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Effect of *Garcinia kola* seeds supplemented diet on growth performance and gonadal development of *Oreochromis niloticus* juveniles breed in ponds

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Abstract

Background: Despite the favorable geo-climatic potential of Cameroon, the national production of tilapia remains low due to poor tilapia growth reported by fish farmers. One of the underlying reasons is the early female maturation at a very small size and precocious breeding in earthen ponds, resulting in overpopulation which leads to stunted growth and therefore to the production of unmarketable fish size. Studies have shown that dietary supplementation of *G. kola* enhanced growth in young *Clarias gariepinus* and *Oreochromis niloticus*. It was also reported that *G. kola* inhibited spawning in Tilapia adult females. Therefore, this study sought to assess the effects of *Garcinia kola* as growth promoter and inhibitor of gonadal development in young *Oreochromis niloticus*.

Methods: A total of 108 juveniles weighing 13.32 ± 0.62 g were randomly distributed in 9 hapas of 12 fishes each (9 females and 3 males) and fed for 70 days with three isonitrogenous diets, 40% crude protein with increasing *Garcinia kola* supplementation levels of 0 (normal diet), 6% and 10% (experimental diets). Physico-chemical parameters of the water (temperature, dissolved oxygen, pH, nitrate, nitrite, ammonia, and transparency) were measured twice a week. Every 14 days, fish were harvested, counted, and weighed. At the end of the experiment, three fish of each sex per replicate were sacrificed and their gonad and liver collected and weighed. Data were statistically analyzed using one-way analysis of variance repeated measure followed by Newman-Keuls multiple tests.

Results: The results showed that all physico-chemical parameters of the water were within the recommended values for Tilapia culture. Tilapia fed 6% *Garcinia kola* supplemented diet displayed higher final body weight in males (38.60 ± 3.50 g) and females (36.77 ± 3.62 g) compared to those receiving normal diet (36.23 ± 1.36 g and 25.87 ± 3.32 g; respectively to the final body weight in males and females). The gonadosomatic index and hepatosomatic index indicated no significant variation in males while in females, these were significantly low in the experimental fish compared to control fish.

Conclusion: The results of this study demonstrated that supplementation of *G. kola* seeds in diets of young Tilapia improved growth performance and impaired gonadal development in females.

Keywords: *Oreochromis niloticus*, *Garcinia kola*, Growth, Gonad development

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Background

In Africa, particularly in Cameroon, fish food represents the primary source of animal protein. It offers better types of essential minerals, amino acids and is low in undesirable saturated fats (Hussain, 1986). To cope up with nutritional requirements of increasing population, aquaculture is considered as the only possible solution to increase fish production. Tilapia being an important food fish worldwide, significant developments have been recorded during the last three decades in its farming. About 85 countries worldwide are involved in fish farming and about 98% of tilapia produced there are grown outside their original habitats (Shelton, 2002). It provides one of the most important sources of animal protein and income throughout the world (Sosa et al. 2005). In some African countries such as in Egypt, the culture of Nile tilapia *(Oreochromis niloticus*) has increased dramatically in the last few years; while in Cameroon the global production remains insignificant despite the natural potential of the country. One of the major drawbacks to tilapia culture is the early female maturation at very small size (15–30 g) (Mair and Little, 1991; Popma and Lovshin, 1995), and precocious breeding in earthen ponds resulting in overpopulation which often leads to stunted growth. Mair and Little (1991) enumerated various methods and techniques available for the control of prolific breeding in tilapia. However, each technique or method has its own limitations. Monosex culture of all-male populations, which exhibits faster growth rates and which is usually produced through androgenous hormone sex reversal, is the preferred option, and is used extensively in the countries that produce large numbers of tilapia like China (Phelps, 2006). Considering the problem associated with the use of androgenous hormonal treatment, such as environmental and public health concerns and the limitations of existing methods and techniques documented by Mair and Little (1991), there is a need to explore other technologies to control undesirable tilapia recruitment in ponds using natural reproduction inhibitors found in plants to enhance better growth and improved flesh (Jegede, 2010). *Garcinia kola* commonly called Bitter kola belongs to the family Clusiaceae. It is a multipurpose tree indigenous to West and Central Africa (Manourová et al. 2019). The seed of *G. kola* is traditionally served to visitors for entertainment; it is also chewed by men as an aphrodisiac or used to prevent or relieve colic disorders or cure head or suppressed cough (Madubunyi, 2010). Previous studies on rats and poultry have shown that inclusion of *G. kola* seeds in powder and methanolic extracts form improved their growth performance (Oluyemi et al. 2007). Moreover, studies on *Oreochromis niloticus* have shown that dietary supplementation of *G. kola* seeds powder promotes the growth performance. It was also shown that dietary supplementation of *G. kola* seeds powder inhibits spawning in *Oreochromis niloticus* adult females; while in Tilapia fry, it was demonstrated that supplementation of *G. kola* can induce sex conversion (Sulem-Yong et al. 2018; Tigoli et al. 2018). To our knowledge, this study is the first on the effect of dietary inclusion of *G. kola* on gonadal development in nonpuber *Oreochromis niloticus*. Therefore, the present work was undertaken to evaluate the effect of dietary supplementation of *Garcinia kola* seed powder on growth performances and gonadal development of *Oreochromis niloticus* juveniles.

Methods

Collection and acclimation of experimental fish

The experiment was carried out in a small-scale private farm located at Bomabom (LN: 3°41′0″–°46′30″ and LE: 1°7′30″–11°13′0″) in the central region of Cameroon. A total of 108 juveniles of *Oreochromis niloticus* were used; each weighing 13.32 ± 0.62 g with an average length of 8.76 ± 0.41 cm. They were randomly distributed in triplicate into 9 hapas (made up of mosquito net cloth with size 1′ × 1′ × 0.5′) of 12 juveniles each (9 females and 3 males). The hapas suspended in an earthen pond (800 m^2) with the help of four bamboo poles, one at each corner of the cage. The hapas were suspended in the pond such that three-quarters of each hapa was submerged in water whereas one-quarter remained outside. The roof of the hapas was covered with mesh to stop the experimental fish from jumping out and to prevent natural predators (snakes, kingfishers, frogs) from getting in. The fish were then allowed to acclimatize for 4 days prior to the experiment. During the acclimation, the fish were fed with normal diet.

Experimental diet formulation and preparation

A balanced dietary ration formula was prepared to meet the nutritional requirements of Nile tilapia according to NRC (2011) (Table 1). Three isonitrogenous diets were prepared: an unenriched control diet plus two test diets. The test diets were supplemented with 6% and 10% *Garcinia kola* at the expense of maize meal. In preparing experimental diets, the dried ingredients were ground into fine particles. After weighing and mixing manually for 10 min, the preparations were moistened with warm water (400 ml kg^{-1}) and mixed for another 20 min. During the mixing, palm oil was added slowly along with warm water to achieve a proper consistency. The resulting mixture was then passed through a meat extruder to obtain a 2-mm pellet. The "spaghetti-like" strands were sun-dried and stored in airtight containers prior to use. The chemical composition of the test diets was analyzed by standard methods (AOAC, 1990). Moisture was analyzed by drying the sample in an air convection oven at 105 °C overnight. Crude protein was analyzed by the Kjeldahl method after acid digestion (% crude protein =

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

Ingredients	Normal diet	Normal diets + *G. kola* (6%)	Normal diets + *G. kola* 10%
Fish meal	26	26	26
Garcinia kola meal	//	6	10
Soybean cake	23	23	23
Cottonseed cake	22	22	22
Maize meal	10	4	0
Wheat bran	10	10	10
Palm oil	4	4	4
Premix	5	5	5
Total	100	100	100
Proximate composition (%)			
Protein	40.47	40.03	39.73
Lipid	13.23	13.14	13.12
Ash	12.75	12.71	12.68
Moisture	7.74	8.04	7.94
Dry matter	92.26	91.96	92.06
Energy (kcal/100 g)	420.63	418.17	417.20

% nitrogen × 6.25) while crude lipid was determined by extraction with petroleum ether using the Soxhlet method. The ash content in the diet was analyzed by combustion of samples in a muffle furnace at 550 °C for 12 h (Table 1).

Experimental design

Mixed-sex Nile tilapia *O. niloticus* were used in the feeding trial. At the initiation of the experiment, individual weight and length of all fishes per treatment were measured for determination of both initial weight and length. The acclimatized juveniles were randomly distributed in three replicates in 9 hapas each at a stocking density of 12 fish per hapas (9 females and three males). In the first triplicate, fish were fed with normal diet to serve as controls while in the second and third triplicates, they were fed with the *Garcinia kola* supplemented diet at rates of 6% and 10%, respectively. Fish were hand-fed four times per day (08:00 a.m., 11:00 a.m., 14:00 p.m. and 17:00 p.m. respectively) at a rate of 5% of their body weight per day. Feeding rates were adjusted every 14 days for 70 days based on the weight gain of each group of fish per 14 days. Physico-chemical parameters of the water in each hapa such as temperature was measured using a maximum-minimum thermometer; dissolved oxygen (O_2) was determined using JBL Test Kits, pH, nitrate (NO_3^-), nitrite (NO_2^-), and ammonia (NH_3) were measured twice a week before feeding using test strips (JBL Easy Test 6in1) while transparency was monitored using a Secchi disk (Table 2).

Data collection

Growth performances, feed utilization, and somatic indices were assessed by determination of weight gain (WG), specific growth rate (SGR), feed intake (FI), condition factor (K), feed conversion ratio (FCR), protein efficiency ratio (PER), survival rate (SR), hepatosomatic index (HSI), and gonadosomatic index (GSI). Calculations were carried out using the following formulae: weight gain (g) = final weight–initial weight; specific growth rate (%/day) = 100 (lnW2–lnW1)/T, where W1 and W2 are the initial and final weight, respectively, and T is the number of days in the experimental period; survival rate (%) = final number of fish × 100/initial number of fish; condition factor = 100 (weight/length^3); feed intake = total dry feed/number of fish; feed conversion ratio (FCR) = feed intake/live weight gain; protein efficiency ratio (PER) = live weight gain/protein fed, where protein fed = % protein in diet × total diet consumed/100; HSI = 100 (liver weight/body weight); GSI = 100 (gonad weight/body weight).

Statistical analysis

All results were expressed as mean ± SD. Data were statistically analyzed using one-way analysis of variance (*ANOVA*-1) repeated measure followed by Newman-Keuls multiple tests with $n = 3$ replicates. Differences were considered significant when $P < 0.05$. All statistics were carried out using GraphPad Prism version 6.0.

Table 2 water quality parameters (Mean ± SD) during 70 days of the experimental period

Parameters	Rearing period (daRearing period (days)					
	0	14	28	42	56	70
Temperature (°C)	28.10 ± 0.35	28.10 ± 1.10	28.71 ± 0.70	28.1 ± 0.80	28.71 ± 0.70	27.96 ± 0.70
Dissolved oxygen (mg/l)	5.56 ± 0.25	5.46 ± 0.35	5.56 ± 0.32	5.55 ± 0.28	5.55 ± 0.38	5.55 ± 0.37
pH	7.20 ± 0.03	7.34 ± 0.10	7.35 ± 0.10	7.36 ± 0.10	7.22 ± 0.20	7.17 ± 0.20
Transparency (cm)	36.60 ± 4.44	36.61 ± 3.70	37.23 ± 3.40	37.23 ± 4.00	38.85 ± 4.10	36.28 ± 2.20
Ammonia (mg/l)	0.58 ± 0.02	0.50 ± 0.05	0.50 ± 0.05	0.50 ± 0.00	0.50 ± 0.08	0.50 ± 0.02
Nitrite (mg/l)	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00
Nitrate (mg/l)	0.12 ± 0.01	0.12 ± 0.01	0.12 ± 0.02	0.12 ± 0.05	0.12 ± 0.05	0.12 ± 0.05

Results

Growth performances

Growth performances of *O. niloticus* juveniles fed with different diet in terms of weight gain and specific growth rate are presented in Fig. 1. The weight gain recorded during fish sampling showed an increase with respect to time but not according to the *G. kola* supplementation rate (Fig. 1a). Feed supplemented with *G. kola* at 6% induced in *O. niloticus* juveniles the highest values of weight gain as from the fourteenth day of the experiment up to the end. At the end of sampling, fish fed with diet supplemented with 6% of *G. kola* presented a weight gain of 19.46 ± 1.31 g, which was significantly ($p < 0.05$) higher by 17.68% and 32.58% compared to that in fish fed with the normal diet (16.02 ± 1.55 g) and diet supplemented with 10% *G. kola* (13.12 ± 1.58 g) respectively (Fig. 1a). Observation on specific growth rate showed significant ($p < 0.05$) increase in fish receiving a diet containing *G. kola* at 6% compared to fish fed with both the normal diet and diet supplemented with 10% *G. kola* during the first two rearing periods (Fig. 1b).

Survival and feeding efficiency

The results presented in Table 3 illustrate the survival rate and feeding efficiency in term of condition factor, feed intake, protein intake, feed conversion ratio, and protein efficiency ratio on the 70th day of the experiment. No mortality was recorded during the culture period. Similarly, no significant variation in condition factor and feed conversion ratio was observed among the different groups during the study. However, for the feed intake, Protein intake and Protein efficiency, significant differences were obtained only in fish fed diet supplemented with *G. kola* at 6% compared to that receiving diet supplemented with *G. kola* at 10%.

Body weights and organs measurements of sexually mature *Oreochromis niloticus*

The average body weights, hepatosomatic index, and gonadosomatic index per treatments in both males and females were computed and were presented in Figs. 2 and 3. In males, the mean values of body weight (Fig. 2), hepatosomatic index (Fig. 3a), and gonadosomatic index (Fig. 3b) among the different groups were not significantly different. After 70 days of experiment, the mean body weights of 36.77 ± 3.62 g obtained in females fed with 6% *G. kola* supplemented diet was significantly ($p < 0.05$) high compared to the control group (25.87 ± 3.32 g) and groups fed with 10% *G. kola* supplemented diet (26.33 ± 3.34 g) (Fig. 2). Moreover, feeding the female *O. niloticus* with a diet supplemented with *G. kola* significantly ($p < 0.05$) decreased both hepatosomatic index and gonadosomatic index compared to the control group (Fig. 3a, b).

Discussion

Fish is one of the most appreciated foodstuff worldwide and particularly in most of the African countries like Cameroon. However, despite the increase in production of cultured fish from some countries, production from some other countries including Cameroon has not improved yet; statistics show that the supply of fish in Cameroon comes to 43% of fishing (22% of inland fisheries, 21% of sea fisheries), 56.8% of imports and only 0.1% of fish farming, that is 1000 t/year (FAO, 2009; Ndah et al. 2011). One of the reasons for low aquaculture production has been attributed to feeding quality. Research is currently focused on improving the quality of fish feed through replacement or addition of appropriate ingredients that encourage faster fish growth. Tropical forests contain many tree species that have supplied edible fruits for centuries. It has been previously reported in many research works that different plant additives can enhance growth in some fish species such

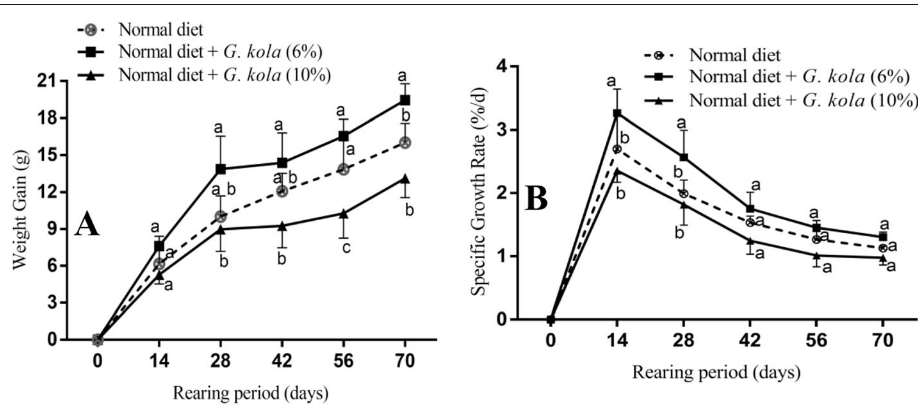

Fig. 1 Effects of diet supplementation with *Garcinia kola* seeds on mean weight gain (**a**) and specific growth rate (**b**) of *Oreochromis niloticus* juveniles. Mean on the same rearing period carrying the same superscript are not significantly different at $p < 0.05$

Table 3 Survival and feed utilization of *Oreochromis niloticus* juveniles fed with different quantities of *Garcinia kola* supplemented diets for 70 days

Parameter	Normal diet	Normal diet + *G. kola* (6%)	Normal diet + *G. kola* (10%)
Initial number	36	36	36
Final number	36	36	36
Survival rate (%)	100[a]	100[a]	100[a]
Initial biomass (g)	159.86 ± 8.71	158.15 ± 6.87	161.72 ± 16.94
Final biomass (g)	352.13 ± 27.28	391.63 ± 13.66	319.18 ± 16.94
Initial weight (g)	13.32 ± 0.72	13.18 ± 0.57	13.48 ± 0.78
Final weight (g)	29.34 ± 2.27	32.64 ± 1.13	26.60 ± 1.41
Final length (cm)	11.35 ± 0.41	12.35 ± 0.10	11.30 ± 0.19
Condition factor	2.00 ± 0.10[a]	1.73 ± 0.04[a]	1.84 ± 0.03[a]
Feed intake (g/fish)	69.94 ± 4.68[ab]	73.81 ± 2.60[a]	63.35 ± 2.68[b]
Protein intake (g/fish)	28.00 ± 1.08[ab]	29.56 ± 0.60[a]	25.37 ± 0.62 [b]
Feed conversion ratio	4.39 ± 0.30[a]	3.80 ± 0.10[a]	4.87 ± 0.37[a]
Protein efficiency ratio	0.57 ± 0.03 [ab]	0.66 ± 0.01 [a]	0.52 ± 0.04 [b]

Values are mean ± standard deviation of 3 replications containing 12 fish per replicate. Values on the same row carrying the same letter are not significantly different at $p < 0.05$

as *Oreochromis niloticus* (Kareem et al. 2016, Hassan et al. 2018). Results from the present study indicate that there was an increase in the growth of the fish fed with different rate of dietary supplementation with *G. kola* seed. However, the highest growth response was observed in the fish fed with *G. kola* seed supplemented meal at a level of 60 g kg^{-1}, indicating that the *G. kola* seed meal supplementation could have enhanced nutrient utilization, which is reflected in improved weight gain, specific growth rate, feed intake, feed conversion ratio, and protein efficiency ratio. In general, relatively high feed conversion ratio values were obtained in all treatments, but the best occurred in fish fed with 60 g kg^{-1} *G. kola* seed meal inclusion even though differences among the treatment means were not significant. Previous studies revealed that *G. kola* seed powder supplemented in animal diets also promoted growth and feed conversion efficiency in *Clarias gariepinus* juveniles (Adeniji et al. 2018) and *Oreochromis niloticus* adults (Sulem-Yong et al. 2018). The proximate and phytochemicals analysis of *G. kola* seeds revealed that it is rich in nutrients such as, vitamins, minerals, phytochemicals but low in anti-nutrients content, indicating that it could be used as supplements in feed manufacturing (Adesuyi et al. 2012; Mazi et al. 2013; Onyekwelu et al. 2015). According to Onyekwelu et al. (2015), the low anti-nutrients content in *G. kola* indicates that its consumption would not pose nutritional or health problems. Moreover, the low protein content observed in the *G. kola* seeds can be indicative that the growth response observed in fish fed with *G. kola* supplemented diet might not be attributed to its nutritional value but mostly to its bioactive compounds. Diab et al. (2008) reported that *O. niloticus* fingerlings fed with medicinal plants supplemented diets exhibited faster growth than those fed with the control diet. According to Kim et al. (1998) unknown factors in various medicinal herbs might lead to favorable results in fish growth trials. Phytochemicals such as phenolic compounds and flavonoids are known as non-nutritive plant chemicals that have protective or disease preventive properties. They are present naturally in seeds, flowers, fruits, vegetables, nuts, and bark of a variety of plants that interplay with nutrients and dietary fiber to protect them (Mazur, 2000). Phytochemicals analysis of *G. kola* seeds revealed the presence of phenols and flavonoids in appreciable amounts (Onyekwelu et al. 2015). It has been established

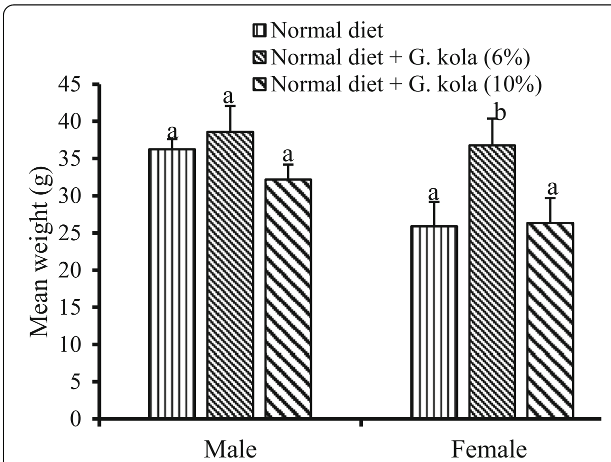

Fig. 2 Mean weight of male and female *Oreochromis niloticus* fed *Garcinia kola* during 70 days. Different letters indicate significant differences at $p < 0.05$

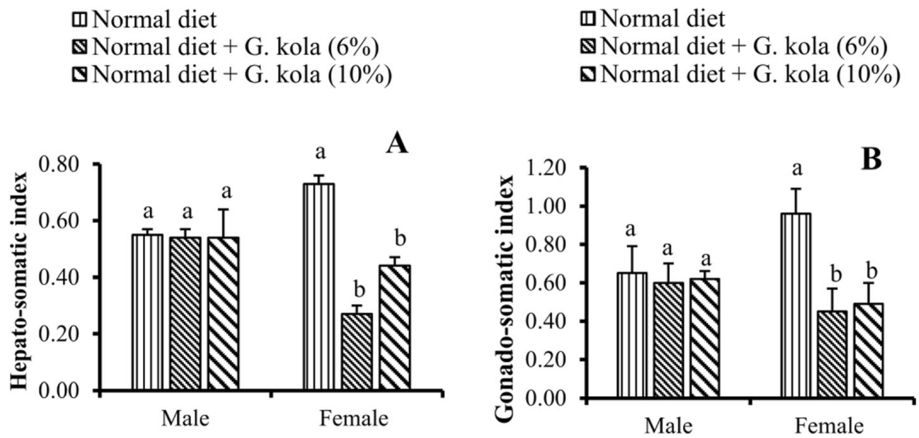

Fig. 3 Hepatosomatic index (**a**) and gonadosomatic index (**b**) of male and female *Oreochromis niloticus* fed *Garcinia kola* after 70 days. Different letters indicate significant differences at $p < 0.05$

that phenols and flavonoids possess many properties which makes them vital to both plants and animals. Some of these properties are their antioxidant potential that protects cells against oxidative damage, anti-microbial properties, and physiological activities. Sim and Nurestri, 2010) also reported that fruits with high phenolic contents generally show stronger antioxidant activities. Thus, the results of the present findings may be due to the presence of bioflavonoids in *G. kola* that would have stimulated growth in both the males and females' experimental *O. niloticus* juveniles, certainly by improving feed intake and feed utilization. In addition, bioflavonoids are known as plant chemicals with estrogenic activity, and studies have shown that estrogen promotes growth in common carp (Kocour et al. 2005). As aforementioned above, phytochemical studies of *Garcinia kola* seeds have revealed relatively low levels of anti-nutritional compounds such as tannin, oxalate, phytate, and trypsin inhibitor (Omeh et al. 2014, Dah-Nouvlessounon et al. 2015). However, the increase in dietary supplementation of *G. kola* is naturally followed by that of the above-mentioned anti-nutritional components. Thus, the low growth in *O. niloticus* juveniles fed with dietary supplementation of *G. kola* seeds at 10% compared to that at 6% might be probably attributed to the increased in anti-nutritional components level in the diet, which would have reduced the secretion of bile and the activity of digestive enzymes as describe by Kaur and Shah (2017).

The first sexual maturity in fish is strongly related to size. According to Gnoumou et al. (2018), size at first sexual maturity in *O. niloticus* depends on the environmental conditions in which the fish grows. Thus, when conditions are favorable, the size at first maturity increases while it decreases when conditions are unfavorable. Under natural conditions, tilapia reaches sexual maturity at a later age and at a higher weight than that raised in culture ponds. For instance, it is established that in several natural lakes in East Africa, *O. niloticus* matures at about 10 to 12 months at a size of 350 to 500 g. The same population in farm or culture ponds, under conditions of near-maximum growth, will reach sexual maturity at an age of 5 to 6 months and 150 to 200 g (Popma and Lovshin, 1995). Under poor conditions of rural fish breeding, farmed tilapias often reach sexual maturity in 3 to 6 months at a size of 15–20 g and spawn before they reach marketable size (Mair and Little, 1991). The results of this study showed that all the fish presented a size above 20 g with the highest size above 35 g in both males and females *O. niloticus* fed with *G. kola* at 6% inclusion rate in the diet. Accordingly, the fish used in the present study would have reached their first sexual maturity. Results on GSI and HSI in males revealed no statistically significant changes between treatments; while in females, the GSI and HSI indices of the experimental groups were significantly lower than those obtained in normal females. Similar results were also obtained by Kareem et al. (2016) during their study on the effects of some dietary crude plant extracts on the growth and gonadal maturity of Nile tilapia (*Oreochromis niloticus*) and their resistance to *Streptococcus agalactiae* infection and by Ramírez et al. (2017) while studying the effect of *Passiflora incarnata* (L) extract on gonadal maturation in young Tilapia (Oreochromis sp). This could indicate that dietary inclusion of *G. kola* seeds powder in addition to its effects as growth promoter in both males and females' *Oreochromis niloticus*, might also exert its physiological effects on the female's reproductive system by delaying or inhibiting gonadal maturation. As it is known, early sexual maturity in Tilapia culture is a well-recognized problem which results in inbreeding in overstocked fish ponds, reduced production, and farmed stocks of generally low quality (Kumar et al. 2018). The low value of the gonadosomatic index obtained in *O. niloticus* females fed *G. kola* supplementation compared to the control group indicates a slowing of the development of the ovaries whose consequence would be a delay in sexual maturity. This shows that the use of *G. kola* as a feed additive would be beneficial to the Tilapia farmer. This could help to reduce the production cost and even the time the fish farmer use during pond management. These effects might be related once more to the presence of bioactive compounds such as flavonoids, known as one of the main classes of phytoestrogens present in a variety of plants (Mazur, 2000). According to Patisaul and Jefferson (2010), the US Environmental Protection Agency (EPA) described "phytoestrogens as naturally occurring plant compounds that are structurally and/or functionally similar to mammalian estrogens and their active metabolites." These compounds have the capacity to alter the structure or function(s) of the endocrine system and cause adverse effects including the timing of puberty, capacity to produce viable and fertile offspring, sex-specific behavior, premature reproductive senescence, and compromise fertility. According to Cheshenko et al. (2008), phytoestrogens might act by inhibiting steroidogenic enzymes through competitive inhibition with natural substrates for a particular enzyme. They are also able not only to bind to respective receptors, but also to directly interact with aromatase CYP19, possibly leading to inhibition of this enzyme involved in the synthesis of 17ß-estradiol, thereby affecting reproductive health of the fish.

Oreochromis niloticus being one of the famous species reared in Cameroon, its growth, metabolism, and reproduction are greatly influenced by the water quality parameters of the culture environment. Water quality is the most important limiting factor in pond fish production as its quality directly affects feed efficiency, growth rates, the fish's health, and survival, as well as the fish reproductive cycle. Any changes in the fish environment add stress to the fish and the higher and faster the changes, the greater the stress. So, the maintenance of the physico-chemical parameters within the acceptable limits are very essential for getting maximum yield in a fish pond (Bhatnagar and Dev, 2013). The water quality parameters revealed the environmental conditions under which the fish were cultured during this study. The average values of water quality parameters such as temperature, transparency, pH, dissolved oxygen, nitrite, nitrate, and ammonia monitored throughout the trials were considered as suitable for the survival, normal growth, as well as good general physiology of *O. niloticus.* These values were in accordance with the findings of Yoo and Lee, 2016, Makori et al. 2017 and Nyadjeu et al. (2018) and could partially justify the absence of mortality observed throughout the study, coupled with experimental fish's apparent good health observed through the results on both the growth and feed utilization.

Conclusion

The results of this study show that supplementation of *G. kola* seeds powder at 6% in diets of *Oreochromis niloticus* juveniles induced the best effect on growth performances. However, on the gonadal development, dietary supplementation of *G. kola* irrespective to the level of inclusion, highly inhibited gonadal development in *Oreochromis niloticus* females; suggesting that for a sustainable development in Tilapia culture, *G. kola* seeds could be used as growth-promoting agent and also control prolific breeding through its capacity to inhibit ovary development.

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Authors' contributions
PN contributed to the study design, data analysis, and writing of the manuscript. JA contributed to the study design and sample collection. NPN drafted the manuscript. METT helped in the study design. All authors reviewed, edited, and approved the manuscript for submission.

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Availability of data and materials
All datasets generated during and/or analyzed during the current study are available from the authors on reasonable request.

Ethics approval and consent to participate
Not applicable

Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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