

Table 4: Percentage proximate composition of experimental diets and fish

	Diets				Fish				
Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Initial	Diet 1	Diet 2	Diet 3	Diet 4
Moisture	7.15	7.31	7.26	7.08	76.77	72.00	71.99	72.03	71.97
Ash	10.25	9.50	9.42	9.19	11.70	9.93	8.40	8.67	8.51
Fiber	13.94	9.50	9.73	8.49	8.30	6.34	7.65	6.510	7.06
Protein	40.25	40.35	40.46	40.80	52.50	60.20	63.75	62.39	62.00
Lipid	4.20	6.15	7.36	9.10	14.13	9.70	11.96	16.99	17.43
NFE	31.36	34.50	33.03	32.42	13.37	13.83	8.24	5.44	5.00
Kcal/100 g	368.50	369.54	370.60	371.20	390.65	383.42	383.60	406.27	420.15

NFE: Nitrogen free extract

Table 5: Mean growth performance of *H. bidorsalis* juveniles fed with varying inclusion levels of dietary flamboyant (*D. regia*) seed meal for 14 weeks

	Treatments			
Parameters	Diet 1	Diet 2	Diet 3	Diet 4
Mean initial weight (g)	32.47[a]	34.09[a]	34.77[a]	33.46[a]
Mean final weight (g)	248.28[a]	296.28[a]	278.02[a]	272.05[a]
Mean weight gain (g)	215.78[a]	262.18[a]	243.24[a]	238.65[a]
Percentage mean weight gain (%)	679.80[a]	801.29[a]	700.91[a]	720.01[a]
Mean growth rate (%/day)	1.56[a]	1.61[a]	1.58[a]	1.59[a]
Specific growth rate (%/day)	2.10[a]	2.23[a]	2.14[a]	2.16[a]
Performance Index (%g/day)	190.63[b]	219.34[a]	197.28[ab]	199.27[ab]
Survival rate (%)	86.66[a]	82.22[a]	79.99[a]	82.21[a]

Means with similar superscripts along the rows are not significantly (p>0.05)

Table 6: Feed utilization of *H. bidorsalis* juveniles fed with varying inclusion levels of dietary flamboyant (*D. regia*) seed meal for 14 weeks

	Treatments			
Parameters	Diet 1	Diet 2	Diet 3	Diet 4
Feed consumed (g)	330.54[b]	371.75[a]	341.72[b]	327.87[b]
Protein consumed (g)	133.04[b]	150.00[a]	138.20[ab]	132.72[b]
FCR	1.53[a]	1.42[a]	1.41[a]	1.37[a]
FCE (%)	65.28[a]	70.53[a]	71.17[a]	72.78[a]
PER (%)	1.62[a]	1.74[a]	1.76[a]	1.80[a]
NPU	5.79[b]	7.50[a]	716.44[a]	7.16[a]
PI (%)	1.33[b]	1.50[a]	1.38[ab]	1.33[b]

Means with similar superscripts along the rows are not significantly different (p>0.05)

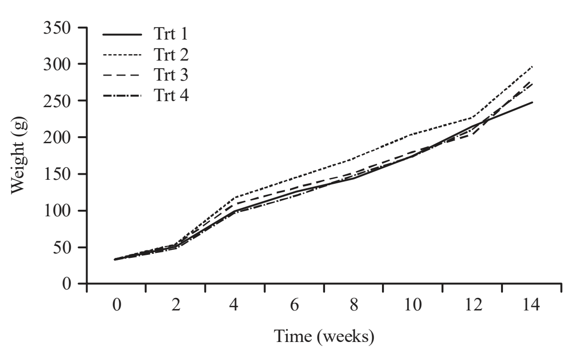

Fig. 1: Mean bi-weekly cumulative weight gain of *H. bidorsalis* juveniles fed with varying inclusion levels of dietary flamboyant (*D. regia*) seed meal in hapas for 14 weeks
Trt: Treatment

Composition of experimental feeds and fish: The percentage proximate compositions of both the test diets and fish are presented in Table 4. Results of the proximate analysis of the test feed presented in the table indicated that diet 1 with 25% wheat offal had the highest fiber and least lipid contents while reverse was the case with diet 4 containing 25% flamboyant seed meal. There was a corresponding trend in each of the two nutrients from diet 1-4. Crude protein remained at 40% with marginal increase from diet 1 to diet 4. Energy level also increased slightly in the same order. The highest deposition of protein was found in fish fed diet 2 and that of lipid in diet 4.

Growth performance of *H. bidorsalis* to cooked flamboyant seed meal: The growth performance indices of *H. bidorsalis* juveniles in the experiment are presented in Table 5 and Fig. 1. From growth results, diet 2 containing 15% flamboyant seed meal gave the highest nominal performance in mean weight gain (MWG), mean growth rate (MGR), percentage weight gain (PWG) and specific growth rate (SGR), whereas, the minimum values were recorded in fish fed diet 1, though without any significant difference (p>0.05) across the treatments. Similarly, no significant difference was found in the survival rate (p>0.05) even though diet 1 without *Delonix regia* seed meal gave the highest survival followed by diets 2, 4 and the least recorded in diet 3. The general performance index (PI) depicted the trend of values observed in MWG, MGR and SGR except for significant difference.

The trend of growth recorded bi-weekly is presented as mean bi-weekly cumulative weight gain in Fig. 1. All treatments exhibited positive growth trends with the fastest burst of growth between weeks 2 and 4 after which there was steady growth.

Feed utilization of *H. bidorsalis* to cooked flamboyant seed meal: Mean feed utilization indices of *H. bidorsalis* from the experiment are shown in Table 6. Fish fed 15% flamboyant seed meal (diet 2) consumed the highest significant quantity of feed (p<0.05). They also consumed significantly the highest quantity of dietary protein compared to others ($p<0.05$) except treatment 3. Feed conversion ratio (FCR), feed conversion efficiency (FCE) and protein efficiency ratio (PER) were not significant among the treatments though with their separate best mean nominal values in treatment 4 and worst in 1. Best and significant net protein utilization (NPU) and Protein Index (PI) were observed in treatment 2.

DISCUSSION

Flamboyant seed meal compared favourably with wheat offal as basal feed stuff for *H. bidorsalis*. The feeds containing this novel ingredient educed nominally better growth performance and superior feed utilization compared to the wheat offal based feed. The water quality that subsisted throughout the experimental period was congenial for the rearing of warm water fishes[41,42] and did not constitute stress to the fish. The crude protein level (40% CP) used in the study was optimum for the culture of *H. bidorsalis*[43]. The proximate analysis of the experimental feeds showed that they all satisfied the nutritional requirements of the fish and the size used in this work. Proximate composition of flamboyant seed meal (FSM) and the percentage reduction of anti-nutritional factors from this study differed from reports of Bake *et al.*[14-17]. The differences in proximate composition and anti-nutritional factors might be due to variation in species, environment, soil conditions, harvesting time and also the techniques of processing the seeds[44,45]. The value of crude protein below 20% found in the flamboyant seeds used in this experiment supports the report of Alemede *et al.*[46] thus necessitating its utilization as basal feed.

The survival rate of the juvenile *H. bidorsalis* in this experiment was high, insignificant and without definite trend to clearly highlight the effect of the feeds therefore, the observed mortalities were more likely to *H. bidorsalis* being cannibalistic. The mean growth performance indices were highest in fish fed 15% FSM based diet (Diet 2) and least in those fed the control diet (Diet 1) without significance saves for performance index. Implication of these results is that the catfish was able to utilize all the diets adequately for growth without suffering any depression. Results from many investigations have revealed that the incorporation of non-conventional plant materials in fish diets often elicits retarded growth due to the presence of anti-nutritional factors[19,47,48], high fiber content[24,49,50] and imbalance of essential nutrients[51,52]. The result of this experiment adduced that the treatments given to *D. regia* seeds were sufficient to deactivate the inherent anti-nutrients in them as well as enhance bioavailability of nutrients for growth. This is in line with the observations of Abowei and Ekubo[8], Fowomola and Akindahunsi[53] and Fawale *et al.*[54]. The growth parameters obtained from this study differed from reports of Bake *et al.*[14-15,17], where *Oreochromis niloticus* and *Clarias gariepinus* fed, respectively, 10 and 20% inclusion levels of FSM had the best growth responses. These differences might be due to differences in fish species, nutrient sources, proximate compositions of feeds and the *D. regia* used.

The stable growth or absence of significant growth superiority among the different treatments indicated that the experimental feeds were safe and met the nutritional requirements of the *H. bidorsalis* juveniles. Fagbenro[55] showed that the dietary optimal protein level for *H. bidorsalis* was between 40-42.5%. Aliu *et al.*[43] recommended that diets containing 40% crude protein and 3000 Kcal kg^{-1} were ideal for *H. bidorsalis* post fingerlings. De Silva *et al.*[9] stated that feeding fish with crude protein above the optimum did not make for significant growth. Li *et al.*[56] similarly did not obtain improved fish growth or protein sparing with further increase of energy beyond the optimal.

Feed utilization parameters obtained in this work suggested favourable utilization of both wheat offal and flamboyant seed meal based feeds for growth. The marginal differences in these parameters might have resulted from insignificant differences in the ratio of crude protein to energy in the different diets[9,43,56]. The FCR values were not within 1.0-1.2 which Huet[57] considered remarkable for very efficient feed but were within acceptable range for good feeds. This variation might be accounted for by some level of wastages being a sinking feed and the chance of escapement from the hapa and not necessarily the feed quality. Jensen[58] reported that FCR for most fishes vary from[14-16] below 1.5-5.0.

In considering *D. regia* seeds in catfish feed formulation, it is imperative to analyze every batch of the seed for exact proximate composition in order to determine its correct usage either as basal feed or protein supplement and the seeds should be fermented and boiled before use.

CONCLUSION

The survival rates recorded in this study were diet independent and reasonably high considering the fact that *H. bidorsalis* has a strong cannibalistic tendency. Feed utilization indices were generally fair across all treatments while growth performance indices recorded in fish fed 15% FSM based diet appeared most favourable though, without clear superiority over others. These indicate that when *D. regia* seeds are well treated, they can be safely used in fish diets at reduced cost for competitive growth rate as with conventional energy sources.

SIGNIFICANCE STATEMENT

This study discovered the suitability of flamboyant seed meal as basal feed ingredient for the feeding of *H. bidorsalis* that can be beneficial for the economic production of the African catfishes generally and this study will help researchers to uncover the critical areas of producing low cost quality catfish feed that many researchers were not able to explore. Thus a new theory on cost effective feeding and economic production of *H. bidorsalis* using *D. regia* seed meal as basal feed stuff may be arrived at.

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