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Research Article

Effect of ginger (*Zingiber officinale*) in the nutrition of african catfish–A cholesterol reducer and fertility enhancer

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Abstract

A twelve weeks nutritional study was carried out to study the effect *Zingiber officinale* on the growth performance, blood profiles, eggs and sperm quality of juvenile African catfish (*Clarias gariepinus*). In which juvenile African catfish (*Clarias gariepinus*) were fed five diets containing 35% CP were formulated having varying inclusion levels (0, 5, 10, 15 and 20 %) of ginger (*Zingiber officinale*) for Diet 1, 2, 3, 4 and 5 respectively. One hundred (100) juvenile African catfish (94.24±0.02g) were randomly selected, divided into five dietary treatments and stocked at the rate of 10 juveniles per tank (120L) and replicated two times. The fish were fed ad libitum twice daily and weight changes were recorded every two weeks. At the end of the feeding trials, blood samples were taken, the sperm and egg sacs were excised from the fish samples selected and the sperm and eggs were collected for analysis. Data collected on weight changes, feed-intake, blood parameters and sperm volume, percentage motility, sperm density, percentage livability and death percentage were subjected to one way analysis of variance (ANOVA) using Completely Randomized Design (CRD).

The results revealed that fish increased significantly in weight ($P < 0.05$) as the level of ginger inclusion increases in diets and utilized the feed efficiently than the control. Significant differences ($P < 0.05$) were observed in all the growth parameters. Treatment4 (fish fed 15% ginger based diet) had the highest mean weight gain (166.71g), percentage weight gain (176.90%), specific growth rate (0.54%), protein efficiency ratio (1.64) and red blood cells (3.86cmm). Also, fish fed 15% ginger based diet (T4) recorded least alkaline phosphate (13.62u/l), alanine transaminase (67.73otu/l), ALT (22.36u/l) and Creatinine (0.18mg/dl). However, fish fed 20% ginger based diet (T5) had higher sperm motility (67.50%), sperm livability (180.85%), egg volume (40ml), egg weight(36.50g) and egg number (25600) while the least sperm motility and livability(45.00%, 92.05%) respectively were obtained in T4. Although, the least values of egg volume, weight and number (25ml, 24g, 16500) respectively were recorded in control (T1).

Therefore, it can be concluded that 15% ginger can be included in the diet of African catfish (*Clarias gariepinus*) to enhance growth, good hematological and reduced antinutrients although, greater success were recorded for reproductive performance using higher level of ginger(20%) without detrimental effect.

Introduction

The African catfish (*Clarias gariepinus*) [1], is a species of catfish of the family Clariidae and is an important fish species in both aquaculture and capture fisheries [2]. It contributes 22% of animal protein in sub-saharan Africa and 40% of animal protein for consumption in Nigeria [3]. In Africa, this catfish has been reported to be the biggest in size in terms of length and weight and popularly cultivated species [4]. In Nigeria, Catfish culture started from inception with aquaculture and is majorly the only hope of fish supply sustainability. Recently all over the world, there is a decline in landing from capture fisheries which is an indication that fish stocks have

exceeded the point of maximum sustainable yield. Apart from Tilapia, African catfish belonging to the family of Clariidae is the most commonly cultivated fish in Nigeria. The steady rise in catfish culture has greatly boosted aquaculture growth in Nigeria. However, the problem of inadequate availability of stock has hampering its production. Although, induced breeding (hypophysation) has been introduced and widely used throughout Nigeria to increase the production of farm-raised catfish [5]. Currently, natural materials (medicinal plants) such as bitter leaf, scent leaf, bitter kola have been widely accepted as feed additives to enhance feed utilization and aquaculture productive, performance and sustainability [6]. Phytogetic feed additives, also known as phytobiotics



products are plant derived products, used in animal feeding to improve performance through amelioration of feed properties, promotion of production performance and improving the quality of animal origin food/feed [7]. Also, ginger being a natural and readily available additive could be used as fertility booster in fish which might also be a possible solution to the inadequacies of fingerlings supply, hence increasing the African catfish market in Nigeria.

Ginger is a flowering plant whose rhizome is commonly used as spice and flavouring agent. It is cultivated nationwide [8]. Ginger is a spice and medicinal plant that has been used in the pharmaceutical, food and chemical industries. It contains anti-oxidative and androgenic activities which has been used in diseases treatment in many countries worldwide [9], Ginger and its constituents have antiemetic, antithrombotic, antihepatotoxic, anti-inflammatory, stimulant, cholagogue. Androgenic and antioxidant properties. As antioxidants it protect DNA and other important molecules from oxidation and damage, and can improve sperm quality and consequently increase fertility rate in men [10]. Ginger, boost metabolism, immune systems as well as effective in decreasing sperm DNA fragmentation (SDF) in infertile men [11].

A study has revealed that inclusion of ginger root powder in laying hens diet increased their egg production and weight compared with control laying hens [12]. It was also reported that, ginger roots essential oil significantly increased the relative uterus weight, egg weight, fertility and hatchability rates in the female quail compared to the control birds. In fish, ginger has been successfully used to control an *Aeromonas hydrophila* infection in rainbow trout [13]. In addition, ginger has been used as immune-modulatory agent in animals and fish to reduce the losses caused by diseases in aquaculture [13,14].

These studies therefore, investigate the effect of ginger in the nutrition, blood profile and reproduction of African catfish.

Materials and methods

Experimental site

This experiment was conducted at the fishery unit of Teaching and Research Farm, Ladoke Akintola University of (LAUTECH), Ogbomoso, Oyo state Nigeria.

Processing of ginger (test ingredient)

The dried ginger was obtained from a local market in Ogbomoso. The ginger were sun dried to a constant weight, ground to fine powder and stored in an air tight container prior the use for the experiment.

Experimental diets

The ingredients such as maize, wheat offal, GNC, soybean, fish meal, oyster shell, bone meal, premix, lysine, salt and vegetable oil were procured from a reputable feed mill in ogbomoso. Five isonitrogenous (35%CP) diets were formulated in which diet 1 contained (0% ginger), diet 2(5% ginger), diet 3

(10% ginger), diet 4 (15% ginger) and diet 5 (20% ginger).The ingredients were mixed thoroughly with varying percentage of ginger and then pelletized to reduce dustiness for proper and easy acceptance by the juvenile. The pellets were sundried to constant weight and packed into air tight sack and stored for use.

Experimental fish

Two hundred (200) juvenile African catfish were obtained from a reputable farm in ogbomoso and acclimatized for the period of two weeks after which, one hundred (100) juvenile African catfish (94.24±0.02g) were randomly selected and divided into five (5) dietary treatments. The fish were stocked at the rate of 10 juveniles (4male:6 females) per tank (120L) and replicated two times (due to the number of fish within the weight ranges selected for the study). The water used was exposed for three days to allow oxygen dissolution into the water. The waste and faeces in all the tanks were siphoned every day to prevent pollution.

Feeding and weighing

The fishes were fed experimental diet (ad libitum) twice daily, both in the morning and evening (8:00hrs and 16:00hrs). Fishes were weighed every two weeks for the period of twelve weeks using an electronic digital weighing balance, the record of the feed consumption was also taken.

Data collection

Data such as fish weight and feed intake were collected during the feeding trial and the following parameters - Mean weight gain (MWG), Percentage weight gain (PWG), Specific growth rate (SGR), Feed conversion rate (FCR), Protein intake (PI), Protein efficiency ratio (PER) were calculated

Mean Weight Gain (MWG) = Final weight (g) - Initial weight gain (g).

Average Daily Weight Gain (ADWG)g/day = Mean Weight Gain (g) / Length of feeding trial (days)

Percentage Weight Gain (PWG)% = Mean Weight Gain/ Initial mean weight (g) x100

Specific Growth Rate(SGR) = $\frac{\log W_2 - \log W_1}{T_2 - T_1} \times 100$

W_1 = initial weight (g), W_2 = final weight (g), Log = natural log to base

$T_2 - T_1$ = time interval between initial and final weight (days)

Feed Conversion Ratio (FCR) = Feed intake/ Net weight gain

Protein Efficiency Ratio (PER) = Net weight gain/ Amount of protein fed

Blood sample collection

Blood samples for haematology and serum analysis were collected at the end of the feeding trial from the caudal penducle of both the test and control fishes with new 2ml syringe. The



blood samples were dispensed into a tube containing Ethylene diamine tetra acetate (EDTA) to avoid clotting of the blood sample and Eppendorf tubes for serum samples preparation. The samples were preserved with ice cubes and taken to the laboratory for analysis.

Milts and eggs collection

Three male and female fishes were randomly selected from all the treatments for milt and egg collection. The fishes were deoxidized and the testes excised and eggs were siphoned from the female ovum with the use of hose. After which the sperm and eggs were viewed under the computer microscope.

Milt count

Concentration of sperm will be determined by counting the numbers of spermatozoa in sample dilute with distilled water (100x) in a Burkhaemocytometer under 400x magnification.

Percentage motility

Each sample were estimated using large microscope at 400x magnification, immediately after addition of 20ul distilled water as an activating solution. During spermatozoa activation, immotile sperm cell (ISC) was counted, when the activation stopped, whole sperm cell (WSC) as counted, motile sperm cell (MC) was calculated.

$$MC = WSC - ISC$$

$$MC\% = MC/WSC \times 100$$

Milt and egg analysis

The milt was analyzed with the use of a computer aided system and the data were, mathematically elaborated to obtain numerical indices expressing the statue of the ejaculation and egg production. The eggs were analysed to determine the volume, weight, colour and number of eggs.

Chemical analysis

Proximate composition of test ingredient (ginger), fish sample and experimental diets were determined according to the methods of Association of analytical chemist [15].

Statistical analysis

All data collected during experimental period were subjected to a one-way analysis of variance (ANOVA) using completely randomized design in accordance with SPSS and Duncan's multiple range tests was employed to reveal significant differences among the means.

Results

The gross composition of experimental diets is as shown in Table 1 and it revealed all the ingredients used for the five diets formulated for the experiment. The proximate composition of ginger (*ZingiberOfficinale*) in Table 2 were as follows : crude protein 8.75%, crude fibre 9.2%, ether extract 4.6%, moisture 6.6% and ash 6.2% .

The proximate composition of the experimental diets is as shown in Table 3. All the diets had averagely 34.75% crude protein, 5.09% crude fibre, 6.80%, ether extract, 7.69% ash, 43.23% nitrogen free extract.

The growth performance and nutrient utilization of juvenile African catfish fed ginger based diets was revealed in Table 4. Highest FMW, MWG,ADWG, PWG, SGR, AFI, PI and PER (260.95g, 166.71g, 1.99g, 176.90%, 0.54, 290.56g, 101.71g, and 1.64) were obtained in treatment 4 (15%ginger) while the least FMW, MWG,ADWG, PWG, SGR and PER (212.15g, 117.91g, 1.40g, 125.12% 0.43%, 1.40%) were recorded in treatment 5(20% ginger) respectively. Although, the least AFI (224.96g) and PI (78.74) were obtained in T1(Control). Also, the least value of FCR (1.74) was obtained at treatment 4 (15% ginger) while the highest FCR (2.04) was found with treatment 5.

The carcass composition of juvenile African catfish fed ginger meal was recorded in Table 5. T3 having the highest CP (51.84%) while T5 has the least CP value (47.25%), T3 has the highest CF (9.00%) and the least was recorded in T1 (7.41%) and the values of other treatments (T2, T4, T5) are closely related having values (8.80, 8.20 and 8.82%) respectively. Ether extract is highest (21.01%) in T5 and lowest (15.24%) in T4, moisture content of T2 is the highest (9.01%) while the highest was recorded in T4 (2.24%). T4 has the highest ash and

Table 1: Gross Composition of the Experimental Diets.

Ingredients	T ₁ (0%)	T ₂ (5%)	T ₃ (10%)	T ₄ (15%)	T ₅ (20%)
Maize	20.60	20.60	20.60	20.60	20.60
Wheat offal	10.30	10.30	10.30	10.30	10.30
GNC	22.20	22.20	22.20	22.20	22.20
Soybean	33.30	33.30	33.30	33.30	33.30
Fish meal	11.10	11.10	11.10	11.10	11.10
Ginger	—	0.02	0.04	0.06	0.08
Oyster shell	0.50	0.50	0.50	0.50	0.50
Bone meal	0.50	0.50	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25
Vegetable oil	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100

Table 2: Proximate Composition of Test Ingredient (Ginger).

Ingredient	Crude Protein	Crude Fibre	Ether Extract	Moisture	Ash
Ginger	8.75%	9.20%	4.60%	6.60%	6.20%

Table 3: Proximate Composition of Experimental Diets.

	CP (%)	CF (%)	EE (%)	Ash (%)	Moisture (%)	NFE (%)
T1	34.75	5.20	6.20	7.62	6.60	39.63
T2	34.76	6.02	5.40	7.60	6.62	39.60
T3	34.75	4.01	6.60	6.80	6.71	41.13
T4	34.75	6.80	5.20	7.81	6.61	38.83
T5	34.72	3.41	10.60	8.60	6.62	36.05



NFE value (13.01 and 9.66%) respectively, ash content (7.45%) is low in T1 while NFE is lowest (5.99%) in T2.

Haematology and serum

Haematology of the experimental fish is presented in Table 6. Highest PCV (48%) was discovered in treatments five (T5) while the lowest PCV value (40%) was found with T2. Treatment one (T1) has the highest WBC (12.00cmm) while treatment four (T4) has the least value (7.60cmm). Treatment two (T2) was discovered to have the highest (37.50%) heterophil while treatment five (T5) has the least (25.00%) value. Highest values of lymphocytes (52.50%) and neutrophils (3.50%), were observed in treatment four (T4) and five (T5) respectively, while the least values (29.00%) and (1.00%) were observed in treatments one (T1) and three (T3) respectively. There was a noticeable difference in the basophil value among the treatments with treatment one (T1) having the highest value (20.00%) and treatment two (T2) having the least value (8.50%) .

The findings of the present study on the haematology revealed that *Clarias gariepinus* juvenile fed with ginger meal

Table 6: Haematology of Juvenile African Catfish Fed Ginger Based Diets.

Parameters	T1	T2	T3	T4	T5	SEM
PCV (%)	45.50 ^{ab}	40.00 ^c	43.50 ^{bc}	43.50 ^{bc}	48.00 ^a	0.65
WBC (cmm)	12.00 ^a	9.25 ^{bc}	8.05 ^{cd}	7.60 ^d	10.00 ^b	0.31
HETERO (%)	35.00 ^{ab}	37.50 ^a	28.00 ^{cd}	31.50 ^{bc}	25.00 ^d	0.93
LYMPH (%)	29.00 ^b	46.00 ^a	51.50 ^a	52.50 ^a	46.50 ^a	0.57
NEUT (%)	1.50 ^c	1.50 ^c	1.00 ^c	2.50 ^b	3.50 ^a	0.17
BASO (%)	20.00 ^a	4.08 ^c	9.50 ^b	5.00 ^c	7.00 ^{bc}	0.92
BLAST (%)	14.50 ^a	11.00 ^{ab}	10.00 ^b	8.50 ^b	12.50 ^{ab}	0.62
Hb (gm/%)	15.10 ^{ab}	13.30 ^c	14.50 ^{bc}	14.50 ^{bc}	15.95 ^a	0.21
RBC (cmm)	3.45 ^{cd}	3.33 ^d	3.70 ^{ab}	3.86 ^a	3.62 ^{bc}	0.04
MCV (fl)	131.50 ^b	120.00 ^b	559.00 ^a	548.50 ^a	132.50 ^b	43.90
MCH (Pg)	43.75 ^a	40.00 ^{ab}	39.85 ^{ab}	37.50 ^b	44.00 ^a	0.67
MCHC(g/dl)	33.20 ^b	33.25 ^{ab}	33.35 ^a	33.30 ^{ab}	33.25 ^{ab}	0.02

a,b,c,d,e superscripts. Means in the same row with the same superscripts are not significantly different ($p > 0.05$). PCV: Packed Cell Volume, BLAST: Blast Cell (erythroblast, lymphoblast, neuroblast), WBC: White Blood Cell, Hb: Haemoglobin, HETERO: Heterophil, RBC: Red Blood Cell, LYMPH: Lymphocytes, MCV: Mean Corpuscular Volume, NEUT: Neutrophils, MCH: Mean Corpuscular Haemoglobin, BASO: Basophil, MCHC: Mean Corpuscular Haemoglobin Concentration

Table 4: Growth Performance and Nutrient Utilization of Juvenile African catfish fed Varying Levels of Ginger Meal.

PARAMETER	T1(control)	T2(5%)	T3(10%)	T4(15%)	T5(20%)	SEM
SURVIVAL RATE (%)	100	100	100	100	100	
IMW(g)	94.24	94.24	94.24	94.24	94.24	0.01
FMW	216.45 ^d	249.25 ^b	245.85 ^c	260.95 ^a	212.15 ^e	3.56
MWG	122.21 ^d	155.01 ^b	151.61 ^c	166.71 ^a	117.91 ^e	3.56
ADWG	1.46 ^c	1.85 ^b	1.81 ^b	1.99 ^a	1.40 ^c	0.04
PWG	129.68 ^d	164.48 ^b	160.88 ^c	176.90 ^a	125.12 ^e	3.78
SGR	0.44 ^{bc}	0.51 ^a	0.50 ^{ab}	0.54 ^a	0.43 ^c	0.01
AFI	224.96 ^e	284.77 ^b	275.47 ^c	290.56 ^a	240.57 ^d	4.80
FCR	1.84 ^b	1.84 ^b	1.82 ^b	1.74 ^c	2.04 ^a	0.02
PI	78.74 ^e	99.67 ^b	96.42 ^c	101.71 ^a	84.20 ^d	1.68
PER	1.55 ^b	1.56 ^b	1.57 ^b	1.64 ^a	1.40 ^c	0.02

a,b,c,d and e superscripts. Means with the same superscript in the same row are not significantly different ($P > 0.05$).

IW: Initial Weight; TFT: Total Feed Taken; ADVG: Average Daily Weight Gain; FW: Final Weight; AFI: Average Feed Intake; SGR: Specific Growth Rate; IMW: Initial Mean Weight; WG: Weight Gain; PI: Protein Intake; FMW: Final Mean Weight; FCR: Feed Conversion Ratio; PER: Protein Efficiency Ratio; MWG: Mean Weight Gain; PWG: Percentage Weight Gain

Table 5: Carcass Composition of Juvenile African catfish fed Ginger Meal.

Parameters	Initial	T1(control)	T2(5%)	T3(10%)	T4(15%)	T5(20%)	SEM
Crude Protein		50.77 ^c	48.13 ^d	51.84 ^a	51.69 ^b	47.25 ^e	0.35
Crude Fibre		7.41 ^d	8.80 ^b	9.00 ^a	8.20 ^b	8.82 ^b	0.11
Ether Extract		19.65 ^b	18.05 ^c	17.23 ^d	15.24 ^e	21.01 ^a	0.37
Moisture		8.01 ^b	9.01 ^a	2.83 ^d	2.24 ^e	3.54 ^c	0.52
Ash		7.45 ^e	10.02 ^d	12.23 ^b	13.01 ^a	11.01 ^c	0.36
NFE		6.71 ^d	5.99 ^e	6.87 ^c	9.66 ^a	8.37 ^b	0.25

NFE: Nitrogen Free Extract, SEM: Standard Error of Means. a,b,c,d and e superscripts. Means with the same superscript in the same row are not significantly different ($P > 0.05$).

of 0.08g (T5) produced the highest Hb (15.95gm/%) while that which was fed 0.02g (T2) produced the least (13.30gm/%) value. Highest values (3.86% and 559.00fl) of RBC and MCV were observed in treatments four (T4) and three (T3) respectively, while the least values (3.33% and 132.50fl) were observed in treatments two (T2) and five (T5) respectively. Treatment five (T5) recorded the highest (44.00Pg) MCH while treatment four (T4) recorded the least value (37.50Pg). Treatments three (T3) and one (T1) were recorded to have the highest (33.35g/dl) and least (33.20g/dl) MCHC respectively.

The serum biochemical indices of African catfish fed ginger based diets were presented in Table 7. All serum indices parameters were significantly different ($P < 0.05$) except urea. It was revealed in Table 7 that highest ALP (19.50) was obtained in treatment 3 (T3) while the least ALP (14.62) was recorded in treatment 4 (T4). Highest AST (104.45) and ALT (28.91) was recorded in treatment 2 (T2) while the least AST (59.70) and ALT (18.45) is obtained in treatment 5 (T5). Highest ALB (14.04) was obtained in treatment 2 (T2) while the least ALB (12.05) was recorded in treatment 5 (T5). Highest TP (39.05) and GLOB (25.01) was recorded in treatment 2 (T2) while the lowest TP (34.19) and GLOB (20.81) was obtained in treatment 1 (T1). Highest CHOL (154.81) was recorded in treatment 5 (T5) while the least CHOL (126.99) was obtained in treatment 1 (T1). Highest creatinine (0.35) was also recorded in both treatment 2 and 5 (T2 and T5) while the least creatinine (0.18) was obtained in treatment 4 (T4).

Sperm and eggs quality

The sperm quality of juvenile African catfish fed ginger based diets in Table 8 recorded highest pH value (7.75) was obtained in T1 while the lowest (7.50) was recorded in all the other treatments (T2, T3, T4 and T5). T1 also has the highest volume (4.50ml), T3 and T4 has the lowest (2.00ml).



Spermocrit highest rate (44.00%) was recorded in T1 while the least (27.50%) was obtained in T4. Sperm motility is highest (67.50%) in T5 and lowest (45.00%) in T4. Highest sperm density(267.50) is obtained in T5 while the lowest (190.50) is T3 .Sperm alive is highest (180.85) in T5 and lowest in T3(114.30) while sperm dead is highest(135.90) in T3 and lowest(79.35) in T2.

The egg quality of juvenile African catfish fed ginger based diets in Table 9, revealed that for parameters (volume, weight and number) T5 has the highest value (40.00ml, 36.50g ,25600) respectively while for parameters (volume, weight, number) T1 has the least value (25.00ml, 24.00g and 16800) respectively

Discussion

Medicinal plants have been reported to be growth promoters and immune boosters in livestock and fish nutrition [6,16-18]. The findings of the present study on growth performance of *Clarias gariepinus* juvenile fed ginger supplemented diets revealed that there was an increase in all the treatments for all parameters, as compared to the control. There was a significant increase in the final weight and weight gain of fish

Table 7: Serum Biochemical Indices of Juvenile African Catfish Fed Varying Levels of Ginger Based Diets.

Parameters	T1 (0)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM
ALP(u/l)	15.69 ^{ab}	17.44 ^{ab}	19.50 ^a	14.62 ^b	18.06 ^{ab}	0.63
AST(u/l)	68.93 ^c	104.45 ^a	91.78 ^b	67.73 ^c	59.70 ^c	2.90
ALT(u/l)	23.52 ^{bc}	28.91 ^a	25.75 ^b	22.36 ^c	18.45 ^d	0.57
TP(g/l)	34.19 ^c	39.05 ^a	36.81 ^b	34.66 ^{bc}	36.34 ^{bc}	0.39
ALB(g/l)	13.38 ^{ab}	14.04 ^a	12.07 ^c	12.74 ^{bc}	12.05 ^c	0.20
GLOB(g/l)	20.81 ^b	25.01 ^a	24.74 ^a	21.42 ^b	24.29 ^a	0.44
CHOL(mg/dl)	126.99 ^b	133.34 ^b	130.16 ^b	151.59 ^a	154.81 ^a	2.51
UREA(mg/dl)	14.95	15.12	15.12	15.12	15.21	0.11
CREATININE(mg/dl)	0.20 ^c	0.35 ^a	0.27 ^b	0.18 ^c	0.35 ^a	0.01

a,b,c,d,e—superscripts. Means in the same row with the same superscripts are not significantly different ($p > 0.05$).

ALP: Alkaline phosphate; AST: Aspartate transaminase; ALT: Alanine transaminase; ALB: Albumin; GLOB: Globulin; CHOL: Cholesterol; TP: Total protein; UREA, CREATININE.

Table 8: Sperm Quality of Juvenile African Catfish Fed Ginger Based Diets.

Parameters	T1(control)	T2(5%)	T3(10%)	T4(15%)	T5(20%)	SEM
Vol(ml)	4.50 ^a	3.50 ^c	2.00 ^d	2.00 ^d	4.00 ^b	0.15
Ph	7.75 ^a	7.50 ^b	7.50 ^b	7.50 ^b	7.50 ^b	0.36
Spermocrit(%)	44.00	38.50	40.00	40.00	42.50	1.28
Motility (%)	62.50 ^b	62.50 ^b	60.00 ^b	45.00 ^c	67.50 ^a	1.14
Sperm Density	236.00 ^b	213.00 ^c	190.50 ^d	200.50 ^{cd}	267.50 ^a	4.31
Sperm Alive	147.67 ^b	133.65 ^b	114.30 ^c	92.05 ^d	180.85 ^a	4.52
Sperm Dead	88.65 ^{bc}	79.35 ^c	135.90 ^a	108.45 ^b	86.65 ^{bc}	4.65

a,b,c,d and e superscripts. Means with the same superscript in the same row are not significantly different ($P > 0.05$). Vol: Volume

Table 9: Egg Quality of Juvenile African catfish fed Ginger Meal.

PARAMETERS	T1(control)	T2(5%)	T3(10%)	T4(15%)	T5(20%)	SEM
EggsVol. (ml)	25.00 ^b	30.00 ^b	40.00 ^a	40.00 ^a	40.00 ^a	1.33
Eggs Weight (g)	24.00 ^b	30.50 ^a	35.00 ^a	35.50 ^a	36.50 ^a	1.10
Eggs Number	16800.00 ^b	21350.00 ^a	24500.00 ^a	24850.00 ^a	25600.00 ^a	767.60

a,b,c,d and e superscripts. Means with the same superscript in the same row are not significantly different ($P > 0.05$).

fed 15% inclusion of ginger than the fish fed the control diet. The same trend was observed for the ADWG, PWG, TFT, SGR, PI and PER. The present study agrees with Iheanacho, et al. [18], who reported significant increase in weight gain(WG), specific growth rate (SGR) and final weight (FW) when *C.gariepinus* juvenile were exposed to varying concentrations (0.25, 0.50, 0.75 and 1.0g/35L) of ginger as compared to the control. The high proximate content of ginger may be an influence on the positive response to growth in treated fish, especially at 15% inclusion level of ginger which has the best response in all the parameters.

Carcass composition was significantly affected by intake of ginger. Moisture content increased with increase in ginger inclusion levels and was least value of 2.24% was found in T4. This agreed with the findings of Ali, et al. [19]. This could be attributed to corresponding decrease in the energy level of diets. Fanullah and Jafri [20], reported a strong inverse relationship between moisture content of fish and the energy level of their diets. The Ash content of fish fed the inclusion level of ginger were significantly different ($p < 0.05$). The highest was recorded in T4 (15% inclusion level of ginger) while the lowest value (7.45) was obtained in T1. Crude fibre was high in T3 and this might be as a result of low ash and crude fibre content of the tested ingredient (ginger) as was also observed by Erdal, et al., [21]. Crude protein of fish decreased with increase in ginger inclusion and recorded the highest in T4. This enhanced the crude protein content of *C. gariepinus*.

Blood is a vital special circulatory tissue, composed of cells suspended in a fluid intercellular substance (plasma) with the major function of maintaining homeostasis [22]. Packed Cell Volume (PCV), also known as haematocrit(Ht or Hct) or erythrocyte volume fraction (EVF), is the percentage of red blood cells in blood [23] and is involved in the transport of oxygen and absorbed nutrients [22]. In this present study PVC values increased from initial value of 45.50% in fish fed the control diet (T₁) to final value of 48.00% in fish fed 1.6g ginger diet (T₅) which contradicts Korzhuev (1964) [23] who stated that fish haematocrit values ranged between 20% and 35%. The results obtained falls within the range of 20% and 50% in agreement with Etim, et al. [24], who also stated that PCV values above 50% are rarely reported. Increased PCV results to an increased primary and secondary polycythemia [22], however, Sotolu and Faturoti [25] reported that lower PCV values is attributed to anaemia, thus the present study reveals that there is no tendency for anaemia.

Red blood cell is involved in the transport of oxygen carried to the tissues and carbon dioxide returned to the lungs in the body [22,26,27]. The red blood cell (RBC_s) increased from the



initial value of 3.45% in the fish fed control diet (T₁) to the final value of 3.86% in fish fed 15% ginger diet (T₄). These values were higher than $1.9 \times 10^{12} L^{-1}$ reported for *Clarias gariepinus* juveniles [28].

The final white blood cell counts (WBC) of *C. gariepinus* juveniles fed ginger included diets ranged between 7.60cmm in fish fed 15% ginger based diet (T₄) and 10.00cmm in fish fed 20% ginger-based diets (T) and were generally lower and significantly different from the initial WBC count (12.00cmm; T₁). [29] stated that increasing or decreasing numbers of WBC_s are normal physiological reactions to toxicants and these shows the response of the immune system under toxic conditions. However, Soetan, et al., 2013 [30], stated that animals with low white blood cells are exposed to high risk of disease infections while those with high counts are capable of generating antibodies in the process of phagocytosis and have high degree of resistance to diseases. They also have high degree of resistance to entrance adaptability to local environmental and disease prevalent conditions [22,31-33].

Mean corpuscular volume (MCV) indicates the status or size of the RBCs and reflects a normal or an abnormal cell division during the production of RBC. The result gotten from the present study showed that fish fed with 10% ginger diet (T₃), gave the highest volume (559.00fl) while the fish fed 5% ginger diet (T₂), had the least (120.00fl) MCV value. These values are higher when compared to 79.20-105.32 μ g/ml reported for *Heteroclaris* [34]. This increase may be attributed to the swelling of the RBCs as a result of low oxygen condition and impaired water balance in fishes exposed to metal pollution [35].

Mean corpuscular haemoglobin (MCH) values were significantly different. The highest value (44.00Pg) was recorded in fish fed 20% ginger based diet (T₅) while the least (37.50Pg) was recorded in fish fed 15% ginger based diet (T₄). These values agrees with Olasunkanmi [36] who reported a significant increase in the final MCH values in *C. gariepinus* fed raw mucuna seed meal-based diets.

The values recorded for mean corpuscular haemoglobin concentration (MCHC) (33.20g/dl, 33.25g/dl, 33.25g/dl, 33.30g/dl and 33.35g/dl) compares fairly well with 33.97% recorded by Adeyemo, (2007)[37] and values ranging between 28.75 and 37.62% recorded for fish fed *M. Oleifera* leaf meal-based diet [38].

Serum biochemical indices

In fish, proteins are among the main energy sources which play an important role in the maintenance of blood glucose [39]. The observed increase in the total protein content of fish in the study fed diet containing 0.02g of ginger could be linked with the level of anti-nutrients present in the diets. Yadav, et al. 2003 [40], who also reported a decrease in serum total protein content in *Channa punctatus* induced with stem-bark extract of *Croton tiglium*. Decrease in total protein in the fish fed control diet maybe exposed to toxic levels of toxicants which could be attributed to either a state of hydration and change in water

equilibrium in the fish or a disturbance in protein synthesis within the liver or both [41].

The slight decrease of serum albumin in the study which can be observed in fishes fed 0.04g and 0.08g of ginger diet might be due to their degradation and utilization for metabolic purposes. The higher values of ALT in the study(5% ginger) may occur due to the blood serum enzyme in the experimental fish efficiently utilized amino acids for metabolic purposes, confirming the observation of Adesina [42]. Transaminases are important enzymes for monitoring the health status of fish [43] and leak out into the bloodstream from dying or damaged liver cells. Increased levels of transaminases in the blood serum of fish are usually associated with dying or damaged liver cells while a decrease could suggest leakage of enzymes into the serum [1,44], which is observed in the study. Increased level of AST in the study which is observed in 15% ginger might be due to stress or due to increased levels of anti-nutrients at higher inclusion.

It increase in response to stress [45] and this can be observed in the study. The lower AST values recorded in fish fed control and 15% ginger based diets corroborated the report of [46] that there was inhibition of AST and ALT activities in the liver of catfish after intoxication with dietary ochratoxin. The observation also agreed with that of Dienne and Olumuji, et al. 2014 [38], who reported elevated ALT, AST and ALP. Activities in fish fed 30% *M. Oleifera* leaf meal diet and above which suggested hepatic cellular damage leading to their leakage into the bloodstream [47]. This is also similar to [48], who reported that increase in serum protein, albumin and globulin level maybe as a result of immune response to certain constituents of the extracts which can be observed in the study. Khahil, et al. [49], also reported that ginger when administered as bath treatment significantly decreased both ALT and creatinine levels in serum of *Clarias gariepinus* infested with gill monogenia, Bello, et al. [50], also reported that the decrease observed in ALT, ALP and ALB activities might be attributed to stress induced during fish sampling for blood collection, capturing and handling procedure

The increased sperm motility, sperm density and sperm alive after 12 weeks of treatment with 20% inclusion revealed that with ginger powder boosts the fertilizing ability of semen. A study of male rats on effects of ginger on reproductive functions proved that ginger enhanced fertility in male especially in sperm characteristics which might be as a result of potentiality of antioxidant and androgenic properties. In this study, sperm pH is slightly above neutral across all the treatments with the fishes fed the control diet having the highest pH value (7.75) while pH values were uniform (7.50) in all other treatments. The milt volume decreased as inclusion levels increased, the fishes fed the control meal recorded the highest value (4.50ml) and the lowest (2.00ml) in fishes fed 10%(treatment 3) and 15% (treatment 4) of ginger meal, this disagrees with the findings of Dada and Ogundiye [49] on the effect of velvet beans on sperm quality on African catfish who observed that milt volume increased as inclusion levels increased having its highest value (0.91ml) in D5 and lowest



(0.59ml) in the fishes fed the control diet. It was also recorded that there was significant difference in the spermatocrit of all treatments, the fishes fed the control diet obtained the highest value (44%), while the least rate (27.50%) was obtained in the fishes fed 15% of ginger meal.

This study revealed that egg volume, weight and number (40ml, 36.50g, 25600) respectively were significantly increased in fishes fed ginger diet inclusion at 20% (treatment 5). This is in agreement with Cek and Yilmaz [51], who reported that the number of eggs is determined based on its weight, the relationship between egg weight and number is also observed in this study. The result obtained from this study also agrees with the findings of Zhao, et al. [11], on the effect of ginger powder on laying performance of laying hens who recorded that egg mass was quadratically increased by ginger powder supplementation at levels up to 20g/kg of diet. This study suggests that ginger has a favourable effect on egg quality of African catfish (volume, number and weight). Furthermore, the increased egg quality shows that treatment with ginger powder improves and enhanced rate of fertilization in eggs.

Conclusion

The result obtained in this study revealed that, inclusion of 15% ginger (treatment 4) in the diet of African catfish generally increased the growth optimally and reduced the serum biochemical indices to the minimal level required by the fish. Although, ginger inclusion as high as 20% enhances carcass, egg quality and sperm fertility. However, it can be concluded that 15% ginger based diet can be included in the diet of African catfish to enhance a better performance.

Recommendation

15% of ginger inclusion in the diet of African catfish is therefore recommended for growth, good carcass quality as well as boosting reproduction (milt and egg) without health deterioration

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