Effects of Using Garden Snail as Fishmeal on the Development of *Heterobranchus Bidorsalis*

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Abstract

The present study aimed to investigate the effect of dietary garden snail meal (Limicloaria flammae) as fishmeal replacement on growth, feed efficiency and economics of Heterobranchus bidorsalis juveniles. A total of 150 juveniles of average weight 7.0g were randomly allotted to rearing plastic tanks (1m x 1m x 1m dimension) based on treatment in triplicates. Then, fish were fed twice daily at 5% body weight for 127 days with isonitrogenous diets containing 42% crude protein with different levels of garden snail meal to replace fishmeal protein at 0% (D1), 25% (D2), 50%(D3), 75%(D4), and 100% (D5). Live weight of fish was taken fortnightly and water quality parameters were monitored weekly. Inclusion level of 25% GSM (D2) significantly increased live weight and weight gain (519.67 and 512.91g) as compared to 0%, 50%, 75% 100% (366.86, 406.21, 335.64, 329.52g final weights respectively). The weight gain of H. bidorsalis was GSM level dependent, but above 50% inclusion level weight gain reduced significantly compared to control group. Inclusion level of 25% GSM significantly reduced FCR(1.32). Moreover, 25% GSM gave highest PER (1.82). The cost of feed and production of H. bidorsalis was significantly reduced by GSM based diets compared to D1(fishmeal). Moreover, D2 and D5 significantly increased profit index and cost benefit ratiocompared to D1, D3 and D4. The Benefit cost ratio was highest at 25% inclusion level of GSM (1.37) while the incidence cost was highest in fish fed control diet (0.81). The benefit cost ratio was greater than 1 (>1) indicating viability of using GSM in H. bidorsalisproduction. Conclusively, GSM inclusion in diet of H. bidorsalis at 25-50% significantly improves absolute weight gain. Moreover, 25-50% inclusion level of GSM significantly increases profit margin in H. bidorsalisproduction. Therefore, 25-50% GSM level is recommended in H. bidorsalisdiet during production.

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Keywords: Economics, Fish growth, *Heterobranchus bidorsalis* juveniles, *Limicloaria flammae* Nutrient composition.

Introduction

Fish is an essential animal protein to human worldwide (Azam *et al.,* 2004). Fishmeal as a feed ingredient is one of the main sources of protein used in feed production because of its richness in essential amino acid, fatty acids and minerals (Alceste *et al*.,2000; Oliva-Teles and Goncalves, 2001). The demand for fish as source of protein has been on the increase due to its human health benefit while wild stock is on a decline due to it over dependence as fishmeal and fish oil in feed industries (FAO, 2010; 2012). To meet up with the increasing human population demand for fish protein, there should be reduction in over dependence on wild stock in feed industries and also an increase in fish aquaculture production. To achieve this fish farmers and fish feed millers must explore alternative protein source by utilizing local fish feed resources maximally so as to make fish farming more economical and sustainable, coupled with the ever-growing population and the need to increase profit, non-conventional feed ingredient should proffer solution because it is able to cut total input in fish production by 60% (Eyo, 2001).

Formulation of diets with ingredients that are locally available and are not in direct competition with human are accepted and seen as a means to reduce the cost of production thereby creating cheap formulated feed (Anyanwu, 2008; Yusuf *et al.,* 2016). To sustain the expansion of global aquaculture production, the usage of dietary fishmeal in feed must be reduced because of its high cost, fluctuating price and availability resulting to impairment of sustainable aquaculture (Shen *et al*., 2019). Therefore, in an attempt to attain a more economically sustainable and viable production, research focus has been directed towards the evaluation and use of unconventional protein sources of both plants and animal's origin (Shen *et al*., 2019).

The use of plant sources has received most attention in recent years in African catfish feeds, but, due to amino acid imbalances, presence of antinutritional factors and low palatability, a high level of replacement of fishmeal with plant feedstuffs is collectively not accepted (Belgin *et al*., 2009;Michael and Kolapo 2017).

The use of garden snail in the diet could lead to better growth than purely fishmeal alone and cost of replacing fishmeal with garden snail meal could be cost beneficial (Sogbesan, 2006; Ovie and Adejavan, 2010).This study was designed to replace fish meal with garden snail meal on the growth and development of *Heterobranchus bidorsalis*.

Methodology

Formulated Experimental Diet

After collection from the wild, the garden snails were sorted, processed and pulverised. The feed ingredients comprised of milled Garden Snail Meal (GSM), fish meal, yellow maize, vitamin/mineral premix, cassava starch (binder), salt, palm oil, methionine, and lysine(Table 1). All diets were isonitrogenous containing 42.0% crude protein. The diets were prepared using GSM to replace fishmeal at various inclusion levels of 0, 25, 50, 75 and 100%. The milled Garden Snail Meal (GSM), fish meal, soya bean meal, yellow maize and fixed ingredients were weighed according to the formulated proportion and mixed in a bowl. Warm water was added to makedough. The resultant dough was pelleted into suitable size pellets. The pellets were collected, air-dried and stored in cellophane bag for feed trial experiment.

Table 1: Ingredient and proximate composition of experimental diets

Ingredients (%)	D1	D2	D3	D4	D5
Yellow maize	25.13	24.19	23.69	23.21	22.79
Snail Meal	0.00	9.27	18.53	27.8	37.06
Fish Meal	37.06	27.8	18.53	9.27	0.00
Soya Beans	33.06	34	34.5	35	35.5
Bone Meal	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50	0.50
Vegetable oil	0.75	0.75	0.75	0.75	0.75
Starch	1.00	1.00	1.00	1.00	1.00
Total	**100**	**100**	**100**	**100**	**100**
Composition (g/100g)					
Moisture	8.24	8.32	8.37	8.61	8.13
Dry Matter	91.76	91.68	91.63	91.39	91.87
Crude lipid	9.47	8.43	8.69	8.87	8.17
Crude protein	41.59	41.57	42.02	41.67	41.52
Crude fibre	4.35	4.68	4.49	4.49	4.33
Ash	10.9	10.76	10.02	10.07	11.24
NFE	25.45	26.23	26.41	25.95	26.61
Gross Energy (Kj/g)	1818.83	1790.69	1814.96	1805.66	1785.83

Experimental Fish and Design

One hundered and fifty *H.bidorsalis* juveniles were collected from National Institute for Freshwater Fisheries Research, New Bussa, Nigeria. They were acclimatized for seven days before the feed trial.The experiment was laid out in a complete randomized block designwith three replications, each replicate contained 10 fish (*H. bidorsalis* juveniles). 15 plastic aquaria with dimension of 1m×1m×1m was used in a static system. Feeding was at 5% body weight (Effiong *et al* 2009) twice daily and the quantity of feed was adjusted based on the new weight after 14 days.

Water quality parameters determination

Water quality parameters were monitoredtwice a week, temperature was taken with a mercury-in-glass thermometer calibrated in degree centigrade (℃). Dissolved oxygen was determined by using the Winkler's protocol. pH and dissolved solids were measured using electronic meter.

Growth, feed utilization and economic analysis of replacement of fish meal with GSM
Weight gain= final body weight-initial body weight
Average daily growth=Mean weight gain (mg)/duration of feeding (days)
SGR (%) = 100 × (ln (final body weight) − ln (initial body weight))/culture days
CF (%) = 100 × (final weight) / (final body length) ^{3}
FCR = feed intake (g)/Total weight gain (g)
SR (%) = 100 × (final number fish) / (initial number fish)
FI = feed intake (g dry feed consumed per fish).
PWG (%) = 100 × (final mean body weight) initial mean body weight)/initial body weight.
PER = fish wet WG/protein intake.
Gross Efficiency Food Conversion (GEFC) =1/FCR × 100 (Sevier *et al.,* 2000).
Economic evaluation of the study

$$\text{Profit Index (PI)} = \frac{\text{Weight of fish produced}}{\text{Cost of feed}}$$

$$\text{Net Profit (NP)} = \text{Sales} - \text{Expenditure}$$

$$\text{Benefit Cost Ratio(BCR)} = \frac{\text{Total sales}}{\text{Total expenditure}}$$

$$\text{Incidence Cost(IC)} = \frac{\text{Cost of feed}}{\text{Weight of fish produced}}$$ (Mazid *et al.*, 1997)

Total Cost (TC) = Fixed Cost (FC) –Total Variable Cost (TVC)
Where: FC= cost of fingerlings TVC = Cost of producing different diets (Sogbesan and Ugwumba, 2006).

Statistical analysis
Data collected were subjected to one-way analysis of variance (ANOVA) using General Linear Model (GLM) procedure of SAS (SAS, 2000) followed by Duncan Multiple Range Test (DMRT) to test difference between levels of means and to separate means, p<0.05 were considered significant.

Results and Discussion

Water Quality parameters in rearing tanks
Water quality parameters in the experimental tanks were presented in Table 2. The water quality parameters obtained were within acceptable range for catfish culture and were not significantly influenced by garden snail meal inclusion level. The pH of water in this present study was within the range reported by Boyd (2001) and FAO (2006). The inclusion levels of GSM in diets did not significantly (p>0.05) influence all water quality parameters

Table 2: Water quality parameters during feed trial

Treatment	D1	D2	D3	D4	D5
Ph	7.00 ± 0.02^a	7.01 ± 0.01^a	7.01 ± 0.01^a	7.01 ± 0.02^a	7.02 ± 0.01^a
Temp (°C)	29.00 ± 0.01^a	29.00 ± 0.13^a	29.00 ± 0.02^a	29.07 ± 0.06^a	29.07 ± 0.12^a
DO (mg/l)	5.00 ± 0.01^a	4.96 ± 0.01^a	4.89 ± 0.06^a	5.08 ± 0.01^a	5.03 ± 0.01^a

Mean ± SEM on the same row with the same superscript are not significantly different (p≥0.05) DO: Dissolved Oxygen

Growth and Nutrient composition of *H. bidorsalis* fed experimental diets

The growth performance parameters of *H. bidorsalis*fed different GSM levels were represented in Table 3 while nutrient composition was represented in Table 4.Severalstudies have indicated that animal protein sources are usable alternatives to fishmeal in the aquaculture industry (Xiao *et al*., 2018). The use of snail meat meal is gaining attention in the aquaculture industry. The weight gain increased with inclusion of Garden Snail Meal in the diet up to75% inclusion level. 25% inclusion of GSM produced the best weight gain (512.91g), similar findings were reported by Sogbesan *et al.* (2006) and Ovie and Adejayan (2010) on catfish. This could be attributed to a better utilization of the diet and diet richness in essential amino acids due to combination of snail meat meal and fishmeal exceeding fishmeal only (FAO/WHO, 1991). Furthermore, Sogbesan *et al.* (2006) attributed the weight gain of catfish to increase in inclusion levels of GSM in the diet, while Ovie and Adejayan (2010) attributed the growth of catfish to acceptance and utilization of GSM due to its digestible protein competing favourably with fishmeal.

Also 50% inclusion of blood meal in the diet of Nile tilapia produced the best weight gain (James *et al*., 2016). The 100% inclusion level of GSM had the least growth which was due to the total absence of fishmeal in the diet thereby affecting utilization. Sogbesan *et al.* (2006) attributed the lowest weight gain in 75% inclusion levels based on the inability of the catfish to utilize nutrients especially protein for growth. Contrary to this present study, catfish fed Maggot meal at 75% inclusion level significantly improved weight gain (Olaniyi and Salau, 2013). Also, 10% inclusion of grasshopper meal in catfish produced the best weight gain (Olaleye-Grace, 2015).

The weight gain observed in all treatments is an indication that fish converted feed protein fed to muscle protein. The improvement in growth observed in fish fed 25 and 50% inclusion level of GSM affirm the synergistic effect of two biological compound (Sogbesan and Ugwumba, 2008). Higher specific growth rate among the treatments D2 and D3 shows better utilization, this corroborates catfish fed maggot meal as reported by Ogunji and Wirth (2009). The FCR indicated better feed in 25 and 50% inclusion levels of GSM (1.32 and 1.39) respectively than the control (1.46), Although the lower the feed conversion the better the weight gain so ideally, 25% inclusion levels of GSM that produced 1.32 was the best FCR. (Adewole and Olaleye, 2014 and Olaleye-Grace, 2015).

Protein Efficiency Ratio (PER) correlates with non-protein energy input of the diet and is a good measure of the protein-sparing effect of lipid and/or carbohydrate (Lie *et al.,* 1989; Tibbets *et al*., 2005). Protein efficiency ratio values increased among the experimental fish with respect to the quantity of total feed intake. Similar observations were made by Sotolu (2008) and Adesina *et al.* (2013). A contrasting result by Ovie and Adejayan (2010) reported no significant variation ($p>0.05$) for FCR, GFCE, PER and SGR in all the levels of inclusion of GSM in catfish fed the diet and diet without garden snail they concluded that the protein quality in the garden snails compares well with that of fishmeal.

Table 3: Growth performance of *H. bidorsalis* fed experimental diets

Parameters	D1	D2	D3	D4	D5
Mean initial weight (g)	6.81±0.24^{a}	6.67±0.17^{a}	6.94±0.24^{a}	7.06±0.16^{a}	6.77±0.28^{a}
Initial standard length (cm)	8.80±0.41^{a}	8.95±0.53^{a}	9.19±0.87^{a}	9.98±0.78^{a}	9.90±0.45^{a}
Mean weight gain (g)	359.94±4.69^{bc}	512.91±13.35^{a}	399.27±38.71^{b}	328.63±21.14^{bc}	322.82±17.75^{c}
Mean final weight (g)	366.86±6.71^{bc}	519.67±9.83^{a}	406.21±30.76^{b}	335.64±36.55^{bc}	329.52±18.87^{c}
Final standard length (cm)	36.16±0.32^{a}	38.02±0.20^{a}	36.67±0.87^{a}	35.84±0.68^{a}	36.47±0.57^{a}
% Length gain (cm)	190.92±10.42^{ab}	223.49±14.52^{a}	208.52±23.36^{a}	147.15±14.87^{bc}	134.21±13.10^{c}
% Weight gain (g)	5209.29±133.93^{bc}	7598.81±344.53^{a}	5746.88±515.21^{b}	4687.94±248.36^{c}	4814.22±167.46^{bc}
Condition factor	0.78±0.02^{b}	0.95±0.01^{a}	0.81±0.02^{b}	0.73±0.01^{c}	0.68±0.01^{d}
length gain (cm)	27.36±0.18^{a}	29.07±0.47^{a}	27.48±1.25^{a}	25.86±1.30^{a}	26.57±1.11^{a}
Average Daily Growth	2.87±0.04^{bc}	4.06±0.10^{a}	3.17±0.30^{b}	2.57±0.14^{c}	2.62±0.17^{bc}
Specific growth rate	3.15±0.02^{bc}	3.45±0.04^{a}	3.22±0.07^{b}	3.07±0.04^{c}	3.09±0.03^{bc}

Mean ± SEM on the same row with the same superscript are not significantly different ($p \geq 0.05$)
GSM- garden snail meal

Table 4: Nutrient utilization of *H. bidorsalis* fed experimental diets

Parameters	D1	D2	D3	D4	D5
TFI(g)	525.77±5.90^{b}	677.02±17.00^{a}	552.40±47.32^{b}	502.51±30.28^{b}	511.10±28.93^{b}
PI (g)	218.67±2.55^{b}	281.42±7.19^{a}	232.12±19.70^{b}	208.64±12.52^{b}	212.96±12.14^{b}
PSR	96.67±3.33^{a}	90.00±0.00^{a}	93.33±3.33^{a}	93.33±3.33^{a}	93.33±6.67^{a}
FCR	1.46±0.02^{c}	1.32±0.01^{e}	1.39±0.02^{d}	1.53±0.01^{b}	1.58±0.00^{a}
PER	1.65±0.02^{c}	1.82±0.01^{a}	1.72±0.02^{b}	1.57±0.01^{d}	1.52±0.00^{e}
GEFC	68.47±0.70^{c}	75.76±0.34^{a}	72.14±0.85^{b}	65.37±0.43^{d}	65.17±0.12^{e}

Mean ± SEM on the same row with the same superscript are not significantly different ($p \geq 0.05$) GSM – garden snail meal

Cost Benefit of Replacement of Fish Meal With GSM

The rising cost of production is primarily driven by higher cost of feed ingredients which are largely imported. Reducing feed cost is primarily an economic issue (FAO, 2015). The cost of feed per kg was highest in D1 (₦429.85) because of the high cost of fishmeal while the cost of feed reduced with inclusion of GSM. 100% inclusion of GSM had the least cost of feed (₦248.73), similar trends were observed in the total cost showing 100% inclusion of GSM having the least total cost (₦222.66) this report is similar to those reported by Balogun *et al.* (2016), reduction in cost with increase in inclusion levels of 25% Bauhinia seed meal and Michael and Kolapo (2017) reported reduction in cost with inclusion of grasshopper meal. Garden snail is mostly available during the rainy season, they can be collected and processed with little effort in order to reduce the cost of available protein source in diet. The highest cost for the control diet affirmed the report of (Sogbesan and Ugwumba, 2008).

The profit index was highest in 100% inclusion level of GSM because of the absence of fishmeal in the compounded diet but unfortunately the net profit per fish could not compete with the profit index because the final average weight per fish was much higher in the 25% inclusion of GSM. This brought the average sales per fish to the highest in 25% inclusion level, this could be attributed to good protein utilization of the GSM (Sogbesan *et al.,* 2006; Ovie and Adejayan, 2010). Moreover, the cheapest feed (100% inclusion level of GSM) could not produce the best final average weight of catfish at the end of the experiment and the best average weight was achieved with a combination of 75% fishmeal and 25% GSM. This is an indicative of D2 having the best benefit cost ratio, similar result was obtained by Sogbesan, (2014) using groundnut shells as non-conventional feedstuff in fish feed formulation.

Table 5: Cost and benefit of replacing Fishmeal with GSM in Diets of *H. bidorsali*

Parameters	D1	D2	D3	D4	D5
Cost of Juveniles(₦)	$45±0.00^{a}$	$45±0.00^{a}$	$45±0.00^{a}$	$45±0.00^{a}$	$45±0.00^{a}$
Cost of Feed/kg(₦)	429.85	399.15	339.39	293.76	248.73
Feeding Cost(₦)	296.43	295.66	242.42	209.83	177.66
Total Cost(₦)	341.43	340.66	287.42	254.83	222.66
Feed intake(g)	$525.77±5.90^{b}$	$677.02±17.00^{a}$	$552.40±47.32^{b}$	$511.10±28.93^{b}$	$502.51±30.28^{b}$
Protein intake(g)	$218.67±2.55^{b}$	$281.42±7.19^{a}$	$232.12±19.70^{b}$	$212.96±12.14^{b}$	$208.64±12.52^{b}$
Profit index(₦)	$1.24±0.04^{c}$	$1.76±0.00^{ab}$	$1.66±0.06^{b}$	$1.57±0.11^{b}$	$1.93±0.06^{a}$
Net Profit(₦)	$-12.03±10.86^{d}$	$127.10±4.21^{a}$	$78.17±5.44^{b}$	$47.25±17.65^{c}$	$73.91±5.34^{b}$
Sales/fish(₦)	$329.40±4.26^{bc}$	$467.10±11.90^{a}$	$365.59±34.89^{b}$	$302.08±16.12^{c}$	$296.57±21.00^{c}$
Benefit Cost Ratio	$0.94±0.04^{c}$	$1.37±0.00^{a}$	$1.27±0.06^{b}$	$1.19±0.10^{b}$	$1.33±0.06^{ab}$
Incidence Cost(₦)	$0.81±0.03^{a}$	$0.57±0.00^{bc}$	$0.60±0.02^{bc}$	$0.64±0.05^{b}$	$0.52±0.02^{c}$
EconomicWeight gain(g)	$0.81±0.03^{a}$	$0.57±0.00^{bc}$	$0.60±0.02^{bc}$	$0.64±0.05^{b}$	$0.52±0.02^{c}$

Mean ± SEM on the same row with the same superscript are not significantly different ($p \geq 0.05$). GSM – garden snail meal

Conclusion

GSM inclusion in diet of *H. bidorsalis* at 25-50% significantly improves absolute weight gain. Moreover, 25-50% inclusion level of GSM significantly increases profit maximization in *H. bidorsalis* production. Therefore, 25-50% GSM level is recommended in *H. bidorsalis* diet during production.

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