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Research Article

Nutrition and reproductive performance of African catfish fed bitter kola (*Garcinia kolal*)

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Abstract

A ten weeks feeding trial was conducted to evaluate the effect of bitter kola on the growth performance, hematology and sperm quality of juvenile African catfish (*Clarias gariepinus*). Six diets of 40% crude protein were formulated with different inclusion levels of bitter kola seed meal. Diet1 (control) has 0g/kg of the seed meal while Diet2, Diet3, Diet4, Diet5 and Diet6 contained 50g/kg, 100g/kg, 150g/kg, 200g/kg, 250g/kg bitter kola seed meal(BKSM) respectively. A total of sixty (60) healthy juvenile *Clarias gariepinus* were randomly selected and distributed in into twelve (12) plastic tanks at stocking rate of five (5) fish per tank and the experiment was replicated twice. Fish were fed twice a day, morning (8;00hr) and evening (17:00hrs) for ten weeks, At the end of the feeding period, blood samples were collected from the fish samples for haematological analysis and growth rate were determined.

FMW, MWG, PWG, SGR, AFI, FCR PI and PER were significantly different across the treatment groups ($p<0.05$). Fish fed dietary treatment T2 (100g/kg BKSM), has the highest values of PWG (83.40%) and PER (0.22) while the lowest values of PWG (11.00%) and PER (0.04) were obtained in dietary treatment T6 (250g/kg BKSM) However, the least value of FCR (0.74) was recorded in fish fed dietary treatment T2 (100g/kg BKSM) while dietary treatment T6 (250g/kg BKSM) had the highest FCR value (1.01).

Haematology of African catfish ranging from HB, PVC, WBC, RBC, MCH, MCHC to lymphocyte were not significantly affected by varying levels of Kola in the diets.

It has been found that fish growth reduced while sperm quality increased with increased levels of bitter kola. Therefore, it can be concluded that bitter kola can be included in the diet of African catfish at the rate of 150g/kg BKSM (T4) for improving the sperm quality and 50g/kg BKSM (T2) for optimum growth performance.

Introduction

Fish serves as a major source of protein for human, providing significant portion of nutrient to a large proportion of people particularly in the developing world [1]. The global production of fish and other aquatic animals for human use occurs either by commercial fishing or through aqua cultural and farming techniques. According to FAO [2], the world production of fish in 2005 consists of 93.2 million tons captured by commercial fishing in wild plus 48.1million tonnes produced by fish farms. Despite the outrageous increase in numbers of people yearly with the production rate of fish, Nigeria, like most third world countries, is not able to meet her animal protein requirement which is traceable to our fish production which has fallen below expectation. Many fish hatcheries in Nigeria are functional at low capacity; producing only a total some of 30million fingerlings per year, although the total existing capacity could easily be 1 billion fingerlings per year. Based on 1992 United Nations Development Project (UNDP) assisted base line study in the total annual fingerlings requirement for Nigerian was 250,000 million while the domestic production stood at 7.2million [3]. In Nigeria, the most common fish reared are tilapia and catfish because they are mostly found in fresh water habitat. Therefore, in fish reproduction under controlled conditions, attempt are made to obtain sperm from the fish with high quality seeds although, several factors affect fish seed quality such as different strains, genetics, nutrition, content of feed and deposition of organic matter, chemical fertilizer into water used for cultured medium and for hatchery purposes [4]. According to [5], there are some common hatchery practices such as handling, cleaning, use of chemicals and water quality problems which do have negative effect on fertilization success in artificial reproduction thereby producing low quality fish seeds Therefore, the need to research into various ways of enhancing fish fertility to meet the growing demand.

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The use of medicinal plants as fertility enhancer has now gained much ground in aquaculture. Plants such as bitterleaf, kigelia [6], *Garcinia kola* [7], have been used to enhance fertility and it is generally accepted that medicine derive from plant products are safer than their synthetic counterparts [8]. Bitter kola (*Garcinia kola*l) belonging to the family of *Clusiaceae* highly esteemed by the native of Africa as Negroes chewed and it is a widespread tree of evergreen forest valued in Nigeria for its medical nuts [9]. Negroes chewed it as a powerful aphrodisiac and as masticatory; they administer them in treating common colds, cough and throat infections. *G. kola* stem bark has been shown to contain a complex mixture of phenolic compounds such as tannin guttiferin, bioflavonoids, xanthenes, benzophenone, kolaflavanone and garciniaflavanone [10], all of which have antimicrobial activity. Besides, *G. kola* exhibits purgative, anti-parasitic, anti-inflammatory, anti-bacterial and anti-viral properties [11]. Therefore, considering the importance of *G. kola*, this study is carried out to investigate the effect of *Garcinia kola* on the growth performance haematology and sperm quality of African catfish.

Materials and methods

Experimental site

The experiment was carried out at the Fishery unit of Teaching and Research farm Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria.

Experimental fish and management

A total number of ninety (90) healthy African catfish were procured from a reputable farm at Ibadan, Oyo State, Nigeria. The fish were acclimatized for two (2) weeks in tanks containing aerated water and they were fed floating feeds to empty their gut so as to maintain a uniform stomach condition in preparation for the experiment. At the end of the acclimatization period, a total number of sixty (60) male fish were randomly distributed into twelve plastic tanks at stocking density of 5 fish per tank and replicated two times. The fish were fed twice daily, both in the morning and evening (9:00 hours and 17:00hours), weighed every two week and the daily feeding rate (5% of the total biomass) were adjusted.

Collection and processing of test ingredient

Bitter kola seeds were procured from a local market in Ogbomoso, Oyo State, Nigeria. The outer coats of the bitter kola were removed and the seeds were sundried, milled to a fine powder and stored in an air tight nylon prior use.

Experimental diets

The feed ingredients were obtained from a reputable feed mill in Ogbomoso, Oyo State, Nigeria. The ingredients include; Fish meal, maize, soya bean meal, groundnut cake, wheat offal, bone meal, oyster shell, vegetable oil, lysine, methionine and salt.

Six isonitrogenous diets containing 40% CP were formulated and Garcinia *kola* meal was included at varying levels (50, 100, 150, 200, 250g/kg) in the diets and they were represented as follows:, D2, D3, D4, D5, D6 respectively. The control basal diet (D1) contained 0% bitter kola Table 1.

Table 1: Gross Composition of Experimental Diets (g/kg).

Ingredients	D1	D2	D3	D4	D5	D6
Maize	8.61	8.61	8.61	8.61	8.61	8.61
Wheat offal	2.87	2.87	2.87	2.87	2.87	2.87
Soy bean	53.14	53.14	53.14	53.14	53.14	53.14
Groundnut cake	21.26	21.26	21.26	21.26	21.26	21.26
Fish meal	10.63	10.63	10.63	10.63	10.63	10.63
Oyster shell	1.00	1.00	1.00	1.00	1.00	1.00
Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20	0.20	0.20
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00
Vegetable oil	0.05	0.05	0.05	0.05	0.05	0.05
Salt	0.05	0.05	0.05	0.05	0.05	0.05
Bitter kola (g/kg)	-	50	100	150	200	250

BKSM-Bitter kola seed meal, D- Diets: D1- control (does not contain BKSM), D2- diet containing 50g/kg BKSM, D3- diet containing 100g/kg BKSM, D4- diet containing 150g/kg BKSM, D5- diet containing 200g/kg BKSM, D6- diet containing 250g/kg BKSM.

Data collection

Growth performance: Records of feed intake and weight gain were taken during the experimental period; hence the following parameters such as Mean Weight Gain (MWG), Percentage Weight Gain (%WG), Specific Growth Ratio (SGR), Feed Conversion Ratios (FCR) and Protein Efficiency Ratio (PER), were calculated.

Weight gain (WG) = W2−W1

Where, WG =Weight gain, W2 is the final weight gain, W1 is the initial weight gain

Mean Weight Gain (MWG) = final mean weight (g)−initial mean weight (g)/number of fishes

Feed Conversion Ratio (FCR) = feed consumed by fish(g)/ mean weight gain(g)

Protein Efficiency Ratio (PER) = weight gain (g)/amount of protein fed

Protein intake (PI) = %CP×AFI or mean feed intake. Where, %CP = Percentage crude protein AFI = Average Feed Intake

Specific Growth Rate (SGR) = ln final weight−ln initial weight×100/Number of days

Percentage Weight Gain (PWG) = Mean weight gain (g)/ initial mean weight(g) ×100

Haematology studies

Blood samples for haematological analysis were collected

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at the end of the feeding trial from the caudal peduncle of both the test and control fish with a sharp surgical blade, the blood samples were dispensed into tubes containing ethylene diamine tetra acetate (EDTA) and empty bottles to determine the following blood parameters.

Red Blood Cells (RBC): The blood of the fish was diluted in an improved newbauer pipette with formal citrate fluid at 1:200. The diluted blood was introduced into a newbauer counting chamber and the red blood cells counted under microscope [12].

White Blood Cells (WBC): For the white blood cell count, blood was diluted at 1:20 with diluting fluid. The resulting mixture was introduce into newbauer counting chamber and counted under the microscope [12].

Packed Cell Volume (PCV): To determine the packed cell volume, a haemotocrit tube was three quarters filled with blood and the ends sealed with critaseal, the tube was then centrifuged in a microhaematocrit for 5minutes at 2000g. The PCV was read by a microhaematocrit reader and expressed as the volume of the erythrocytes per 100cm^3 [12].

Mean Corpuscular Haemoglobin Concentration (MCHC): The mean corpuscular haemoglobin concentration was calculated as:

$$MCHC = \frac{Haemoglobin\ concentration\ (g/100ml)}{Packedcell\ volume}$$ [12].

Mean Corpuscular Volume (MCV): The mean volume of each red blood cell was estimated using the following formular

$$MCV = \frac{packed\ cell\ volume\ (PCV)\times 10}{Brythrocyte\ count}$$

Mean Corpuscular haemoglobin (MCH): The haemoglobin content of a single red blood cell was calculated as;

$$MCH = \frac{Haemoglobin\times 10}{Erythrocyte\ count}$$

Haemoglobin (Hb): The cyamethaemoglobin method was used. 0.02cm^{3}of blood was placed on 4cm^3 of drabkins reagent in a test tube and mixed. After 30minutes, the optical density was read calorimetrically at 540µm. values of haemoglobin were determined by comparing with cyamethaemoglobin standards [13].

Sperm quality determination: Male fish were randomly selected from all the treatments for milt collection. The male fish were sacrificed and the testes were removed, then the sperm were examine and snapped and viewed under the computer aided sperm analysis microscopic system.

Milt count: Concentration of sperm was determined by counting the numbers of spermatozoa in sample dilute with distilled water (100×) in a Burker haemocytometer under 400×magnification [14].

Percentage motility: Each sample was estimated using large microscope at 400×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) was counted; motile sperm cell (MC) was calculated [4].

MC= WSC−ISC

MC%= MC/WSC×100

Sperm morphology: The milt was analysed with the use of a computer aided sperm analysis system and the data were mathematically elaborated to obtain numerical indices expressing the statue of the ejaculation.

Chemical analysis: Proximate composition of test ingredient (bitter kola), fish sample and experimental diets were determined according to the method of A.O.A.C [15].

Statistical analysis: All data collected during experimental period were subjected to one-way analysis of variance (ANOVA) using completely randomized design in accordance with SPSS (2000) and Duncan's multiple range tests was employed to reveal significant differences among the treatment means.

Results

The proximate composition of Bitter Kola Seed Meal (BKSM) is presented in the Table 2. Bitter kola seed meal had a crude protein of 2.45%, crude fiber 6.50%, ether extract 2.50%, ash 6.10% and dry matter 93.46%.

Table 2: The proximate composition of Bitter kola seed meal.(Test Ingredient).

Parameters	Percentage (%)
Crude protein (CP)	2.45
Crude Fiber (CF)	6.50
Ether Extract (EE)	2.50
Ash	6.10
Dry matter	93.46
Moisture	6.54
Nitrogen Free Extract	75.91

The carcass composition of the experimental fish fed varying inclusion levels of bitter kola after the experiment is as shown in Table 3. There was a high significant different (p<0.05) between the crude protein of treatment T5(61.60%) than treatment T1(31.80%) having the lowest crude protein. Treatment T6 had the highest ash (13.10%), treatment T3 had the highest crude fiber, and treatment T2 had the highest ether extract (11.90%) and dry matter (89.80%).

The growth performance and nutrient utilization of Africa catfish fed varying inclusion levels of Bitter Kola Seed Meal (BKSM) is presented in Table 4. All production performance measured were significantly influenced (p<0.05) by the increasing inclusion levels of bitter kola seed meal except the IMW which was not significantly influenced (p>0.5).The result obtained revealed that fish fed 50g/kg BKSM (T2) recorded highest values for the FMW, MWG, SGR, AFI and PER while

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the least values of FMW, MWG, PWG, SGR, AFI, PI and PER were obtained by the fish fed 200g/kg BKSM (T6). Poor FCR were recorded at dietary treatment T2 while the best FCR was recorded at dietary treatment T6.

Haematology of African catfish fed varying inclusion levels of bitter kola seed meal (BKSM) is as shown in Table 5. There were no significant effects ($p>0.05$) on haematological parameters of African catfish fed with varying levels of bitter kola seed meal.

Table 3: Proximate carcass composition of African catfish (*Clarias gariepinus*) fed bitter kola seed meal.

Parameters	T1	T2	T3	T4	T5	T6	SEM
%Crude protein	31.80^{c}	37.63^{c}	53.50^{ab}	52.85^{ab}	61.60^{a}	45.00^{cd}	2.70
%Ash	11.50	7.90	10.00	11.20	10.90	13.10	0.83
%Crude fiber	3.80	4.90	4.20	3.20	3.60	4.10	0.23
%Ether extract	10.70	11.90	10.40	8.35	8.80	8.20	0.72
%Dry matter	85.80	89.80	83.75	87.30	88.50	81.90	1.90

Mean in the same row with the same superscript are not significantly different (P>0.05). BKSM- Bitter kola seed meal, T1- control, T2- (fish fed 50g kola/kg BKSM), T3- (fish fed 100g kola/kg BKSM), T4 - (fish fed 150g kola/kg BKSM), T5- (fish fed 200g kola/kg BKSM), T6- (fish fed 250g kola/kg BKSM), SEM-standard error of means.

Sperm count, percentage motility, percentage immotile, sperm morphology, live and death percentage of African cat fish fed varying inclusion levels of bitter kola seed meal is as shown in Table 6. There were significant difference ($p>0.05$) in all the treatments. The fish fed 150g/kg BKSM (T4) had greatest live percentage, motility percentage, sperm morphology and sperm count (88.68%, 84.40%, 87.27% and 88.40%) compared with fish fed other different inclusion levels of bitter kola seed meal. However, fish fed control diet had the least values of all the parameters measured.

Discussion

The use of bitter kola in the diet of African cat fish in this study has revealed its ability to enhance sperm quality as well as improving growth better than the control diet with no inclusion level of bitter kola seed meal. Differential growth among the control diet and other diets with various inclusion levels of bitter kola seed meal(BKSM) as observed in the study is definitely not due to protein since isonitrogenous diet was used for the study however, variation in this study is strongly linked to the presence of bioflavonoid in *Garcinia kola* which stimulates growth in fish as previously reported by Braide [16]. Kocour, et al., [17], revealed that bioflavonoid is plant

Table 4: Growth Performance and Nutrient Utilization of Juvenile African Catfish Fed Varying Inclusion Levels of Bitter Kola Seed Meal.

PARAMETERS	T1	T2	T3	T4	T5	T6	SEM
IMW (g)	232.40	235.20	228.80	227.85	230.80	234.80	1.00
FMW (g)	403.94^{b}	431.07^{a}	410.20^{b}	401.92^{b}	350.23^{c}	260.64^{d}	4.08
MWG (g)	171.50^{c}	196.10^{a}	181.40^{b}	174.30^{bc}	119.40^{d}	25.80^{e}	12.18
PWG (%)	73.80^{b}	83.40^{a}	79.30^{ab}	76.60^{ab}	51.70^{c}	11.00^{d}	5.32
SGR (%/day)	0.79^{a}	0.87^{a}	0.84^{a}	0.81^{a}	0.60^{a}	0.14^{b}	0.06
FCR	0.91^{b}	0.72^{d}	0.74^{cd}	0.86^{b}	0.79^{c}	1.01^{a}	0.02
AFI (g)	21.71^{a}	22.03^{a}	21.81^{a}	24.55^{a}	19.80^{ab}	15.02^{b}	0.92
PI	1049.20^{a}	881.20^{b}	870.40^{b}	982.00^{a}	792.00^{b}	600.80^{c}	31.73
PER	0.16a^{b}	0.22^{a}	0.21a^{b}	0.18a^{b}	0.15^{b}	0.04^{c}	0.01

Mean in the same row with the same superscript are not significantly different (P>0.05). BKSM- Bitter kola seed meal, T1- control, T2- (fish fed 50g kola/kg diet), T3- (fish fed 100g kola/ kg BKSM), T4 - (fish fed 150g kola/kg BKSM), T5- (fish fed 200g kola/kg BKSM), T6- (fish fed 250g kola/ kg BKSM), SEM: Standard Error of Means; IMW: Initial Mean Weight; FMW: Final Mean Weight; MWG: Mean Weight Gain; PWG: Percentage Weight Gain; SGR: Specific Growth Rate; FCR: Feed Conversion Ratio; AFI: Average Feed Intake; PI: Protein Intake; PER: Protein Efficiency Ratio; SEM: Standard Error of Mean; T: Treatment.

Table 5: Heamatology Of African Catfish Fed Varying Inclusion Levels Of Bitter Kola Seed Meal.

PARAMETERS	T1	T2	T3	T4	T5	T6	SEM
RBC(10^{6}/µl)	3.71	2.63	3.32	3.18	3.44	3.30	0.16
WBC	17.10	14.80	15.50	15.00	16.40	11.75	1.04
HB(g/dl)	9.20	9.80	10.00	10.20	10.51	8.70	0.66
LYM	65.25	61.00	62.00	62.00	60.00	64.00	3.85
PCV (%)	27.00	31.00	33.00	35.00	37.00	29.00	1.94
ALB	1.60	2.09	1.94	1.50	1.64	1.42	0.16
MCV(fl)	72.47	119.23	100.00	109.38	108.82	86.13	8.94
MCH(pg)	24.80	37.36	30.12	32.08	30.52	26.13	2.25
MCHC(g/dl)	35.93	31.61	30.30	29.14	28.38	30.00	1.88

Mean in the same row with the same superscript are not significantly different (P>0.05). BKSM- Bitter kola seed meal , T1- control, T2- (fish fed 50g kola/kg BkSM), T3- (fish fed 100g kola/kg BKSM), T4 - (fish fed 150g kola/kg BKSM), T5- (fish fed 200g kola/kg BKSM),T6- (fish fed 250g kola/kg BKSM). RBC: Red Blood Cell; WBC: White Blood Cell; HB: Haemoglobin; LYM: Lymphocyte; PCV: Packed Cell Volume; ALB: Albumen; MCV: Mean Corpuscular Volume; MCH: Mean Corpuscular Haemoglobin; MCHC: Mean Corpuscular Haemoglobin Concentration; SEM: Standard Error of Mean.

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Table 6: Effect of Bitter kola on sperm motility of African catfish (*Clarias gariepinus*).

Parameters	T1	T2	T3	T4	T5	T6	SEM
Sperm Count	85.40^{c}	83.80^{d}	86.40^{bc}	88.40^{a}	83.20^{d}	87.60^{b}	2.05
% Motility	82.42^{cd}	83.13^{b}	82.00^{d}	84.40^{a}	82.11^{cd}	82.86^{c}	1.84
% Immotile	17.58	16.87	18.00	15.60	17.89	17.14	1.56
%Sperm morphology	85.87^{b}	85.71^{bc}	85.15^{c}	87.27^{a}	84.38^{d}	84.91^{cd}	2.34
Live %	88.17	88.24	87.26	88.68	86.48	88.57	2.67
Death %	11.83	11.76	12.75	11.32	13.54	11.43	0.78

Mean in the same row with the same superscript are not significantly different (P>0.05). BKSM- Bitter kola seed meal, T- Treatment: T1- control, T2- (fish fed 50g kola/kg BKSM), T3- (fish fed 100g kola/kg BKSM), T4 - (fish fed 150g kola/kg BKSM), T5- (fish fed 200g kola/kg BKSM), T6- (fish fed 250g kola/kg BKSM), SEM – standard error of means.

chemicals with estrogenic activity which promotes growth in fishes. Although, high consumption of plant species containing tannin such as *Garcinia kola* significantly reduced voluntary feed intake in ruminants while low consumption seem not to have any affect [18].

A retarded growth effect was reported by Akpantah, et al., [19], on rat treated with *Garcinia kola* seed extract for six weeks. However, the results observed shows that there was significant differences (p>0.05) in the mean weight of fish fed with *Garcinia kola* seed meal. The weight of the fish was depressed progressively in all the treatments subjected to *Garcinia kola* at the inclusion level from 50-250g/kgBKSM despite the drying process of bitter kola which would have reduce the effectiveness of tannins, the higher the inclusion level of bitter kola seed meal in the feed, the lower the weight. This is attributed to the inhibition of protein metabolism by tannins in *Garcinia kola* may be responsible for weight depression in African catfish fed on *Garcinia kola* seed meal in this study. Anti-atherogenic and anti-adipogenic effect of kolaviron present in *Garcinia kola* seed which inhibits the accumulation of lipid droplets in fat cells when other extracts are low [20].

Haematological parameters are routinely used for the evaluation of physiological environment and husbandry stressors in fishes [21]. In recent year good management practices have been advocated as effective's ways of reducing stress in fish culture [22]. Many researchers have proved that change in blood characteristics of African catfish is due to stress, exposure to the environmental pollutant or by pathogen [22-24]. Also, haematological component of blood are valuable in the monitoring of feed toxicity especially with feed constituents that affects the formation of blood in culture fisheries [25]. Packed cell volume (PCV) range of 27.00 to 37.00% observed in this study is within range of 20 to 50% reported by Piestse, et al., [26]. And rarely do values above 50% being reported [27,28]. Reduction in the concentration of the PCV in the blood usually suggests the presence of toxic factor example of which is haemagglutin which has adverse effect on blood formation [25]. White blood cells (WBC) and lymphocytes result recorded in this study showed a decrease as the level of bitter kola seed meal increases in the diet. The highest value 17.10×10^{3}/µ for WBC was recorded in the control diets as well as that of lymphocyte 65.25%. WBC and LYM are the defense cells of the body. Douglas and Jane [29], demonstrated that the amount has implication in immune response and the ability to fight infection. High WBC is usually associated with microbial infection or the circulating system [25]. The value recorded in this study (11.75-17.10) is also within the range recommended value of (16.13×10^{3} to 16.39×10^{3}mm) as reported by Sotolu and Faturoti [30]. The range of Red Blood Cell (RBC) recorded in this study is ($2.63-3.71\times10^{6}$/µ) which is fairly comparable to (1.70×10^{6} to 4.00×10^{6}mm^{-3}) recommended by Bhasker and Rao [31] and more than that (2.24×10^{6} to 2.49×10^{6} mm^{-3}) by Sotolu and Faturoti (2009)[30].

Sperm quality can be quantified by evaluation of sperm motility and fertilization rate but the former is a faster approach than the latter [31]. The dietary inclusion level of *Garcinia kola* seed meal affected some parameters of sperm quality in *Clarias gariepinus* such as sperm count, percentage motility, and live percentage. The treatments were significantly different (p<0.05). Researchers observed that spermatozoa of *Clarias gariepinus* were active or motile for only 30 sec. Motility of the spermatozoa is the most commonly used indicator for sperm quality since high motility is a prerequisite for fertilization and correlates strongly with fertilization process [33,34]. Moreover, reproductive capacity is the most conclusive way of testing sperm motility [5].

In this study, the sperm count, sperm motility, sperm morphology and live percentage were higher in treatment 4(88.40%, 84.40%, 87.27%, 88.68%) respectively than treatment T1. Treatment T5 was observed to have the lowest percentage motility (82.11%), sperm morphology (84.38) and live percentage (86.48%). It was reported by Uko, et al., [7], that rats fed *Garcinia kola* seed extract exhibited increased libido (sexual instinct) for the male rats justifying the use of *Garcinia kola* by native as an aphrodisiac, but did not improve pregnancy rates in female rats as a measure of the male fertility index. The findings of Adeparusi, et al., [6], also agrees that male *Clarias gariepinus* fed *Kigelia africana* had significantly higher sperm count than the control.

Conclusion

In conclusion, this study showed that:

- *Garcinia kola* at all inclusion levels was insignificant on the haematological parameters of *Clarias gariepinus* meaning that the fish can tolerate higher inclusion of *Garcinia kola* without any adverse effect.
- Inclusion of Bitter kola seed meal at the rate of 150g/kg (T4) in the diet of African catfish enhances sperm

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quality (highest sperm count, sperm motility, sperm morphology and live percentage)

- Higher level of Bitter kola seed meal inclusion *in* the diet of African cat fish reduced the growth performance.

Recommendation

It is therefore suggested that:

- Bitter kola (*Garcinia kola*) seed meal at 150g/kg inclusion level can be used by fish farmers to enhance sperm quality and thereby increasing the production rate of African catfish (*Clarias gariepinus)*.
- The use of Bitter kola (*Garcinia kola*) seed meal for improving sperm fertility is not exorbitant in price (with respect to the quantity required by the farmers) therefore it is of high economic value because it reduces the cost of production compare to hormonal drugs that are very expensive.

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