



**Growth Performance, Feed Utilization And Cost Benefits
of *Heterobranchus bidorsalis* (Geoffroy St Hilaire, 1809)
Fed Fermented Apple-Ring (*Faidherbia albida*) Seed Diet**

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ABSTRACT

The study evaluated the growth performance and feed utilization of African catfish, *Heterobranchus bidorsalis*, fed varying levels of fermented *Faidherbia albida* seed meal as a replacement for soybean for 90 days. Five experimental feeds (Diets 1, 2, 3, 4, and 5), each with about 40 % crude protein content, were formulated at diet 1 = 0 %, diet 2 = 25 %, diet 3 = 50 %, diet 4 = 75 %, and diet 5 = 100 % inclusion levels of fermented *F. albida* seed meal (FFA). Fish were acclimatized for one week and stocked in 35L capacity plastic bowls for each feed with 3 replicates. The initial mean weight of fish was 1.2.00 - 1.21 g. Fish were fed at 5% body weight daily and adjusted accordingly every fortnight. Water quality parameters were noted morning and evening bi-weekly. Treatments that contained 25 % FFA gave the highest performance with respect to mean weight gain, specific growth rate, and relative growth rate. The feed utilization indices were generally fair across all treatments, with best performance in the treatment containing 25 % FFA. Feed conversion ratio gave the highest value of 1.80 in 100 % (D5) compared to the lowest (1.30) obtained in fish fed the control. Feed conversion ratio differed significantly ($P < 0.05$) among the treatments. Fish fed the control and D2 diets gave the highest values (0.29) of protein efficiency ratio, and the lowest value of 0.11 was recorded in fish fed the 100% diet. The results revealed that 25 % (D2) fermented *F. albida* can be included in the diet of *H. bidorsalis* without adverse effects on the fish.

Key words: *Heterobranchus bidorsalis*, Growth Performance, *Faidherbia albida*, Fermented

INTRODUCTION

High cost of fish feed is one of the problems hampering aquaculture development. Expensive feeds will be marginalized or even nullify the profitability of fish farming production, consequently lowering yield in terms of quality and quantity. Fish feed accounts for at least 60 % of the total cost of production; hence has motivated research into locally available, cheap, and unconventional feeds as alternative feedstuffs for fish (Tiamiyu *et al.*, 2013) to reduce the cost of production without compromising the health of the fish. A number of plants continue to be investigated for their potential in supplementing or even replacing conventional feedstuffs. This study therefore seeks to determine the optimum inclusion levels of *Faidherbia albida* seed meal in the diets formulated for *Heterobranchus bidorsalis*, a widely cultured fish species in West Africa.

Faidherbia albida (Acacia) has a common name "Apple-ring" and is locally called Gawo" in Hausa. There are a number of species in this genus *Faidherbia* totaling about 900 species, and 700 of these are found to be native in Australia and about 200 species in tropical areas of Africa, America and Asia (Barnes *et al.*, 1996). They are drought-resistant tree species capable of withstanding very harsh environmental conditions and can grow in several soil types,

including water-logged areas (Wood, 1992). The pods are orange-brown in colour and coiled or twisted, containing 10-30 dark brown seeds and a tough seed coat which is leathery and waterproof to maintain their viability over several years on the ground (Wood, 1992). Hassan *et al.* (2007) reported that *Faidherbia albida* contains 10-13 % protein in pods and 26-28 % in the seeds, while Wickens (1969) found the entire pod to contain 10.6-17.0 % protein and 27 % protein in the seed. Igwebuike (2001) reported chemical analysis of *Faidherbia albida* seed to be protein 26.36 %, fibre 8.50 %, extract 2.72 %, ash 4.36%, nitrogen-free extract 58.04%, calcium 0.44 %, phosphorus 0.19%, and tannins 0.53%. Abu *et al.* (1997) obtained crude protein of 31.93 %, fibre 12.25 %, ether extract 3.21 %, ash 3.4%, and nitrogen-free extract 54.51 %. Hassan *et al.* (2007) reported 20.6 % and 19.5 % crude protein on a dry matter basis in the seed and pulp of *Faidherbia albida*, respectively. This Study aimed to search for locally available, cheap, and unconventional feeds as alternative feedstuffs to soybean for fish.

MATERIALS AND METHODS

Study Site

The study was conducted in the Teaching and Research Fish Farm of the Department of Fisheries, Faculty of Agriculture, University of Maiduguri, Maiduguri. The area is located at Latitude 11°51'N and longitude 13° 05'E. It is characterized by a hot and dry season and a short duration of erratic rainfall (3-4 months per annum. Ambient temperatures are lower in December and January, ranging from 15-20 °C (night), and high in March to June, ranging from 33-44 °C with relative humidity of 25 -34.5 % (Duwa *et al.*, 2011)

Collection and Processing of the Legume Seeds

Freely fallen ripped pods of *Faidherbia albida* were picked on the ground under the trees on the University of Maiduguri campus, threshed, and winnowed to obtain the seeds. The seeds were removed by threshing and winnowing. The already prepared seeds were washed with saline water to remove dirt, residual pulp, microbial loads, and other debris to reduce contamination.

Processing and Fermentation of the seeds

The *Faidherbia albida* seeds were reduced in size with a pestle and mortar according to methods in Antyev (2017). *Faidherbia albida* seed meals were moistened, and 1 % of sodium hypochlorite solution was added to sterilize the seeds. Then a mixture of 0.1 mL of acetic acid and 0.1 M sodium ethanoate was used to prepare a 10 mL buffer solution of pH 4- 6, which created an enabling medium for fungal growth (FAO /WHO, 2011). The plastic was kept in a dark room at room temperature according to the methods of Akomedaye and Gabriel-Ajobiwe (2011)

Formulation and preparation of experimental diets

Five Isonitrogenous experimental diets 1, 2, 3, 4 and 5 were formulated to contain 0 %, 25 %, 50 %, 75 % and 100% fermented *Faidherbia albida* seed meal (FFA), respectively. The crude protein (CP) value of *Faidherbia albida* seeds derived from the proximate analysis conducted was 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, pelletized, sun-dried, and packaged in a labelled polyethylene bag and stored till feeding time.

Experimental design and procedure:

A completely randomized design (CRD) was employed in this research. The 35 L capacity bowls used were divided into 5 sets of 3. Each random set was assigned to a given feed treatment, and the three 35 L capacity bowls formed replicates. These gave 5 treatments and 3 replicates per treatment. The fish in each bowl were weighed at the beginning of the experiment to determine the initial mean weight (1.2.01 g). Subsequent weighing and measurement were done bi-weekly. Fish in each replicate were fed daily at 5 % of their total

body weight, split equally into morning and evening rations, for 90 days.

Purchasing and Acclimatization of Experimental Fish

One hundred and fifty (150) fingerlings of *Heterobranchus bidorsalis* were obtained from Dalhim Fish Farm in Maiduguri, Borno State, Nigeria, and were transported to the study site. The fish were kept acclimatizing and fed commercial diets for a week.

Flow-through System

A semi-flow-through system comprising 35 L capacity plastic bowls was designed and constructed using plastic bowls on a wooden platform and PVC pipes (Michael, 2015). Continuous aeration and renewal of the water in the bowls were carried out every morning.

Table 1: Percentage Composition of Ingredients with Fermented *Faidherbia albida* Seed Meal

Ingredients (%)	Treatments				
	Diet1	Diet2	Diet3	Diet4	Diet5
Fish Meal (62)	35.38	35.38	35.38	35.38	35.38
Soybean Meal (44)	35.38	29.21	21.67	12.21	0.00
FFA (31.5)	0.00	9.74	21.67	36.63	55.94
Yellow Maize (10)	24.45	21.37	16.98	11.48	4.38
Premix*	1.00	1.00	1.00	1.00	1.00
Lysine	0.40	0.40	0.40	0.40	0.40
Methionine	0.40	0.40	0.40	0.40	0.40
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50
Vitamin C	0.20	0.20	0.20	0.20	0.20
Vegetable Oil	1.00	1.00	1.00	1.00	1.00
Starch	0.50	0.50	0.50	0.50	0.50
Crude protein	39.98	39.67	39.47	39.20	38.89
Dicalciumphosphate	0.50	0.50	0.50	0.50	0.50
Chromium III oxide	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.0	100.0	100.00
Calculated Analysis (%)					
Dry Matter	90.35	87.22	87.03	86.83	86.55
Crude Protein	40.00	39.93	39.93	39.92	39.93
Eather Extract	6.85	7.10	7.44	7.84	8.36
Crude Fibre	3.35	3.77	4.26	4.88	5.68
Ash	6.09	6.56	7.14	7.87	8.81
Nitrogen Free Extract	30.96	29.75	28.17	26.21	24.43

such that the problem of oxygen depletion, pollution from excreta, and other waste products is minimized. A total of fifteen (15) circular plastic bowls of 35 liters capacity were used. The bowls were cleaned, disinfected with saline solution, and allowed to dry for 24 hours, after which water was supplied to two-thirds of their capacity from the borehole, and 10 fish were randomly allocated to each bowl and reared for 90 days

Water Quality Parameters

Water quality was monitored every two weeks throughout the feeding trial using the method described in Fakunle *et al.* (2013). Temperature ($^{\circ}\text{C}$) and pH were measured by a PEN pH meter, while a dissolved oxygen meter (JBP 607) was used to measure dissolved oxygen in milligrams per litre (mg/l), and ammonia was measured.

Growth Parameters

The following data were collected: initial length, final length, initial weight, final weight, total feed intake, survival, and growth parameters were estimated as shown below.

Feed intake

Feed intake = total feed supplied bi-weekly for one hundred and eighty days.

Weight Gain (WG)

$$MWG = W_2 - W_1$$

Where: W_2 = final weight, W_1 = initial weight.

WG = weight gain.

Relative Growth Rate (RGR)

$$RGR = \frac{W_2 - W_1}{W_1} \times 100$$

Where: $\ln$ = natural logarithm, W_2 = final weight of the fish in grams, W_1 = initial weight of the fish in grams, T = rearing period in days.

Specific Growth Rate (SGR)

$$SGR = \frac{\log W_2 - \log W_1}{T} \times 100$$

Where: $\log W_2$ = logarithm of final weight of fish,

$\log W_1$ = logarithm of initial weight of fish, T = rearing period in days.

Feed Conversion Ratio (FCR)

$$FCR = \frac{\text{Dry weight of feed consumed (g)}}{\text{Weight gain (g)}}$$

Protein efficiency ratio

$$PER = \frac{\text{final weight} - \text{initial weight}}{\text{protein intake}}$$

Where protein intake = % protein in diet $\times$ total feed consumed

Condition Factor (K)

This is also known as the pond-eval index. It is a product of fish showing the relationship between weight and length.

$$K = \frac{100W}{L^3}$$

Where; W = weight of the fish (g), L = length of the fish (mm).

Data Analysis: Data obtained from the experiments were subjected to one-way analysis of variance (ANOVA). Means were compared using Duncan multiple range test (Duncan, 1955) at a 95% confidence level with the aid of Statistica 8.0.

RESULTS

Growth performance parameters are presented in Table 2. Mean weight gain gave the highest value of 18.61g/fish in the control and the lowest mean weight gain of 10.23g/fish in D5 FFA (fermented *Faidherbia albida*). There is no significant difference ($p > 0.05$) in mean weight gain between control and D2, but they are significantly different ($p < 0.05$) from other treatments. Bi-weekly weight gain gave the highest value of 1.45 g/fish/week in control and the lowest mean weight gain of 0.75 g/fish/week in 100% FFA. There is no significant difference ($p > 0.05$) in bi-weekly mean weight gain between the fish fed control and D2, but they are significantly different ($p < 0.05$) from other treatments. Relative growth rate and specific growth rate gave the highest values of 1382.01/% and 5.56 g/day in the control and D2. The lowest values of 337.54% and 1.00 g/day are recorded in fish fed D5. The values of relative growth rate (RGR) and specific growth rate (SGR) in fish fed control and D2 show no

significant differences ($p > 0.05$) but are significantly different ($p < 0.05$) from other treatments. Feed conversion ratio gave the highest values of 1.80 in 100% (D5) compared to the lowest (1.30) obtained in fish fed control. Feed conversion ratio differed significantly ($p < 0.05$) among the treatments. Fish fed control and D2 diets gave the highest values (0.29) of protein efficiency ratio, and the lowest value of 0.11 was recorded in fish fed the 10D1 diet.

Table 2: Growth Performance and Feeds Utilization of *Heterobranchus bidorsalis* Fingerlings Fed Fermented *Faidherbia albida* Diets for 90 Days

Parameters	Treatments					SEM
	Diet1	Diet2	Diet3	Diet4	Diet5	
MWG (g/Fish)		18.61 ^a	17.96 ^a	11.60 ^b	11.37 ^c	10.23 ^d
0.27						
LG (cm)	6.2 ^a	6.23 ^a	5.74 ^b	5.45 ^b	4.73 ^b	0.31
RGR (%)	1382.01 ^a	1185.23 ^a	574.65 ^b	374.46 ^c	337.54 ^c	2.27
SGR (g/day)	5.56 ^a	5.39 ^a	4.65 ^b	3.45 ^c	1.00 ^d	0.17
PI(g)	576.53 ^a	522.93 ^b	300.40 ^d	134.53 ^d	1.89 ^e	5.78
FCR	1.30 ^e	1.40 ^d	1.56 ^c	1.69 ^b	1.80 ^a	0.01
PER	0.29 ^a	0.27 ^{ab}	0.23 ^b	0.09 ^c	0.11 ^c	0.02
K	1.74 ^a	1.68 ^a	1.27 ^c	1.36 ^c	1.54 ^{ab}	0.12

Means with the same superscripts in the same row are not significantly different ($P > 0.05$)

Key

MWG = Mean weight Gain

LG = Length Gain

RGR = Relative Growth Rate

SGR = Specific Growth Rate

K = Condition Factor

FCR = Feed Conversion Ratio

PER = Protein Efficiency Ratio

PI = Protein Intake

Table 3: Economic Benefit of Fermented *Faidherbia albida* in the Diets of *H. bidorsalis*

Parameters	Treatments				
	Diet1	Diet2	Diet3	Diet4	Diet5
Cost of feed (₦)/Kg	496.66	461.70		410.20	
367.0	349.8				
Mean feed intake(g)	410.80	410.0	152.30		
100.40	88.20				
Mean feeding cost (₦)	204.03		189.30	61.10	
36.85	30.86				
Cost of fingerlings (₦)	35	35	35	35	35
Total Expenses (₦)	239.03	224.3	96.1	71.85	
65.86					
Mean final weight(g)	262.94	251.58		89.1	60.99
55.52					
Cost of fish (₦)/Kg	1200	1200	1200	1200	1200
Mean yield cost (₦)	315.53	301.89		106.92	
73.19	66.62				
Net profit	76.5	77.59	10.82	1.34	0.76
Profit Index	0.53	0.54	0.22	0.16	0.16
Benefit cost ratio	1.28	1.33	1.11	1.00	1.03
Incident cost	1.89	1.84	4.50	0.60	6.00

There are significant differences ($p < 0.05$) in protein efficiency ratio among the treatments.

Protein intake in fish fed the control diet was the highest (576.53), while fish fed the 100% diet gave the lowest value of 111.89. The condition factor (K) of fish fed the control diet indicated the highest value of 1.74 in the control, followed by 1.68 in D2. The lowest is obtained in D4 and D5. There is no significant difference in the condition factor of fish fed D3 and D4, but they are significantly different ($p < 0.05$) from other treatments.

Table 3 presents the economic viability of fermented *Faidherbia albida* seed meal in the diets of *Heterobranchus bidorsalis*. The highest (N496.66) cost of feed is recorded in the control, while the lowest cost of N349.80 was obtained in 100% fermented *Faidherbia albida*. As the inclusion levels of fermented *Faidherbia albida* increase, there is a reduction in the cost of feed. Also, the total expenses reduced from N239.03 to N65.86 at 100% inclusion levels of fermented *Faidherbia albida* seed meal. Net profit recorded the highest value of 77.59 in 25% fermented *Faidherbia albida* and the lowest (0.76) in 100%. The highest profit index of 0.54 was obtained in 25% fermented *Faidherbia albida*, while the lowest (0.15) was obtained in 100%. The benefit-cost ratio of 1.33 in 25% fermented *Faidherbia albida* is the highest, and the lowest (1.00) is recorded in the 75% fermented *Faidherbia albida* diet

DISCUSSION

The increase in weight gain and specific growth rate in all the treatments indicated that *Heterobranchus bidorsalis* responded positively to all the diets. This study agreed with the report of Adeshina *et al.* (2013). Similarly, Hossain *et al.* (1995) reported weight gain and specific growth rate *aet al.* (ost important measurements of diet productivity. The growth parameters recorded in *Heterobranchus bidorsalis* fed a 25% inclusion of fermented *Faidherbia albida* seed meal can be compared to the control (Table 2), followed by fish fed a 50% *Faidherbia albida* seed meal diet. A similar observation was reported by Hassan *et al.* (2015) using fermented sunflower meal diets, and this disagrees with the 20% fermented sickle pod seed meal diet (Bake *et al.*, 2015). Also, it disagrees with Aliu and Odeh (2019), who reported the highest weight gain at D5 in the *Phaseolus linatus* seed meal diet. Previous studies (Oso *et al.*, 2011; Anene *et al.* 2012; Tihamiyu *et al.*, 2014) recorded better growth indices in *Clarias gariepinus* at D2 inclusion of various legume seed meal diets. The better performance at 25% fermented *Faidherbia albida* seed meal diets in this study may be due to the presence of low molecular weight metabolites such as free amino acids, which act as feed attractants in fish rations (Erbas *et al.*, 2005), while the reduction in growth performance with higher inclusion levels (100%FFA) may be due to the presence of residual anti-nutrients and changes in palatability in the ingredients. The result is in line with the findings of Jimoh and Aroyehun (2011) and Bake *et al.* (2012), who recorded poor growth in higher inclusion levels of most plant protein source-based meals. Hence, a lower Inclusion level (25% of *Faidherbia albida* seed meal) may not affect the growth and nutrient utilization of the fish. The condition factor (K) is used in Fisheries science to express robustness and general well-being of fish (Bello *et al.*, 2012).

The condition factor of *Heterobranchus bidorsalis* fed a 25% fermented *Faidherbia albida* seed meal diet is comparable to that of fish fed control diets. All the condition factor values were above 1.0, which agreed with Sogbesan (2007). The best (Lowest) feed conversion ratio (1.30) was observed in the control (Table 2), hence, superior utilization of the diets was obtained in the control, followed by D2 *Faidherbia albida* seed diet (with FCR of 1.40). Adikwu (2003) documented that the lower the feed conversion ratio (FCR), the better the feed utilization. The FCR values ranged from 1.30 to 2.18 in this study did not agree with the 5.72 to 5.18 values recorded by Bello *et al.* (2012). Also, the result indicated superiority over 2.46 to 2.66 recorded by Bekibele (2005). Protein efficiency ratio (PER) is known to be regulated by the non-protein input of the diet and is a measure of the protein-sparing effect of lipid and carbohydrate (Tibbets *et al.*, 2005), Desilva and Adenson (1995) reported that Protein

Efficiency Ratio is a measurement of how well the protein sources in a diet could provide the essential amino acid requirement of fish fed. The economic viability of feeding *Heterobranchus bidorsalis* with fermented *Faidherbia albida* seed meals (FASM) showed that Net Profit, Profit Index, and Benefit-Cost Ratio were highest at 25% inclusive a benefit-cost ratio of 1.33 recorded at 25% inclusion of FASM. At every ₦1.00 investment made, a 1.33 benefit-cost ratio will be realized. The trends of net profit, profit index, and benefit-cost ratio recorded are consistent with those of Haruna and Orire (2020) and Falaye *et al.* (2021). There was a reduction in the cost of feed consumed in production, which indicated economic benefit.

CONCLUSION

The growth parameters in fish fed control and D2 showed no significant differences ($p < 0.05$). Feed utilization indices in control and D2 were comparable. The reduction in mean weight gain and specific growth rate as the inclusion level increases might be due to residual anti-nutritional factors. The outcome of this study indicated that inclusion of fermented *Faidherbia albida* seed meals is best at 25%. It means, therefore, that *Heterobranchus bidorsalis* can be fed with fermented seed meals of fermented *Faidherbia albida* at 25% inclusion level.

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