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Evaluation of African Catfish *Clarias gariepinus* Responses to Graded Levels of Zinc Practical Diet

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Abstract

Growth performance, serum biochemistry and physiological response of the African catfish (*Clarias gariepinus*) juveniles to graded levels of practical dietary zinc in feed were investigated. Water quality was monitored throughout the period of the study and the results showed that all parameters were within the tolerable ranges for catfish. The mean weight of fish fed diet borne zinc nutrients revealed that there were no significant differences in growth responses to graded levels of dietary zinc inclusions of 0.00, 5.46, 10.96, 16.40, 21.86, and 27.33mg Zn kg. However the mean weight for the diet increased with respect to dietary zinc inclusion. There was no significant difference in the specific growth rate, feed conversion ratio, protein efficiency ratio, gross feed conversion efficiency, relative growth rate and feed intake of *Clarias gariepinus* juvenile fed with the experimental diets at different dietary zinc inclusion level. The blood biochemistry results indicated that the PCV of fish fed with diets were significantly different (P>0.05) only for those fed diet 3, 4 and 5 that shows no significant differrence. The serum biochemistry revealed that there was significant variation in the serum total protein of the experimental fish with the highest values in diet 4 (3.55 mg Zn kg^{-1}) recorded in fish fed with diet containing 16.40 $mgZnkg^{-1}$while the least concentration value was recorded in fish fed with diet 2 (5.46$mgZnkg^{-1}$). This study revealed that inclusion of dietary zinc in diet of *Clarias gariepinus* had no significant difference on the growth performance, nutrient utilization, haematology and serum biochemistry parameters of the fish.

Keywords: Practical dietary zinc, nutrient utilization, African catfish.

Introduction

Trace minerals which are needed in minute quantity at a time for the general health maintenance, growth and other biochemical functions in the body of animal (Haruna, 2003). Their deficiency perturbs the general wellbeing of the body. Zinc has been recognized to play a vital role in almost every aspect of living systems either directly or indirectly (Shukla *et al*., 2002). Normal zinc levels in freshwater and seawater are known to be insufficient to meet the requirement of growing aquatic species (Spray *et al*., 1988; Willis and Sunda, 1984). Gatlin and Wilson, (1983) reported that when catfish diets were low in zinc, appetite was reduced, resulting in low growth, low bone zinc and calcium levels and serum zinc concentration. Zinc is an important trace element in fish nutrition as it is involved in various metabolic pathways and serves as a specific co-factor of several enzymes.

Watanabe *et al*., (1997) reported that zinc may also have a structural role in nucleoproteins. Research on zinc-gene interactions has also assigned a basic role for this element in controlling growth (Chesters, 1991). Fish feed is singled out as the most expensive operating cost in aquaculture (Nwanna, 2002). Therefore, any biochemical components of fish diet that needs varying in terms of proportion of inclusion, which will render the protein in feed more bioavailable and promote faster growth of a healthy fish that is relatively cheap should be considered and encouraged. The role of trace elements such as Zinc in biological systems has been well documented in virtually all cultured animals and in humans (Vakili and Rashidi, 2011; Watanabe *et al*., 1997), but the knowledge as relate to their utilization in fish is however limited (Watanabe *et al*., 1997). The responses of *Clarias gariepinus* to graded levels of zinc nutrient were therefore investigated.

Materials and Methods

Experimental Design

Graded levels of dietary zinc were incorporated into a practical diet at 40% crude protein from the ingredients shown in table 1. African catfish (*Clarias gariepinus*) juveniles (12.50±3.53g) were obtained from a reputable fish hatchery in Ibadan, Nigeria. A total of 180 juvenile fish were sorted out into 6 equal groups of 3 replicates each at 10 fish per tank with 25 litres of water. The experimental fish were fed with the control diet

Table 1. Gross and proximate composition of the experimental diets

Ingredients	Diet 1 0.00mg/kg	Diet 2 5.46mg/kg	Diet 3 10.96mg/kg	Diet 4 16.40mg/kg	Diet 5 21.86mg/kg	Diet 6 27.33mg/kg
Fish meal	25.84	25.84	25.84	25.84	25.84	25.84
Soya bean meal	25.84	25.84	25.84	25.84	25.84	25.84
G/nut cake	12.92	12.92	12.92	12.92	12.92	12.92
Yellow Maize	25.41	25.41	25.41	25.41	25.41	25.41
Vegetable Oil	4.00	4.00	4.00	4.00	4.00	4.00
Dicalcium phosphate	0.50	0.50	0.50	0.50	0.50	0.50
Zinc-free mineral mix*	2.00	2.00	2.00	2.00	2.00	2.00
Vitamin mix*	2.00	2.00	2.00	2.00	2.00	2.00
Binder (Cassava)	1.50	1.50	1.50	1.50	1.50	1.50
Zinc mineral	0.000	0.005	0.011	0.016	0.022	0.027
Proximate composition (%)						
Protein	36.89	36.89	36.89	36.89	36.89	36.89
Fat	7.81	7.81	7.81	7.81	7.81	7.81
Ash	6.77	6.77	6.77	6.77	6.77	6.77
Fibre	6.49	6.49	6.49	6.49	6.49	6.49
M.C	9.67	9.67	9.67	9.67	9.67	9.67
NFE	32.4	32.4	32.4	32.4	32.4	32.4
Zn	1.18	6.64	12.11	17.58	23.04	28.51

Zn = $mgkg^{-1}$ *Biovita fish vitamin and minerals providing per kg of diet: 20,000 i.u., Vitamin A, 300 i.u, Vit. E 800mg, Ascorbic acid 100mg, Vit. D3 200mgVit.E.8mg, Vit.K3 20mg, Vit.B3 60mg, Vit.B6 300mg, Biotin 15mg, Vit. K 200mg, Cobalt 40mg, Iron 5.0mg, Iodine 30mg, Manganese 5mg, Copper 5mg, Lysine 10mg, Methionine 10mg.

(0.00mgZn kg^{-1} inclusion level) for 14 days. The fish were later fed graded levels of zinc nutrient (5.46, 10.93, 16.40, 21.86, and 27.33mg Zn kg^{-1}) dry diets respectively for 12 weeks. The fish were fed at 5% of their body weight twice daily (morning and evening). Rearing water in the fish tanks were exchanged twice in a week with freshwater from deep well. Zinc concentrations of the freshwater from the deep well were measured before and after use.

The following growth performance and nutrient utilization parameters: weight gained, total length, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), protein intake (PI), gross feed conversion efficiency (GFCE), relative growth rate (RGR), feed intake (FI) and condition factor (CF) of the experimental fish in the different treatments was measured bi-weekly throughout the duration of the study according Ashley-Dejo *et al.* (2014) .

Preparation of the Diet Performance

The practical diet was formulated from the ingredients shown in Table 1. Zinc supplemented diets formulated by dissolving the minerals in warm water thereafter mixing with prepared starch before mixing it homogenously to the feed ingredients respectively. To achieve the required graded levels of zinc nutrient in the diets, various milligrams of zinc sulphate (reagent grade) were weighed using the sensitive balance PW 124 AE Adams®) at 15, 30, 45, 60, 75mg respectively. The zinc contents of the practical diets were determined by Buck 211 Atomic Absorption Spectrophotometry at a wavelength of 232nm and a slope of 1.

Growth parameter

The average weight, total length, standard length, and head length of fish from each tank were measured every two weeks throughout the 12 weeks duration of the experiment.

Water quality assessment

The water quality parameters such as DO, pH, Temperature were measured using dissolved oxygen kit (K-7152), pH meter and thermometer, while zinc and calcium ions concentrations were determined following the methodology described in Apha (1995).

Haematology

Blood samples were pooled from fish at random at the beginning of the experiment and at the end from each group 20 hours after the final feeding. These samples were pooled to obtain one composite sample per treatment. Blood samples were collected into centrifuge tubes by cardiac puncture from the experimental fish using syringe fitted with needle (0.5mm diameter) and divided into two equal parts. To one part ethylene diaminetetraacetic acid (EDTA) was added to avoid the blood samples from clotting and the following were carried out; red blood cell (RBC) counts described by Schalm *et al.* (1975), white blood cell (WBC) counts, differential packed cell volume (% PCV) described by Jain (1986) and haemoglobin (Hb) concentration Mitruka and Rawnsley (1977). Using the above data, mean cell volume (MCV), mean cell haemoglobin (MCH) and meal cell haemoglobin concentration (MCHC) were calculated as described by Jain (1986).To the second part serum biochemistry was determined as follows; Albumin was determined as described by Weis (1965), Alanine aminotransferase (ALT) and Aspartate Aminotransferase (AST) was determined as described by Reitman *et al.* (1957), Creatinine was also determined, and zinc concentration was determined by Buck 211 Atomic Absorption Spectrometry at a wavelength of 232nm, using hollow cathode and standardizing with zinc stock solution of 1ppm concentration.

Statistical Analysis

Data obtained in the study were subjected to ANOVA and further comparison between pairs of means was determined using fisher's least significant difference (LSD) as described by Duncan (1955).

Results

Water Quality Parameter

Water quality was monitored throughout the period of the study and the values indicated met the tolerable ranges for catfish survival Table 2 below.

Table 2. Water quality analysis

Parameters	Ca (mg/l)	Zn (mg/l)	DO(mg/l)	TEMP. ^{0}C	pH
Initial	34.67±0.15^c	0.03±0.00^a	4.20±0.09^c	30.83±0.57^b	7.27±0.31^a
Diet 1	31.32±0.47^b	0.05±0.00^a	4.07±0.31^b	27.23±3.26^a	7.33±0.15^a
Diet 2	30.25±0.05^a	0.05±0.00^a	4.02±0.16^a	30.30±0.61^{ab}	7.37±0.06^b
Diet 3	31.01±0.24^b	0.05±0.00^a	3.83±0.48^a	30.80±0.44^b	7.39±0.20^b
Diet 4	30.20±0.13^a	0.04±0.00^a	4.03±0.21^a	30.40±1.04^b	7.54±0.09^c
Diet 5	30.11±0.02^a	0.19±0.24^b	4.14±0.22^b	31.77±1.33^c	7.42±0.08
Diet 6	30.83±0.21^{ab}	0.05±0.00^a	3.94±0.07^a	30.38±0.57^b	7.38±0.17^b

N.B: Means with the same alphabets as superscripts on the same row are not significantly different from each other (P>0.05)

Fish growth parameters

The results for the growth parameters for *Clarias gariepinus* juvenile fed graded levels of dietary Zinc are presented in Table 5. The results for the mean weight revealed that there are no significant variations (P>0.05) in mean weight of the fish fed graded levels of dietary zinc.

However, the mean weight for the diet increased with increase in dietary Zinc inclusion Table 2. Fish fed with Diet 3 had the highest mean weight while the least mean weight was recorded from the fish fed with Diet 6. The total length (TL) revealed that there were significant variations at P<0.05 in the mean total length of the fish fed with different diets and in between the week.

The results for the TL showed that the mean values for the fish fed with Diet 2, 3 and 6 differ significantly from those fed on Diet 1. Similarly, the values for the fish fed with Diets 1, 4 and 5 had no significant variations among each other. The fish fed Diet 6 had the highest mean TL. The least value was recorded for fish fed with Diet 1. The SGR, FCR, GFCE, FI and RGR, also showed no significant variations among fish fed graded levels of dietary zinc.

Table 3. Growth and nutritional utilization parameters of *Clarias gariepinus* fed graded levels of dietary zinc for 12 weeks

Parameters	Treatments						SEM
	Diet 1 0.00mg/kg	Diet 2 5.46mg/kg	Diet 3 10.96mg/kg	Diet 4 16.40mg/kg	Diet 5 21.86mg/kg	Diet 6 27.33mg/kg	
Mean initial weight (g)	12.5	12.5	12.5	12.5	12.5	12.5	0.00
Mean final weight (g)	21.34^a	21.93^a	21.86^a	21.39^a	21.19^a	19.80^a	0.31
Weight gained (g)	2.89^a	3.11^a	3.10^a	2.94^a	3.09^a	2.78^a	0.06
TL	14.83^a	15.73^b	15.74^b	15.45^{ab}	15.18^{ab}	15.78^b	0.16
SGR	0.47^a	0.51^a	0.50^a	0.48^a	0.49^a	0.53^a	0.01
FCR	3.30^a	2.90^a	7.40^b	1.70^c	1.80^c	2.10^c	0.09
GFCE	142.05^a	189.12^a	153.22^a	171.01^a	212.10^a	230.11^a	13.90
PER	0.08^a	0.086^a	0.08^a	0.078^a	0.08^a	0.09^a	0.00
PI	39.03^a	40.35^{ab}	40.92^{ab}	40.23^{ab}	39.25^{ab}	37.18^a	0.55
RGR	17.00^a	18.60^a	18.10^a	17.30^a	17.90^a	18.90^a	0.30
CF	0.66^a	0.58^b	0.57^b	0.59^b	0.61^b	0.52^c	0.02
FI	9.33^a	9.37^a	9.48^a	8.75^a	8.79^a	8.66^a	0.15

N.B: Means with the same alphabets as superscripts on the same row are not significant from each other (P>0.05).

Legend: TL-Total length; SGR-Specific growth rate; FCR-Feed conversion ratio; PER-Protein efficiency ratio; P.I- Protein intake; RGR-Relative growth rate; C.F-Condition factor; F.I-Feed intake.

Fish blood biochemistry

The PCV revealed that there are no significant variations among the values for the fish fed with Diets 3, 4 and 5. There are also no significant differences among the values for fish fed with Diets 1 and 6. However, there are significant differences among the fish fed with Diets 1, 2 and 3. Fish fed with Diet 2 had the highest PCV value and the minimum PCV value was recorded in fish fed with Diet 1. The haemoglobin (Hb) values for fish fed with Diets 1, 2, 3, 4 and 6 showed significant differences among each other, while Diets 4 and 5 showed no significant differences among each other. Fish fed with Diet 2 had the highest Hb value and the minimum value was recorded in fish fed with Diet 1.

No significant difference (P>0.05) was recorded in the Red Blood Cell (RBC) of the fish samples fed with Diet 3 and 4 while fish fed with Diet 4 and 5 also had no significant differences. However, the values for fish fed with Diets 1, 2 and 3 showed significant differences among each other. The highest value was recorded in Diet 1 followed by 3 and 6 with the same values, while the minimum value was recorded in Diet 2.

The Mean Cell Volume (MCV) showed that fish fed with Diet 4 and 5 had no significant differences, while fish fed with Diets 1, 2, 3 and 6 showed significant differences, with Diet 2 showing the highest value, followed by Diet 5 and while the minimum value was recorded in Diet 1.

The Mean Cell Haemoglobin Concentration (MCHC) showed that there are significant differences among all the fish fed different Diets with the highest value in Diet 2 and the minimum value in fish fed with Diet 1. The results for mean cell haemoglobin (MCH) showed that there are no significant differences among fish fed with Diets 3, 4 and 5, while fish fed diets 1, 2 and 6 showed significant differences among each other.

White blood cell (WBC) showed that fish fed on Diet 1 and 4 had no significant differences however, Diets 2, 3, 5 and 6 showed significant differences. The highest values were recorded in those fed on Diet 3 and the least value in Diet 2.

The Neutrophil showed no significant differences among fish fed with Diets 1 and 4, while those fed with Diets 2, 3, 5, and 6 showed significant differences. The highest value was recorded in

Table 4. Blood biochemistry parameters of *Clarias gariepinus* fed graded levels of zinc diet for 12 weeks

Parameter	Initial	Diet 1 0.00mg/kg	Diet 2 5.46mg/kg	Diet 3 10.96mg/kg	Diet 4 16.40mg/kg	Diet 5 21.86mg/kg	Diet 6 27.33mg/kg	SEM
PCV (%)	25.00	27.00^{a}	31.00^{b}	30.00^{c}	30.00^{c}	30.00^{c}	27.00^{a}	0.70
HB (g/dl)	8.30	8.26^{a}	10.37^{b}	9.67^{c}	9.40^{d}	9.47^{d}	8.67^{e}	0.30
RBC (10^{6}/mm^{3})	2.21	3.72^{a}	3.44^{b}	3.62^{c}	3.54^{cd}	3.53^{d}	3.62^{c}	0.04
MCV (fl)	1131.20	725.77^{a}	890.77^{b}	828.69^{c}	847.42^{d}	849.82^{d}	737.37^{e}	27.22
MCHC (%)	33.20	30.59^{a}	33.54^{b}	32.30^{c}	31.30^{d}	31.63^{e}	32.19^{f}	0.41
MCH (Pg)	3.76	2.18^{a}	2.95^{b}	2.64^{c}	2.62^{c}	2.65^{c}	2.34^{d}	0.11
WBC (10^{3}/mm^{3})	32.40	15.17^{a}	10.61^{a}	18.787^{c}	15.17^{a}	23.27^{d}	11.27^{c}	1.94
Hetro. (%)	27.00	31.00^{a}	28.00^{b}	29.00^{c}	24.00^{c}	31.00^{d}	32.00^{e}	1.19
Lymph. (%)	71.00	62.00^{a}	65.00^{b}	65.00^{b}	72.00^{c}	63.00^{d}	62.00^{a}	1.54
Mono.	1.00	2.00^{a}	3.00^{b}	3.00^{b}	2.00^{a}	3.00^{b}	2.00^{a}	0.22
Eosi	1.00	4.00^{a}	3.00^{b}	3.00^{b}	2.00^{c}	3.00^{b}	4.00^{a}	0.31
Baso	0.00	1.00^{a}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.17
Platelet	110.00	94.00^{a}	100.00^{b}	153.00^{c}	98.00^{a}	110.00^{d}	103.00^{c}	89390.00

N.B: Means with the same alphabets as superscripts on the same row are not significantly different from each other (P>0.05).

Legend: Hb-Haemoglobin; RBC-Red blood cell; MCV-Mean cell volume; MCHC-Mean cell haemoglobin concentration; MCH-Mean cell haemoglobin; WBC-White blood cell.

fish fed with Diet 6 and the least value in fish on Diet 4.

The Lymphocytes values showed no significant differences among fish fed on Diets 1 and 6, also fish fed on Diets 2 and 3 were not significant differences. The highest value was recorded in fish fed Diet 4 while the minimum values were in fish fed with Diets 1 and 6 respectively.

The serum biochemistry revealed that there are significant variations in the serum total protein (T.P) among fish fed on all the Diets, with the highest values in fish fed Diet 4 and the minimum values in fish fed Diet 2.

The results for the Albumen showed that there are no significant variations among fish fed Diet 2 and 5, while fish fed Diet 1, 3, 4 and 6 shows significant difference among each other. The highest value is recorded in fish fed Diet 1, followed by fish fed diet 5 with the minimum value in fish fed Diet 3.

The values for Urea showed no significant difference among fish fed diet 1 and 2, also fish fed diet 4 and 5 showed no significant difference. There are significant variations in fish fed Diet 3 and 6. The highest value recorded is in fish fed Diet 6 and the minimum in fish fed Diet 3.

The values for Aspartate aminotransferase (AST) revealed that there are significant variations among all the fishes fed graded levels of zinc Diet with the highest value recorded in fish fed Diet 1 and the minimum in fish fed Diet 2. The values for alanine aminotransferase (ALT) also revealed that there are significant differences among all the fishes fed graded levels of zinc Diet, with the highest value recorded in fish fed Diet 1 and the minimum value in fish fed Diet 5 followed by fish fed Diet 6. The values recorded for Cholesterol showed that there is no significant variations among fish fed diet 1 and 3 while diet 2, 4, 5 and 6 showed significant variations. The highest value is shown in fish fed diet 1 while the minimum value was recorded in fish diet 2. The result for serum glucose showed that there are no significant variations among fish fed Diet 1 and 2, while fish fed Diet 3, 4, 5 and 6 showed significant variations, with the highest values in fish fed Diet 4 followed by Diet 3 and the minimum values in fish fed Diet 5 followed by Diet 6.

The results for Serum Zinc and Calcium revealed that there are significant variations among all the Diets with highest values in fish fed Diet 6 and the minimum values in the fish fed Diet 1.

Table 5. Serum parameters of *Clarias gariepinus* juvenile fed graded levels of zinc diet for 12 weeks

Parameters	Initial	Diet 1 0.00mg/kg	Diet 2 5.46mg/kg	Diet 3 10.96mg/kg	Diet 4 16.40mg/kg	Diet 5 21.86mg/kg	Diet 6 27.33mg/kg	SEM
T.P (g/dl)	3.18	3.51^a	3.06^b	3.17^c	3.55^d	3.26^e	3.48^f	0.08
Alb. (g/dl)	1.17	1.36^a	1.27^b	1.13^c	1.33^d	1.28^b	1.32^e	0.03
Urea (mg/dl)	1.25	4.16^a	4.16^a	3.67^b	4.62^c	4.62^c	5.09^d	0.20
Creat. (mg/d)	0.75	4.62^a	4.52^b	5.16^c	5.47^d	4.63^a	4.32^e	0.18
AST.(U.I/1)	229.31	151.82^a	94.24^b	20.41^c	89.52^d	116.22^e	96.85^f	9.54
ALT.(U.I/I)	58.4	16.83^a	16.48^b	15.27^c	14.91^d	9.92^e	10.29^f	1.25
Chol.(mgf/dl)	144.94	139.02^a	117.38^b	139.67^a	133.77^c	131.77^d	136.39^e	3.36
Gluc.(mg/dl)	39.24	40.65^a	41.46^a	44.99^b	55.28^c	19.51^d	37.13^e	4.84
Ca (mg/dl)	11.29	9.22^a	8.77^b	9.67^c	10.25^d	10.04^a	10.29^f	0.25
Zn (mg/ml)	0.00	14.00^a	13.00^b	16.00^c	21.00^d	18.00^a	23.00^f	1.62

N.B: Means with the same alphabets on a row as superscripts are not significantly different from each other (P>0.05).

Legend: T.P- Total protein; Alb.-Albumin; Creat.-Creatinine; AST-Aspartate aminotransferase; ALT-Alanine aminotransferase; Chol.-Cholesterol; Gluc.-Glucose; Ca-Calcium; Zn-Zinc.

Discussion

Growth and Nutritional performance

Dietary zinc supplementation has been associated with many benefits both as a growth promoter (Tan and Mai, 2001), chemotherapeutic (John *et al.,* 2012), reproductive enhancer and disease resistance (Chhorn *et al*., 2011) in animals. Its uses cut across human, terrestrial and aquaculture nutrition. This study attempted to investigate the African catfish *Clarias gariepinus* juvenile's growth, haematology and serum biochemistry response to fed graded levels of practical dietary zinc. The mean weight of fish fed dietborne zinc nutrients revealed that there were no significant differences in growth responses of *Clarias gariepinus* juvenile fed practical diet with graded levels of zinc inclusions of 0, 5, 46, 10.96, 16.40, 21.86, and 27.33mg Zn kg^{-1}. This result agrees with the results of Hung *et al.* (2010), that showed no significant differences ($P>0.05$) in weight gain, feed conversion ratio (FCR) and protein efficiency ratio (PER). It also showed a relationship with other research works on zinc requirements for feeding channel catfish, blue tilapia (*Oreochromis aureus*), Japanese eels *(Angulla japonica*) or Atlantic salmon with practical diets of approximately 100-200mg Zn kg^{-1} dry diet. For a wide range of fish species, diet-borne zinc concentrations approximately 20mg Zn kg^{-1} diets were sufficient in a semi purified diet as long as the daily ration provided zinc doses of approximately 0.3-4mg kg^{-1} body $weight^{-1}$ (Clearwater *et al*., 2002). Ayyat *et al.,* (2012) reported an average daily weight gain of 22.52, 54.95 and 38.74% respectively in fish fed practical diets supplemented with 25, 50 and 100mg Zn kg^{-1} of diet, with the highest weight gain in Nile tilapia fed practical diet at 50mg Zn kg^{-1} dry diet. The reasons for the high dietary zinc inclusions in fish feed by Ayyat *et al*., (2012) as mentioned above were because of the high percentage of Phytic acid in plant ingredients which had the tendency of inhibiting the bioavailability of zinc in the diets. A typical Catfish diets is said to constitute more than 90% of plant ingredients (Reigh and Yan, 2001). This could actual be one of the major reasons why no significant differences in weight gain were recorded in the fishes fed practical diets in this study.

Dietary zinc inclusions altered the haematological parameters of the fish in this present study, and this is as observed by Ekrem *et al*. (2013). In this study, *Clarias gariepinus* juveniles fed graded levels of dietborne zinc showed an increase in values for Hematocrit and RBC with significant differences to the initial values and diet 1 (control), while values for the other dietary inclusions were slightly not different from each other. On the contrary, Ekrem *et al*. (2013) reported a decrease in the values of Hematocrits with high concentrations of zinc and an increase with low and medium zinc concentrations. The values for the lymphocytes and heterophil in this study reflected a relative decline with increase in the levels of dietary zinc inclusion. This was perhaps an indication that neither was the dietary zinc sufficient to boost growth nor bioavailable for the fishes, and this is supported by some research works on Tilapia and African catfish *Clarias gariepinus* (Osman *et al*., 2010). The white blood cell (WBC) values showed a slight decline with increasing dietary zinc inclusion. This indicated that the dietary zinc in this study did not reach any levels adverse to fish health.

The values for the serum total protein (T.P) and albumin in this study were significantly different among the diets with slight increases with incremental levels of dietborne zinc. Urea and Creatinine values were significantly different among the diets with slight increase with incremental levels of dietary inclusions. This perhaps was as a result of some stress among the fish fed diets in the course of the experiment, and it is in line with the findings of Mona *et al*, (2013). Cholesterol and Glucose levels among fish fed graded levels of dietborne zinc were significantly different among the diets with cholesterol decreasing in values as dietary zinc inclusion increases. The lowering of cholesterol may be attributed to an increase in lipid utilization for meeting additional energy requirements to mediate stress as suggested by Srisvastava *et al*. (2002) in *Channa punctatus*, Sindhe *et al*. (2002) in *N. notopterus.* The AST and ALT values decreased along the diets with the highest values in the control diet. This result did not align with thee reported result of Mona *et al*. (2013) where African catfish *Clarias gariepinus* fed 15mg kg^{-1} zinc oxide showed a significant increase in AST, ALT and Cholesterol levels in the blood of *Clarias gariepinus*. This could be due to the form of zinc used which influences the bioavailability of dietary zinc for fish. The values for Calcium and Zinc levels in the serum increased with increased zinc inclusions and this was indicated in the level of zinc deposition in the fish blood. However, Lange and Ausseil, (2002) reported that exposure of trout to zinc did not result in significant elevation in the tissue levels of zinc.

Conclusion and Recommendation

Clarias gariepinus fed graded levels of dietary zinc in a practical diet at concentrations evaluated in this study showed no significant variations in growth responses. There were slight alteration in haematology and serum biochemistry among the fish fed practical diets in response to dietary zinc within the weeks. There were gradual increases in the levels of serum zinc as dietary zinc increases. Therefore, further research work is needed on the factors that affect the bioavailability of micronutrients required by catfish in a plant based diet with a focus on the effect of anti-nutritional factors in fish diets.

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