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DIETARY EFFECTS OF *Cinnamomum zeylanicum* Linn BARK ON GROWTH, MORPHOMETRIC INDICES AND HAEMATOLOGICAL PARAMETERS OF *Clarias gariepinus* JUVENILES

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ABSTRACT

A 56-day feeding trial was aimed at determining the dietary supplementation of Cinnamon bark on growth and physiological parameters of *Clarias gariepinus* juveniles. Fish (12.39±0.02g) were replicated thrice with 20 fish per replicate, fed twice daily at 3% biomass of 40% crude protein. The experimental diets composed of 0% Cinnamon Bark (control), 0.5% Cinnamon Bark $(CB)_2$, 1% Cinnamon Bark $(CB)_3$, 2% Cinnamon Bark $(CB)_4$, and 30mg/kg diet Chloramphenicol $(CHRL)_5$ (positive-control). Biological evaluation, morphometric and histomorphometric indices were measured. Haematological and blood serum indices were determined using standard methods. *Clarias gariepinus* juveniles fed control diets had better growth indices than the treated groups. Morphometric indices were significantly increased ($P < 0.05$) in the treated groups compared to the control. The results of histomorphometric showed higher values in cryptal depth, villi height, villi length, goblet cell, villi width and muscular thickness within the treated groups compared to the control. There were significant differences ($P < 0.05$) among the dietary groups for all the indices measured except for the villi width. Also, white blood cell, lymphocytes, total protein, alanine aminotransferase, and aspartate aminotransferase were better in treated groups compared to the control diet. The result suggests that Cinnamon bark enhance growth, morphometric indices, and haematology parameters of *Clarias gariepinus* juveniles.

Keywords: *Clarias gariepinus, Cinnamomum zeylanicum*, Chloramphenicol, Haematology, Morphology

IINTRODUCTION

Nutrition plays a very important role in the maintenance of healthy fish and marketable fish product. Therefore, the use of functional feed are novel to the aquaculture industry and there is an outsized number of feed additives available to enhance fish growth performance. A number of these additives cause unfavourable side effects, which create drug-resistant bacteria and immunosuppression within the host (Panigrahi and Azad, 2007).

Attempts to use natural materials like medicinal plants might be widely accepted as feed additives to boost the efficiency of feed utilization and animal productive performance (Mohamed *et al*., 2003). Banyapraphatsara (2007) and Shalaby *et al*. (2006) have used medicinal plants to boost growth, feed efficiency and health management of fish.

Medicinal plants like cinnamon might be used as a growth promoter for health management of fish. Cinnamon is employed mainly as an antioxidant, which protects from oxidative damage. It also has anti-inflammatory properties that help to boost immunity against bacterial and fungal infections and tissue damage. Cinnamon lowers blood glucose levels and features a powerful anti-diabetic effect (Bell, 2009).

However, there's a dearth of information in both qualitative and quantitative utilization of cinnamon on *C. gariepinus*. This study was therefore aimed towards evaluating the effect of dietary supplementation of cinnamon at different inclusion levels on growth, morphometric characteristics, haematology, and plasma biochemistry of *C. gariepinus*.

MATERIALS AND METHODS

Plant Identification and Treatment

Cinnamon bark obtained from Mooju Foods and Supplement, Lagere, Ile Ife, Osun State, Nigeria was used during the experiment and was identified at the Department of Biological Sciences (Botany Programme), Olusegun Agagu University of Science and Technology, Okitipupa. The dry plant was ground with a hammer mill (5000 g) and the powder obtained was kept in an airtight container until required.

Experimental Site

The study was conducted at the Teaching and Research Unit of Department of Fisheries and Aquaculture Technology, Olusegun Agagu University of Science and Technology, Okitipupa between August and October 2019. The temperature of the research laboratory range between 24°C to 28°C.

Experimental Animal and Management

Four hundred and forty (440) *C. gariepinus* juveniles of the mean weight of 12.39±0.02g were purchased from a farm in Akure. The fish were acclimatized for two weeks and fed commercial diets (2 mm Coppens). The feeding was stopped 24 h to the commencement of the experiment. The model consisted of 5 treatment groups: Control (0% cinnamon bark), CB 2 (0.5% cinnamon bark), CB 3 (1.0% cinnamon bark), CB 4 (2% cinnamon bark) and CHRL 5 (30mg/kg chloramphenicol). Twenty (20) fish were weighed using a digital sensitive weighing scale (SF 400, 10000g x1g, China) and randomly assigned into each experimental treatment and replicated three times. The fish were intensively managed in 15 experimental bowls using the static renewal method. The water was replaced every three days to stop fouling from food residues. The faecal droppings and left over feed were siphoned in the morning and evening (one hour after feeding).

Experimental Feed, Formulation and Feeding

Different inclusion levels of powdered cinnamon: 0.5%, 1.0%, and 2% were added to other ingredients such as fish meal, soybean, yellow maize, rice bran, starch, vegetable oil, vitamin premix and Di-calcium phosphate to produce five experimental diets of 40% crude protein (Table 1). The negative control was without cinnamon and the positive control was supplemented with 30mg/kg Chloramphenicol. The fish were fed twice daily (morning and evening) at 3% body weight for 56 days. Feeding was adjusted to new body weight gain every week.

Table 1: Gross Composition of the Experimental Diets (g/100g)

Ingredients/Parameters	Control (0%)	CB 2 (0.5%)	CB 3 (1.0%)	CB 4 (2.0%)	CHRL (30mg/kg)
Fish meal	9.70	9.70	9.70	9.70	9.70
Soybean	19.40	19.40	19.40	19.40	19.40
Blood meal	9.70	9.70	9.70	9.70	9.70
Yellow maize	21.75	21.75	21.75	21.75	21.75
Rice bran	21.75	21.75	21.75	21.75	21.75
Starch	1.00	1.00	1.00	1.00	1.00
Vegetable oil	2.00	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00	1.00
DCP	2.00	2.00	2.00	2.00	2.00
Vitamin premix	2.00	1.50	1.00	-	-
CB	-	0.05	1.00	2.00	-
CHRL	-	-	-	-	2.00
Total	100.00	100.00	100.00	100.00	100.00

* vit-mit premix (vitamin and mineral premix) each 2.5kg of premix contains; vitamin A, 12.5 million international unit (MIU); D3, 2.5 MIU; E, 40g; K3 2g; B1, 5.5g; B6, 5g; Niacin 55g; Calcium pantothenate 11.5g; Chlorine chloride, 500g; Folic acid, 1g; Biolin, 0.08g; Manganese, 120g; Iron, 100 g; Zinc, 80g, Copper, 8.5g; Iodine, 1.5g; Cobalt, 0.3g; Selenium, 0.12g; Antioxidant, 120g. DCP= Dicalcium phosphate, CHRL= Chloramphenicol CB= Cinnamon Bark

Biological Evaluation

Growth performance indices such as weight gain, percentage weight gain, survival rate, specific growth rate, feed conversion ratio, nitrogen metabolism and protein efficiency ratio were calculated as described by Olusola and Olawoye (2019).

Weight gain = final body weight - initial body weight

Weight gain (%)

$$= 100 \frac{\text{(final body weight - initial body weight)}}{\text{Initial body weight}}$$

Increase in standard length (CM) = $L_2 - L_1$

Where: L_2 = Final standard length

L_1 = Initial standard length

Specific growth rate (SGR) =

$$100 \frac{(\log_e \text{final body weight} - \log_e \text{initial body weight})}{\text{Time (days)}}$$

Feed conversion ratio (FCR) =

$$\frac{\text{Dry weight of feed fed (g)}}{\text{Fish weight gain (g)}}$$

Survival rate (%) =

$$\frac{\text{Initial Number of Fish Stocked} - \text{Mortality}}{\text{Initial number of fish stocked}} \times 100$$

Condition factor (K) = $100W/L^3$

Where: W = Weight of fish (g)

L = Standard length (cm)

$$\text{Nitrogen metabolism} = \frac{(0.549)\,(a+b)\,h}{2}$$

Where, a = initial mean weight of fish

b= final mean weight of fish

h = experimental periods in days

Blood Collection

Blood samples (5 mL each) for haematological and serum biochemistry were collected from 5 fish samples in each treatment group and pooled together using a hypodermic needle and syringe (2 mL). The blood samples were collected into a labelled sterile bottle containing Ethylene Diamine Tetra Acetic Acid (EDTA) as an anticoagulant for haematological parameters and 5 mL was put into a bottle without EDTA for biochemical indices. The blood sample was transported in an ice cooler within 45 min after collection to the State Specialist Hospital where haematological and biochemical indices such as packed cell volume, haemoglobin, red blood cell, white blood cell, mean cell volume, mean cell haemoglobin concentration, neutrophil were measured. Other parameters: lymphocytes, monocytes, eosinophil, basophil, total protein globulin, albumin, alanine aminotransferase, aspartate aminotransferase and glucose were determined as described by Henry (1964), Trinder (1969) and Tietz *et al.* (1983).

Viscero-Intestino Somatic Index

Three (3) *C. gariepinus* juveniles were obtained before and after the experiment from each treatment and weighed to calculate the viscerosomatic index (VSI) and intestinosomatic index (ISI). Three different VSI and ISI were measured in each treatment, recorded and an average value was calculated as follows:

VSI (%) = 100 x (viscera weight [g]/whole fish weight [g])

ISI (%) = 100 x (intestinal weight [g]/whole fish weight [g]) (Nugroho *et al.* 2019).

Morphometric characteristics

After 56 days of the feeding trial, morphometric analysis of fish was measured for *C. gariepinus*: SL= Standard length, H= height, TL= Total length, HL= head length, DW= Dorsal width (Plate 1).

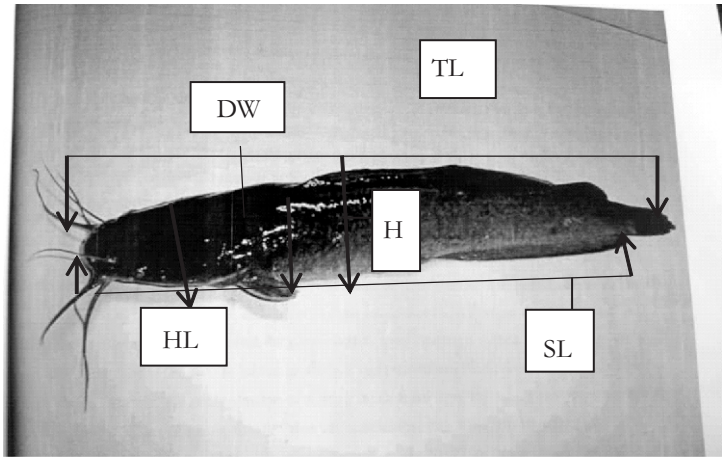

Plate 1: Morphometric measurement of *C. gariepinus*

Histomorphometric Evaluation.

The *C. gariepinus* juveniles (one from each treatment) were killed by severing the spinal cord with a sterile knife and aseptically eviscerated, washed and rinsed in distilled water. The organ (intestine) of *C. gariepinus* was taken and fixed in 10% buffered formalin for 24 h. Histological examination was carried out in the Histopathology Laboratory of the Department of Veterinary Pathology, University of Ibadan. The slides were prepared for histology as described by Culling (1974) and Drury *et al.* (1967) for the organs and tissues. Measurements of cryptal depth, villi length and width were taken using a microscope (Olympus CX21, Japan) with a micrometer as described by Bello *et al.* (2012), Eyarefe *et al.* (2008) and Spadoni *et al.* (2005). Four different villi were measured in each slide per parameter, recorded and an average value calculated.

Statistical Analysis

Data generated from the study were subjected to one-way analysis of variance (ANOVA) in a completely randomized design using SPSS version 20 (2012). Duncan multiple range tests were used to separate significant mean at P = 0.05

RESULTS

Growth Performances and Nutrient Utilization of *C. gariepinus* Juveniles Fed with Cinnamon Enriched Diet for 56 days

The result of the experiment revealed a general increase in the values of all treatments in terms of weight gain, specific growth rate, feed conversion ratio, percentage weight gain and nitrogen metabolism (Table 2).

Table 2: Growth Performance and Nutrients Utilization of *Clarias gariepinus* Fed with different Inclusion Level of Experimental Diets for 56 days

Parameters	Control	CB 2	CB 3	CB 4	CHRL 5
Initial body weight (g)	12.39±0.03^{a}	12.39±0.03^{a}	12.39±0.03^{a}	12.39±0.03^{a}	12.39±0.03^{a}
Final body weight (g)	36.16±0.38^{c}	28.87±5.46^{b}	24.65±0.64^{b}	17.57±1.07^{a}	29.86±0.91^{bc}
Weight gain (g)	23.77±0.33^{c}	16.48±5.49^{b}	12.26±0.61^{b}	15.18±1.05^{a}	17.47±0.93^{bc}
Weight gain %	191.75±2.47^{c}	133.07±4.60^{b}	98.7±4.71^{b}	41.80±8.34^{a}	141.03±7.82^{bc}
Feed conversion ratio	0.95±0.01^{a}	2.04±0.61^{bc}	2.48±0.11^{bc}	2.70±0.10^{c}	1.66±0.08^{ab}
Specific growth rate (g)	0.88±0.5^{c}	0.64±0.13^{b}	0.55±0.00^{b}	0.30±0.14^{a}	0.73±0.00^{bc}
Survival rate	92.50±3.54^{b}	85.00±0.07^{ab}	75.00±0.00^{a}	72.50±3.54^{a}	95.00±7.07^{b}
Nitrogen metabolism (g)	746.31±6.09^{c}	634.26±83.50^{b}	569.40±10.18^{b}	460.55±16.96^{a}	649.47±13.47^{bc}
Initial condition factor	1.21±0.01^{a}	1.21±0.01^{a}	1.21±0.01^{a}	1.21±0.01^{a}	1.21±0.01^{a}
Final condition factor	1.23±0.43^{a}	0.85±0.35^{a}	0.83±0.21^{a}	0.65±0.01^{a}	1.00±0.1^{a}

Key: CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05)

Morphometric characteristics of *C. gariepinus* Fed with Cinnamon Bark for 56 Days

The result showed that all the treated groups had better values in head length, dorsal width, total length, and height compared to the control, the values obtained before the experiment, and were significantly different (P< 0.05) among the dietary groups (see Tables 3a-e).

Table 3a: Measurement of a Standard Length (cm) of *C. gariepinus* Fed Experimental Diets for 56 days

Weeks	Control	CB 2	CB 3	CB 4	CHRL 5
0	10.10±0.00^{a}	10.10±0.00^{a}	10.10±0.00^{a}	10.10±0.00^{a}	10.10±0.00^{a}
2	11.60±0.9^{a}	11.07±0.33^{a}	11.80±0.14^{a}	10.88±0.21^{a}	10.87±0.19^{a}
4	12.45±0.78^{a}	12.13±0.42^{a}	11.65±0.21^{a}	12.01±0.40^{a}	11.27±0.37^{a}
6	11.77±1.08^{a}	13.17±0.09^{a}	12.09±0.30^{a}	11.67±0.37^{a}	7.70±0.93^{a}
8	14.55±1.80^{a}	15.36±1.35^{a}	14.51±1.31^{a}	13.38±0.34^{a}	14.40±0.11^{a}

Key: CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05).

Table 3b: Measurement of Height (cm) of *C. gariepinus* Fed the Experimental Diet for 56 days

Weeks	Control	CB 2	CB 3	CB 4	CHRL 5
0	1.40±0.00^{a}	1.40±0.00^{a}	1.40±0.00^{a}	1.40±0.00^{a}	1.40±0.00^{a}
2	2.17±0.05^{c}	1.95±0.07^{ab}	2.05±0.07^{bc}	1.82±0.02^{a}	1.92±0.02^{ab}
4	2.05±0.11^{a}	1.89±0.12^{a}	1.85±0.11^{a}	1.97±0.19^{a}	1.90±0.00^{a}
6	2.22±0.12^{ab}	2.45±0.07^{b}	2.30±0.14^{ab}	2.12±0.16^{a}	2.27±0.05^{ab}
8	2.42±0.19^{a}	2.53±0.15^{a}	2.51±0.13^{a}	2.39±0.16^{a}	2.50±0.07^{a}

Key: CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05).

Table 3c: Measurement of Total Length (cm) of *C. gariepinus* Fed the Experimental Diet for 56 days

Weeks	Control	CB 2	CB 3	CB 4	CHRL 5
0	12.03±0.00^{a}	12.03±0.00^{a}	12.03±0.00^{a}	12.03±0.00^{a}	12.03±0.00^{a}
2	13.50±0.25^{a}	12.92±0.45^{a}	13.47±0.47^{a}	12.63±0.42^{a}	12.47±0.09^{a}
4	14.35±0.78^{b}	13.95±0.40^{b}	13.72±0.02^{b}	14.00±0.42^{b}	12.12±0.09^{a}
6	13.95±1.20^{ab}	15.11±0.16^{b}	13.95±0.21^{ab}	13.50±0.28^{a}	14.85±0.35^{ab}
8	15.26±0.20^{a}	18.17±0.07^{c}	15.78±0.76^{ab}	16.80±0.85^{bc}	17.03±0.33^{bc}

Key: CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05).

Table 3d: Measurement of the Head Length (cm) of *C. gariepinus* fed with the Experimental Diet for 56 days

Weeks	Control	CB 2	CB 3	CB 4	CHRL 5
0	1.80±0.00^{a}	1.80±0.00^{a}	1.80±0.00^{a}	1.80±0.00^{a}	1.80±0.00^{a}
2	2.62±0.07^{b}	2.25±0.0.07^{ab}	2.28±0.07^{ab}	2.30±0.08^{ab}	2.17±0.14^{a}
4	2.47±0.05^{b}	2.33±0.00^{a}	2.35±0.07^{ab}	2.27±0.00^{a}	2.25±0.07^{a}
6	2.57±0.05^{b}	2.52±0.02^{ab}	2.52±0.2^{ab}	2.52±0.23^{a}	2.57±0.12^{b}
8	2.92±0.01^{c}	2.77±0.02^{bc}	2.73±0.01^{b}	2.39±0.04^{a}	2.77±0.08^{bc}

Key: CN = cinnamon, CHRL= chloramphenicol, mean of duplicated data followed by the same letter in a row are not significantly different (P>0.05).

Table 3e: Measurement of Dorsal Width (cm) of *C. gariepinus* fed with the Experimental Diet for 56 days

Weeks	Control	CB 2	CB 3	CB 4	CHRL 5
0	1.30±0.00^{a}	1.30±0.00^{a}	1.30±0.00^{a}	1.30±0.00^{a}	1.30±0.00^{a}
2	1.77±0.19^{b}	1.60±0.14^{ab}	1.63±0.00^{ab}	1.73±0.00^{b}	1.52±0.02^{a}
4	1.53±0.04^{a}	1.47±0.09^{a}	1.57±0.05^{a}	1.60±0.14^{a}	1.60±0.00^{a}
6	1.94±0.05^{a}	2.12±0.26^{a}	1.82±0.21^{a}	1.82±0.21^{a}	2.07±0.23^{a}
8	2.17±0.04^{a}	2.31±0.14^{a}	2.08±0.15^{a}	2.10±0.64^{a}	2.30±0.01^{a}

Key: CN = cinnamon, TM = thyme CHRL = Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05).

Viscero-Intestinal Organ of *C. gariepinus* Fed with Cinnamon Bark for 56 days

There was an increase in the value of the final intestine and final visceral organ compared to the value obtained before the experiment. Also, there was a significant difference (P<0.05) in the final intestinal and viscera index among the diet groups (Table 4).

Table 4: Viscera-Intestino Somatic Index of *C. gariepinus* Fed Experimental Diet for 56 days

	Control	CB 2	CB 3	CB 4	CHRL 5
Initial intestine (g)	5.30±0.03^{a}	5.30±0.03^{a}	5.30±0.03^{a}	5.30±0.03^{a}	5.30±0.03^{a}
Final intestine (g)	17.70±0.25^{ab}	20.59±1.93^{b}	19.00±1.97^{b}	12.83±1.99^{a}	18.85±3.08^{b}
Initial viscera (g)	9.71±0.02^{a}	9.71±0.02^{a}	9.71±0.02^{a}	9.71±0.02^{a}	9.71±0.02^{a}
Final viscera (g)	24.46±0.50^{a}	27.04±0.08^{b}	32.46±3.12^{b}	22.54±0.62^{a}	26.94±5.74^{ab}

Key: CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05).

Haematological Profile of *C. gariepinus* before and after Experiment Fed Cinnamon Bark for 56 days

There were increased values of some haematological parameters after the experiment when compared with the values obtained before the experiment. The packed cell volume, Haemoglobin, Lymphocyte, Red blood cell, white blood cell, MCHC, MCH, Platelet, Neutrophil, monocytes and Eosinophil were not significantly different (P>0.05) among the dietary groups while MCV was significantly different (P< 0.05) among the dietary groups (Table 5).

Table 5: Haematology Parameter of *C. gariepinus* Juveniles Treated with Cinnamon Bark for 56 days

Parameters	Before	Control	CB 2	CB 3	CB 4	CHRL 5
PCV (%)	41.00±2.82^{a}	43.00±2.82^{a}	42.00±2.82^{a}	40.00±2.82^{a}	44.00±2.82^{a}	45.00 ± 2.82^{a}
HB (g/dl)	13.70±2.83^{a}	14.30±2.83^{a}	14.00±2.83^{a}	13.40±2.83^{a}	14.70±2.83^{a}	15.00 ± 2.83^{a}
RCB (x 10^{12}/l)	5.10±2.80^{a}	14.50±2.80^{a}	14.30±2.80^{a}	14.30±2.80^{a}	14.80±2.80^{a}	4.60 ± 2.80^{a}
WBC (x 10^{9}/l)	10.80±2.80^{a}	11.80±2.83^{a}	11.90±2.83^{a}	11.90±2.83^{a}	12.40±2.83^{a}	12.70 ± 2.83^{a}
PLAT (m/µl)	28.70±2.83^{a}	30.10±2.83^{a}	33.40±2.83^{a}	30.90±2.83^{a}	30.50±2.83^{a}	35.60 ± 2.83^{a}
MCV (Fl)	80.40±2.80^{a}	95.60±2.80^{b}	97.70±2.80^{b}	93.00±2.80^{b}	91.70 ± 2.80^{b}	97.80 ± 2.80^{b}
MCH (Pg)	26.90±2.80^{a}	31.80±2.80^{a}	32.60±2.80^{a}	31.25±2.80^{a}	30.60±2.80^{a}	32.60 ±2.80^{a}
MCHC (g/dl)	33.40±2.80^{a}	33.30±2.80^{a}	33.30±2.80^{a}	33.50±2.80^{a}	33.30±2.80^{a}	33.30 ± 2.80^{a}
LYMP (x 10^{9}/l)	33.00±2.80^{a}	30.00±2.80^{a}	32.00±2.80^{a}	33.00±2.80^{a}	33.00±2.80^{a}	31.00 ± 2.80^{a}
NEUTRO (x 10^{9}/l)	65.00±0.3^{a}	65.00±0.3^{a}	70.00±0.3^{a}	64.00±0.3^{a}	68.00±0.3^{a}	65.00 ± 0.3^{a}
MONO (x 10^{9}/l)	2.00±0.1^{a}	0.00±0.1^{a}	2.00±0.1^{a}	2.00±0.1^{a}	2.00±0.1^{a}	3.00 ± 0.1^{a}
EOSINO (x 10^{9}/l)	0.00±0.1^{a}	0.00±0.0^{a}	1.00±2.03^{a}	0.00±0.1^{a}	0.00±0.0^{a}	1.00 ± 2.83^{a}

NOTE: PCV = packed cell volume, Hb =Haemoglobin, RBC = Red blood cell, WBC =white blood cell, MCV = Mean cell volume, MCHC = Mean Cell Haemoglobin concentration ,Neutro = Neutrophil, Lym = Lymphocytes, Mono = Monocytes, EOS = Eosinophil, CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05).

Plasma Biochemistry Profile of *C. gariepinus* before and after Experiment Fed with Cinnamon Bark for 56 days

The treated groups, CB 3, CB 4 and CHRL 5 performed better than the control and the value obtained before the experiment. There was no significant difference (P> 0.05) among the dietary groups in globulin and albumin levels, while there was significantly differences (P< 0.05) among the dietary groups in total protein and albumin/ globulin ratio (Table 6).

Table 6: Plasma Biochemistry Profile of *C. gariepinus* before and after Experiment

Parameters	Before	Control	CB 2	CB 3	CB 4	CHRL 5
Total protein (g/dl)	73±2.83^{ab}	75±2.83^{ab}	70±2.83^{a}	74±2.83^{ab}	79±2.83^{b}	74±2.83^{a}
Albumin (g/dl)	38±0.3^{a}	38±0.3^{a}	36±0.3^{a}	40±0.3^{a}	39±0.3^{a}	40±0.3^{a}
Globulin (g/dl)	35±2.83^{a}	37±2.83^{a}	34±2.83^{a}	34±2.83^{a}	40±2.83^{a}	34±2.83^{a}
Albumin /globulin ratio	1.10±0.2^{a}	1.0±0.2^{a}	1.10±0.2^{a}	1.20±0.2^{b}	1.10±0.2^{a}	1.20±0.2^{a}

CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05)

Blood Serum Profile of *C. gariepinus* before and after Feeding Trials Fed with Cinnamon Bark for 56 days.

The result showed some variations in the values of AST, ALT and glucose after the experiment. These values were relatively similar to the values obtained before the experiment. Also, general reduction in the values of AST and glucose were observed when compared to the value obtained before the experiment and control. There were no significant differences ($P > 0.05$) among the dietary groups (See Table 7).

Table 7: Blood Serum Profile of *C. gariepinus* before and after Feeding Trials Fed with Cinnamon Bark for 56 days

Parameters	Before	Control	CB 2	CB 3	CB 4	CHRL 5
ALT	12.00±0.3^{a}	12.00±0.3^{a}	12.00±0.3^{a}	13.00±0.3^{a}	8.00±0.3^{a}	9.00±0.3^{a}
AST	14.00±0.2^{a}	13.00±0.2^{a}	11.00±0.2^{a}	12.00±0.2^{a}	10.00±0.2^{a}	12.00±0.2^{a}
Glucose	5.00±2.83^{a}	4.30±2.83^{a}	4.20±2.83^{a}	4.20±2.83^{a}	4.10±2.83^{a}	4.10±2.83^{a}

Key: ALT= Alanine aminotransferase, AST= Aspartate aminotransferase CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05)

Histomorphometric Analysis of *C. gariepinus* Fed with Cinnamon Bark for 56 days

The result of the experiment showed that the villi height, villi length, cryptal depth, and goblet cells were significantly different (P>0.05) among the dietary groups while the muscular thickness and villi width have no significant difference (P>0.05) among the dietary groups (Table 8).

Table 8: Histomorphometric Analysis of *C. gariepinus* Fed with Cinnamon Bark for 56 days

	Control	CB 2	CB 3	CB 4	CHRL 5
Villi height (μm)	3459.87±3.33^{a}	5349.09±3.68^{b}	3418.40±1.1^{a}	3626.85±5.15^{a}	3414.92±372^{a}
Villi width (μm)	434.32±93^{a}	594.36±161^{a}	669.65±274^{a}	730.91±16^{a}	597.32±71^{a}
Villi length (μm)	447.59±79^{a}	632.60±132^{b}	570.13±92^{ab}	477.34±42^{ab}	576.10±73^{ab}
Cryptal depth (μm)	393.65±53^{a}	615.14±64^{b}	452.66±95^{ab}	580.77±53^{bc}	311.14±90^{a}
Goblets cell	2.33±1.5^{a}	4.67±1.5^{ab}	3.33±1.5^{a}	4.67±1.1^{ab}	6.33±1.5^{b}
Muscular thickness (μm)	633.44±91^{a}	908.60±138^{b}	921.57±149^{b}	921.44±161^{b}	671.13±85^{ab}

CB = Cinnamon Bark, CHRL= Chloramphenicol, mean of duplicated data, mean followed by the same letter in a row is not significantly different (P>0.05)

DISCUSSION

The result revealed that the control had the highest weight gain when compared to treated groups and were significantly different (P<0.05) among the dietary groups. This study is in agreement with the report of Koochaksaraie *et al.* (2011) and Ebrahimi *et al.* (2013) who observed that the control had better weight gain when compared to the treated groups. The growth performance of fish fed control diet had the highest percentage weight gain, weight gain, food conversion ratio, nitrogen metabolism, SGR and SR, and these were significantly different (P<0.05) among the dietary groups. The result of the condition factor of this study was within the value reported by Wade (1992), who observed a condition factor of 1.0 as the best natural condition factor for fish.

The result obtained in this study showed that there was an increase in head length, total length, dorsal width, and height in the treated groups when compared to the value obtained before the experiment. Generally, it was observed that the head length, standard length, total length, dorsal width, and height increased as the month of exposure increases. Also, it was observed that as the inclusion level of cinnamon increased, the morphometric characteristics decreased and there were no significant differences (P>0.05) among dietary groups at 6 and 8 weeks of the study. This result was in agreement with Nugroho *et al.* (2019) who reported an increase in the values of head length, standard length, total length, dorsal width, and height in the treated groups when compared to the control of the fish fed with 1% *Myrmeco diatuberosa*.

This result obtained in this study showed an increase in the final intestine and viscera organ in the treated groups when compared to the control and the value obtained before the experiment. There was a significant difference ($P<0.05$) among the dietary groups in the final intestine and the viscera organ. This result was in agreement with Nugroho *et al*. (2019) who reported a significant increase in the final intestine and viscera organs at the end of the experiment in the treated groups compared to the control.

In this present study, the PCV and Hb concentrations within the treated groups were above the control except CB 2 and CB 3. These values were in accordance with the report of Jordan *et al*. (1992) who recorded 40-54% and 12-18g/dl for PCV and Hb, respectively for catfish. The values of the WBC, MCV, platelets, lymphocytes, neutrophils, and monocytes were better in the treated groups compared to the control. Also, there were no significant differences ($P>0.05$) among the dietary groups except in MCV which recorded significant differences ($P<0.05$) among the dietary groups. These parameters revealed immunomodulatory properties of cinnamon bark as a result of phytochemical constituents present in the plant.

The mean corpuscular volume (MCV) range (80.40 - 97.78 fl) was within the range of 87.50 - 200.00 fl; 79.20 - 105.32 fl reported by Dienye and Olumuji (2014) and Anyanwu *et al*. (2011) for *C. gariepinus* and *Heteroclarias*, respectively. The mean corpuscular haemoglobin concentration (MCHC) range (33.30 - 33.50 %) recorded in this present study is different to the report of Adedeji and Adegbile (2011) who reported 30.70% for *C. gariepinus*. The MCH range (26. 90 – 32.60 pg) obtained in this study was higher than the range (20.82 - 26.60 pg) reported by Anyanwu *et al*. (2011) for *Heteroclarias* fed *Carica papaya* leaf meal incorporated diet. However, all the haematological parameters measured in this study were within the recommended ranges reported by Jordan *et al*. (1992) for *C. gariepinus*.

The result of the serum enzyme indices obtained in this study showed a decreased value in Alanine aminotransferase (ALT) except for CB 3 (1%) which was higher than the control and value obtained before the experiment, while Aspartate aminotransferase (AST) in the treated groups showed a decreased value when compared with the control and the value obtained before the experiment. Shalaby *et al*. (2006) reported a decrease in AST and ALT fed *O. niloticus* with *Allium sativum* which agreed with the present study. However, the result obtained in this study is at variance with those reported by Dienye and Olumuji (2014) who observed an increase in AST and ALT in *C. gariepinus* fed dietary levels of *Moringa oleifera*. Glucose is used as an indicator of stress (Thomas and Labor, 1992). Our study revealed that there was a total decrease in glucose value obtained at the end of the experiment when compared to the value obtained before the experiment. The values obtained in the treated groups were lower than the control and there were no significant differences ($P>0.05$) among the dietary groups.

The results of histomorphometric indices of *C. gariepinus* showed higher values in cryptal depth, villi height, villi length, epithelial cell, villi width and muscular thickness within the treated groups compared to the control. These values were significantly different ($P<0.05$) among the dietary groups except for villi width in which there was no difference ($P>0.05$) among all the treatment groups. This report agrees with the work of Bello *et al*. (2012) who reported higher values in cryptal depth, villi length and villi width of the treated groups than the control of *C. gariepinus* fed onion bulb and walnut leaf-based diets.

Also, this report was similar with Selim and Reda (2015) who observed higher goblet cell number in Nile tilapia fed diets containing probiotics when compared to the control. Silva *et al*. (2015) reported that Nile tilapia reared in the cage fed with diet supplemented with *B. amyloliquefaciens* for 90 days showed a significant increase in the number of goblet cell when compared with the control.

CONCLUSION

From the results of this study, it can be concluded that cinnamon bark can be incorporated in the diets of *C. gariepinus* juveniles as feed additives to improve physiological functions of the fish which may increase productivity in fish farming.

CONFLICT OF INTEREST

During this study, no conflict of interest was observed.

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