EFFECTS OF TURMERIC (*CURCUMA LONGA*) ROOT POWDER SUPPLEMENTATION IN DIETS FED TO THE AFRICAN CATFISH (*CLARIAS GARIEPINUS* BURCHELL, 1822)

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ABSTRACT

A two-month study was conducted to investigate the effect of turmeric root on the haematology, growth performance and feed utilization of the African catfish (Clarias gariepinus). A total of one hundred and fifty (150) four week old C. gariepinus fingerlings were randomly allotted into five treatments with three replicates each. Five dietary treatments containing varying levels of 0.00, 0.25, 0.5, 0.75 and 1.0 g of turmeric as supplement were pelleted with other ingredients for the experimental diet. Fish fed with 0.25 and 1.00 g of turmeric supplemented feed had the best growth performance although 0.25 g supplementation group performed significantly better on week 8. The acceptability of the diet was less than four seconds in all treatments, 0.25 g of turmeric supplemented diet was most readily accepted by the fish followed closely by the 0.75 and 1.00 g/100 g of feed. The haematological profile of the fish showed that the turmeric supplemented diet was good for the fish and were within range irrespective of their different values across the concentration. This was true for all the parameters apart from the neutrophil which was the lowest at 0.25 g concentration of turmeric supplement with 15.33 ± 1.16 compared to the control with 19.67 ± 1.53 ($p<0.05$) which is an indication that the fish may be suffering from acute neutrophilia. It was concluded that turmeric supplemented feed improved the growth performance and the immunity of the fish at 1.00 g inclusion of turmeric as supplement per 100 g of feed.

Keywords: *Curcuma longa,* Fish diet, Haematological profile, Diet acceptability, Catfish

INTRODUCTION

African catfish, *Clarias gariepinus* Burchell, 1822 (Siluriformes: Clariidae) is one of the most important fish species that is currently being cultured both within and outside its natural range of tropical and sub-tropical environments (Adewolu *et al.,* 2008). Over the past 35 years, Nigerian aquaculture production has grown by 12% per year when compared to the world average of 8%, from a little over 6000 metric tons in 1980 to nearly 307,000 metric tons in 2016 (Kaleem and Sabi, 2021). Nigeria is the largest aquaculture fish producer in sub-Saharan Africa, accounting for 52% of the total farmed fish production in the region. Nigeria's aquaculture focuses mainly on freshwater fish, with catfish species accounting for 64% of aquaculture production in 2015 (WorldFish, 2018). The African catfish is the most cultured species in Nigeria due to its resistance to stress, high fecundity, fast growth, high market acceptability and easy larval production in captivity (Akinwole and Faturoti, 2007; Toko *et al.* 2007; Dauda *et al*., 2018). The increased interest in culture fisheries is due to the rapidly

depleting wild fish supply which is fast becoming insufficient. One of the challenges to aquaculture growth in tropical Africa is disease outbreaks resulting from the varied and unregulated culture practices. Various pathogens of bacteria, fungal and protozoan origins affect catfish during culture. Disease outbreaks in aquafarms lead to huge losses to farmers as trained fish health professionals/ extension agents are almost non-existent thereby leading farmers to resort to the indiscriminate antibiotic use. Indiscriminate antibiotic use has become an emerging public health concern as antibiotic resistance usually follows suit (Pepi and Focardi, 2021). There is therefore the need to explore sustainable alternatives to antibiotics use in aquafarms. Production practices and diets patterns that boost the immune system and give long term protection to fish culture facilities should be encouraged (Carbone and Faggio, 2016; Assefa and Abunna, 2018). Turmeric - *Curcuma longa* L. (Zingiberales: Zingiberaceae) is a rhizomatous herbaceous perennial plant of the ginger family which contains atsiri oil which is reported to improve the function of the digestive tracts (small intestine) and also stimulates the production of digestive enzymes resulting in improved digestion and increased nutrients metabolism (Manal *et al.,* 2014). It is also reported to boost the immune system of animals (El-Bahr *et al*., 2007; Carbone and Faggio, 2016; Assefa and Abunna, 2018). Curcumin which is the active ingredient from the spice turmeric is a potent antioxidant (El-Bahr *et al*., 2007; Salamah and Al-Bahr, 2007) and has hepatoprotective properties (Pal *et al.,* 2001).

Haematological studies have been found useful for disease prognosis and for therapeutic as well as feed stress monitoring (Fazio, 2019). The blood components are influenced by the quantity and quality of feed and also the level of anti-nutritional elements or factor present in the feed (Akinmutimi, 2004). Turmeric is also regarded as a universal panacea in herbal medicine with a wide spectrum of pharmacological activities (Akeredolu *et al*., 2022).

The objective of the study was to determine the effect of turmeric supplementation on the haematological parameters, growth performance and nutrient utilization of *C. gariepinus* fingerlings.

MATERIALS AND METHODS

Experimental Site: This study was carried out at the Wet Lab of the Department of Zoology and Environmental Biology, University of Nigeria, in Nsukka Local Government Area of Enugu State, Nigeria.

Procurement and Acclimatization of Experimental Animal: A total of 150 *C. gariepinus* fingerlings weighing 23.49 ± 2.76 g were used. The test catfish fingerlings were purchased from Freedom Fisheries Nsukka and transported in a 5 liter container to the Wet Lab of the Department of Zoology and Environmental Biology, University of Nigeria, Nsukka. They were placed in big plastic tank (500 x 300 x 425 cm^3) and allowed to acclimatize there for two weeks. During the acclimatization, the fish were fed 5% of their body weight with 2 mm Coppens (50% crude protein, 19.5 MJ/kg digestible energy) (AllTechCoppens, 2023) in divided ration, twice daily (8:00 am and 16:00 pm). The water in the plastic tanks were changed at least twice weekly and during each change, the walls and bottoms of the plastic tanks were washed thoroughly to reduce the risk of fungal and algal infection (Eyo,1999). The culture tank was aerated and covered with plastic mosquito net held in place by rubber bands to prevent the catfishes from jumping out. The water temperature during the experimental period ranged from 26.6 – 28ºC. The pH and alkalinity were between 7.0 - 7.1 and 111.11 - 113.44 mg/l, respectively.

Preparation of Turmeric Supplement: Turmeric rhizomes were purchased from Ogige Market in Nsukka, Nsukka LGA of Enugu State, Nigeria. There were properly washed, peeled, cut into small pieces and oven dried at 50°C and monitored every 120 minutes' interval until 15% moisture was obtained. Plant materials were ground into fine powder using a Macsalab 200

Cross Beater Lab Mill, Macsalab, South Africa. The powdered sample was then stored in an air-tight amber glass container (Lahari *et al.*, 2020) at room temperature until needed.

Preparation of Experimental Diet: The formulation of the diet treatments was gotten through Pearson's Square Method using the proximate analysis of the diet ingredients using 50% protein (Table 1). Turmeric powder were supplemented as follows: Diet A has 0.25 g of turmeric supplement, Diet B has 0.50 g turmeric supplement, Diet C has 0.75 g of turmeric supplement, Diet D has 1.0 g of turmeric supplement and Diet E, the control diet had no turmeric supplement. The diet ingredients and turmeric powder were weighed out (100 g) and homogenously mixed with 0.2 liters of water to produce dough. The mixed dough was transferred into heat resistance polythene bag, sealed tightly and properly labeled. The bagged and sealed dough were pressure cooked for 30 minutes at 110^{o}C. The heat treatment aided in binding of the diet through gelatinization of starch, lipid mobilization and activation of the dietary nutrients (Eyo, 1997). The different diet dough was individually run through a sieve with 2 mm dye and the resulting stands were cut into pellets and sun-dried separately. The resulting diets were stored separately in labeled dry air-dried plastic container. All prepared diet was proximately analyzed (AOAC, 2005).

Experimental Design: The experiment used the completely randomized block design (CRBD) in allocating of 150 *C. gariepinus* fingerlings. The fish were divided into five groups with varying mean length and weight of 5.54 ± 3.62 cm and 4.04 ± 2.46 g. The experiment was run in three replicates each. They were then divided into five treatment groups of thirty (30) fishes each. The fish (Group A, B, C, D and E) were fed with feed formulated locally with varying levels of turmeric (0.25, 0.50, 0.75 and 1.00 g) per 100g of feed respectively, while group E was used as the control group. The fish were fed 7.5% of their body weight with the respective formulated diets in a divided ration, twice daily (8:00 am and 16:00 pm). The water in the plastic tanks were changed at least twice in a week to remove the foul smell developed by the waste and excreta of the fish. Electronic weighing balance was used in measuring the body weight of the fish; ruler and thread were used to measure the standard length of the fish. The body weight and standard length were measured fortnightly.

Growth Performance of *Clarias gariepinus* fed with Turmeric Supplemented Diets: For the growth performance studies, the following parameters using standard procedures were evaluated: weight gain (Emmanuel and Solomon, 2013), specific growth rate (SGR) (Hopkins, 1992), condition factor (k) (Getso *et al.*, 2017), feed efficiency ratio, survival rate and normalized biomass index (NBI) (Manal *et al.,* 2014).

Acceptability of Turmeric Supplemented Diets Fed to *Clarias gariepinus*: Acceptability was accessed using the "time to strike index" (Eyo, 1997). Fifteen catfishes starved overnight to induce hunger were left in a separate glass aquarium containing 15 litres of water. One pellet of each diet type was dropped in the glass aquarium; the time that elapsed from the moment the pellet penetrates through the water surface to the moment the fishes struck the pellet with its mouth was recorded in seconds. The above experiment was replicated thrice for each the of the dietary types. The "acceptability index" was calculated as the reciprocal of time to strike (Eyo, 1997).

Haematological Profile of *Clarias gariepinus* fed Turmeric Supplemented Diets: The procedure for the haematological test; packed cell volume (PCV), white blood cell (WBC) count, red blood cell (RBC) count, haemoglobin concentration (Hb) and WBC differential counts followed the methods described by Schalm *et al.* (1975) and Sood (2006).

Statistical Analysis: Data were analysed using Microsoft Excel (Microsoft Incorporated, Redmond, USA) and Statistical Packages for Social Sciences (SPSS) version 23.0 (IBM Corporation, Armonk, USA).

Table 1: Composition of dietary ingredients

Feed	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrate (%)
Fish Meal	9.00	63	2.50	3.00	16.50	6.0
Soya Bean Meal	3.50	42.85	6.0	2.50	5.0	40.18
Corn Meal	7.00	8.30	4.80	2.60	1.50	75.55
Wheat Meal	3.40	16.27	2.96	2.76	2.21	72.20

Effects of feed composition on growth performance indicators (weight gain, growth rate, SGR and K) were estimated using full factorial generalized linear model with feed composition and duration of administration as fixed factors. Feed acceptability, time to strike and haematological parameters were compared using ordinary one-way analysis of variance (ANOVA). Mean were separated using LSD. Level of significance was set at $p<0.05$.

RESULTS

Growth Performance of *Clarias gariepinus* fed with Turmeric Supplemented Diets: Weight of *C. gariepinus* fingerlings for the duration of administration of Turmeric supplemented diet is summarized in Table 2. The weight of fish in all the experimental groups including the control increased progressively until termination of the study. Mean weights of fish were not same for all the groups from the start of the study. Weight gain increased as the duration of feed administration prolonged. The increase was approximately linear in all the groups. Gain in weight was highest in week 8 and least in week 2 (Figure 1). Weight gain in groups fed diets supplemented with 0.25 g and 1.00 g turmeric was significantly higher compared to those fed other fractions of the supplemented diet and the control. The difference in weight gain was significant from week 4 (feed supplements: $F = 21.95$, $p < 0.05$; duration: $F = 79.79$, $p<0.05$). Weight gain was similarly between 0.25 and 1.00 g turmeric supplementation groups, however, 0.25 supplementation group performed significantly better on week 8. SGR of the which were different between the groups on week 2 converged by week 4. SGR was not different within supplementation and relative to the control ($p<0.05$). SGR appeared to converge at 2%/day (Figure 2).

Condition factor of the fish was not affected by the Turmeric feed supplementation. Even though there was a general decline in K of fish in all the experimental groups and control, there was no meaningful difference between groups (Table 3). Mean K on week 0 was above 1 in all the groups but declined to below 1 across the groups from weeks 4 till week 8. The feed efficiency ratio shows how effective the feed was to the catfish. The lower the FER, the better efficient the feed is. The feed efficiency ratio was significantly higher in the fishes fed with 0.5 and 0.75 g of Turmeric supplemented feed was lowest in the fish fed with 1.00 g of turmeric supplemented feed (Table 4). The survival at the end of the experiment showed that the survival rate of *C. gariepinus* fingerlings increased as the turmeric in the diet increased. The survival rate was significantly higher in the fish administered with 1.00 g of turmeric supplement diet and similar in the fish fed with 0.25 and 0.50 g of turmeric supplemented diet (Table 4). The NBI of fish raised on various concentrations of turmeric supplemented diet are summarized in Table 4. The NBI was different significantly between the groups ($F = 17.50$, $p<0.05$). Groups A and D had similar NBI which were significantly high compared to groups B, C and E (Table 4).

Feed acceptability, measured as time interval between feed introduction and the first obvious probing is shown in Figure 3. Average time to strike was below 4 seconds for all the feed types. It was higher in the control and the 0.50 g/100g turmeric group. The fish accepted the 0.25 g turmeric diet more readily than all other diets. This was followed closely by 0.75 g and 1.00 per 100 g turmeric diets.

Table 2: Weight of *Clarias gariepinus* fingerlings raised on turmeric supplemented diet for 8 weeks

Concentrations (g/100g meal)	Duration (week)				
	0	2	4	6	8
Control	2.21 ± 1.33^{b1}	3.35 ± 2.12^{b1}	5.02 ± 3.51^{b2}	7.22 ± 5.33^{b3}	10.06±7.36^{b3}
0.25	6.50 ± 2.73^{a1}	7.15 ± 2.12^{a1}	12.88 ±7.04^{a2}	18.61 ±9.25^{a3}	24.37±11.26^{a3}
0.50	2.76 ± 1.10^{b1}	3.44 ± 1.25^{b1}	4.97 ± 2.57^{b1}	8.12 ± 4.21^{b2}	11.46 ± 5.86^{a3}
0.75	2.41 ± 0.83^{b1}	3.31 ± 1.63^{b1}	5.42 ±3.19^{b12}	7.58 ± 4.47^{b2}	10.43 ±5.53^{b2}
1.00	6.34 ± 1.79^{a1}	8.31 ± 3.00^{a1}	12.60 ±5.49^{a2}	16.68 ±7.14^{a3}	21.11 ± 9.15^{a4}

Values as mean ± SD. Values with different alphabet superscript along a column for each parameter were significantly different, while values with different numeric superscript across a row were significantly different ($p<0.05$)

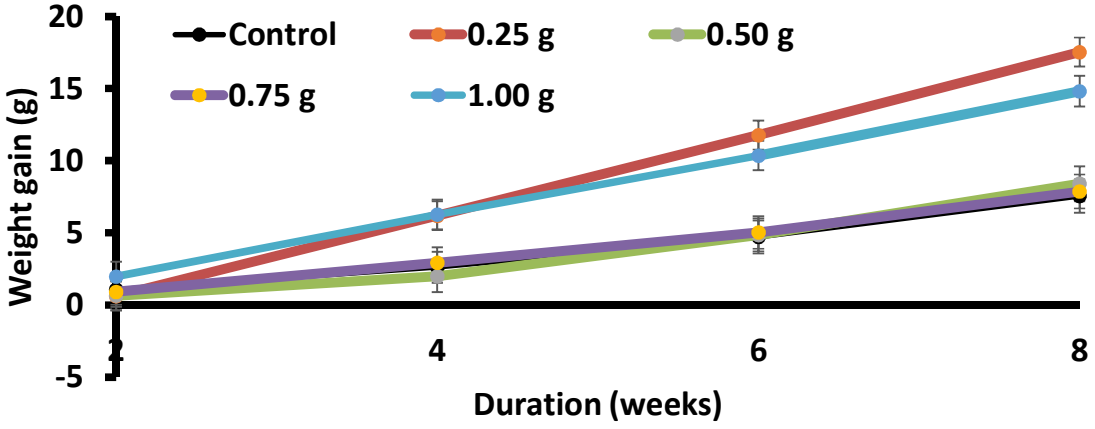

Figure 1: Weight gain of *Clarias gariepinus* fingerlings raised on turmeric supplemented diet for 8 weeks

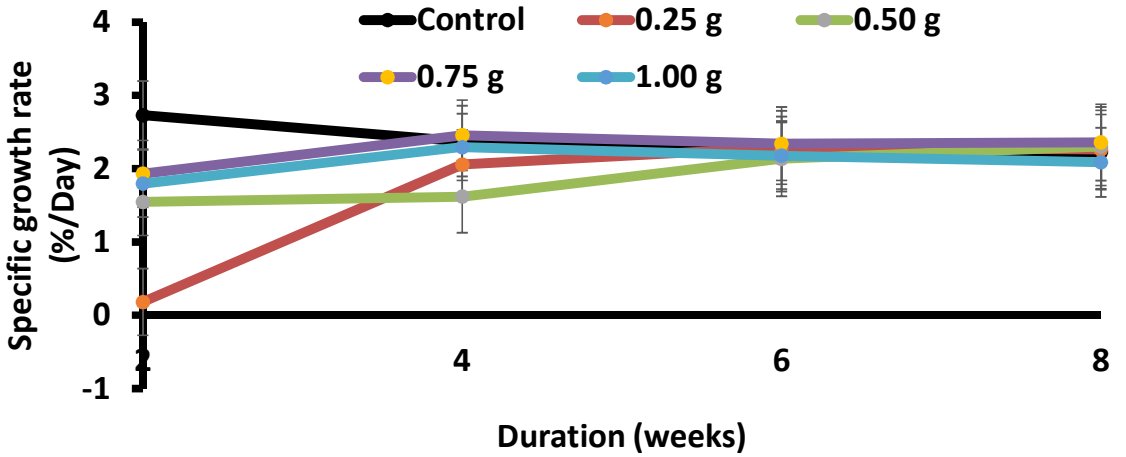

Figure 2: Specific growth rate of *Clarias gariepinus* fingerlings raised on turmeric supplemented diet for 8 weeks

Table 3: Condition factor of *Clarias gariepinus* fingerlings raised on turmeric supplemented diet for 8 weeks

Concentrations (g/100g meal)	Duration (week)				
	0	2	4	6	8
Control	1.17 ±0.30^{a1}	0.94 ±0.13^{a1}	0.90 ± 0.18^{a1}	0.95 ± 0.17^{a1}	0.96 ± 0.52^{a1}
0.25	1.18 ±0.33^{a2}	0.88 ± 0.19^{a12}	0.86 ± 0.30^{a12}	0.85 ± 0.17^{a12}	0.79 ± 0.09^{a1}
0.50	1.10 ±0.32^{a1}	0.96 ± 0.23^{a1}	0.90 ± 0.12^{a1}	0.97 ± 0.18^{a1}	0.95 ± 0.26^{a1}
0.75	1.25 ±0.25^{a2}	0.88 ± 0.12^{a1}	1.05 ± 0.77^{a12}	0.84 ± 0.11^{a1}	0.86 ± 0.14^{a1}
1.00	1.11 ±0.26^{a2}	0.92 ± 0.10^{a12}	0.84 ± 0.11^{a12}	0.78 ± 0.10^{a1}	0.83 ± 0.30^{a12}

Values as mean ± SD. Values with different alphabet superscript along a column for each parameter were significantly different, while values with different numeric superscript across a row were significantly different (p<0.05)

Table 4: Feed efficiency ratio (FER) and survival rate of *Clarias gariepinus* fingerlings raised on turmeric supplemented diet for 8 weeks

Concentration (g/100g meal)	Feed Efficiency Ratio (FER)	Survival Rate (%)	NBI
Control	0.39 ± 0.05	76.67 ± 3.67	49.86 ± 38.48^{b}
0.25	0.38 ± 0.02	70.00 ± 3.30	262.51 ± 101.54^{a}
0.50	0.43 ± 0.04	70.00 ± 3.30	49.66 ± 0.72^{b}
0.75	0.43 ± 0.06	73.33 ± 20.0	43.04 ± 4.03^{b}
1.00	0.33 ± 0.02	90.00 ± 10.0	272.69 ± 25.78^{a}

Values as mean ± SD. Values with different alphabet superscript along a column for each parameter were significantly different, while values with different numeric superscript across a row were significantly different (p<0.05)

Acceptability of 0.25 g turmeric was significant compared to the control and the 0.50 and 1.00 g turmeric supplement diets (Figure 3).

Hematological Profile of *Clarias gariepinus* fed with Turmeric Supplemented Diets: Turmeric feed supplementation was associated with modification to the haematological parameters of the fish. PCV and the white blood cell differential parameters, lymphocytes, monocytes, eosinophil and basophil were similar among the groups irrespective of turmeric supplementation. RBC, Hb and WBC were significantly different between the groups. RBC and WBC were lowest in fish administered 1.00 g turmeric supplemented diet and Hb highest (Table 5). The difference was significant compared to the control for WBC and Hb ($p<0.05$). Neutrophil count was lowest at 0.25 and 1.00 g turmeric supplementation. The difference was significant compared to other groups (Table 5).

DISCUSSION

Intrinsic factors related to the physiology, genetic and morphology to extrinsic ecological factors involving the living conditions especially the food and feeding habits of the fish are the interacting factors affecting the internal motivation or drive for feeding on special diet range (Lagler *et al.*, 1977). Specific features such as age, size, sex, season and site of collection as well as species of fishes in question are of primary importance in determining the nutritional contents and acceptability of the fish diets fed to these species (Eyo, 2003). Hardy (1989) reported that over 18,000 dietary ingredients have been used in the manufacturing of animal diets worldwide. Some of these ingredients cannot be utilized by fish in their diet. Thus, the ever continuous research into alternative and cheaper protein and energy sources. Medicinal plants have received increasing attention as spices for human and additives (supplements) in diets for animals. However, only few studies have been done on the use of feed additives in fish nutrition (El-Bahr and Saad, 2008; Lawhavinit *et al.,* 2011). The enhanced growth response observed in this study may be due to improved feed consumption and feed utilization, which is an indication of increased nutrient digestibility and antioxidant activity of turmeric (Osawa *et al.,* 1995) that stimulates protein synthesis by enzymatic system.

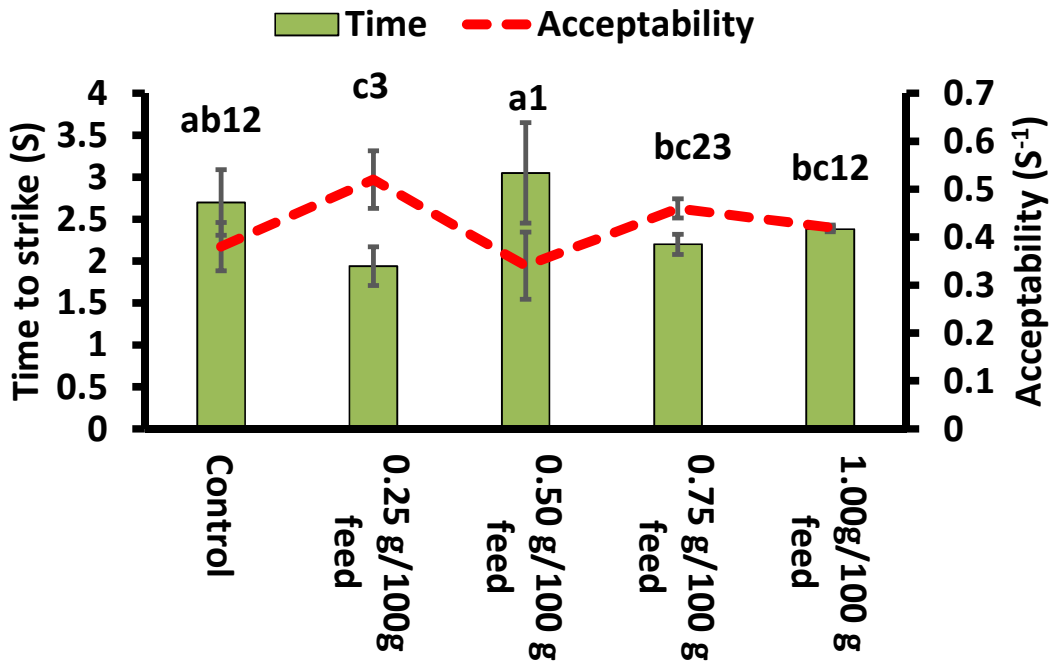

Figure 3: Diet acceptability of feeds fed to *Clarias gariepinus* fingerlings. *Bars with different alphabet label were significantly different for time to strike, while those with different numeric labels were significant for acceptability (s^{-1}) ($p<0.05$)*

Table 5: Haematological status of *Clarias gariepinus* fingerlings raised on turmeric supplemented diet for 8 weeks

Parameters	Concentration (g/100g meal)				
	Control	0.25	0.5	0.75	1
PCV (%)	27.67 ± 0.58	27.67 ± 1.53	29.00 ± 1.00	28.67 ± 1.16	27.67 ± 0.88
RBC (x10^{12}/L)	10.56 ± 0.12^{ab}	10.65 ± 0.06^{ab}	10.83 ± 0.15^{a}	10.79 ± 0.47^{a}	10.32 ± 0.07^{b}
Hb (g/dL)	10.33 ± 0.12^{b}	10.43 ± 0.21^{ab}	10.30 ± 0.10^{b}	10.20 ± 0.26^{b}	10.73 ± 0.12^{a}
WBC (x10^{9}/L)	9633 ± 208^{a}	9433 ± 208^{ab}	9333 ± 208^{ab}	9733 ± 586^{a}	8933 ± 208^{b}
Neutrophil (%)	19.67 ± 1.53^{a}	15.33 ± 1.16^{b}	20.00 ± 2.65^{a}	20.00 ± 1.00^{a}	18.33 ± 2.08^{ab}
Lymphocytes (%)	78.00 ± 2.65	81.00 ± 1.00	77.00 ± 1.73	77.67 ± 2.52	77.67 ± 2.52
Monocytes (%)	2.33 ± 0.58	2.33 ± 0.58	2.67 ± 0.57	1.67 ± 1.16	2.33 ± 0.58
Basophil (%)	0.33 ± 0.58	0.67 ± 0.58	0.33 ± 0.58	1.00 ± 1.00	1.33 ± 0.58
Eosinophil (%)	0.33 ± 0.58	0.33 ± 0.58	0.67 ± 0.58	0.33 ± 0.58	0.33 ± 0.58

Values as mean ± SD. Values with different alphabet superscript along a column for each parameter were significantly different ($p<0.05$)

This was in agreement with the finding of Pransin (2006) who reported that goldfish fed turmeric supplemented diets, had highest acid protease, alkaline protease and lipase activity, enhanced growth rate and yellow pigmentation. Also, Rojtinnakorn *et al.* (2012) showed that all turmeric extract fed fish had significant higher digestive enzymes specific activities and enhanced growth rate. All the test fish groups fed the different experimental diets gained body weights and lengths progressively to the end of the experiment, thus showing that the fish responded positively to the diets. This was in line with the result reported by Lawhavinit *et al.* (2011) that ethanolic turmeric extracts improved weight gain when supplemented in white shrimp diet at 15 g/kg. Weight gains in groups fed diets supplemented with 0.25 and 1.00 g turmeric were significantly higher compared to those fed other fractions of the supplemented diet and the

control. Growth rate was similarly higher among fish in the 0.25 and 1.00 g turmeric supplementation, however, 0.25 g supplementation group performed significantly better on week 8. This indicated that inclusion of turmeric at that level was very effective on their growth. Furthermore, in synergy with turmeric supplementation, the growth performance of the African catfish in the treatment groups was influenced by intrinsic and extrinsic factors such as age, size, type of seed, season and site of collection.

There was a general numerical decline in K values of catfishes in all the experimental groups and control except for week 0. This indicated that the K values of the fish were not significantly affected by turmeric supplement. K is thus an indicator of growth and feeding intensity of *C. gariepinus* fingerlings fed different levels of turmeric powder. The K gives information on the physiological condition of the catfish in relation to its welfare. Getso *et al.* (2017) reported that fishes with a low K values are presumably believed to have experienced adverse physical environment or insufficient nutrition. According to Mbaru *et al*. (2011), from a nutritional point of view, increase in K values indicates the accumulation of fat and sometimes gonadal development. Getso *et al.* (2017) reported that from a reproductive point of view, the highest K values are reached in species if the fish is fully mature and have higher reproductive potentiality. It was observed that the catfish species fed turmeric supplemented diets in the present study recorded inconsistent K values (> and < 1.0), with only catfishes in the fed turmeric diets at week 0 showing slight increases in (K > 1.0). K values below 1 falls within the abnormal range as recommended (Mbaru *et al*., 2011; Ujjania *et al*., 2012). All the fish species turmeric diets at week 0 in the present study had Ks ≥ 1 and were within the normal ranges recommended by Ujjania *et al.* (2012) who stated that K greater or equal to one is good, indicating a good level of feeding and proper environmental condition.

The NBI value computed at the end of the experiment suggested that there may be some relationship between the quality of administered diet and survival rate of the *C. gariepinus* fingerlings fed with 1.00 g of turmeric supplemented diet which was the highest value for this index due to their high survival rate and weight gain. The NBI at 1 g was within the range reported in diploid *C. gariepinus* by Ossai (2019).

The feed efficiency also showed that the fish fed with 1.00 g/100 g turmeric supplemented diet had the lowest NBI indicating that this concentration of turmeric in the diet was best utilized by the fish. The findings of this study was in agreement with the report of Bethke *et al.* (2013) on feed efficiency versus feed conversion ratio demonstrated on feeding experiments with juvenile cod. The results of this study indicated that the various levels of turmeric supplementation in diets played significant roles in the survival and utilization of feed by the catfish.

The turmeric supplemented diets were readily accepted by the catfish in all the treatment groups. Acceptability of 0.25 g turmeric supplemented diet was significant and this was followed closely by 0.75 and 1.00 g per 100 g turmeric supplemented diets compared to the control and the 0.50 g turmeric supplement diets. The time to strike and general acceptability of turmeric supplemented diets especially 0.25 g may be due to the correct energy/protein balance of the diet and indicted the acceptance of turmeric as supplement in catfish diets. Apart from the effects of turmeric in enhancing diets acceptance, Ossai (2019) had previously stated that internal motivation and other physiological parameters may have contributed and influenced the time to strike of the pellets.

The result of the haematological parameters revealed that PCV and the WBC differential counts; lymphocytes, monocytes, eosinophil and basophil were similar among the groups irrespective of turmeric supplementation, which showed that the turmeric did not have any significant effect on these parameters in the fish. The values of the PCV (27 – 29%) in this study fell within the normal range (20 – 35%) (Rinchard *et al*., 2003). Furthermore, the findings of this study was similar to Sodamola *et al.* (2016) who reported the effect of turmeric root powder (TRP) on the haematology of *C. gariepinus* fell

in the range of 22 – 26%. PCV was best in the fish fed with 0.50 g of turmeric supplemented feed. The catfish fed with 1.00 g of turmeric supplement had the lowest RBC and WBC values and the best Hb value. The highest WBC was recorded in the blood of catfish fed 0.50 and 0.75 g of turmeric supplemented diets. This indicated that the catfish had high immunity or resistance to disease (El-Bahr and Saad, 2008). Akinwande *et al.* (2006) reported that a measurable increase in WBC of fish and any other animal is a function of immunity and resistance to vulnerable diseases. Compared to the control, the catfish fed with 0.25 g of the turmeric supplemented diet suffered from acute neutrophilia because of the low neutrophil percentage. This is similar to Nwani *et al.* (2015) report on the physiological effects of paraquat in juvenile African catfish. The low percentage of neutrophil could be that the fish fed with that concentration of diet induces stress on the fish or that the fish may be suffering from infection which may have led to the low survival rate in the fish.

Conclusion: Catfish fed 0.25 g/100 g of turmeric supplemented diet had the highest growth performance and acceptability index. The study showed that the catfish fed with that concentration had acute neutrophilia, indicating that the catfish was under stress at that concentration and as such low survival rate. Therefore, based on the result obtained from this study, the fish fed with 1.00 g/100 g of turmeric supplemented diet had the highest survival rate, feed efficiency, NBI, an impressive growth rate, acceptability indices and good haematological profile may best be chosen by farmers involved in fish farming.

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