Asian Journal of Fisheries and Aquatic Research

Volume 25, Issue 6, Page 43-56, 2023; Article no.AJFAR.109852
ISSN: 2582-3760

Growth Performance and Nutrient Utilizations of *Heterobranchus bidorsalis* (Geoffory Saint Hilaire, 1809) Fed on Fermented Sorghum Bran Meal Diets

A. H. Ishaku [a*], Y. Ahmed [a], M. E. Ali [b], E. Kela [c] and O. A. Sogbesan [d]

[a] Department of Fisheries Technology, Yobe State College of Agriculture, Science and Technology Gujba, Nigeria.
[b] National Biotechnology Development Agency, Billiri, Gombe, Nigeria.
[c] Department of Biological Sciences, Gombe State University, Gombe, Nigeria.
[d] Department of Fisheries, School of Agriculture, Modibbo Adama University, Yola, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2023/v25i6716

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/109852

Original Research Article

Received: 25/09/2023
Accepted: 29/11/2023
Published: 22/12/2023

ABSTRACT

The growth of aquaculture faces a high cost of feed which is about 60% to 75% of total production costs. An effort should be made to increase the profit by reducing the cost of feed as minimal as possible. This study investigated the growth performance and nutrient utilizations of *Heterobranchus bidorsalis* fed on fermented sorghum bran meal diets. sorghum bran was fermented at 10% moisture for seven days and samples for proximate analysis were collected on

**Corresponding author: Email: ahishaku@gmail.com;*

the first, fourth and seventh day. The highest crude protein was obtained in seventh day fermentation with 17.59±1.53% and the lowest was obtained in the zero day (control) with 10.53±1.53. Four isoproteic diets (40% crude protein) were formulated at 25%, 50%, 75% and 100% inclusion level to replace maize meal. The diets were fed to *H.bidorsalis* for twelve weeks. The experimental fish were fed 5% body weight throughout the experiment. The results obtained from the feeding trial showed that the fish fed on 100% inclusion level shows significance difference ($p<0.05$) in mean weight gain compared to fish fed on other diets. The highest mean weight gain (MWG) was obtained in the fish fed on 100% inclusion level diet (D_5) with 43.39±1.86g and the lowest was obtained in control diet (D_1) with 28.97±0.54g. The highest Average Daily Growth (ADG) and Specific Growth Rate (SGR) were obtained in the fish fed on (D_5) with 0.52±0.56 and 1.07±0.64 while the lowest were obtained in the fish fed on control diet with 0.35±0.51 and 0.91±0.65 respectively. The nutrient utilizations showed significant difference ($p<0.05$) in fish fed on (D_5) compared to others. The highest feed conversion ratio (FCR) was obtained in fish fed on (D_5) with 0.48±0.16 and the lowest was obtained in control with 0.41±0.24. The highest protein intake (PI), protein rating (PR) and protein growth rate (PGR) were obtained in the fish fed on (D_5) with 43.12±1.27, 0.52±0.72 and 1.04±0.71 while the lowest were obtained in the fish fed on control with 29.99±0.71, 0.35±0.45 and 1.00±0.53 respectively. The highest Protein Efficiency Ratio (PER) was obtained in the fish fed on (D_5) with 1.01±0.07 and the lowest was obtained in the fish fed 50% inclusion level diet (D_3) with 0.95±0.62. The highest Apparent Net Protein Utilization (ANPU) and Apparent Net Lipid Utilization (ANLU) were recorded in the fish fed on (D_5) with 23.35±0.92 and 161.22±0.26 while the lowest were recorded in the fish fed on (D_1) with 14.68±1.05 and 131.27±0.74 respectively. This study revealed the positive effects of incorporating fermented Sorghum bran meal into the diet of *H. bidorsalis.*

Keywords: Growth performance; Nutrient utilizations; Proximate composition and H. bidorsalis.

1. INTRODUCTION

"The development of fish farming is often faces high feed cost, approximately 70 to 89% of total production costs, causing declining profit" [1]. "An attempt to increase the profit is to reduce the feed cost as minimal as possible; one way to do this is to explore the source of local feed ingredients that can be used as an alternative for fish feed. In selecting the local feed ingredients, several factors should be considered. Amongst others are: the availability of the materials, the cost, the content of nutrients, and the competition with humans" [2]. "However, problem of high cost of feeding in aquaculture is further exacerbated due to the scare and expensive nature of some of the ingredients used in the formulation of fish feeds. In other to solve the problem of scarce and expensive feed ingredients, a number of non-conventional feedstuffs have been investigated most of which are alternative protein sources since this nutrient is considered as the most expensive nutrient" [3].

"Heterobranchus bidorsalis (Geoffroy Saint-Hilaire 1809) belongs to the genus heterobranchus and family Clariidae. It is one of the most cultured and economically important freshwater fish species that contributes immensely to the annual freshwater fish production in Nigeria. It is readily acceptable among Nigerian fish farmers and consumers; hence, it commands high commercial values, and is an important source of animal protein. It also serves as a model organism in research, it is cultured intensively and extensively in Africa, Europe and Asia. The economic benefits of this fish species are due to its hardiness, fast growth, large size attainable and ability to withstand changes in the environmental conditions" [4].

"Sorghum bicolor commonly called sorghum is a grass species belonging to the family Poaceae which is cultivated for its edible grain. Sorghum is mostly cheaper than maize and abundantly available in most parts of the Northern Nigeria. The projected production targets of maize and sorghum in the country for the year 2012 were put at 13,388,000 and 9,859,110 metric tonnes, respectively" [5]. "Sorghum is similar in chemical composition to maize and has a nutritional quality comparable to other cereals" [6]. "However, the presence of anti-nutritional factors like tannin, phytates and cyanogenic and glucosides among others could probably have effect on nutrient utilization and growth of fish. Processing of sorghum either by fermentation removes these anti-nutritional factors" [7]. "The processing of sorghum produces some by-products one of which is the Fermented Sorghum. 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 meal and feeding them to livestock and poultry. Fermented sorghum waste has a chemical composition that is similar to maize therefore, it necessitates research into its use as a replacement for maize which is conventional feed ingredient in the diets of fish" [7].

2. MATERIALS AND METHODS

2.1 Experimental Location

The experiment was carried out at teaching and research fish farm of the Department of fisheries Technology, School of Sciences, Yobe State College of Agriculture, Science and Technology Gujba, Yobe State, Nigeria.

2.2 Experimental Design and Units

A Completely Randomized Design (CRD) was used in this experiment in which four inclusion levels of the fermented sorghum bran meal to replace with maize (control). Four treatments and control in triplicate making fifteen experimental units for the experiment.

One hundred and fifty (150) *Heterobranchus bidorsalis* fingerlings of 6.16±0.21g were procured and acclimatized for seven (7) days and fed with a control diet and then the fish were stab for twenty four hours (24 hours) to empty their stomach. Subsequently, they were randomly assigned to twelve (12) treatments in triplicate each and control. Ten (10) fish fingerlings were assigned in each plastic bowl of 30 litres volume of water.

2.3 Source of Experimental Ingredients and Fish

The Maize, Soybean, Sorghum bran, Salt, Starch and Oil, were purchased from feedstuffs market in Damaturu, Yobe State. The experimental fish was procured from MBG Mega Fish Farm 6km Gujba road Damaturu, Damaturu Local Government Area of Yobe State, Nigeria while the fishmeal, vitamin premix and chromic oxide were purchased from Mike Fish Farm Maiduguri, Borno state, Nigeria for the study.

2.4 Processing of Sorghum Bran

Sorghum bran was collected in three different bowls, ground into powder, then sieved and fermented using solid fermented procedure as described by Pedersen and Sogbesan [8,9]. Each sample was solidly fermented (wet at 10% moisture and keep in container at ambient temperature) for 24 hours (1 day), 96 hours (4 days), and 168 hours (7 days). Afterward, the fermented samples were sun dried for 94 hours (4 days approximately) as described. The fermented samples were taken to the laboratory for proximate analysis and the best was used to replace with maize at 25%, 50%, 75% and 100%.

2.5 Proximate Composition of the Fermented Sorghum Bran Meal and Experimental Diets

The fermented Sorghum bran at a various fermentation period and the experimental diets were analysed for crude protein, crude fibre, crude lipid, ash and a nitrogen free extracts according to Association of official analytical chemists official methods of chemical analysis [10].

2.6 Determination of Moisture

The moisture content of the samples were determined by weighing the samples and oven dried at 80^{o}C for 24 hours. The loss in weight gave the moisture content of the original sample.

$$\text{Moisture (\%)} = \text{Loss in Weight due to drying} / \text{Weight of Sample Take} = W2 - W3\ x100 / W2 - W3$$

W_1 = Weight of crucible
W_2 = Weight of crucible + sample
W_3 = Weight of crucible + sample after drying

2.7 Determination of Ash

The ash content of the samples were determined by the method described by Association of official analytical chemists official methods of chemical analysis [10].

2.8 Determination of Crude Lipid

The crude lipid was determined by the continuous solvent extraction method in a Soxhlet apparatus as described by James [11].

2.9 Determination of Crude Fibre

The crude fiber was determined by the Weende method described by Association of official analytical chemists official methods of chemical analysis [10].

2.10 Determination of Crude Protein

The protein content of the samples were determined by the Kjeldhal method reported by Association of official analytical chemists official methods of chemical analysis [10]. The total nitrogen was determined and multiplied by the factor, 6.25, to obtain the protein concentration or content.

2.11 Determination of Nitrogen Free Extract

The carbohydrate content of the test samples were determined by estimation using the arithmetical difference method described by Association of official analytical chemists official methods of chemical analysis [10]. The carbohydrate content was calculated and expressed as the nitrogen free extract.

2.12 Experimental Diet Formulation

Two grams (2g) of fermented Sorghum bran meal sample was collected and analysis for moisture, dry matter, ash, crude lipid, crude fibre, crude protein and nitrogen free extract according to the method of Association of official analytical chemists official methods of chemical analysis [10]. The processed Sorghum bran was used to replace maize in an iso-nitrogenous experimental diets consisting of 40.00% crude protein. The other feed ingredients making up the experimental diets comprised of fish meal, soybean meal, vitamin/mineral premix, wheat flour (binder), salt and palm oil. Five (5) diets including control were formulated using Pearson square method as shown in Table 1.

2.13 Experimental Diets Preparation

The milled feed ingredients were weighed according to the formulated proportion calculated based on Pearson square method and mixed in a bowl. Warm water was added to make the mixture moist forming homogenous dough. The resultant dough was extruded through pelleting machine in to suitable size pellets. The pellets were sun-dried. The dried pelleted feeds were broken into smaller sizes, packaged and stored in cellophane bag to avoid spoilage. The sample of each diets was analyzed in the laboratory for proximate composition following standard methods of analysis [10].

2.14 Feeding of Experimental Fish

The fish was starved for 24 hours to empty their gastro-intestinal tracts before the commencement of feeding trials [12]. 24-weeks (6 Months) feeding trial was carried out in triplicate groups of 10 fingerlings each per plastic bowl. Fish was fed at 5 % of their body weight per day (2.5% in the morning 8.00 - 9.00 AM and 2.5% in the evening 5:00-6:00PM) throughout the duration of the experiment. The quantity of feeds were be adjusted based on the weight of fish for next weeks throughout the duration of the feeding trials.

2.15 Growth Performance and Nutrient Utilization

The weight and quantity of feed per each setting was recorded on weekly basis. Therefore, the following growth and nutrient utilizations parameters were calculated as follows:

2.15.1 Weight gain

The total and mean weight gain was calculated for each replicate and treatment as follows: Weight gain/fish (g/fish) = $Wf - Wi$

Mean weekly weight gain (g/week) = $Wf - Wi/N$

Where Wf = final weight of fish at the end of the experiment

Wi = initial weight of fish at the beginning of the experiment

N =number of weeks

2.15.2 Average Daily Growth (ADG)

The average daily growth was determined using the following formula

ADG= $Wf - Wi/t$

Where Wf = final weight of fish at the end of the experiment

Wi = initial weight of fish at the beginning of the experiment

T= Rearing period

2.15.3 Relative Growth Rate (RGR)

This is the percentage ratio of the weight gained to the initial body weight which was determined according to Fasakin et al.[13].

RGR (%) = $Wf - Wi/Wi\ x\ 100$

2.15.4 Specific Growth Rate (SGR)

This is the percentage daily weight gain was computed according to Hepher [14].

SGR (%/day) = $LogWf - LogWi/t \ x\ 100$

Where log Wf = logarithm of the fish final weight

log Wi = logarithm of the fish initial weight
t = experimental period in days.

2.15.5 Survival (SR)

The percentage survival rate was calculated according to Fasakin et al[13].

SR (%) = $Nf/Ni \ x\ 100$

Where Ni=Number of cultured animal/fish stocked at the beginning of the experiment
Nf = Number of cultured animal/fish alive at the end of the experiment.

2.15.6 Feed Intake (FI)

This was taken as the addition of the amount of feed supplied during the experimental period.

2.15.7 Feed Conversion Ratio (FCR)

This is a numerical value used to measure the utilization of feed for growth [15].

Food conversion ratio was calculated following [16].

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

2.15.8 Protein Intake (PI)

This is the numerical value of the quantity of protein present in the feed fed to the fish during the experimental periods and was determined following [17].

PI (g of protein in 100 g diet/fish) = Total feed intake x % crude protein in the diet.

2.15.9 Protein Efficiency Ratio (PER)

This index uses growth as a measure of nutritive value of dietary protein. It was determined from [17].

PER= $\text{Mean weight gain g}/\text{Mean protein intake (g of protein in 100g of diet/fish)}$

2.16 Protein Rating

This is a measure of the daily protein intake efficiency in the fish feed and was determined using method reported by Steffens [18].

Protein rating = Daily protein intake x PER.

2.16.1 Protein Growth Rate (PGR)

This measured the relativeness of the daily protein gain by the fish and was calculated using [19].

PGR (%) = $\frac{\text{LogP2}-\text{LogP1}}{\text{n}}\text{x}100$

Where Log P1= initial logarithm of the fish carcass protein content

Log P2 = final logarithm of the fish carcass protein content; n =number of weeks

2.16.2 Gross Protein Value (GPV)

This is a commonly used biological method for evaluating proteins quality in a feed. This was determined using [20].

GPV = $\frac{A}{Ao}$

Where: A= Weight gain of the fish fed test diet (g)/

Protein intake of test diet (g of protein in100g of diet/fish)
Ao = Weight gain of the fish fed control diet (g)/
Protein intake of control diet (g of protein in 100g of diet/fish)

2.16.3 Apparent Net Protein Utilization (ANPU)

ANPU expresses the percentage of ingested protein that is retained by deposition in the carcass when no correction for endogenous nitrogen losses is made. This was calculated following [21].

ANPU (%) = $P2 - P1/P1 \ x\ 100$

Where: P1 = Protein in fish carcass (g) at the beginning of the experiment

P2 = Protein in fish carcass (g) at the end of the experiment
PI = Protein intake (g of protein in 100g of diet/fish)

Table 1. Gross ingredient composition (g/100g) of the experiment diets

S/N	Ingredients (g/kg)	Inclusion Levels				
		0% Diet 1	25% Diet 2	50% Diet 3	75% Diet 4	100% Diet 5
1	Fish Meal	33.33	33.33	33.33	33.33	33.33
2	Soybean Meal	30.34	30.34	30.34	30.34	30.34
3	**Maize Meal**	**31.33**	**23.50**	**15.67**	**7.83**	**0.00**
4	**FSBM**	**0.00**	**7.83**	**15.67**	**23.50**	**31.33**
5	Vitamin premix	1.50	1.50	1.50	1.50	1.50
6	Starch	1.50	1.50	1.50	1.50	1.50
7	Salt	0.50	0.50	0.50	0.50	0.50
8	Oil	1.00	1.00	1.00	1.00	1.00
9	Chromic oxide	0.50	0.50	0.50	0.50	0.50
Total		100	100	100	100	100
Calculated % Crude Protein		40.00	40.400	40.00	40.00	40.00

Key: FSBM = Fermented Sorghum Bran Meal

Vitamin and Minerals premix: Vitamin A -20,00,000 I.U.; D3- 4,00,000 I.U.; E - 200,000 I.U; K -1,200mg; B1-10,000mg.; B2- 30,000mg.; B6- 19,000mg.; B12-1,000.; Niacin-200,000mg.; Folic Acid-5,000mg.; Panth Acid-50,000mg.; Biotin-400mg.; Antioxidant 125g.; Vitamin C-150g.; Choline chloride-400g.; Manganese-30g.; Zinc-40g.; Iron-40g.; Copper 4g.; Iodine-5g.; Selenium-0.2mg.; Cobalt-0.2mg.; Calcium-600g.; Lysine- 100,000mg.; Phosphorus-4,000g.; Methionine-100g. (AGRO BAR-MAGEN NIG.LTD)

**Calculated gross energy = Protein x 23.6kJ/100g + Lipid x 39.5kJ/100g + NFE x 17.2kJ/100g (Blaxter, 1989)*

2.16.4 Apparent Net Lipid Utilization (ANLU)

ANLU expresses the percentage of ingested lipid that is retained by deposition in the carcass when no correction for the endogenous lipid losses is made. This was calculated following [21].

ANPU (%) = $L2 - L1/L1 \ x \ 100$

Where: L1 = Lipid in fish carcass (g) at the beginning of the experiment
L2 = Lipid in fish carcass (g) at the end of the experiment

LI = Lipid intake (g of lipid in 100g of diet/fish)

2.16.5 Apparent Digestibility Coefficient (ADC) of dry Matter

This was calculated according to the method used by Smith [22].

ADC (%) $= 100 - (100(\%Chromic\ oxide\ in\ diet / Chromic\ oxide\ in\ \ feces))$

2.17 Statistical Analysis

All data generated were subjected to descriptive statistics to determine the mean values and then subjected to analysis of variance (ANOVA) at 95% probability level where the significant differences were detected. Means values were separated using Least Significant Difference (LSD). All data were analyzed using SPSS (statistical Package for Social Sciences) version 20.0 statistical package.

3. RESULTS

3.1 Proximate Composition of the Fermented Sorghum Bran Meal Diets and Fish *Carcass*

Table 2 and 3 shows proximate composition of the experimental diets and experimental fish carcass. The fermented sorghum bran meals diets shows that; the highest percentage moisture content was recorded in the diet D_5 with 11.53±0.78 and the lowest was recorded in diet D_1 with 10.00±0.34. Diet D_1 had the highest percentage dry matter of 90.00±1.34 and diet D_5 had the lowest content with 88.47±1.06. The highest percentage ash content was recorded in diet D_1 with 5.42±0.43 and the lowest was in diet D_5 with 3.85±0.67. Diet D_1 had the highest fibre content of 6.64±1.42 and the lowest was recorded in diet D_5 with 4.33±0.66. Diet D4 had the highest percentage crude lipid of 7.80±1.54 and the lowest was recorded in diet D_5 with 5.80±1.35. The highest percentage crude protein was recorded in diet D_5 with 45.06±1.54 while the lowest was recorded in diet D_1 with 40.44±1.43. There is no significance differences ($P<0.05$) between diet D_1 and D_2. However, there is a significance differences ($P<0.05$) between control and diet D_5. The highest percentage

nitrogen free extract was recorded in diet D_2 with 32.54±1.54 and the lowest was recorded in diet D_4 with 29.230.74. There is a significance difference between the diets fed.

The proximate composition of the experimental fish carcass shows that the fish fed diet D_5 had the highest percentage moisture content of 9.76±0.63 and the lowest was recorded in the fish fed diet D_2 with 8.62±0.84 while the highest percentage dry matter was recorded in the fish fed diet D_2 with 91.38±1.48 and the lowest was recorded in the fish fed diet D_5 with 90.24±1.92. The highest percentage ash and crude fibre were recorded in the fish at the initial stage before subjecting them to experimental diets with 5.42±0.32 and 6.64±0.53 respectively while the lowest were recorded in the fish fed diet D_5 with 3.14±0.65 and 3.39±0.73 respectively. The highest percentage crude lipid and crude protein were recorded in the fish fed diet D_5 with 21.89±1.58 and 52.35±1.44 respectively while the lowest were recorded in the fish at the initial with 8.38±1.38 and 42.44±2.54 respectively. There is a significance differences ($P<0.05$) between the treatments. The highest nitrogen free extract was recorded in the fish at initial with 28.12±1.76 and the lowest was recorded in the fish fed diet D_5 9.47±0.67.

3.2 Growth Performances and Nutrients Utilizations

The growth performances and nutrients utilizations of *H.bidorsalis* fed experimental diets are shown in Table 4 and 5.

The mean initial weight was highest in diet D_5 with 6.25±0.63g and the lowest was in diet D_3 with 6.04±0.75g. Fish fed diet D_5 had the highest total final weight with 397.88±1.67g while the lowest was recorded in diet D_1 with 303.91±2.24g. The mean final weight was highest in diet D_5 with 49.74±0.17g and the lowest was recorded in diet D_1 with 35.05±1.86g. The total weight gain was highest in diet D_5 with

Table 2. Proximate composition of the fermented sorghum bran meal diets

	D_1 (Control)	D_2	D_3	D_4	D_5
Inclusion levels %	**0**	**25**	**50**	**75**	**100**
Moisture	10.00±0.34^c	10.52±1.03^c	10.57±1.53^c	11.33±1.54^b	11.53±0.78^a
Dry Matter	90.00±1.34^a	89.48±0.65^b	89.43±1.54^b	88.67±1.82^c	88.47±1.06^c
Ash	5.42±0.43^a	4.32±0.54^b	4.54±0.54^b	4.64±1.54^b	3.85±0.67^c
Crude Fibre	6.64±1.42^a	4.55±1.54^b	4.78±1.29^b	4.67±0.93^b	4.33±0.66^c
Crude Lipid	7.38±0.13^a	6.53±0.54^c	7.34±1.04^b	7.80±1.54^a	5.80±1.35^c
Crude Protein	40.44±1.43^e	40.54±1.76^d	41.56±0.23^c	42.33±1.75^b	43.06±1.54^a
NFE	30.12±1.54^a	33.54±1.54^a	31.21±1.65^b	29.23±0.74^c	31.43±0.43^b

Means in the Same Row with Different Superscripts are Significantly Different (P<0.05)

Table 3. Proximate composition of *Heterobranchus bidorsalis* Carcass Fed Fermented Sorghum Bran Meal Diets

Parameters	Initial	D_1 (Control)	D_2	D_3	D_4	D_5
Inclusion Levels %	**0**	**0**	**25**	**50**	**75**	**100**
Moisture	9.00±0.54^b	8.91±0.23^c	8.62±0.84^c	9.25±0.62^b	9.47±1.73^a	9.76±0.63^a
Dry Matter	91.00±2.43^a	91.09±1.64^a	91.38±1.48^a	90.75±1.38^b	90.53±1.26^b	90.24±1.92^b
Ash	5.42±0.32^a	3.33±1.56^b	3.98±1.36^b	3.76±0.71^b	3.56±0.81^b	3.14±0.65^b
Crude Fibre	6.64±0.53^a	4.86±0.75^b	4.01±0.82^b	3.95±0.24^c	3.64±0.62^c	3.39±0.73^c
Crude Lipid	8.38±1.38^c	19.38±2.86^b	21.09±2.04^a	21.38±1.27^a	21.52±1.37^a	21.89±1.58^a
Crude Protein	42.44±2.54^d	48.67±2.76^c	51.08±1.48^b	51.78±1.36^b	52.11±1.53^a	52.35±1.44^a
NFE	28.12±1.76^a	14.85±1.85^b	11.22±1.52^c	9.88±0.92^d	9.70±1.45^d	9.47±0.67^d

Means in the same row with different superscripts (P<0.05) are significantly different

335.35±1.68g and the lowest was recorded in diet D_1 with 243.10±0.65g. The mean weight gain recorded was highest in diet D_5 with 43.49±1.86g and lowest was recorded in diet D_1 with 28.97±0.54g. There is a significance differences ($P<0.05$) between the treatments. The values for average daily growth (ADG), specific growth rate (SGR) and relative growth rate (RGR) was highest in fish fed diet D_5 with 0.52±0.56g, 1.07±0.64g and 695.84±0.14g respectively and the lowest value was recorded in diet D_1 with 0.35±0.52g, 0.91±0.65g and 476.48±1.05g respectively. There is a significance differences ($P<0.05$) between the treatments. The highest mean final length was measured in the fish fed diet D_5 with 18.2±0.71cm and the lowest was recorded in diet D_1 with 16.3±1.03cm. The highest condition factor (K) was recorded in the fish fed D_4 and D_5 with 0.83±0.03 each and the lowest was recorded in diet D_3 with 0.79±0.81. The highest percentage survival rate in the fish exposed to the experimental diets was recorded in diet D_2 with 90±0.19% and the lowest was recorded in the fish fed diet D_5 with 80±0.36%. There is a significant difference ($P<0.05$) between the fish fed different experimental diets. The highest mean feed intake was recorded in fish fed D_5 with 89.84±0.27g and the lowest was recorded in the fish fed diet D_1 experimental diet with 71.41±0.54g. Fish fed diet D_5 experimental diet had the highest feed conversion ratio (FCR) of 0.48±0.16 and the lowest were found in the fish fed diet D_1 experimental diet with 0.41±0.24. There is a significance differences ($P<0.05$) between the treatments. The highest protein intake and protein efficiency ratio were recorded in the fish fed diet D_5 experimental diet with 43.12±1.27 and 1.01±0.07 respectively while the lowest were found the fish fed diet D_1 experimental diet with 29.99±0.71 and 0.97±1.28 respectively. The highest gross protein value (GPV) and protein rating (PR) were recorded in the fish fed diet D_5 with 1.04±0.71 and 0.52±0.72 respectively while the lowest were found in the fish fed diet D_1 (Control) with 1.00±0.53 and 0.35±0.45 respectively. There is a significance differences ($P<0.05$) between the treatments. The highest protein growth rate was recorded in the fish fed treatment D_5 diet with 0.76±0.26 and the lowest was recorded in the fish fed treatment D_1 diet with 0.49±0.65. The highest apparent net protein utilization and apparent net lipid utilization were recorded in the fish fed diet D_5 with 23.35±0.92 and 161.22±0.26 respectively and the lowest were recorded in the fish fed diet D_1 with 14.68±1.05 and 131.27±0.74 respectively. The highest apparent digestibility coefficient of dry matter was recorded in the fish fed diet D_5 with 62.50±0.73 and the lowest was recorded in the fish fed diet D_1 28.57±0.82.

4. DISCUSSION

The result obtained from the proximate composition of the fermented bran meal diets revealed that; one hundred (100%) percent in inclusion level of the fermented sorghum bran meal diet had the best percentage moisture content, crude lipid and crude protein level and the lowest crude fibre compared to others. The variation observed from the values often exists during the process of chemical analysis of experimental ingredient and diet as reported by Falaye et al [23]. This was a result of fermentation level which improve the protein composition and reduced crude fibre content of the fermented bran meal and diets. This result is in line with findings by Sogbesan [3] who reported 33.45% crude protein in Mucuna soaked in water with ash for 72 hours. The results agreed with the findings of Obe snd Idowu1 [7,24] who reported that; the fermentation increase protein level of the feed ingredients and with Mohammed [25] who reported an increase in moisture content, protein content level of fermented sorghum by-product meal at seven days fermentation period. Nitrogen free extract (NFE) values recorded from this study was lowest in diet containing highest inclusion level of fermented sorghum bran meal. This result is comparable with the values reported by Agbabiaka et al [26]. The NFE values of the treatment diets with growth promoters decreased with increasing inclusion levels compared with that of the control diet. This result is in agreement with the findings of Murthy et al[27] who reported a reduction in the NFE values of fish diet with growth promoters. The study also agreed with Farizaldi et al [28] who reported decrease in nitrogen free extract in the diet of *Clarias gariepinus* fed on fermented coconut waste at varying inclusion levels. It is also agreed with Ojokoh et al [29] who reported that the fermentation decreases fibre and carbohydrate level of Pumpin and Sorghum.

The proximate composition of the experimental fish carcass revealed that the crude protein content of the initial fish carcass was lower at the end of the experiment. The results obtained from this study revealed that the fish fed 100% inclusion level of fermented sorghum bran meal diet had higher protein content compared to others. This result is in line with Solomon et

al[30] who reported that *H*. *bidorsalis* and *Clarias gariepinus* fed commercial feed show a high crude protein in and their inter-generic crosses. Also, it is in consistent with Obe [7] who reported significant increase in crude protein level in Heteroclarias carcass fed on fermented sorghum waste meal diets. Furthermore, the result is in agreement with Imodagbe [31] who reported that feeding of *Heterobarnchus bidorsalis* on garden snail as a replacement to fish meal significantly increase crude protein of the carcass. The carcass crude lipid of the fish fed on diet with 100% inclusion level was higher compared to others and this shows the exchange of the lipid composition of the experimental diets. The present study is in agreement with the findings of Obe [7] who similarly reported increased values of crude fat in the final carcass of Heteroclarias fed on fermented sorghum waste meal diets. The observation is agreement with Imodagbe [31] who reported that feeding of *Heterobarnchus bidorsalis* on garden snail as a replacement to fish meal significantly increase crude lipid of the carcass. The nitrogen free extract was higher in the fish sample before the commencement of the experiment and reduces with increase inclusion levels. Nitrogen-free extract (NFE) in the initial fish reduced significantly in the final carcass values among the treatment diets. This result is in line with Imodagbe and Adedekum [31; 32] who reported that the nitrogen free extract content of African catfish reduces if it fed with butterfly pea seed meal.

The results obtained from this study of Growth performance and Nutrients utilizations revealed that the fish fed 100% inclusion level diet had the best mean final weight, mean weight gain, average daily growth rate, specific growth rate and relative growth rate compared to other fish fed treatments diets and control as well. The result obtained from this study is in agreement with Mohammed [25] who reported better growth performance in African catfish *Clarias gariepinus* (Burchell, 1822) fed on fermented sorghum by-product meal diets. The result also is in line with the findings of Oyelere [33] who reported increase in weight gain, specific growth rate, average daily growth and survival rate of *Clarias gariepinus* (Burchell, 1822) fed on varying levels of *Albizia lebbeck* (Benth) leaf meal. It also agreed with Idowu1 [24] who reported increase in growth performance in *Clarias gariepinus* fed on fermented sorghum at varying levels with best at 100% inclusion level. The result obtained from this study is in agreement with [4] who reported increase in growth parameters of *Hetrobranchus bidorsalis* fed on *Eucalyptus globulus* leaf supplemented diets. The result obtained on condition factor (K) revealed that fish fed diet containing 100% inclusion level had the best condition factor compared to others. The result also agreed with [34] who reported the range of 0.8 to 1.4 in length-weight relationship of *Hetrobranchus bidorsalis* diploid and triploid progenies raise under the same environmental condition. This result is in line with [33] who reported that, good condition factor in *Clarias gariepinus* fed on varying levels of *Albizia lebbeck* leaf meal. The results on nutrients utilization obtained from this study revealed that the fish fed diet containing 100% inclusion level had best feed intake, feed conversion ratio, protein intake, protein efficiency ratio, gross protein value, protein rating and protein growth rate compared to others fed treatment diets and control. The results obtained from this study revealed that the experimental fish utilized the diet very well as observed in the results presented. The result obtained is in line with [35] who reported that sex reversed Red Tilapia (*Oereochromis niloticus* x *Oreochromis mossambicus*) can be fed with fermented palm kernel meal as protein source. The results obtained also is in line with [36] who reported better feed conversion ratio, protein efficiency ratio and protein conversion ratio in African catfish fed on fermented Bambara nut meal as substitute of fishmeal. The results also agreed with [37] who reported better feed utilization in African catfish *Clarias gariepinus* fingerlings fed on *Laucera leucocephala*. The result also agreed with the findings of [38] who reported efficient nutrient utilizations in African catfish fed on varying inclusion level of fermented un-sieved yellow maize. The result obtained also agreed with [25] who reported good feed conversion ratio and protein efficiency ratio in *Clarias gariepinus* fed on fermented sorghum by-product meal diets.

The apparent net protein utilization, apparent net lipid utilization and apparent digestibility coefficient of dry matter obtained were best in fish fed diet containing 100% inclusion level. This is as a result of feeding the fish with a good diet and water quality management. The result obtained from the study is in agreement with the result obtained by [33] who reported increase in growth and better net protein utilization in *Clarias gariepinus* fed on varying levels of *Albizia lebbeck* leaf meal diet. The result

Table 4. Growth Performance of *Heterobranchus bidorsalis* fed fermented sorghum bran Meal diets for 84 days

	Experimental Diets				
	D_1 Control	**D_2**	**D_3**	**D_4**	**D_5**
Inclusion Levels %	**0**	**25**	**50**	**75**	**100**
Total Initial Weight (g)	60.81±0.21^{c}	62.05±0.54^{a}	60.35±1.17^{b}	62.21±1.26^{a}	62.53±0.72^{a}
Mean Initial Weight (g/fish)	6.08±0.37^{a}	6.21±0.54^{a}	6.04±0.75^{a}	6.22±1.02^{a}	6.25±0.63^{a}
Total Final Weight (g)	303.91±2.24^{e}	366.40±1.82^{c}	356.97±1.72^{d}	388.62±0.89^{b}	397.88±1.67^{a}
Mean Final Weight (g/fish)	35.05±1.86^{e}	40.71±1.38^{d}	41.17±1.05^{c}	46.65±1.83^{b}	49.74±0.17^{a}
Total Weight Gain (g)	243.10±0.65^{e}	304.35±1.83^{d}	296.62±1.86^{c}	326.41±0.28^{b}	335.35±1.68^{a}
Mean Weight Gain (g/fish)	28.97±0.54^{e}	34.50±1.82^{d}	35.13±0.65^{c}	40.43±1.74^{b}	43.49±1.86^{a}
Average Daily Growth (%/fish)	0.35±0.51^{b}	0.41±0.68^{c}	0.42±0.52^{b}	0.48±0.17^{a}	0.52±0.56^{a}
Specific Growth Rate (%/day)	0.91±0.65^{b}	0.97±0.53^{b}	0.99±0.56^{b}	1.04±0.08^{a}	1.07±0.64^{a}
Relative Growth Rate (%/fish)	476.48±1.05^{e}	555.56±1.26^{d}	581.62±0.92^{c}	650.00±1.38^{b}	695.84±0.14^{a}
Mean Initial Length (cm/fish)	4.4±0.32^{a}	4.4±0.52^{a}	4.4±0.12^{a}	4.3±0.43^{a}	4.3±0.15^{a}
Mean Final Length (cm/fish)	16.3±1.03^{c}	17.2±0.32^{b}	17.3±0.25^{b}	17.8±0.65^{b}	18.2±0.71^{a}
Condition Factor (K)	0.81±0.65^{c}	0.80±0.17^{a}	0.79±0.81^{a}	0.83±0.53^{a}	0.83±0.03^{a}
Percentage Survival Rate	86.67±1.37^{a}	90.00±0.19^{a}	86.67±0.25^{b}	83.33±0.63^{c}	80.00±0.36^{d}

Means in the Same Row with Different Superscripts are Significantly Different (P<0.05)

Table 5. Nutrients Utilizations of *Heterobranchus bidorsalis* Fed Fermented Sorghum Bran Meal Diets for 84 Days

	Experimental Diets				
	D_1 Control	**D_2**	**D_3**	**D_4**	**D_5**
Inclusion Levels %	**0**	**25**	**50**	**75**	**100**
Total feed intake (g)	659.42±2.54^{e}	739.15±1.84^{b}	736.88±1.92^{b}	798.99±2.61^{a}	796.55±1.52^{a}
Mean feed intake (g)	71.41±1.54^{e}	76.84±1.04^{d}	80.71±0.93^{c}	87.10±1.64^{b}	89.84±0.27^{a}
Feed conversion ratio (FCR)	0.41±0.24^{b}	0.45±0.18^{a}	0.42±0.67^{b}	0.46±0.82^{a}	0.48±0.16^{a}
Protein intake (g/100gdiet/fish)	29.99±0.71^{d}	34.58±0.26^{d}	37.13±1.93^{c}	40.94±0.67^{b}	43.12±1.27^{a}
Protein efficiency ratio (PER)	0.97±1.28^{b}	1.00±0.21^{a}	0.95±0.62^{b}	0.99±0.23^{b}	1.01±0.07^{a}
Gross protein value (GPV)	1.00±0.53^{a}	1.03±0.52^{a}	0.98±0.82^{b}	1.02±0.71^{a}	1.04±0.71^{a}
Protein rating (PR)	0.35±0.45^{b}	0.41±0.72^{b}	0.42±0.61^{b}	0.49±0.02^{a}	0.52±0.72^{a}
Protein growth rate (PGR)	0.49±0.65^{b}	0.67±0.15^{b}	0.72±0.64^{a}	0.74±0.17^{a}	0.76±0.26^{a}
Apparent net protein utilization (ANPU)	14.68±1.05^{c}	20.36±0.18^{c}	22.01±1.74^{b}	22.79±0.65^{b}	23.35±0.92^{a}

	Experimental Diets				
	D_1 Control	**D_2**	**D_3**	**D_4**	**D_5**
Inclusion Levels %	**0**	**25**	**50**	**75**	**100**
Apparent net lipid utilization (ANLU)	131.27±0.74^{b}	151.67±1.93^{b}	155.13±0.65^{b}	156.80±0.63^{b}	161.22±0.26^{a}
Apparent digestibility Coefficient (ADC) of dry matter	28.57±0.82^{e}	37.50±1.03^{d}	50.00±1.07^{c}	57.14±0.46^{b}	62.50±0.73^{a}

Means in the Same Row with Different Superscripts are Significantly Different (P<0.05)

obtained also agreed with [39] who reported better protein efficiency ratio, apparent digestibility coefficient of crude protein, apparent digestibility coefficient of crude lipid and apparent digestibility coefficient of crude fibre in hybrid catfish fingerlings fed on graded levels of germinated Sword Beans (*Canavalia gladiate*) seed meal.

5. CONCLUSION

This study revealed that there is a positive effects of incorporating fermented Sorghum bran meal into the diet of *H.bidorsalis*. The study also revealed that; the solid state fermentation of Sorghum bran improve proximate composition of the bran and diets. Feeding of *H.bidorsalis* with diets incorporated with fermented Sorghum bran meal at 100% inclusion levels will improve the growth performance and nutrient utilizations thereby making it viable to the farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Suprayudi MA. Local Raw Materials: Challenges and expectations of future aquaculture (Abstract). Proceedings of the National Symposium on Biotechnology Aquaculture III October BDP, FPIK, IPB. 2010;7:31.
2. Handajani D, Widodo J, Wahju G. Fish Nutrition. Muhammadiyah University Press Poor. 2010;271.
3. Sogbesan AO, Ugwumba AAA Nutritional Evaluation of Termite (*Macrotermes subhyalinus*) Meal as animal protein Supplements in the Diets of *Heterobranchus longifilis* Fingerlings. Turkish Journal of Fish and Aquatic Science, 2008;8:149-157.
4. Afe OE, Dada AA, Olufayo MO. Growth Performance and Nutrient Utilizations of *Hetrobranchus bidorsalis* Fed *Eucalyptus globulus* Leaf Meal Supplemented Diets. Applied Tropical Agriculture, 2019;25(2): 152-160.
5. FAO . FAOSTAT. Food and Agriculture Organisation of the United Nations; 2011.www.fao.org.
6. Aderolu AZ, Kuton MP, Odu-Onikosi SG, Substitution effect of sorghum meal for maize meal in the diet of catfish (*Clarias gariepinus*, Burchell, 1822.) juvenile. *Resource Journal of Fish. Hydrobiololgy,* 2009;4(2): 41-45.
7. Obe BW. Growth Performance and Nutrient Utilization of Catfish Hybrid (*Heterobranchus bidorsalis* X *Clarias gariepinus*) Fed Fermented Sorghum (*Sorghum bicolor*) Waste MealDiets. International Journal of Applied Science and Technolog. 2014; 4(3):156-160.
8. Pedersen JF, Fritz JO Forage and forder. In sorghum origin, history, technology, and production. *Smith* CW, Frederksen RA; 2000.
9. Sogbesan OA, Mohanta KN, Sahoo PK. Jayasankar P. *In*: Application of Solid State Fermentation Technology In Aquaculture. 2012;76-83.
10. Association of official analytical chemists official methods of chemical analysis. 17th Edition.Washington, D.C., U.S.A. 2010;214-245.
11. James CS. : Analytical chemistry of foods. Chapmann and Hall, New York. 1995;126.
12. Eyo AA. Fundamentals of fish nutrition and diet development an overview. 2004;1-33. *In* AA. Eyo (ed). National workshop on fish feed development and feeding practices in aquaculture NIFFRI, New-bussa 15th to 19th September, 2003;65.
13. Fasakin EA, Balogun AM, Edomwagogbon O. Aspects of chemical and biological evaluation of dried maggot meals in production diets for clarid catfish, *Clarias gariepinus*. World Journal of Biotechnology. 2004;5,753-762.
14. Hepher AH. Nutrition of pond fishes. Cambridge university press, *Cambridge* (UK), 388 P.E stg. 1988;45.50.
15. Adikwu AB. Growth performance of and haematological profile of *Oreochromis niloticus* (Linn, trewavas, 1983) Fingerlings fed Differently Processed Cotton seed (*Gossypium hirsute* Linn, 1735) Meal. PhD. *Thesis* Department of Wildlife and Fisheries Management, University of Ibadan. 2003;213-242.
16. Burel C. Boujard T, Tulli F, Kaushik SJ. Digestibility of extruded pea, extruded lupin and rapeseed meal in rainbow trout (*Oncoryhychus mykiss*) and turbot (*Psetta maxissa*). Aquaculture. 2000;188: 285-298.
17. Sveier H, Raae AJ, Lied E: Growth and protein turnover in Atlantic salmon (*Samo salar L*.); the effect of dietary protein level and protein particle size. *Aquaculture,* 2000;185:101-120.

18. Wilson RP. Amino acids and proteins. In: Fish Nutrition (J.E Halver, Ed). Academic Press Inc. California. 1989;111 – 115.
19. Steffens SG. Effect of replacing maize with cassava root meal and maize/sorghum brewers dried grains on the performance of starter broilers. Proceeding of 9th Annual Conference of Animal Science Association of Nigeria. Sept. 13 – 16, Ebonyi State University, Abakiliki. 2004;49 – 51.
20. Devendra C. Tropical legumes in animal nutrition. CAB International, Wallingford, Oxon, UK. 1989;95 –133.
21. Ali MZ. Dietary protein and energy interaction in african catfish *Clarias gariepinus* (Burchell, 1822). PhD. *Thesis* Department of Aquaculture University of Aquaculture, Stirling, United Kingdom . 2001;274.
22. Smith KJ. Practical significance of gossypol in fish feed formulation. Journal of American Oil Chemistry Society*. 1970;* 47:448-450.
23. Falaye CA, Chikwunde AG, Micheal BJ. Improving Nutritional Quality of Millet (*Pennisetum americannum*) by Solid State Fermentation and the Effects on the Growth Performance of African Catfish. Journal of Natural Sciences Research, 2014;3(6):45-52.
24. Idowu1 TA, Ishaku AH, Adedeji1 HA, Olaniyi IJ. Sogbesan OA. Effect of Varying Levels of Fermented Sorghum (*Sorghum Bicolor*) On Growth and Haematology Profiles of *Clarias Gariepinus* (Burchell, 1822) Fingerlings. Journal of Agriculture and Environment. 2016;12(1): 89-96.
25. Mohammed RA, Jauro IA, Ishaku AH, Usman S. Growth Performance and Haematological Profiles of *Clarias gariepinus* (Burchell, 1822) Fed Fermented Sorghum By-product Meal. Journal of Agriculture and Environment. 2017;13(2):137-147.
26. Agbabiaka IA. Madubiuka FN, Ekenyeni, BU. Haematology and serum characteristics of African Catfish (*Clarias gariepinus* Burchell, 1822) fed graded level of tiger nut based diet. American Journal of Experimental Agriculture, 2013;3(4):988-995.
27. Murthy HN, Joseph KS, Madiwal A, Gerald DR, Badiger M, Lakshmi K, Reshma H. P hysicochemical characteristics of the seed and seed oil of potentially medicinal plants. Ziziphus oenophia. Journal of Dietary Supplement. 2016;14(6) 691-696.
28. Farizaldi K, Novirman J, Yeti M. Effect of Fermented Coconut Waste to *Clarias Gariepinus*. International Journal Agricultural Science. 2017;1(1)21-27.
29. Ojokoh AO. Proximate Composition and Anti-nutrients Content of Pumpin (*Cucurbita pepo*) and Sorghum (*Sorghum bicolor*) Flour Blends Fermented with *Lactobacillus plantarum*. Journal of Science. 2014;16(3):425-435.
30. Solomon SG, Afeguba GA, Abeje A. water stability and floatation test of fish feed pellets using local starch sources and yeast (*Saccharomyces cerevisae*). International Journal of Latest Trends in Agriculture and Food Science. 2011;1(1): 21-27.
31. Imodagbe MO, Abdullahi SA, Yusuf A, Umar R, Wada YA, Lawal A. Impact of Garden Snail (*Limicolaria flammea*) Meal as Fish Meal Replacement on Whole-Body Biochemical Composition in Juvenile *Hetrobranchus bidorsalis*. Nigerian Journal of Animal Science Technology. 2020;3:(1) 69-79.
32. Adedekum VA. Replacement value of sorghum dust for maize in diets for broiler chicks. Proc 27th Ann. Conf. Nig. Soc. for Anim. Prod. March 17–21, Federal University of Technology, Akure. 2021;109 – 112.
33. Oyelere EA, Balogun JK, Abubakar BY. Growth and nutrient utilization of African Catfish (*Clarias gariepinus*) (Burchell, 1822) Fed Varying Levels of *Albizia lebbeck* (Benth) Leaf Meal. Agrosearch. 2016;16(1):15-24.
34. Agbebi OT, Otubusin SO, Olufeogba SO. Length-weight relationship of *Hetrobranchus bidorsalis* (Geoffroy St Hilaire, 1809) Diploid and Triploid progenies raise under the same environmental condition. Nigerian Journal of Animal Production. 202;(11) 34-42.
35. Wattana W, Karan T, Waraporn H, Naraid S. Optimal replacement of soybean meal with fermented palm kernel meal as protein source in a Fishmeal-Soybean-meal Based Diet of Sex Reversed Red Tilapia (*Oreochromis niloticus* x *Oreochromis mossambicus*). Animals. 2021;11: 2287.
36. Eyidi UD, Etim EO. Use of solid state fermented bambara nut meal as substitute of fishmeal in the diet of African Catfish

Clarias gariepinus. Iranian Journal of Fisheries Science. 2018;19 (4):1889-1910.

37. Fakolade AN, Owoeye EA, Igboanugo C S. Effect of replacement of soybean with leucera leucocephala on growth performance of African catfish (*Clarias gariepinus*) fingerlings. International Journal of Fisheries and Aquatic Studies. 2021;9(3):131-134.
38. Omoike A, Falaye AE, Adesina SB. Practical growth performance of and 1nutrients utilizations of Catfish *Clarias gariepinus* Fed Varying Inclusion Level of Fermented Un-sieved Yellow Maize. Journal of Natural Science Research. 2020;10:(6)43-50.
39. Bake GG, Theeophilus R, Abdullahi A, Nwangwu DC. Aliyu MH. Growth Responses and Haematological indices of Hybrid catfish fingerlings fed varying inclusion levels of fermented Sword Bean (Canavalia gladiate) seed meal in a concrete tank. International Journal of Innovative Studies in Aquatic Biology and Fisheries. 2019; 5(2):21-30.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/109852