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GROWTH PERFORMANCE AND HAEMATOLOGICAL PROFILES OF *Clarias gariepinus* (BURCHELL, 1822) FED FERMENTED SORGHUM BY-PRODUCT MEAL

R. A. Mohammed[1], I. A. Jauro[1], A. H. Ishaku[2] and S. Usman[3]

[1]Department of Fisheries, School of Agriculture and Agricultural Technology, Modibbo Adama University of Technology Yola, P.M.B. 2076, Yola Adamawa State, Nigeria
[2]Department of Fisheries Technology, Yobe State College of Agriculture, Gujba, P.M.B. 1104, Damaturu, Yobe State, Nigeria
[3]Ministry of Agriculture and Natural Resources Damaturu, Yobe State, Nigeria

ABSTRACT

Sorghum (*Sorghum bicolor*) is a source of dietary energy in fish feed. Hence its by-product is studied in this work. Sorghum by-product was fermented at varying periods (3, 5 and 7days). Four isoproteic (40% crude protein) diets were formulated containing the fermented product to replace maize meal. The diets (3, 5 and 7 days fermented sorghum by-product (FSB)) were fed to *Clarias gariepinus* fingerlings with average weight (5.96 ± 0.4g) for 12 weeks at 5% body weight. The weight, survival and nutrients utilization were monitored biweekly. The result shows that fingerlings fed 7days FSB had the highest mean weight gain of 38.30 ± 0.58g while the lowest was recorded in the fish fed control diet 27.58 ± 0.45g. The percentage survival rate was highest in the fish fed maize meal and 3days FSB with 93.3% while lowest was recorded in fish fed 7days FSB with 83.30%. The nutrients utilization showed significant difference ($p<0.05$) in fish fed fermented sorghum by-product diets compared to those fed control diet. Highest feed intake, feed conversion ratio, protein intake and the protein efficiency ratio were recorded in the fish fed 7 days FSB diet while the lowest was in those fed control diet. There was variation in some of the haematological parameters. The highest packed cell volume, haemoglobin, red blood cell and white blood cell were observed in group C with 21.00, 7.06, 7.80 and 6.51%, respectively, while the lowest was recorded in the fish fed maize meal with 12.68, 2.90, 6.20 and 4.33%. The cost benefit analysis of the experiment indicated that fish fed diet containing 7days FSB had the highest net profit, profit index and the lowest incidence of cost compared to fish fed other diets. From the result of the study, 7days FSB will be ideal for catfish culture.

Keywords: Growth performance; Sorghum by-product; blood profile; *Clarias gariepinus*

INTRODUCTION

Carbohydrates are the cheapest sources of dietary energy for fish and other livestock species (Shiau and Linn, 2001). Carbohydrates have the physical function of acting as a binder in the formulation of diets (Fagbenro *et al*., 2003). It is essential to ensure that adequate energy level is provided in fish diets so as to realize protein sparing effect and to ensure higher percentage of amino acids in protein being available for growth and other physiological function (Abu *et al.*, 2009). The digestibility of carbohydrates has been shown to vary with their complexity, treatment and levels of inclusion (Adeparusi and Jimoh, 2002).

Maize is one of the major sources of metabolisable energy in most compounded diets for catfish as it is readily digestible by fish (Olurin *et al*., 2006). FAO (2005) reported that maize, which is predominantly used for human consumption in Nigeria, is not provided in sufficient quantities. The increasing prohibitive cost and scarcity of maize have necessitated the need to search for underutilized energy feed ingredients.

The high cost of fish feed has been recognized as a major factor militating against rapid development of aquaculture in the developing countries because most of the conventional feedstuffs are being used in human foods and animal feeds hence bringing about exorbitant prices and scarcity of such feedstuffs. Maize as an example of such feedstuff, commonly used as a carbohydrate or energy source in fish diets (Obe, 2014).

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 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 (FAO, 2011). Sorghum is similar in chemical composition to maize and has a nutritional quality comparable to other cereals (Aderolu *et al*., 2009; Abdullah, 2015). 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 by fermentation removes these anti-nutritional factors (Obe, 2014). The processing of sorghum produces some by-products one of which is the Fermented Sorghum Waste. Fermented Sorghum by-product (FSB) is a by-product obtained from the production of 'ogi-baba', a common cereal gruel and staple food for several communities in Nigeria. After the starch is gotten from the sorghum meal the waste is used as livestock and poultry feed. FSBM 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 (Obe, 2014).

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at Teaching and Research Fish Farm, Department of Fisheries, Modibbo Adama University of Technology, Yola which is located on latitudes 7^{o} and 11^{o}N and 11^{o} and 14^{o}E. Yola in respect of vegetation zone is in Sub- Sudan and Northern Guinea Savannah zones with temperature ranging from 15.2^{0}C and annual rainfall of 520-1100 mm which starts in May and ends in October. The wettest months are August and September while the dry season is from November to April.

Experimental Design

A completely randomized design (CRD) was used for this study. One hundred and twenty (120) *Clarias gariepinus* fingerlings with mean weight of 5.96±0.4g were used. Equal amounts of fermented sorghum by-product were incorporated to replace maize meal. Four diets including the control were used.

Acquisition of Sorghum by-product and Experimental Fish

The sorghum by-product used for this study was obtained from Sorghum milling outlets in Girei Open Market, Girei Local Government Area, Adamawa State. *Clarias gariepinus* fingerlings were procured from the Department of Fisheries, Modibbo Adama University of Technology Yola, Teaching and Research Fish farm.

Proximate Composition of Sorghum by Product

The processed sorghum by-product was analyzed for proximate composition. Two grammes from each of the samples were used for analysis of proximate composition (dry matter, crude protein, crude lipid, ash, crude fibre, and nitrogen free extract) following the method of Association of Official Analytical Chemists (2010).

Experimental Diet Formulation

The processed sorghum by product was used to replace maize at an inclusion level of 30% in all the iso-nitrogenous experimental diets (Diet 1-3) and for all the fermentation days except Diet 4 which is the control. The other feed ingredients making up the experimental diets were fish meal, groundnut cake, vitamin/mineral premix, cassava starch (binder), salt, palm oil, methionine, and lysine as in Table 1.

Table 1: Feed Formulation and Composition of the Experimental Diets (% dry matter)

Ingredients (g/kg)	Diet 1	Diet 2	Diet 3	Control (Diet 4)
Fish meal	30.00	30.00	30.00	30.00
FSBM	30.00	30.00	30.00	00.00
Maize meal	00.00	00.00	00.00	30.00
Groundnut cake	34.00	34.00	34.00	34.00
Vitamin premix	2.00	2.00	2.00	2.00
Starch	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Palm-oil	0.50	0.50	0.50	0.50
Methionine	1.00	1.00	1.00	1.00
Lysine	1.00	1.00	1.00	1.00
Total	100	100	100	100
% Crude Protein	40.0	40.0	40.0	40.0

Key: FSBM = Fermented Sorghum by-product meal

Growth Performance and Nutrient Utilization

Weekly weight (experimental fish) and feed were used to assess the growth response to feed in terms of percentage (%) weight gain, relative growth rate, specific growth rate, Survival rate, Feed intake, Feed conversion rate, Protein intake and Protein efficiency rate.

Blood Collection and Haematological Analysis

The experimental fish were randomly sampled for haematological parameters following the methods of Kori-Siakpere *et al*. (2005). Blood samples of the fish were collected before the commencement of feeding trial (day 0) and at the end of the experiment, blood samples of fish were collected from the caudal vein by using sterile syringe, blood collected was expressed into EDTA (anticoagulant) bottle and labelled. Red blood cells (RBC) White Blood cells (WBC) hemoglobin (Hb), packed cell volume (PCV) and leukocyte differential count and haemoglobin concentrations were determined using Kori-Siakpere *et al*. (2005). . Erythrocyte indices which include Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC) were also determined using Kori-Siakpere *et al*. (2005).

Cost Benefit Analyses

The cost benefit analyses were carried out to estimate the cost of feed needed by fish using the various experimental diets. Cost of feed was the only economic criterion in this case. The cost was based on current prices of feed ingredients in the experimental locality as at the time of purchase. The economic evaluations of the diets were calculated according to New (1989) and Mazid *et al*., (1997).

Data Analysis

Data generated from the experiment were subjected to analysis of variance (ANOVA) using SPSS. Means were separated using Duncan's multiple range test (DMRT).

RESULTS

Nutritional Composition of Experimental Ingredients and Diets

Table 2 shows the proximate composition of the feed ingredients while Table 3 shows the proximate composition of the experimental diets. The percentage moisture content was highest in 7days fermented sorghum by-product with 17.20% while the lowest was recorded in maize meal with 12.38%. The percentage dry matter content was highest in maize meal with 87.62% while the lowest was recorded in 7days fermented sorghum by-product meal with 82.80%. The percentage ash content was highest in 5days fermented sorghum by-product meal with 2.32% while the lowest was recorded in maize meal with 0.80%. The percentage crude fibre was highest in 5 days fermented sorghum by-product meal with 8.90% while the lowest was recorded in maize meal with 1.50%. The percentage crude lipid was highest in 7days fermented sorghum by-product with 2.55% while the lowest was recorded in 3days fermented sorghum by-waste product with 1.85%. The percentage crude protein was highest in 7days fermented sorghum waste by-product with 15.10% and the lowest was recorded in maize meal with 10.10%, while the nitrogen free extract was highest in maize meal with 73.02% and the lowest was recorded in 7days fermented sorghum by-product with 55.45%.

The proximate analysis of the experimental diets revealed that diet C had the highest percentage moisture content with 11.00% while diet D had the lowest percentage moisture content with 9.50%. The percentage dry matter in the experimental diet was highest in diet D with 90.50% while the lowest percentage dry matter was recorded in diet C with 89.00%. Diet A and D had the highest percentage ash content with 5.50% each while the lowest was recorded in diet C with 4.00%. Diet D had the highest percentage crude fiber with 4.60% while the lowest was recorded in diet C with 4.20%. The percentage crude lipid recorded was highest in diet D with5.50% while the lowest crude lipid was recorded in diet C with 4.00%. The percentage crude protein recorded was highest in diet C with 48.65% crude protein and the lowest was recorded in diet D with 44.50%. Diet D had the highest percentage nitrogen free extract with 30.34% while the lowest was recorded in diet C with 28.15 as shown in Table 3.

Table 2: Proximate composition of Fermented Sorghum by-product and Maize

Parameters	Group A (3days FSB)	Group B (5 days FSB)	Group C (7 days FSB)	Group D (Maize)
% Moisture	15.00	16.15	17.20	12.38
% Dry matter	85.00	83.85	82.80	87.62
% Ash	2.32	1.95	1.50	0.80
% Crude fiber	7.94	8.90	8.20	1.50
% Crude lipid	1.85	2.00	2.55	2.20
% Crude protein	13.85	14.00	15.10	10.10
% NFE	59.04	57.00	55.45	73.02

FSB = Fermented Sorghum by-product

Table 3: Proximate Composition of the Experimental Diets (g/100g)

Parameters	Diet 1	Diet 2	Diet 3	Diet 4 (control)
% Moisture	10.00	10.25	11.00	9.50
% Dry matter	90.00	89.75	89.00	90.50
% Ash	5.50	4.20	3.75	5.50
% Crude fiber	4.40	4.30	4.20	4.60
% Crude lipid	5.00	4.40	4.00	5.50
% Crude protein	45.25	47.09	48.65	44.56
% NFE	29.85	29.76	28.40	30.34

A, B, C = 3, 5, 7 days fermented sorghum by-product meal replaced diet, respectively; C = control diet

Growth Performance and Survival Rate

Table 4 shows the growth performances and survival rate of *Clarias gariepinus* fed experimental diets for the period of 84 days. The mean initial weight was highest in treatment A (61.45±0.15) and the lowest was in treatment D (57.28±0.19). The mean final weight was highest in treatment C (45.58±0.57) and the lowest was recorded in treatment D (33.72±0.83). The total weight gain was highest in treatment C (319.00±0.73) and the lowest was recorded in treatment D (257.33±1.13). The values for relative growth rate (RGR) (630.97±0.12) and specific growth rate (SGR) (0.97±0.34) were highest in fish fed treatment diet C. The percentage survival rate recorded in the fish exposed to the experimental diets was highest in treatments A (93.3±0.01) and D (93.30±0.07). There was no significant difference between the mean initial weight of fish fed experimental diets A, B and C.

The mean initial weight of those fed Diets A and C didn't differ significantly ($p>0.05$) as is also the case with Diets B and D. Diets A and C differ significantly ($P<0.05$) from those fed diets B and D. The final weight, mean final weight, weight gain, mean weight gain and relative growth rate all differ significantly ($P<0.05$) between all the groups. Specific growth rate for group A and D didn't show significant difference, the same applies to Percentage survival between group B and D.

Nutrient Utilizations

The nutrient utilizations of the fish fed experimental diets are shown in Table 5. The feed intake (FI) for the fish fed experimental diet recorded was highest in the fish fed experimental diet C (90.59 ± 0.25) while the lowest was recorded in treatment D (72.31±1.7). Fish fed treatment C had the highest feed conversion ratio (FCR) (0.42±0.41), while the lowest was recorded in treatment D (0.38±0.09). The protein intake (PI) (44.07±0.08) and protein efficiency ratio (PER) for the fish fed experimental diets was highest in treatment C and the lowest was in treatment D (32.22±0.11 and 0.62±0.47 respectively).

The feed intake (FI) values were significantly different ($P< 0.05$) between all the groups. Mean Feed Conversion Ratio (FCR) between Group A and B didn't show any significant difference ($P> 0.05$) while they differ significantly ($P< 0.05$) from Group C and D. The mean protein intake values for all the groups differ significantly from each other, the same applies to the Protein Efficiency Ratio (PER).

Table 4: Growth performances and survival rate of *Clarias gariepinus* fed experimental diets for period of 84 days.

Parameters	A	B	C	D
Initial weight (g)	61.45 ± 0.15^a	59.04 ± 0.78^a	60.69 ± 0.35^a	57.28 ± 0.19^b
Mean initial weight (g)	6.15 ± 0.28^a	5.90 ± 0.89^b	6.07 ± 0.51^a	5.73 ± 0.44^b
Final weight (g)	337.67 ± 0.91^c	356.18 ± 1.01^b	379.69 ± 0.52^a	314.61 ± 0.52^d
Mean final weight (g)	36.19 ± 0.23^c	39.58 ± 0.18^b	45.58 ± 0.57^a	33.72 ± 0.83^d
Weight gain (g)	276.22 ± 1.52^c	297.14 ± 0.18^b	319.00 ± 0.73^a	257.33 ± 1.13^d
Mean weight gain (g)	29.61 ± 1.02^c	33.02 ± 0.67^b	38.30 ± 0.58^a	27.58 ± 0.45^d
Relative growth rate (%)	481.46 ± 0.95^c	559.66 ± 1.12^b	630.97 ± 0.12^a	481.33 ± 0.75^c
Specific growth rate (%/day)	0.86 ± 0.29^c	0.92 ± 0.75^b	0.97 ± 0.34^a	0.86 ± 0.19^c
% Survival	93.30 ± 0.01^a	90.00 ± 0.02^b	83.30 ± 0.11^c	93.30 ± 0.07^b

Mean in the same row with different superscripts are significantly different ($p<0.05$)

A, B, C = 3, 5, 7 days fermented sorghum by-product meal replaced diet, respectively; D = control diet

Table 5: Nutrient utilizations of *clarias gariepinus* fed experimental diets for period of 84 days

Parameters	A	B	C	D
Feed intake	76.77 ± 0.98^{c}	82.78 ± 0.51^{b}	90.59 ± 0.25^{a}	72.31 ± .17^{d}
Feed conversion ratio	0.39 ± 0.57a^{b}	0.40 ± 0.29^{b}	0.42 ± 0.41^{a}	0.38 ± 0.09^{c}
Protein Intake	34.74 ± 0.32^{c}	38.98 ± 0.12^{b}	44.07 ± 0.08^{a}	32.22 ± .11^{d}
Protein efficiency ratio	0.65 ± 0.23^{c}	0.70 ± 0.02^{b}	0.79 ± 0.75^{a}	0.62 ± 0.47^{d}

Data in the same row with different superscripts are significantly different (p<0.05)
A, B, C = 3, 5, 7 days fermented sorghum by-product meal replaced diet, respectively; D = control diet

Haematological Response

The haematological responses of *Clarias gariepinus* to experimental diets is as shown in Table 6.

Table 6: Some Haematological Response of *Clarias gariepinus* fed Experimental Diets

Parameters	A	B	C	D
PCV (%)	30.20± 0.36 ^{c}	33.10 ± 1.28^{b}	36.00 ± 0.86^{a}	26.68 ± 0.92^{d}
Hb (g/dl)	4.45 ± 0.54^{c}	6.67 ± 0.61^{b}	7.06 ± 1.54^{a}	2.90 0.47^{d}
RBC	6.57 ± 1.36^{c}	7.01 ± 0.94^{b}	7.50 ± 0.27^{a}	6.20 ± 1.86^{d}
WBC	15.19 ± 0.43^{c}	17.63 ± 1.76^{b}	20.31 ± 0.82^{a}	16.00 ± 0.53^{d}
MCH (pg)	6.77 ± 0.75^{c}	9.52 ± 0.83^{a}	9.41 ± 0.95^{b}	4.68 ± 0.99^{d}
MCHC(T/L)	43.97 ± 1.06^{a}	37.06 ± 0.62^{c}	33.62 ± 1.26^{d}	37.76 ± 0.69^{b}
MCV (µ^{3})	15.40 ± 0.54^{c}	25.68 ± 0.376^{b}	28.00 ± 0.92^{a}	12.39 ± 0.46 ^{d}

Means in the same row with different superscript are significantly different (p<0.05)

The values for packed cells volume (PCV) (36.00±0.86%), haemoglobin (Hb) (7.06±1.54), the red blood cells count (RBC) (7.50±0.27) recorded was higher in treatment C and lowest recorded in treatment D. The value for white blood cells (WBC) (17.63±1.76) was higher in the fish fed treatment C diet compared to other treatments. The mean corpuscular haemoglobin (MCH) value (9.41±0.95) recorded was highest in fish fed treatment C diet and the lowest (4.68±0.99) was recorded in the fish fed treatment D diet. The value for mean corpuscular haemoglobin concentration (MCHC) recorded was highest (43.97±1.06) in treatment A and the lowest value (37.06±0.62) was recorded in treatment C. The mean corpuscular volume (MCV) was recorded to be highest (28.00±0.92) in the fish fed treatment C while the lowest value (12.39±0.46) was recorded in treatment D.

Cost Benefits Analysis of Experimental Diets

The cost benefit analysis of feeds, fed to *C. gariepinus* is presented in Table 7. The cost of feeds was higher in D_4 with a value of ₦40.15 while lowest was recorded in D_1, D_2 and D_3 ₦34.15 each. The cost of feeding recorded was highest in D_3 with a value of ₦30.94 while the lowest was recorded in D_1 with a value of ₦26.22.The estimate mean of investment cost recorded was highest in D_3 with a value of ₦60.94,while the lowest was recorded in D_1 with a value of ₦56.22.The highest net profit was recorded in D_3 with a value of ₦24.56, while the lowest was recorded in D_4 with a value of ₦18.50.The highest profit index was recorded in D_3 with ₦2.50, while the lowest was recorded in $D_4$with a value of ₦1.93.The incidence of cost recorded was highest in D_4 with a value of ₦1.46,while the lowest was recorded in D_3 with a value of ₦0.89.The benefit cost ratio recorded was highest in D_1 with a value of ₦ 1.41, while the lowest was recorded in D_4 with a value of ₦1.31..

Table 7: Cost Benefit Analysis of Experimental Diets and Fish

Cost Benefit Parameters	D_1(A)	D_2(B)	D_3(C)	D_4(D)
Cost of feed (₦)	34.15 ± 0.28^{b}	34.15 ± 0.57^{b}	34.15 ± 0.42^{b}	40.15 ± 0.67^{a}
Mean cost of fingerlings stocked (₦)	30.00 ± 0.00^{a}	30.00 ± 0.00^{a}	30.00 ± 0.00^{a}	30.00 ± 0.00^{a}
Cost of feeding (₦)	26.22 ± 0.41^{d}	28.27 ± 0.03^{c}	30.94 ± 0.98^{a}	29.10 ± 1.28^{b}
Estimate mean investment cost (₦)	56.22 ± 1.01^{d}	58.27 ± 0.98^{c}	60.94 ± 0.51^{a}	59.10 ± 0.21^{b}
Mean yield cost (₦)	79.50 ± 0.54^{c}	81.60 ± 0.08^{b}	85.50 ± 1.02^{a}	77.60 ± 0.92^{d}
Net profit (₦)	23.28 ± 0.52^{ab}	23.33 ± 0.15^{b}	24.56 ± 0.28^{a}	18.50 ± 0.57^{c}
Profit index (₦)	2.33 ± 0.72^{ab}	2.39 ± 0.42^{b}	2.50 ± 0.08^{a}	1.93 ± 0.98^{c}
Incidence of cost (₦)	1.15 ± 0.29^{b}	1.03 ± 1.09^{d}	0.89 ± 0.11^{c}	1.46 ± 0.57a
Benefit cost ratio (₦)	$1.41 \pm o.17^{a}$	1.40 ± 0.28^{b}	1.40 ± 0.16^{b}	1.31 ± 0.35c

Data in the same row with different superscripts are significantly different ($p<0.05$)
A, B, C = 3, 5, 7 days fermented sorghum by-product meal replaced diet, respectively; D = control diet

Water Quality Parameters Monitored Before and During the Study

Water quality parameters monitored before and during the study were temperature, dissolved oxygen and water pH as shown in table 8. The temperature recorded at beginning of the experiment was 25.8 ± 0.12^{o}C. This value decreased to 23.5 ± 0.11^{o}C at the end of the experiment. The dissolved oxygen measured at the beginning was 6.7± 0.27mg/l while 5.6 ± 0.41mg/l was recorded at end of the experiment. The water pH was 7.3± 0.63at the beginning of the experiment while 8.9±0.73 was recorded at the end.

Table 8: Water Quality Parameters Monitored Before the Study and at the End of the Study

Parameters	Before the Study	At the End of the Study
Temperature (^{o}C)	25.8± 0.12	23.5± 0.01
D.O (mg/l)	6.7± 0.27	5.6± 0.41
pH	7.3± 0.63	8.9±0.73

DISCUSSION

The proximate composition of the feed ingredients and experimental diets shows that 7days (72 hours) fermented sorghum by-product had the best percentage moisture content and crude protein compared to others. This could be as a result of fermentation level which reduced the effect of anti-nutrient substances and improves the protein composition of the sorghum by-product. This result is in line with findings by Sogbesan and Ugwumba (2008) who reported 33.45% mucuna soaked in water with ash for 72hours.

The result obtained from this study revealed that fish fed treatment C diet (7day fermentation) had the highest mean weight gain, relative growth rate (RGR), specific growth rate (SGR), feed intake (FI), feed conversion ratio (FCR), protein intake (PI) and protein efficiency ratio (PER) compared to other fish fed treatments A, B and D (unfermented maize) as well. The acceptance of 7 days fermented sorghum waste by-product by *Clarias gariepinus*, indicate that the replacement of maize meal could be more profitable to fish farmers as the maize contain protein inhibitors as reported by (Sogbesan and Ugwumba (2006) and Aderolu *et al*. (2009), who report that the presence of anti-nutritional factors like tannin, phytate, cyanogenic and glucosides among other could probably have effect on nutrients utilization and growth of the fish. The survival rate in this study indicated that feeding *Clarias gariepinus* with 7 days fermented sorghum by-product could give up to 83% survival rate. The good nutrient quality, which translated into good growth in fish fed 7 days fermented sorghum by-product, could be as a result of fermentation method adopted.

The haematological indices of *Clarias gariepinus* shows that the packed cells volume, the haemoglobin, the red blood cells, the white blood cells, the mean corpuscular haemoglobin, the mean corpuscular volume was highest in fish fed diet C and the lowest values were recorded in fish fed diet D. this observation is in line with the work of Adeyemo (2005), who reported that the reduction in the value of packed cell volume, haemoglobin and red blood cell were due to the presence of toxic substances in the diet of the fish. While the increase in white blood cell is usually associated with microbial infection or presence of foreign body or antigen in the circulatory system Saleh *et al*. (1998).

This research has indicated that cost of feed was higher in control diet compared to other diets. Cost of feeding was higher in the fish fed D_3. The net profit and profit index was higher in the fish fed D_3 while the incidence of cost was low in fish fed D_3. The cost benefit ratio was higher in the fish fed D_1. These results corresponded with the report of Bolagun (2014) who reported that high net profit, profit index, mean yield cost and low incidence of cost determine the profitability of business.

The result of the water quality parameters recorded at the beginning and at the end of the study indicated that the water quality parameters were at recommended levels. This occurred as a result of continuous changing of the water during the study period.

CONCLUSION

This study showed that 7days fermented sorghum by-product incorporation into the diet of *Clarias gariepinus* as basal ingredient improves the growth of fish but the survival rate was least compared to others. Based on the result obtained from cost benefit analysis 7days fermented sorghum by-product incorporation in to the diet of *Clarias gariepinus* minimized the cost of production and maximized the profit. This study also, revealed that fermentation is an effective method of breaking down of nutrient inhibitors as a result of microbial activities on the whole sorghum by-product.

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