Tamko ANN, et al., J Aquac Fisheries 2024, 8: 100
DOI: 10.24966/AAF-5523/1000100

HSOA Journal of Aquaculture & Fisheries

Research Article

Diet Supplementation of *Cyprinus Carpio* with *Garcinia Kola* Seed Powder: Effect on Productive Performance and Body Composition

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Abstract

This study was undertaken to assess the effect of dietary supplementation of *Garcinia kola* powder on growth, feed nutrient utilisation and body composition of *Cyprinus carpio* fingerlings. A total of 240 fingerlings (5±1,01g), collected in a hatchery pond of the farm were randomly distributed in triplicate in 12 hapas installed in a fertilised pond. They were fed for 56 days with four diets: control diet (D0mg/kg diet) without dietary supplement and three experimental diets (D75mg/kg diet, D150mg/kg diet and D300mg/kg diet) containing *G. kola* powder at different doses. Intermediate sampling was performed biweekly for fish counting and biometric measurements. From the results obtained, feeding *Cyprinus carpio* fingerlings with diet D150mg/kg diet induced both the best productive performance and body composition compared to others, particularly the control diet. Weight gain (WG=34.21±1.13g), specific growth rate (SGR=3.32±0.08%/day) and feed conversion ratio (FCR= 1.49+0.08) were significantly different compared to control (WG=17.72±1.41g, SGR=1.03±0.08%/day and FCR=2.46±0.11), with high impact in body nutrient retention. Body composition in protein (15.94±0.03%) and lipid (1.84±0.01%) was significantly high compared to that of the start fish (protein=10.53±0.04%, lipid=0.80±0.01%) and those produced with the control diet (protein=14.28±0.03%, lipid=1.50±0.07%). This finding shows that dietary supplementation with G. kola at 1.5% inclusion improved growth performance, feed nutrient utilisation and retention as well as body biochemical composition in *Cyprinus carpio* fingerlings; making it a potential additive that can be included in the diet of common carp to improve its production.

Keywords: Body composition; *Cyprinus carpio*; Garcinia kola; Growth, Nutrient utilisation

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Citation: Tamko ANN, Nyadjeu P, A'assiyatou Z, Tomedi-Tabi ME (2024) Diet Supplementation of *Cyprinus Carpio* with *Garcinia Kola* Seed Powder: Effect on Productive Performance and Body Composition. J Aquac Fisheries 8: 100.

Received: December 23, 2024; **Accepted:** December 31, 2024; **Published:** December 31, 2024

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Introduction

Food security is one of the biggest concerns these days [1]. The food needs of a population that is expanding and becoming more urbanised require greater intervention in production systems. In order to contribute in improving food security by supplying animal proteins with high nutritional value, chemicals like antibiotics, mostly as feed additives, are being utilised more and more to enhance aquaculture production. The use of antibiotics in aquaculture systems induced an increase in the emergence of resistant microorganisms [2] and also an increase in environmental pollution. Residues of antimicrobials in the flesh of farm animals have received much attention in recent years because of public health concerns [3]. The banning of antibiotic as growth promoters for animal feeding led to the development of several alternatives [4]. Nowadays, new initiatives in the livestock industries are seeking to promote the use of alternative materials that combine the effects of nutritional and medicinal properties, simultaneously. This is expected among others benefits to reduce the high cost of production in the livestock industry as a result of the reduction in dual costs of feed and drugs [4]. Several plants with medicinal value which can be used as natural growth promoters have been identified [5]. *Garcinia kola* is one of them with both medicinal and nutritional properties which has been the subject of several studies [6].

Garcinia kola (bitter kola) also known as African wonder nut, belongs to the Guttiferae family. It is an economic and highly valued perennial crop distributed throughout West and Central Africa and is regarded as a miracle plant because every component has medicinal use [7,8]. Traditionally, the nuts of bitter kola are chewed as masticatory substance to stimulate the flow of saliva, and the kernel of the nuts are widely traded and eaten as a stimulant [4]. The seeds were found to have significant biological activity due to *G. kola* containing nutritionally and pharmacologically essential compounds [8]. This plant is also widely used for its medicinal properties; thanks to its phytochemicals compounds: Oleorisin, tannin, saponins, alkaloids, cardiac glycosides, bioflavonoids (such as kolaflavonone and 2 hydroxyflavonoids), garcioic and garcinal together with tocotrienol, polyisoprenylated benzophenone and reducing sugar, are some bioactive compounds isolated from bitter kola [9,10]. Bioflavonoids isolated from *Garcinia kola* is an active chemical, a plant growth promoter and has been reported for its potent antioxidant and anti-inflammatory properties [11]. Benzophenones, flavonoids, and xanthenes are also among the components found in *G. kola* [8]. These components are known to have antiparasitic, anti-inflammation, antibacterial, and

antiviral activities. These properties facilitate food use, thus promoting the bioavailability of nutrients. Bitter kola seeds powder has been reported to promote growth in rats [12], poultry [13], sharptooth catfish, *Clarias gariepinus* [7] and *Oreochromis niloticus* [14]. The growth promotion could be attributed to efficient nutrient digestibility and utilisation [15] as major constituents of bitter kola (alkaloids and flavonoid) stimulate an increase in gastric acid secretion (Oluwole and Obatomi, 1991). The effect of *Garcinia kola* as anti-pollutant has also been proved [16].

Cyprinus carpio (Common carp) a very well-known benthivorous fish, belonging to the family Cyprinidae, which is considered the largest family of freshwater fish [17]. With 4.2 million tonnes produced in 2020, common carp is the fourth most produced aquaculture species, representing 8.6% of inland aquaculture world-wide [18]. It is widely distributed in almost all countries of the world and has been imported in Cameroon from Israel in 1969. It adapts well to the tropical climate of the western highlands area since it reproduces naturally in pond [19]. Common carp can be used as a management tool to control the system ecology to achieve high growth and production of filter-feeding fish [17]. It is an important seed dispersal for aquatic vector for aquatics plants [20]. However, common carp farming is facing several issues which are limiting the expansion of its production, as diseases and the rising cost of conventional raw materials for feed formulation. These are lead farmers to look an alternative resource to the conventional raw materials for safe and sustainable carp production [21]. Regarding the importance of common carp as protein sources, its use in a polyculture system, this study was carried out to investigate the effect of *Garcinia kola* powder on productive performance and body composition of *Cyprinus carpio* fingerlings.

Materials and Methods

Study area and Experimental facility

The study was carried out from March to July 2021 in the technical facilities of a private fish farm (GIC AIO) at Batié in the West Region of Cameroon. A total of 250 *Cyprinus carpio* fingerlings weighing 5±1,01g coming from the same farm were used. Ten (10) fingerlings were set aside for the initial body biochemical analysis and the others (240) were randomly distributed in 12 hapas (0.5m ×0.5m × 1m, L: W: H and mesh: 2mm) installed in an 80m^2 fertilised pond.

Test ingredient processing

Garcinia kola seeds were purchased from a local market at Batié. The outer coats of the bitter kola were removed and the seeds were sundried, milled in fine particle, packaged in sterile 1-mm thick high-density polyethylene sachet, labelled and stored away from humidity until used.

Diet formulation and preparation

Four isonitrogenous diets (50% crude proteins) were formulated. Feed ingredients including fish meal, soybean cake, peanut cake, wheat bran, maize meal, Cassava meal were obtained from a local market at Batié. Amount of 0 (control), 75, 150 and 300mg of bitter kola seeds powder per kg of diet were mixed with a basal diet and the diets were represented as D0mg.kg^{-1} diet, D75mg.kg^{-1} diet, D150mg.kg^{-1} diet and D300mg.kg^{-1} diet respectively (Table 1). All the ingredients were ground into fine particles, weighing and mixing manually for approximately 15min. The preparation was then moisturised with warm water (400mL/kg) and mixed for 30 minutes. Palm oil was added during mixing to achieve proper consistency and cassava starch was added as a binder. The mixing product was then pelleted into a 2.0 mm diameter pellet using a pellet machine. The diets were then sundried during 48 hours and packed in polyethylene bags, sealed and appropriately labelled before stored in a freezer. The diets were analysed for proximate composition using the AOAC method (1990); to determine the percentage composition of the various components of the diet. Moisture was determined by drying the sample in an air convection oven at 105°C overnight. Crude protein was analysed by the Kjeldahl method after acid digestion (%crude protein=%nitrogen × 6.25), while crude lipid was determined by extraction with petroleum ether using the Soxhlet method. The ash content in the diet was analysed by combustion of samples in a muffle furnace at 550°C for 12 h (Table 1).

Ingredients	D0mg/kg diet	D75mg/kg diet	D150mg/kg diet	D300mg/kg diet
Garcinia kola	0	0,75	1,5	3
Fish Meal	35	35	35	35
Soybean cake	23.9	23.9	23.9	23.9
Peanut cake	10	10	10	10
Wheat bran	7.1	7.1	7.1	7.1
Maize meal	5	5	5	5
Cassava meal	1	1	1	1
Premix	1	1	1	1
Palm oil	1	1	1	1
iodizes salt	1	1	1	1
Vitamin C	1	1	1	1
Proximate composition				
Protein	50,4	47,6	50,5	50,6
Lipid	17,6	18,4	18,5	17,2
Ash	7	9	9	9
Moisture	10	12	9	11
Dry matter	90	88	91	89
Energy (kcal/100g DM)	460	456	456,5	450

Table 1: Formulations and proximate composition of experimental diets (g/100g dry weight).

Experimental design

Two hundred and forty (240) farm-raised *C. carpio* fingerling weighing 5 ± 1.01g were acclimatised for 7 days before being randomly distributed into 12 hapas (20 fish hapas^{-1}) representing four treatments named D0mg kg^{-1} or control without *G. kola* seed powder and four experimental treatments D75mg kg^{-1}, D150mg kg^{-1} and 300mg kg^{-1} where diets were supplemented at 0.75%, 1.5% and 3% with *G. kola* seed powder. Fish were fed at 5% of their body weight three time a day (08:00am, 12pm and 06:00pm). All fish were weighed and counted fortnightly and feeding rates were adjusted accordingly. During the experimental period Temperature (T°C), pH, transparency, Dissolved Oxygen (DO), Nitrites (NO_2^-) and Nitrates (NO_3^-) were measured twice a day (6 am and 5 pm) before feeding (Table 2).

Measurement of growth performances, feed efficiency and nutrient retention

An intermediate sampling was carried out every 14 days, during which all fishes in each treatment were counted, weighed and total

	Rearing period (days)				
Parameters	1	14	28	42	56
T°C (°C)	22.33±0.46	20.9±0.42	20.15±1.34	21.38±1.16	19.95±0.21
Transparency (cm)	27.55±3.60	24.2±1.13	24.1±0.14	22.5±0.70	22±1.41
pH	7.25±0.35	7.25±0.35	7.44±0.79	7.25±0.35	7.755±0.3
D.O (mg/l)	5.5±0,01	5.4±0.01	5.5±0.02	5.3±0.03	5.5±0.01
NO_2^- ($mg.l^{-1}$)	0.00±0.00	0.01±0.00	0.01±0.00	0.01±0,00	0.01±0,00
NO_3^- ($mg.l^{-1}$)	0.00±0.02	0.10±0.01	0.10±0.01	0.10±0.05	0.10±0.04

Table 2: water quality parameters (Mean±SD) during 56 days of the experimental period.

body length measured after a 24 hours fast. At the end of the experimental period (56days), growth performances, feed efficiency parameters, and nutrient retention were assessed by determination of Weight Gain (WG), Specific Growth Rate (SGR), Feed Intake (FI), feed conversion ratio (FCR), Protein Efficiency Ratio (PER), survival rate (SR), and Nutrient Retention (NR). Calculations were carried out using the following formulae:

a) $WG(g) = Wf - Wi;$

b) $SGR\ (\%g/day) = \frac{\ln Wf - \ln Wi}{T} x\ 100$

Where: Wf = final weight; Wi = initial weight; Lf= final length; Li= initial length; T= number of days in the experimental period;

c) $SR\ (\%) = \frac{\text{Final number of fish}}{\text{Initial number of fish}} x\ 100$

d) $FI\ (g/fish) = \frac{\text{Total dry feed distributed}}{\text{number of fish}}$

e) $FCR = \frac{\text{Feed intake}}{\text{Fish weight gain}}$

f) $PER = \frac{\text{Fish weight gain}}{\text{Protein fed}}$

Where, $\text{Protein fed} = \frac{\text{Total feed consumed x Crude protein in feed}}{100}$

g) $NR\ (\%) = \frac{\text{Final carcass composition} - \text{Initial carcass composition}}{\text{Amount of nutrient fed}} x\ 100$

Organosomatic indices

Organosomatic indices were used to know the condition of the experimental fish by determining the Viscero Somatic Index (VSI) and Hepatosomatic Index (HSI) according to Kubiriza *et al*. [20] as follows:

$$Viscero\ somatic\ index\ (VSI) = \frac{FVM}{FBM} \times 100$$

Where FVM=Fish visceral mass (g); FBM= Fish body mass (g)

$$Hepatosomatic\ index = \frac{LM}{BM} \times 100$$

Where LM = liver mass (g); BM = body mass (g)

Statistical analysis

All results were expressed as mean ± SD. The data collected during every fish sampling were analysed by one-way analysis of variance (*ANOVA*-1) repeated measure followed by Tukey's multiple comparisons test with n=3 replications containing 20 fish each. Differences were regarded as significant when $p<0.05$. Regression analysis was used to determine the relationship between some dependent variables (fish growth and protein retention) and the independent variables such as dietary levels of *G. kola* seed powder and protein intake. All statistical analyses were conducted using *GraphPad Prism* version 6.0.

Results

Growth performances

Growth performances of *Cyprinus carpio* fingerlings fed with different diets in terms of weight gain and specific growth rate are presented in (Figure 1). There were improvements in the growth responses of fish fed on *G. kola* meal. The fish fed diet containing *G.kola* meal at the dose of 150mg/kg recorded significantly highest ($P<0.05$) mean final weight of 40.54 ±1.10g followed by the fish fed the lowest dose of 75mg/kg, with 37.14±0.75g. However; fish fed control diet recorded significantly ($P<0.05$) lowest value of 24.22±0.96g. High SGR was observed in fish fed *G. kola* diet at 150mg/kg followed by those fed 75mg/kg, 300mg/kg and control diet respectively. The survival rates (SR) in th experimental treatments D150mg/kg and D300mg/kg diets were 100% versus the control (SR= 93%). Moreover, the relationship between fish growth and dietary inclusion level of *G.kola* meal is illustrated by the nonlinear regression curve ($Y=-0.00073x^2+0.22x+0.24$) shown in (Figure 2). It clearly appears a very close relationship between fish growth and dietary inclusion level of *G.kola* meal with $R^2=0.97$. The optimum value of dietary inclusion of *G.kola* was 1.5% beyond which a decrease is observed.

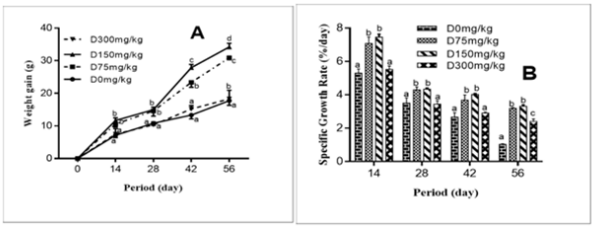

Figure 1: Effect of dietary inclusion level of *Garcinia kola* meal on weight gain (A) and specific growth rate (B) of *Cyprinus carpio* fingerlings for 56 days. Means on the same sampling period carrying different superscripts are significantly different from each other at $p<0.05$.

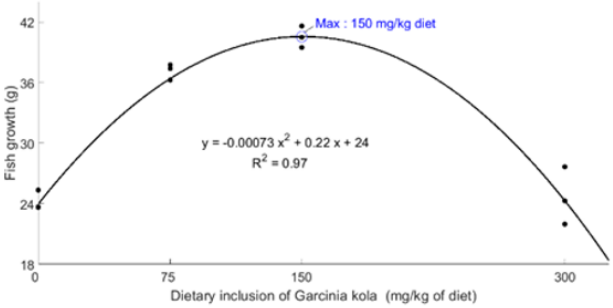

Figure 2: Regression analysis between Fish growth (g) and Dietary inclusion of *Garcinia kola*. Equation and coefficient of determination are specified.

Feed nutrient utilisation and biological parameters

Nutrient utilisation and some biological parameters of *Cyprinus carpio* fed varying inclusion levels of bitter kola seed meal during 56 days, are presented in (Table 3). All the parameters measured were significantly influenced ($p<0.05$) by the increasing inclusion levels of *G. kola* seed meal except the viscerosomatic and hepatosomatic index which were not significantly influenced ($p>0.05$). The highest values for feed intake (FI=51.08±1.73), protein intake (PI=25.70±0.58), and lipid intake (LI=9.19±0.36) were recorded with fish in treatment D150mg/kg, while the lowest values were obtained with fish in treatment D300mg/kg. There were no significant differences ($p>0.05$) in the FCR values of D75mg/kg and D150mg/kg whereas there was a significant difference ($p<0.05$) between FCR value of these treatments and the treatments D0mg/kg and D300mg/kg.

The equation resulted from orthogonal test were square equation as $Y = - 0.000023x^2 + 0.0071x + 0.87$, $R^2 = 0.83$ and $Y= -0.000057x^2 + 0.018x + 2.4$, $R^2 = 0.80$ [Figure 3]. This non-linear regression analysis to express a relationship between protein efficiency ratio, lipid efficiency ratio and dietary inclusion of *Garcinia kola* powder (mg/kg of diet) revealed that, there is a correlation between protein efficiency ratio (R^2=0.83), lipid efficiency ratio (R^2=0.80) and dietary inclusion of bitter kola seed meal. The optimum dose of the *G.kola* in the feed was 150mg/kg with the maximum value of Lipid Efficiency Ratio (LER =3.73±0.21).

Parameter	D0mg/kg	D75mg/kg)	D150mg/kg	D300mg/kg	p
Wi	6.50±0.50	6.23±0.23	6.33±0.21	6.37±0.23	ns
Wf	24.22±0.96^{a}	37.14±0.75^{b}	40.54±1.10^{b}	24.64±0.36^{ac}	**
FI (g/fish)	42.33±2.31^{a}	47.33±2.52^{ab}	51.08±1.73^{ab}	38.33±2.65^{ac}	*
PI (g/fish)	21.30±1.53^{a}	22.30±0.58^{ab}	25.70±0.58^{ac}	19.00±1.00^{ad}	*
LI (g/fish)	7.66±0.75^{a}	8.52±0.90^{ab}	9.19±0.36^{ab}	6.45±0.39^{ac}	*
Survival (%)	93.0±7.64	97.00±5.77	100.00±0.00	100.00±0.00	ns
FCR	2.46±0.11^{a}	1.55±0.17^{b}	1.49±0.08^{b}	2.10±0.30^{ab}	*
PER	0.80±0.03^{a}	1.37±0.14^{b}	1.33±0.07^{b}	0.96±0.15^{ab}	**
LER	2.26±0.10^{a}	3.59±0.18^{b}	3.73±0.21^{b}	2.84±0.22^{ac}	**
VSI (%)	12.40±0.44	12.53±0.57	12.47±0.33	12.22±0.06	ns
HIS (%)	1.43±0.15	1.52±0.17	1.63±0.08	1.60±0.40	ns

Table 3: Feed utilisation and organosomatic indices of *Cyprinus carpio* fed the experimental diet for 56 days.

Values are mean ± standard deviation of three replicates of 25 fish each. Mean within the row with different superscripts are significantly different each other at $p>0.05$. ns, $p\leq0.05$; *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$

Ni, initial number of fish; Nf, final number of fish; Wi, initial body weight of fish; Wf, final body weight of fish; FI, feed intake; PI, protein intake; LI, lipid intake; SR, survival rate; FCR, feed conversion ratio; FER, feed efficiency ratio; PER, protein efficiency ratio; LER, lipid efficiency ratio,VSI, viscero somatic index; HIS, hepatosomatic index.

Whole-body proximate composition and nutrients retention

The whole-body composition and nutrient retention of the experimental fish fed varying inclusion levels of bitter kola at the end of experimental period (56 days) are presented in (Table 4). The moisture and ash values were not significantly different ($P>0.05$) in the initial fish compared to those obtained at the end of the experiment. However, opposite effects were noticed regarding other macronutrient contents such as proteins, lipids and energy. Differences in the amount of protein and energy in the body of fish fed diet with 1.5% *G. kola* was significantly different compared to the fish fed 3% ($p < 0.05$), while a significant difference in the lipid amount was obtained between fish fed 1.5% dietary supplementation compared to control diet ($P<0.05$). The highest retention value of ash (16.07±0.50% dry feed) and protein (22.24±0.22% dry feed) were obtained with treatment D150mg/kg compared to other treatments, with the lowest ash value was recorded in treatment D300mg/kg (8.31±0.68), and the lowest protein value with the control diet (12.77±0.23).

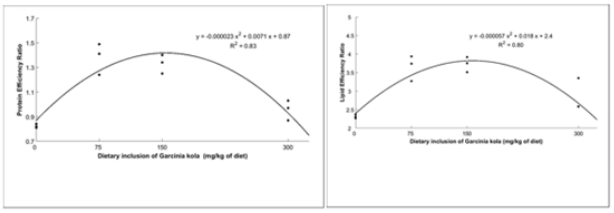

Figure 3: Relationship between protein efficiency ratio, lipid efficiency ratio and Dietary inclusion of *Garcinia kola* powder (mg/kg of diet).

(Figure 4) illustrates the relationship between macro-nutrient retention (%) and dietary supplementation of *Garcinia kola* powder (mg/kg of diet). The nonlinear regression showed that there is a highly relation and closely correlation between the protein retention (R^2=0.84), lipid retention (R^2=0.96), energy retention (R^2=0.99), ash retention (R^2=0.96) and dietary supplementation of bitter kola seed meal with the maximum supplementation obtained in treatment D150mg/kg beyond which a decrease is observed.

Discussion

The aquaculture industry is gearing up to fulfil the increasing demand for fish protein in the market. Aquaculture made a record contribution of 49.2% to global aquatic animal production in 2020. However, aquaculture production of fed aquatic animals remains significantly higher than that of non-fed species [18]. In some regions, such as Africa and Cameroon in particular, feed-free aquaculture is not yet well developed. The development of sustainable aquaculture therefore remains crucial to meet the growing demand for aquatic food products. Sustainable aquaculture requires the use of quality inputs that are easily assimilated by the fish, thus reducing pollution and ensuring good water quality. Water quality is the most important limiting factor in fish production as its quality directly affects feed efficiency, growth rates, fish's health, and survival [14]. Water quality parameters recorded during this study, were within the range recommended for the culture of common carp. The mortalities observed in the fish fed control diet and treatment D75mg/kg could be probably attributed to stress-induced during fish manipulations.

Plant-originated diet additives are known to enhance feed taste or palatability as well as appetite stimulation, digestive enzyme activity, boosting aquatic animal growth performance [23,24]. Enhancement of growth response is due to the presence of some bioactive compounds (flavonoids and phenols) which have antioxidant, anti-inflammatory, antimicrobial and antiviral properties [25]. Flavonoids, non-nutritive

Parameters	initial	D0mg/kg	D75mg/kg)	D150mg/kg	D300mg/kg	p
Whole body Composition (% or kJ/g WW)						
Moisture	83.00±0.02	85.00±0.02	80.00±0.01	81.00±0.05	80.00±0.02	ns
Ash	1.50±0.01	1.80±0.01	2.90±0.04	2.00±0.01	1.53±0.03	ns
Protein	10.53±0.04^{a}	14.28±0.03^{b}	14.93±0.01^{b}	15.94±0.03^{b}	12.21±0.06^{a}	***
Lipid	0.80±0.01^{a}	1.50±0.07^{b}	1.73±0.01^{c}	1.84±0.01^{c}	1.50±0.05^{b}	***
Energy	57.97±0.02^{a}	80.30±0.07^{b}	76.28±0.03^{b}	81.20±0.01^{b}	69.36±0.10^{a}	**
Nutrient Retention (% dry feed)						
Ash		11.90±0.47^{a}	15.84±0.19^{b}	16.07±0.50^{b}	8.31±0.68^{a}	*
Protein		12.77±0.23^{a}	21.62±0.08^{b}	22.24±0.22^{c}	13.37±0.49^{a}	***
Lipid		4.52±0.34^{a}	6.44±0.37^{b}	6.36±0.06^{b}	4.87±0.68^{a}	*
Energy		8.53±0.48^{a}	12.17±0.72^{b}	13.04±0.50^{b}	8.89±0.04^{a}	**

Table 4: Proximal composition and nutrient retention of Cyprinus carpio juveniles obtained after 56 days of feeding.

Values are mean ± standard deviation of three replicates of 35 fish each. Mean within the row with different superscripts are significantly different each other at $p<0.05$. ns, $p\geq0.05$; *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$

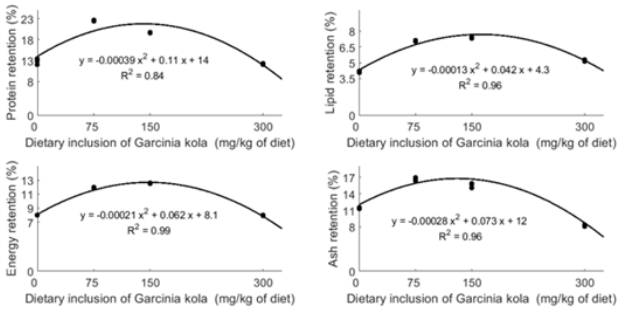

Figure 4: Relationship between Macro-nutrient retention (%) and Dietary supplementation of *Garcinia kola* powder (mg/kg of diet).

plants components with low molecular weight found in all part of plants, can affect the digestive tract, protecting the intestinal epithelium, and decrease the population of growth-depressing gut microbial metabolites, thereby increasing the available nutrients for the animal's utilisation [26,27]. The results obtained in the present study, indicate that the dietary supplementation of *G.kola* significantly enhanced the fish growth performance and feed utilisation. The plant product did not have a negative influence on growth performance except for the batch treated with high level of *G. kola* powder (D300mg/kg). Our results show that the greatest weight gain was obtained with the treatment D150mg/kg, beyond this quantity, the increase in the proportion of *G.kola* had a depressive effect on the growth of the common carp. These results are similar to those obtained by Iwuji and Herbert (2012) who worked on rabbits and showed that above a certain inclusion rate of bitter kola (150mg/kg), weight gain was depressed. Our results also corroborated the findings of Dada and Ikuerowo. (2009), who after evaluating the effect of ethanolic extract of *Garcinia kola* seed on growth of catfish broodstock, showed that the weight gain increased as the inclusion levels of *G. kola* seeds in the diets increased up to 1 g/kg diets and decreased as the inclusion levels increased up to 2 g/kg feed. Oguntoye and Mafindi [15]. also observed that, despite the fact starter broilers chicks tolerate the bitterness of bitter kola, depressed feed intake was observed at highest inclusion level. Although growth is enhanced with bitter kola supplementation, high dose of *G kola* in fish diet may reduce feed intake as a result of its taste. The presence of tannins in bitter kola seeds could also explain this situation. Phytochemical assay of *G. kola* seeds showed that tannin (0.347%) is present in significant amount [28,29]. Despite treatment (drying) of the bitter kola seeds to reduce the content of tannin, the higher the inclusion level of bitter kola seed meal in the feed, the lower the weight [30]. Ingredients containing tannin give feed an unpleasant taste and reduce consumption due to decreased palatability, high consumption of plant species containing tannin significantly reduced voluntary feed intake and low feed utilisation, while low consumption seem not to have any affect [22,31]. Tannins derived from this plant are bitter and form a high polyphenolic complex with proteins, they inhibit absorption by binding with dietary nutrients and forming indigestible complex, thus making proteins unavailable in the diet [9,22] and then reducing the growth response. Since, all the diet was isonitrogenous, weight gain observed in the present study was influenced by seed inclusion level. Improvement of final body weight recorded in fish fed diet with 1.5% bitter kola, may be due to increasing nutrient absorption from the gastrointestinal tract, and also thanks to the presence of bioflavonoids; a plant chemical with estrogenic activity which promotes growth in fishes [24,30]. This result agrees with the findings of Ilo *et al* [30]. who reported that 1.5%-GKSM diet significantly improved the final body weight of rabbits with the better conversion of feed to meat.

The Feed Conversion Ratio (FCR) is a major indicator of feed efficiency in fish farming. The lower the FCR, the higher the weight gain obtained from the feed. In the present study, while the weight gain decreased the FCR increased. The value of the feed conversion ratio in treatment D150mg/kg was significantly lower than in the control and D300mg/kg; with protein intake and lipid intake comparatively higher in D150mg/kg than in D300mg/kg. The lowest FCR value recorded in D150mg/kg indicates a better level of utilisation of bitter kola diet than the control and D300mg/kg diets. These results also corroborated the finding of Ilo *et al*. [30], who worked on rabbit. They reported that FCR was improved at the 1.5% (150mg/kg) level of GKSM compared with 3% and 4.5% levels of GKSM. The increase inclusion level of bitter kola up to 150mg/kg in fish feed can be an indication that overdose could be detrimental to fish. It has been demonstrated that a 3% inclusion of GKSM had a significant reduction in bile secretion and digestive enzyme activities, resulting

in a noticeable decrease of weight gain hence the highest FCR. Feed conversion ratio efficient fish also had higher retention in protein, lipid and energy. Retention in energy, lipid and protein obtained in this study was significantly affected by the dietary inclusion level. The mineral retention was different among the diets. Significantly high fish protein, ash, lipid and energy retention recorded during the present study can be ascribed to differences in feed intake with increased efficiency of mineral retention in treatement D150mg/kg. Inclusion of bitter kola at a certain level enhanced better feed utilisation as such favoured tissues build up [15]. Higher levels of bitter kola had been reported to have growth-depressing effects on rabbits [30]; broiler birds [5] and fish [7,32]. Anti-nutrient factors (tannins and oxalate) present in bitter kola seed may reduce the bioavailability of minerals, such as calcium, which animals use [30], resulting to poor feed intake by fish.

Conclusion

Dietary supplementation with *Garcinia kola* powder significantly improved growth performance and body composition of *Cyprinus carpio* fingerlings. The inclusion level of 1.5% *Garcinia kola* powder in the diet resulted in better weight gain, specific growth rate and feed conversion ratio. Additionally, the supplemented diet led to increased protein and lipid content in the fish body. These results indicate that *Garcinia kola* could be a beneficial additive to improve the fish's grower feed quality and thereby the production of *Cyprinus carpio*.

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