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HAEMATOLOGICAL PROFILES OF *CLARIAS GARIEPINUS* FINGERLINGS FED GRADED LEVELS OF BLOOD MEAL – BOVINE RUMEN DIGESTA BLEND DIETS

H. A. Adewole and *V. F. Olaleye

Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria

*Corresponding Author email: olafoluwa_59@yahoo.com

ABSRACT

An experiment was conducted to test the effect of feeding graded levels of Blood meal – Bovine rumen digesta blend diets (BMBRD) on the haematological profiles of *Clarias gariepinus* fingerlings (10.32±1.96 g). Five approximately iso-nitrogenous (35% crude protein) experimental diets were prepared with 0%, 25%, 50%, 75% and 100% BMBRD meal inclusion respectively to replace the fishmeal component of the control diets. The prepared experimental diets were fed in duplicate to 8-week old *C. gariepinus* fingerlings in each dietary group for 86 days. A commercial feed was exclusively fed as the control diet. The fish stocked in 12 glass tanks (60 cm x 30 cm x 30 cm) at the rate of 12 fish per tank were fed at the rate of 5% of their body weight per day, in two equal installments. Analysis showed that the water pH in each of the culture media significantly differ ($P<0.05$) from each other. The haemoglobin values of the fish fed the control and 75% BMBRD diets were significantly different ($P<0.05$) from the heamoglobin. However, the MCHC values of the fish fed experimental diets were not significantly ($P>0.05$) from the MCHC value of the fish fed control (DBR) diet. The study concluded that blood meal – bovine rumen digesta could satisfactorily replace fishmeal in the diet of *C. gariepinus* fingerlings without affecting the haematological profiles of the fish.

Keywords: Blood meal, Rumen digesta, *Clarias gariepinus*, Haematology.

INTRODUCTION

Clarias gariepinus Burchell is one of the most cultured fish species in Nigeria because of the good adaptability to captivity condition, rapid growth rate, flesh tastiness, hardiness and disease resistance ability (Skelton, 1993; Olagunju *et al.*, 2007; Anoop *et al.*, 2009 and Vanguard, 2009). The plasticity of the catfish diet (Anoop *et al.*, 2009) and its ability to convert waste by-product feedstuffs into useful fish flesh make the species the choice fish of culture in Nigerian aquaculture (Anoop *et al.*, 2009 and Emokaro, 2010).

Fish meal which is the main ingredient in *Clarias gariepinus* diet is a primary choice protein source because it increases feed efficiency and fish growth through better feed palatability, digestion and nutrient absorption (Mile and Chapman, 2012). Due to its expensiveness however, promising alternative plant and animal protein sources that are cheap and affordable have been tried in catfish diets to replace the fish meal component (Solomon and Sadiku, 2007; Goda *et al.*, 2007; Ingweye *et al.*, 2010 and Ferouz *et al.*, 2012). In most cases, total replacement of the fish meal component has not been achieved due to lack of some essential amino acids (Anderson *et al.*, 1995), presence of anti-nutritional factors or toxicants (Murray *et al.*, 2010 and Ferouz *et al.*, 2012) or poor feed digestibility (Murray *et al.*, 2010).

Blood meal, a common sustainable source of animal protein (Otubusin *et al.*, 2009), has not been successfully utilized as a wholesale substitute for fish meal in catfish feeds due to observed deficiencies (Otubusin *et al.*, 2009).

Documented deficiencies include poor amino acids balance with lysine being relatively high (7-8%) and isoleucine being very low (Sauvant, 2004). The relatively high lysine content in the blood meal makes it an excellent supplemental protein source to complement plant included feed ingredient such as cattle rumen digesta (McDonald *et al.*, 2002).

The heterogenous nature of cattle rumen digesta made up of dense microbial population (Czerkawski, 1986) and digested feed at different stages of degradation (McDonald *et al.*, 2002) made it a suitable candidate in various animal feed preparations (Agbabiaka *et al.*, 2012). Odunsi (2003) and Dairo *et al.* (2005) had also reported that blend of cattle rumen digesta complemented the amino acid in-balance reported in the blood meal. Rumen contents has also been shown to be suitable feed ingredient in catfish diets because it contains no anti-physiological factors (Adeniji and Balogun, 2002). Studies on blend of bovine blood meal and rumen digesta (BBRDM) as a replacement for fishmeal have been reported in the diet of *C. gariepinus* fingerlings (Adewumi, 2012; Adewole, 2014). The main objective of the present study was to examine the haematological profiles of *Clarias gariepinus* juveniles fed differently substituted Blood Meal – Bovine Rumen Digesta diets

MATERIALS AND METHODS

Experimental Design

One hundred and forty four (144) laboratory acclimatized 8-weeks old *C. gariepinus* juveniles (10.32 ±1.96 g) were fed graded levels of 35% crude protein iso-nitrogenous Blood Meal – Bovine Rumen Digesta based diets. The BMBRD meal was made from mixture of fresh bovine blood and rumen digesta in the ratio of 1:1 (weight/weight), cooked for 60 minutes with stirring until it formed a paste which was sundried on a clean drying slab for 4 days (Adewole, 2014). The dried BMBRD blend was later ground into a meal and analyzed for the proximate composition (A.O.A.C., 1990). Experimental diets were then formulated using fish meal, wheat offal and yellow maize meals (purchased from Segsco Farm Feeds, Ile-Ife) mixed with graded levels of BMBRD meal. In the experimental diets, the fish meal component of the diet was replaced at 0, 25, 50, 75 and 100% respectively by the BMBRD meal. The ingredients analysed for their proximate composition (Table 1) were weighed according to the formulations (Table 2), moistened, thoroughly mixed and pelletized using 2 mm die in a Horbart pelleting machine. The moist pellets tagged 0% BMBRD, 25% BMBRD, 50% BMBRD, 75% BMBRD and 100% BMBRD diets respectively were sundried for 5 days until crispy and stored at room temperature for subsequent experimental feeding. The experimental diets were analyzed for the proximate composition (AOAC, 1990) to confirm the formulations (Table 1).

Experimental Feeding

The fish were stocked in duplicates for each dietary treatment and the control at the rate of 12 juvenile per tank (60 cm x 30 cm x 30 cm). The entire test fish were starved for 24 hr prior to the commencement of the experimental feeding to allow for digestion of already eaten food and also prepare the fish for the test diets. The test diets were fed twice daily, at the rate of 5% of the body weight, shared between 0800hr to 0900hr and 1700hr to 1800hr daily for a period of 86 days. The tanks were cleaned every 3 days and replenished with water from a holding reservoir

Water Quality Determination

The water quality parameters analysed in duplicates in the culture media were temperature, pH and dissolved oxygen which were determined *in situ* daily using mercury in glass bulb thermometer, Jenway 3020 pH meter and Milwaukee Dissolved Oxygen Meter (MW 600) respectively. The levels of calcium, magnesium, and nitrate ion were determined weekly according to the methods of Ademoroti (1996).

Haematological Techniques

Blood samples were taken by caudal vein puncture using a 2 ml syringe on a set of four *Clarias gariepinus* juveniles from each treatment tank separately into a 2 ml heparinized tubes. Haematocrit (Hct) was determined using the methods of Snieszko (1960) while the heamoglobin level were determined using Cyanomethaemoglobin (Larsen and Snieszko, 1961). The red and white blood cell counts were determined using Improved Neubauer Counting

Chamber while the mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were obtained according to the method described by Dacie and Lewis (2001).

Statistical analysis

The data collected were reported as means (± S.D) and subjected to analysis of variance (ANOVA) and Duncan's New Multiple Range Test ($P < 0.05$) using the statistical software package SPSS 16.0

RESULTS

Water Quality

The mean temperature of water in the culture tanks which varied between 25.64^0C ±0.06 (75% BMBRD treatment) and 26.25^0C ±0.35 (control treatment) were not significantly different (P>0.05) from each other (Table 3). Irrespective of the feed offered, the water in all the culture tanks was slightly acidic varying between 6.11±0.03 (25% BMBRD) and 6.66 ±0.01 (75% BMBRD). Analysis also showed that the water pH in each treatment tank were significantly different (P<0.05) from each other. Introduction of the experimental feed into the culture tanks decreased the dissolved oxygen content significantly. Analyses showed a significant (P<0.05) variation in DO content between the treatments with the dissolved oxygen levels varying between 2.36 ±0.74 mg/L (50% BMBRD treatment) and 7.76 ±0.79 mg/L (control treatment).

The NO_3 levels in the culture water were not significantly affected by the introduction of the experimental and the control feeds (Table 3). However, the Ca^{2+} concentrations in the culture tanks which varied slightly with treatments were not significantly different (P>0.05) but was found to be significantly lower (P<0.05) than the Ca^{2+} level recorded when the fish was fed the control diet. The Mg^{2+} concentrations which varied between 7.01 ±0.15 mg/L (25% BMBRD treatment) and 7.83 ±0.20 mg/L (0% BMBRD treatment) were not significantly different (P>0.05) in the experimental and the control culture tanks.

Haematological Indices

Analyses of the heamatological indices of the cultured fish (Table 4) revealed that the packed cell volume (PCV) were not significantly different (P>0.05) in the fish fed the experimental diets and the control. Fish fed 0% BMBRD diet had the lowest haemoglobin (Hb) value (6.40 ±1.56 g/dL) while the highest heamoglobin value (9.12 ±1.68 g/dL) was recorded for the fish fed 75% BMBRD diet. However, the haemoglobin values of the fish fed the control and 75% BMBRD diets were not significantly different (P>0.05) from each other, but were significantly different (P<0.05) in the fish fed 0% BMBRD, 50% BMBRD and 100% BMBRD diets (Table 4).

In spite of the recorded variations in the RBC, there were no significant differences (P>0.05) in the RBC of the fish fed the experimental graded BMBRD diets and the control. The lowest white blood cell count (WBC) (1.64×10^{-12}/L) was recorded in the fish fed 50 % BMBRD diet while the highest value (2.39×10^{-12}/L) was recorded in the fish fed 0% BMBRD diet. The recorded WBC which were not significantly different (P>0.05) between the fish fed the control diet and 50% BMBRD diets were significantly lower (P<0.05) in the fish fed 0% BMBRD diet. Mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), and the mean corpuscular volume (MCV) values of the fish fed different experimental diet were generally low in the fish fed 0% BMBRD diet. The mean MCH was significantly lower (P<0.05) in the fish fed 0% BMBRD diet when compared with those fed on other experimental and control diets. The MCV in the fish fed on the control, 0% BMBRD, 50% BMBRD, and 75% BMBRD diets were found to be significantly lower (P<0.05) than in the fish fed 25% BMBRD and 100% BMBRD diets

The fish fed control diet however, had the highest mean corpuscular heamoglobin concentration (MCHC) (33.23 ±0.24 g/dL) which was significantly higher (P<0.05) than the MCHC of the fish fed 0% BMBRD diet. However, the MCHC values were found not to be statistically different (P>0.05) from those fed 25% BMBRD, 50% BMBRD, 75% BMBRD and 100% BMBRD diets.

DISCUSSION

Temperature of aquatic environment is important for ensuring survival and normal metabolism of fish (Forghally *et al.*, 1973). In all the treatments during the period of study, water temperature was within the recommended range of between 25^0C and 32^0C for optimum growth in warm water fishes (Boyd and Licktoppler, 1979). The pH, which was observed to be slightly acidic in the culture tanks, could be as result of the presence of rumen digesta in the experimental diets. Li *et al.* (2013) had earlier reported that pH of rumen digesta of cows fed by high forage diets are always between 6.0 and 7.0 which is considered to be the optimum for cellulolytic bacteria activity (Mould *et al*., 1983). The presence of the rumen–digesta blend as an important component of the experimental diets was probably responsible for lowering the pH of culture water. However the pH recorded were still within the recommended range for freshwater fish culture (Boyd, 1979; Olatunde, 2004). The low level of dissolved oxygen in the treatment tanks could probably be attributed to depletion of dissolved oxygen during bacterial decomposition of the organic matters in the uneaten feed and feacal matter. Bacteria respiratory activities in the treatment tanks would also contribute to depletion of dissolved oxygen concentration. Veado *et al.* (2000) observed that introduction of excess organic matter results in depletion of oxygen from aquatic systems especially in warm stagnant conditions.

Haematological Profile

The heamatological profile recorded in the fish showed that the experimental diets were not in any form or at any level toxic to the fish indicating that the diets supported the fish eco-physiology to a reasonable extent. Heamoglobin and PCV determinations carried out routinely to check the health status of fish (Agbede *et al.*, 1999) was lower than the values reported by Osuigwe *et al.* (2005) and Agbabiaka *et al.* (2013) for the African catfish fed a tiger nut diet. However, the result was similar to those reported by Adeyemo *et al.* (2003) on haematological response of *C. gariepinus* to temperature variations and Gabriel *et al*. (2004) on the influence of sexual variation and acclimation temperature on the heamoglobin content and PVC of *C. gariepinus*. Similar results were reported by Terry *et al*. (2000) and Adam (2004) in the Red Tilapia, Nile Tilapia, Curimbata and hybrid Tilapia. The values recorded for haemoglobin and PCV in this study were within the normal range reported for the African catfish (Erondu *et al.*, 1993; Musa and Omoregie, 1999). The red blood cell counts recorded in the fish fed the different experimental diets were higher than what was reported by Adeyemo *et al*., (2003); Gabriel *et al.* (2004) and Agbabiaka *et al.* (2013). Similar results were however recorded for other fish by Terry *et al*. (2000); Nilza *et al.* (2003) and Adam (2004). The red blood cell count and PCV were probably affected by dietary treatment (Aletor and Egberongbe, 1998). The blood component of the BMBRD meal which is very rich in iron present in haemoglobin of the cow's blood probably enhanced erythropoiesis in the fish. Blood profiles have been reported to be influenced by water quality parameters such as temperature, dissolved oxygen, pH, ammonia (Adeyemo *et al.*, 2003). Increase in WBCs count probably occurred as a response of fish to stress resulting from unfavorable alteration in water quality or production of antibodies against the growth of bacteria in the water media. The relatively lower WBCs count recorded in the fish during the study when compared to values reported by Adam and Agab (2006) and Agbabiaka *et al.* (2013) probably showed that the fish fed the different experimental diets were less susceptible to dietary stress, alteration of water quality, and bacteria infestation when compared with previous studies. The range in the mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) obtained during the study were similar to those reported by Terry *et al.*(2000), Nilza *et al.* (2003) and Gabriel *et al.* (2004). Factors that may have induced the observed variations apart from the dietary treatment include environmental conditions, sex and age of fish. Banergee *et al.* (2002) however reported that under normal conditions, the blood profile should be reasonably constant for any species with changes falling with narrow limit as observed in this study.

Table 1: Proximate composition of the feedstuffs and the experimental diets

	Crude protein (%)	Crude fibre (%)	Lipid (%)	Ash (%)	Moisture (%)	NFE (%)
Ingredients						
Fish meal	68.50	0.40	10.40	17.40	3.00	0.30
BMBRD	45.50	9.48	1.15	10.93	9.82	23.12
Wheat offal	16.34	12.34	1.69	6.58	11.35	51.70
Yellow maize	10.80	3.50	3.60	8.40	11.81	61.89
Diets						
DBR**	45.00	2.60	14.00	7.50	11.00	19.9
0%BMBRD	35.90 [a]	2.14 [a]	3.40 [a]	8.17 [a]	9.99[a]	40.14
	±0.11	± 0.16	± 0.02	± 0.58	±0.40	
25%BMBRD	35.99 [a]	2.91 [a]	3.50 [a]	7.85 [a]	11.54[a]	38.21
	±0.01	± 0.19	± 0.02	± 0.34	±1.12	
50%BMBRD	35.98[a]	3.85 [b]	3.10 [a]	8.40 [a]	10.78[a]	37.89
	±0.02	± 0.09	± 0.02	± 0.23	±1.46	
75%BMBRD	35.59[a]	3.87 [b]	4.00 [a]	7.82 [a]	10.49[a]	38.23
	±0.05	± 0.16	± 0.02	± 1.15	±1.19	
100%BMBRD	35.48[a]	4.78 [c]	3.90 [a]	8.32 [a]	9.66[a]	37.94
	±0.02	± 0.07	± 0.02	± 0.24	±0.55	

Means within column with different superscripts are significantly different ($p<0.05$).

**Manufacturer's nutrient specification

NFE = Nitrogen-free Extract = 100 – (Crude protein + Crude fibre + Lipid content + Moisture content + Ash) (A.O.A.C, 1990).

Table 2: Ingredient compositions in the formulated experimental diet (g/100g)

Ingredient	0% BMBRD	25% BMBRD	50% BMBRD	75% BMBRD	100% BMBRD
Fish meal	52.0	39.0	26.0	13.0	-
BMBRD	-	1.3	2.6	39.0	52
Wheat offal	23.0	23.0	23.0	23.0	23.0
Yellow maize	23.0	23.0	23.0	23.0	23.0
Vit/Min Premix *	1.0	1.0	1.0	1.0	1.0
Vegetable oil	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

*Biomix from Bio-organics production were provided per kg of diet: Vitamin A, 12,500 IU; Vitamin D, 2,500 IU; Vitamin E, 40 mg; Vitamin K, 2 mg; Vitamin B1, 3 mg; Vitamin B2, 5.5 mg; Niacin 55 mg; Calcium pantothenate, 11.5 mg; Vitamin B 6, 5mg; Vitamin B 12, 0.025 mg; Choline chloride, 500 mg; Folic acid, 1 mg; Biotin, 0.08 mg; Manganese, 120 mg; Iron, 100 mg; Zinc, 80 mg; Copper, 8.5 mg; Iodine, 1.5 mg; Cobalt, 0.3 mg; Selenium, 0.12 mg; Anti-oxidant, 120 mg.

Table 3: Mean Physico-chemical parameters of the water culture tanks before and during the feeding trials

Treatment	Water Temp. (^oC)	pH	Dissolved Oxygen Conc. (mg/L)	Nitrate (mg/L)	Calcium (mg/L)	Magnesium (mg/L)
Control ± S.D	26.25^{a} ± 0.35	6.55^{a} ± 0.03	7.76^{a} ± 0.79	1.15^{a} ± 0.18	27.65^{a} ± 1.63	7.35^{a} ± 0.10
0 % BMBRD ± S.D	25.83^{a} ± 0.01	6.63^{b} ± 0.03	3.84^{b} ± 1.36	1.05^{a} ± 0.01	22.59^{b} ± 1.79	7.01^{a} ± 0.15
25 % BMBRD ± S.D	25.80^{a} ± 0.01	6.11^{c} ± 0.03	2.40^{b} ± 0.11	2.24^{a} ± 0.33	21.86^{b} ± 0.88	7.05^{a} ± 0.63
50 % BMBRD ± S.D	25.80^{a} ± 0.04	6.54^{d} ± 0.01	2.36^{b} ± 0.74	0.78^{a} ± 0.11	21.01^{b} ± 0.26	7.80^{a} ± 0.11
75 % BMBRD ± S.D	25.64^{a} ± 0.06	6.66^{e} ± 0.01	2.68^{b} ± 0.34	1.25^{a} ± 0.28	21.37^{b} ± 0.12	7.61^{a} ± 0.27
100 % BMBRD ± S.D	25.66^{a} ± 0.01	6.60^{b} ± 0.01	4.58^{ab} ± 1.62	1.05^{a} ± 0.01	22.56^{b} ± 1.08	7.83^{a} ± 0.20

*Means within column with different superscripts are significantly different ($p<0.05$).

Table 4: Heamatological parameters of the cultured fish fed the different experimental diets

Treatment	PCV (%)	Heamoglobin (Hb) g/dl	RBC x $10^{12}L^{-1}$	WBC x $10^{12}L^{-1}$	MCH (pg)	MCV (fl)	MCHC (g/dl)
Control ± S.D	28 [a] ± 0.70	8.89 [a] ± 0.80	3.88 [a] ± 0.20	1.75 [a] ± 0.18	26.46 [a] ± 5.60	79.66 [a] ± 17.47	33.23 [a] ± 0.24
0 % BMBRD ± S.D	26 [a] ± 2.83	6.40 [b] ± 1.56	3.45 [a] ± 0.87	2.39 [b] ± 0.29	17.26 [b] ± 0.15	73.32 [a] ± 15.30	24.09 [b] ± 5.23
25 % BMBRD ± S.D	28 [a] ± 0.01	8.47 [ab] ±1.89	3.15 [a] ± 0.91	2.04 [ab] ± 0.85	28.98 [ab] ± 14.45	92.20 [b] ± 28.00	30.47 [ab] ± 6.41
50 % BMBRD ± S.D	27 [a] ± 0.70	7.89 [b] ± 0.94	3.94 [a] ± 0.36	1.64 [a] ± 0.50	24.71 [a] ± 0.15	84.10 [a] ± 10.95	29.85 [ab] ± 4.34
75 % BMBRD ± S.D	28 [a] ± 2.83	9.12 [a] ± 1.68	3.48 [a] ± 0.34	1.66 [a] ± 0.28	26.56 [a] ± 7.40	80.18 [a] ± 8.81	32.82 [ab] ±5.62
100 % BMBRD ± S.D	25 [a] ± 2.12	7.11 [b] ±1.60	2.84 [a] ± 0.48	1.71 [ab] ± 0.52	24.97 [a] ± 1.34	91.08 [b] ± 13.18	27.81 [ab] ± 5.49

Means within column with different superscripts are significantly different ($p<0.05$).

CONCLUSION

The study concluded that blood meal – bovine rumen digesta could satisfactorily replace fishmeal in the diet of *Clarias gariepinus* juveniles without affecting the haematological profiles of the fish.

REFERENCES

Adam, H. M. (2004). Comparative studies on the effect of water quality on haematological of *Orechromis niloticus* under culture condition. Ph.D. Thesis. Sudan University of Science and Technology. Pp207

Adam, H.M and Agab, H. (2006). Haematological and biochemical indices of *Clarias gariepinus* collected from river Nile Sudan. Sudan University of Science and Technology. Pp 6

Ademoroti, C. M. A. (1996). Standard method for water and effluents Analysis. Foludex press Ltd. Ibadan. Pp 205.

Adeniji, A. A. and Balogun, O. O. (2002). Utilization of flavor treated blood rumen content mixture in the diets of laying hens. Nigerian Journal of Animal Production 28 (1&2): 34-39.

Adewole, H.A. (2014). Growth performance in *Clarias gariepinus* Burchell fingerlings fed blood meal- bovine rumen digesta blend. M.Sc. Thesis. Obafemi Awolowo University. Pp 106.

Adewumi, A. A. (2012). Bovine blood and rumen digesta in catfish, *Clarias gariepinus* (Burchell 1822) diet. European Journal of Scientific Research 83 (2):167-172.

Adeyemo, O.K., Agbede, S.A., Olaniyan, A.O. and Shoaga, O.A. (2003). The haematological response of *Clarias gariepinus* to changes in acclimation temperature. African Journal of Biomedical Research 6: 105 – 108.

Agbabiaka, I.A., Madubuike, F. N. and Uzoagba, C. U. (2012). Performance of

catfish (*Clarias gariepinus*, Burchell, 1822) fed enzyme supplemented dried rumen digesta. Journal of Agricultural Biotechnology and Sustainable Development 4(2):22 -26.

Agbabiaka I.A., Madubuike F. N. and Ekenyem B.U. (2013). Heamatology and serum

characteristics of African catfish (*Clarias gariepinus* Burchell) fed graded levels of tigernut based diet. American Journal of Experimental Agriculture 3(4):988-995.

Agbede, S. A., Ogunsanmi, A. O., Taiwo, V. O., Oso, J. A. and Ogundipe, T. I. (1999). Toxic effects of poultry faeces on *Clarias gariepinus* broodstock. Tropical Veterinarian 17:181-191

Aletor, V.A. and Egberongbe, O. (1998) Feeding differently processed soybean and haematological indices in the chicken diet. Journal of Poultry Science 5(3):34-36

Anderson, J.S., Lall, S.P., Anderson, D.M. and McNiven, M.A. (1995). Availability of amino acids from various fish meals fed to Atlantic salmon *(Salmo salar).* Aquaculture 138: 291-301.

Anoop, K.R., Sundar, K.S.G., Khan, B.A. and Lal, S. (2009). Common Moorhen *Gallinula chloropus* in the diet of the African catfish *Clarias gariepinus* in Keoladeo Ghana National Park, India. Indian Birds 5(2):22-23.

AOAC (1990). Official Methods of Analysis. (Helrich, K. Ed.) 15th Edition, Vol. 1. Association of

Official Analytical Chemists (AOAC), Arlington, VA.

Banergee, S.K., Patra, B.C., Bandeypahyay, P. and Teway, A. (2002). Changes of blood parameter in carp *Catla catla.* Journal of Aquatic Biology 17(11):79-84

Boyd, C. E. (1979). Water Quality in warm water fish ponds. Auburn University, Alabama. Pp259.

Boyd, C. E. and Lichtkoppler, F. (1979). Water Quality Management In Fish Pond Culture. Research and Development Series. Project AID/DSAN-90039. Auburn University, Auburn, Alabama. 22:13-15.

Czerkawski, J. W. (1986). Introduction to Rumen Studies 4th ed, Pergamon Press.

Dacie, J.V. and Lewis, S.M. (2001). Practical Haematology, 9th Ed. Churchill Livingstone, London. 633 pp.

Dairo, F.A.S, Aina, O.O. and Asafa, A.R. (2005). Performance evaluation of growing rabbits feed varying levels of rumen contents mixture. Nigerian Journal of Animal Production 32: 67-72.

Emokaro, C.O., Ekunwe, P.A. and Achille, A. (2010). Profitability and viability of catfish

farming in Kogi State, Nigerian Journal of Agricultural Biological Science 6(3): 215-219

Erondu, E.S., Nnubia, S. and Nwanukwe, F.O. (1993) Haematological studies on four catfish species raised in fresh water pond in Nigerian. Journal of Applied Ichthyology 9(3-4):250-256

Ferrouz, Y.A., Kurt, A.R. and Kasiuvis-wanathan, M. (2012). Aternative Protein Sources for Aquaculture feeds. Journal of Aquaculture Feed Science Nutrition 4(1):1-26.

Forghaly, A.M., Ezzat, A.A. and Shabana, M.B. (1973). Effect of temperature and salinity changes on the blood characteristics of *Tilapia zilli* in Egyptian littoral lakes. Comprehensive Biochemistry and Physiology 46a: 183-193.

Gabriel, U.U., Ezeri, G.N.O. and Opabunmi, O.O. (2004). Influence of sex, source, health status and acclimation on the haematology of *Clarias gariepinus* (Burchell, 1822). African Journal of Biotechnology 3: 463–467.

Goda, A.M.A.S., Wafa, M.A., El-Haroun, E.R and Chowdhury, M.A.K. (2007). Growth performance and feed utilization of Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) and tilapia galilae *Sarotherodon galilaeus* (Linnaeus, 1758) fingerlings fed plant protein-based diets. Aquaculture Research 38*:* 827-837.

Ingweye, J.N., Kalio, G.A., Ubua, J.A. and Umoren, E.P. (2010). Nutritional evaluation of wild sicklepod (*Senna obtusifolia*) seeds from obanliku, South-Eastern Nigeria. American Journal of Food Technology 5: 1-12.

Larsen, H.N. and Snieszko, S.F. (1961) Comparison of various methods of determination of haemoglobin in trout blood. Prague Fish Culture 23: 6-7.

Li, S., Danscher, A.M. and Plaizier, J.C. (2013). Subactue Ruminal Acidosis (SARA) in dairy cattle: new developments in diagnostic aspects and feeding management. Canadian Journal of Animal Science 94(1):353-364.

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D. and Morgan, C. A. (2002). Animal Nutrition India 6th ed, Pearson Education Plc. Ltd Publishers.

Miles, R.D. and Chapman, F.A. (2012). The benefits of fishmeal in aquaculture diets. University of Florida, IFAS Extension. FishSite, http://www.thefishsite.com/articles/200/the-benefits-of-fish-meal-in-aquaculture-diets.

Mould, F. L., Orskov, E. R. and Mann, S.O (1983). Associative effects of mixed feeds. 1. Effects of type and level of supplementation and the influence of rumen pH on cellulolysis in vivo and dry matter digestion of various roughages. Animal Feed Science Technology. 10(1):15-30

Murray, H.M., Lall, S.P., Rajaselvam, R., Boutilier, L.A. and Blanchard, B. (2010). A nutrigenomic analysis of intestinal response to partial soybean meal replacement in diets for juvenile Atlantic halibut, *Hippoglossus hippoglossus*, L. Aquaculture 298: 282-293.

Musa, S.O. and Omoregie, E. (1999). Haematological changes in mudfish, *Clarias gariepinus* (Burchell 1822) exposed to malachite green. Journal of Aquatic Science 14:37-42.**Nilza, L. R., Ligia, M.M., Dense, O.S., Rassia, B. P., Celso, V. N., Tania, U. N., Benicio, A.**

F. and Benedito, P.F. (2003). Haematological and biochemical values for Nile tilapia (*Orechromis niloticus*) cultured in semi-intensive system. Acta Scientiarum Biological Sciences Maringa. 25 (2): 385-389.

Odunsi, A. A. (2003). Blend of bovine blood and rumen digesta as a replacement for fishmeal and groundnut cake in layer diets. International Journal of Poultry Science 2(1): 58-61.

Olagunju, F.I., Adesiyan, I.O. and Ezekiel, A.A. (2007). Economic viability of Catfish production in Oyo State, Nigeria Journal of Human Ecology 21(2): 121-124

Olatunde, O. A. (2004). Treatment and Testing method in water management. Earth watch Journal. Pp. *35 – 43*.

Osuigwe, D. I., Obiekezie, A.I. and Onuoha, G.C. (2005). Some haematological changes in hybrid catfish (*Heterobranchus longifilis* x *Clarias gariepinus*) fed different dietry levels of raw and boiled jackbean (*Canavalia ensiformis*) seedmeal. African Journal of Biotechnology 4: 1017-1021.

Otubosin, S. O., Ogunleye, F. O., and Agbebi, O. T (2009). Feeding trials using local protein sources to replace fishmeal in pelleted feeds in catfish (*Clarias gariepinus* Burchell 1822) Culture. European Journal of Scientific Research 31(1):142-147.

Sauvant, D., (2004). Tables of Composition and Nutritional Value of Feed Materials: *Pigs, Poultry, Cattle, Sheep, Goats, Rabbits, Horses and Fish*. 2nd Edn., Wageningen Academic Publishers, Wageningen, The Netherlands, ISBN-13: 9789076998411, Pp: 304.

Skelton, P.H. (1993). A complete guide to the freshwater fishes of southern Africa. Halfway House, South Africa, Southern Book Publisher, 388 pp. **Snieszko, S.F.** (1960). Microhaematocrit as a tool in fisheries research. U.S Fish and Wildlife Service Special Scientific Report. pp. 341-351.

Solomon, S. G. and Sadiku, S. O. E. (2005). Proximate composition of silkworm caterpillar meal (SCM) (*Anaphe infracta*) processed under thermally controlled and uncontrolled conditions. Proceedings of the 20th Annual Conference of the Fisheries Society of Nigeria (FISON). Port Harcourt. 14th-18th November, 2005. pp 140-143.

Teixeira, M. A. (2000). Haematological and biochemical profiles of rat (*Rattus norvegicus*) kept under micro-environmental ventilation system.

Brazilian Journal of Veterinary Research and Animal Science 37(50).

Terry, C., Hrubec, T. C. and Stephen, A. S. (2000). Haematology of fish. Veterinary Clinic and Pathology 174: 1120-1125.

Vanguard, (2009). "Nigeria: Catfish farming a variable investment". Lagos, Nigeria.

Veado, M.A.R.V., de Oliveria, A.H., Revel, G., Pinte, G., Ayrault, S. and Toulhoat, P. (2000). Study of water and sediment interactions in the Das Velhas River, Brazil - Major and trace elements. Water SA, 26(2): 255-262.