Growth Performance and Nutrient Utilization of Catfish Hybrid (*Heterobranchus bidorsalis* X *Clarias gariepinus*) Fed Fermented Sorghum (*Sorghum bicolor*) Waste Meal Diets

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Abstract

Fingerlings of "Heteroclarias" were stocked randomly into ten tanks at 10 fingerlings per tank and subjected to five treatments with each treatment replicated twice. Fermented Sorghum Waste, which is the test ingredient, was included at 0%, 20%, 40%, 60% and 80% in the five diets formulated at 40% crude protein. The experiment lasted for 70 days. Fish fed with diet D2 (20% inclusion level) had the best growth rate with specific growth rate of 2.08±0.08, feed conversion ratio of 1.03±0.05 and protein efficiency ratio of 1.46±0.09 while fish fed with diet D5 (80% inclusion level) had the least growth rate with specific growth rate of 1.89±0.08, feed conversion ratio of 1.33±0.06 and protein efficiency ratio of 1.13±0.06. There was no significant difference in all the growth and nutrient utilization data for fish fed diets D1 to D4 but they differed significantly from fish fed diet D5. It can be concluded that Fermented Sorghum Waste Meal can replace maize up to 60% inclusion level as an energy source in the diets of "Heteroclarias" fingerlings without adverse effects on nutrient utilization and growth performance.

Keywords: Hybrid catfish, Fermented Sorghum Waste Meal, Nutrient utilization, Growth performance

Introduction

Fish farming involves raising fish in tanks or enclosures, usually for food or commercial purposes. Fish farming in Nigeria is currently a very lucrative business and it is mainly boosted by the continuous rise in the demand for the African catfish. This trend therefore makes catfish culture the most popular form of fish farming in Nigeria with *Clarias gariepinus*, *Heteroclarias spp.* and *Heterobranchus spp.*being the most desirable for culture (Adekoya *et al*.,2006), and they have remained an important species for research in aquaculture. Fish contains protein of very high quality and has sufficient amounts of all the essential amino acids required by the body for maintenance of lean tissues (Fagbenro and Adeparusi, 2003) which makes it a very important food for humans.

Although no dietary requirement for carbohydrate has been demonstrated in fish diet (NRC, 1993), however, if carbohydrates are not provided in the diet, other compounds such as protein and lipids are catabolized for energy and for the synthesis of various biologically important compounds usually derived from carbohydrates (Wilson, 1994). Thus, it is important to provide the appropriate concentration of carbohydrate in the diet of fish.

The high cost of fish feed has been recognized as a major factor militating against rapid development of aquaculture in the developing countries due to most of the conventional feedstuffs being used in human foods and animal feeds hence bringing about exorbitant prices and scarcity of these feedstuffs. Maize is an example of such feedstuff, commonly used as a carbohydrate or energy source in fish diets. There is therefore a necessity for research into non-conventional carbohydrate ingredients that can replace maize without compromising fish growth and health.

Sorghum bicolor commonly called sorghum is a grass species belonging to the family Poaceae which is cultivated for its edible grain (NRC, 1996).

Sorghum is similar in chemical composition to maize and has a nutritional quality comparable to other cereals (Aderolu *et al*., 2009). However, the presence of anti-nutritional factors like tannin, phytates and cyanogenic glucosides among others could probably have effect on nutrient utilization and growth of fish. Processing of sorghum either by fermentation or wet-milling removes these anti-nutritional factors. The processing of sorghum produces some by-products one of which is the Fermented Sorghum Waste.

Fermented Sorghum Waste (FSW) is a by-product gotten from the manufacture of 'ogi-baba' a common cereal gruel and staple food for several communities in Nigeria. The waste is usually discarded after the starch is gotten from the sorghum. FSW has a chemical composition that is similar to maize which therefore necessitates research into its use as a replacement for maize in the diets of fish.

"Heteroclarias" is an inter-specific hybrid of *Clarias gariepinus* and *Heterobranchus bidorsalis* which transfer or combine desirable traits of the two species (Bartley *et al*., 2000; Kori-Siakpere *et al*., 2006). Hybridization is one of the genetic improvements in aquaculture industry which has been recognized as a tool for stock improvement and management purposes. Several studies have demonstrated that *Clarias gariepinus* X *Heterobranchus bidorsalis* hybrid exhibit superior growth, improved survival and general hardiness than true breed of either *Clarias gariepinus* or *Heterobranchus bidorsalis* (Madu *et al*., 1991; Salami *et al*., 1993; Nwadukwe, 1995). The technology was widely accepted as it gave 58% internal rate of return (IRR) on investment (Adeogun *et al*., 1999).

In this study, the nutrient value and economic viability of Fermented Sorghum Waste (FSW) is being evaluated in the diet of catfish hybrid "Heteroclarias". It is hoped that this study will provide baseline information on its potential in the diet of catfish hybrid "Heteroclarias".

Materials and Methods

Feed formulation and preparation: Fermented sorghum waste (FSW) was purchased from a local processor in Ikere Ekiti while other ingredients for the experimental diets were purchased from a feed market in Ado-Ekiti. The wet FSW which is a by-product of wet-milling fermented sorghum was sundried at 28^{o}C for two days after which a part of it was analysed for its proximate composition and the rest was milled into fine particles. It was then used to replace maize meal at 0%, 20%, 40%, 60% and 80% inclusion levels in the experimental diets.

Diet D1 was the control and did not contain FSW meal. Diets D2, D3, D4 and D5 were formulated with FSW meal replacing maize at 20%, 40%, 60% and 80% respectively. The ingredients for each diet were mixed thoroughly together with hot water and the diets were pelleted using Hobart A-200 pelleting machine with a die size of 2.0mm. The pellets were then sundried at 28^{o}C for three days, packed in well labeled containers and stored in a cool and dry place till use.

Table 1: Gross Composition of Diets

Ingredients	Diet D1	Diet D2	Diet D3	Diet D4	Diet D5
Fishmeal (72%)	31.65	30.57	29.54	28.46	27.43
Soybean meal (45%)	31.65	32.73	33.76	34.84	35.87
Maize meal (10%)	29.70	23.76	17.82	11.88	5.94
FSWM (14.8%)	-	5.97	11.88	17.82	23.76
Vitamin/Mineral premix	4.0	4.0	4.0	4.0	4.0
Vegetable oil	2.0	2.0	2.0	2.0	2.0
Methionine	0.3	0.3	0.3	0.3	0.3
Starch	0.7	0.7	0.7	0.7	0.7
Total	100	100	100	100	100

Feeding Trial: The experiment was carried out in the Teaching and Research Farm of the Ekiti State University. Ten rectangular plastic tanks each with a dimension of 70cmX45cmX40cm were used. The water level was maintained at 2/3 capacity in all the tanks throughout the period of the experiment. Water used was from an underground borehole at the Teaching and Research Farm of the University.

One hundred juveniles of hybrid catfish "Heteroclarias" were purchased from Hope fish farm, Ala quarters, Akure with mean weight of 17.06±0.23. The fish were allowed to acclimate to the water condition for seven days in the plastic tanks before the commencement of the experiment, randomly stocked at the rate of ten fish per tank.

Each treatment was replicated twice and the experiment lasted for 70days during which five diets were fed to the fish in each corresponding tank.

The experimental diets were fed to the fish to satiation and fish were weighed fortnightly. The fish were fed twice daily between 8.00am – 9.00am and 6.00pm – 7.00pm for the entire period of the experiment, feaces and other dirts in the tanks were siphoned out every morning before feeding. The growth rates were recorded and data collected were used to evaluate the performance of each diet.

All treatments were subjected to the same environmental conditions. Water quality measurements were taken fortnightly: temperature was measured using a mercury-in-glass thermometer, dissolved oxygen by dissolved oxygen meter and pH using a pH meter.

Biological Evaluation

Diet performance was determined as follows:

i Weight gain= Final weight of fish (w_2) – Initial weight (w_1)

ii Specific Growth Rate (SGR)= $\frac{\log_e \text{final weight} - \log_e \text{initial weight} \times 100}{\text{Time period (Days)}}$

iii Protein Efficiency Ratio (PER) = $\frac{\text{Fish weight gain (g)}}{\text{Protein consumed (g)}}$

iv Feed Conversion Ratio (FCR) = $\frac{\text{Weight of feed (g)}}{\text{Fish weight gain (g)}}$

Proximate analyses: The proximate analyses of FSW meal, that of the five experimental diets and the fish before and after the experiment were carried out using the method of A.O.A.C (1990).

Cost analysis: The cost of producing 1kg of the different feeds where FSW meal was included at varying inclusion levels were calculated and compared with the production cost of 1kg of the control diet which has no FSW meal. Costing was done according to the prevailing market prices of ingredients that were used in the diet as at the time of the experiment. The cost of producing 1kg of fish for each feed was also calculated.

Statistical analysis: The biological data collected from the experiment were subjected to one-way analysis of variance (ANOVA) using SAS package and the differences were separated using Duncan multiple range test (1955).

Results

The result of the proximate composition of the FSW is shown in Table 2. It had a crude protein content of 14.80, fat content of 1.88, crude fibre of 8.95, moisture content of 16.10, ash content of 1.94 and Nitrogen Free Extract (NFE) of 56.33.

Table 2: Proximate Composition of Feed Ingredients Used

	*FISH MEAL	*SOYBEAN MEAL	*MAIZE MEAL	**FERMENTED SORGHUM WASTE
Crude protein	72.00	45.00	10.00	14.80
Lipid	8.38	0.50	2.10	1.88
Crude fibre	0.10	7.00	1.00	8.95
Ash	5.32	6.00	0.70	1.94
Moisture	2.10	9.40	12.38	16.10
NFE	12.10	32.10	73.82	56.33

Sources: * Cruz (1997) ** Laboratory analysis during experiment.

Proximate Composition of Experimental Diets

The chemical composition of the experimental diets is given in Table 3. All the diets had the same crude protein level. Diet D1 had the highest lipid content while diet D5 had the least lipid content. Crude fibre was highest in diet D5 and lowest in diet D1. The ash content was also highest in diet D5 and lowest in diet D1.

Table 3: Proximate Composition of Experimental Diets

	DIET D1	DIET D2	DIET D3	DIET D4	DIET D5
Crude protein %	40.00	40.00	40.00	40.00	40.00
Lipid %	3.43	3.31	3.24	3.14	3.05
Crude fibre %	2.54	3.09	3.36	4.18	4.72
Ash %	3.79	3.87	3.95	4.03	4.11
Moisture %	7.32	7.62	7.91	8.21	8.51
NFE %	42.92	42.11	41.27	40.44	39.61

Proximate Composition of the Experimental Fish Carcass

The carcass composition of the experimental fish is given in Table 4. Fish fed with diet D2 has the highest protein value while fish fed with diet D3 has the least protein value. Crude protein level of all the fish fed with different diets increased compared to the initial protein level. Ash content was highest in fish fed with diet D4 and the lowest was found in fish fed with diet D1. Moisture content for fish fed with diet D5 was the highest while fish fed with diet D4 had the lowest moisture content.

Table 4: Carcass Composition of Experimental Fish

	Initial	Diet D1	Diet D2	Diet D3	Diet D4	Diet D5
Crude protein	51.28	54.63	56.85	54.19	55.37	55.64
Lipid	14.26	13.77	13.09	14.74	14.39	13.19
Ash	16.80	14.74	14.82	14.85	14.87	14.83
Moisture	12.45	11.45	11.53	11.59	11.30	11.62

Water Quality Parameters

Table 5 shows the result of water parameters recorded during the period of the experiment. The temperature and dissolved oxygen throughout the period of the experiment ranged between 22.75-23^{0}C and 7.05-7.1mg/litre respectively while the pH values ranged between 6.70 and 6.75.

Table 5: Mean water quality parameters recorded during the experimental period

Tank	Temperature (^{0}C)	DO (mg/litre)	pH
D1	22.90±0.10	7.10±0.00	6.70±0.00
D2	22.75±0.05	7.10±0.00	6.75±0.05
D3	22.75±0.05	7.10±0.00	6.70±0.00
D4	22.90±0.10	7.05±0.05	6.75±0.05
D5	23.00±0.20	7.05±0.05	6.70±0.00

Nutrient Utilization and Growth of Experimental Fish

Table 6 shows the mean weight gain, the average daily weight gain (ADWG), the specific growth rate (SGR), protein efficiency ratio (PER) and feed conversion ratio (FCR) of the experimental fish. The initial mean weight of fish was 17.02 while the final mean weight was 71.01.

The highest weight gain (58.35±3.52) was achieved with the fish fed diet D2 containing 20% inclusion level of FSW followed by the fish fed diet D1 (57.60±13.97) with 0% inclusion level and the least weight gain (45.25±2.37) was recorded with the fish fed diet D5 containing 80% inclusion level of FSW. All other parameters recorded followed the same trend with best values recorded for fish fed D2, followed by that fed D1, while the least was recorded in fish fed D5. However, there were no significant differences ($p>0.05$) between the weight gain, ADWG and PER for diets D2, D1, D3 (40% inclusion level) and D4 (60% inclusion level) but there was significant difference ($p<0.05$) between diet D5 and the other diets. For SGR, there were no significant differences ($p>0.05$) between any of the five diets while for FCR, there were no significant differences ($p>0.05$) between the values for diets D1, D3 and D4 but they differed significantly from the values for other diets, there was significant difference ($p<0.05$) between the value for diet D2 and all other diets, and between diet D5 and all other diets with D5 having the poorest FCR value.

Table 6: Performance Evaluation of "Heteroclarias" fed with Fermented Sorghum Waste Meal

PARAMETERS	Diet D1	Diet D2	Diet D3	Diet D4	Diet D5
Initial weight	17.00±1.15[a]	17.10±0.23[a]	17.00±0.00[a]	17.10±1.04[a]	16.90±0.46[a]
Final weight	74.60±12.82[a]	76.15±3.29[a]	70.60±4.16[a]	72.05±2.94[a]	61.65±1.91[b]
Weight gain	57.60±13.97[a]	59.05±3.52[a]	53.60±4.16[a]	54.95±3.98[a]	44.75±2.37[b]
Survival	95±5.77[b]	100±0.00[a]	100±0.00[a]	95±5.77[b]	95±5.77[b]
Average daily weight gain	0.82±0.20[a]	0.83±0.05[a]	0.77±0.06[a]	0.79±0.06[a]	0.65±0.03[b]
Specific growth rate	2.10±0.34[a]	2.08±0.08[a]	2.03±0.08[a]	2.06±0.15[a]	1.89±0.08[a]
Protein efficiency ratio	1.44±0.35[a]	1.46±0.09[a]	1.34±0.10[a]	1.38±0.10[a]	1.13±0.06[b]
Feed conversion ratio	1.09±0.23[b]	1.03±0.05[c]	1.12±0.08[b]	1.10±0.07[b]	1.33±0.06[a]

Means with the same letters are not significantly different by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Cost Analysis of Experimental Diets

The cost analysis of the experimental diets is shown in Table 7. The feed with the highest cost per kg feed is the control (D1), while that with the lowest cost per kg feed is D5. Diet D5 had the least cost per kg fish while diet D1 had the highest cost per kg fish.

Table 7: Cost Analysis of Experimental Diets

INGREDIENTS	CONTROL COST(₦)	DIET D2 COST(₦)	DIET D3 COST(₦)	DIET D4 COST(₦)	DIET D5 COST(₦)
Fishmeal (72%)	167.75	162.02	156.56	150.84	145.38
Soybean Meal (45%)	42.73	44.19	45.58	47.03	48.42
Maize Meal	29.70	23.76	17.82	11.88	5.94
FSWM	-	1.78	3.56	5.35	7.13
Vegetable Oil	5.20	5.20	5.20	5.20	5.20
Fish Premix	40.00	40.00	40.00	40.00	40.00
Methionine	4.20	4.20	4.20	4.20	4.20
Starch	1.40	1.40	1.40	1.40	1.40
Cost/kg Feed	290.98	282.55	274.32	265.90	257.67
Cost/kg Fish	617.15	570.30	524.56	477.77	432.03

Discussion

At the end of the study, the result shows that Fermented Sorghum Waste Meal can serve as a replacement for maize in enhancing productivity in the diet of the African Clariid catfish hybrid, "Heteroclarias".

The physico-chemical parameters of water used for fish culture during the experimental period were within the range recommended for African catfish culture (Swann and Ladon, 1990).

All the experimental diets were accepted by the experimental fish indicating that the incorporation of FSW meal in fish diets did not have adverse effect on the palatability of the experimental diets. This might be attributed to the processing technique which the sorghum seed was subjected to prior to pap production. This finding agrees with Fagbenro (1999), Francis *et al.,* (2001) and Siddhuraja and Becker (2003) who reported that reduction in antinutrient by different processing techniques resulted in better palatability and growth in fish.

It was observed from the study that fish fed diet containing 20% inclusion level of FSW performed better in all the parameters measured than fish fed on maize (control) as the sole energy source and even at inclusion level up to 60% of FSW, there was no significant difference (p>0.05) in the parameters measured compared with the control which had 0% inclusion level of FSW. The study also showed that as the inclusion level of FSW meal in the fish diet increased, it resulted in reduced growth of experimental fish. This was evident in the poor values recorded for all growth performance and nutrient utilization parameters in diet D5 which had the highest inclusion level of FSW. However, good values recorded for all growth and nutrient utilization parameters in fish fed diet D2 (10% FSW) means that the fish were able to utilize diet D2 more than the other diets.

The poor values observed in diet D5 (80% FSW) is an indication of poor diet utilization which may be attributed to high inclusion level of FSW in the diet and this could be due to its high fiber content.

The percentage survival was good throughout the experimental period. This could be as a result of good water quality management, good handling and the suitability of FSW meal as an ingredient in "Heteroclarias" diet. It was also observed that survival rate was highest in diet D2 and D3 (100%) while for the others, it was 95%.

When considering the cost, all the feeds from 20 – 80% inclusion of FSW were less costly than the maize – based diet, with the cost reducing as the level of inclusion of FSW increased which means they would be more economical than the maize based diet. Diet D1 has the highest cost per kg of feed and fish while diet D5 has the least cost per kg of feed and fish. However, it is not advisable that fish is reared with diet D5 because of the poor growth and nutrient utilization recorded when FSW was included at 80% inclusion level.

Conclusion

The high cost of maize which is the major carbohydrate source in fish diet has been a problem in fish culture; this is addressed in the present study in the use of Fermented Sorghum Waste Meal as a replacement for maize in fish feed. Fermented Sorghum Waste which is usually discarded after the processing of sorghum into pap has proved to be efficacious in animal feed preparation.

From the study, the use of Fermented Sorghum Waste Meal (FSWM) to replace maize which is a highly competitive source of carbohydrate in fish diet had the best result in terms of nutrient utilization and growth at 20% inclusion level and was not significantly different from the control (0% inclusion level) even at inclusion levels up to 60%. It was also observed that when considering the cost, all the feeds from 20 – 80% inclusion of FSW were less costly than the maize – based diet, which means they would be more economical than the maize based diet. However, because of the poorer performance of the fish fed on diet with 80% inclusion level of FSW as compared with the control diet, it is not advisable to exceed 60% inclusion level in feeding "Heteroclarias" fish.

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