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RESEARCH ARTICLE

EFFECT OF DIFFERENT LEVELS OF PROTEIN DIETS ON GROWTH PERFORMANCE OF AFRICAN CATFISH (*CLARIAS GARIEPINUS* BURCHELL, 1822) FINGERLINGS IN TANKS

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ABSTRACT: The growth performance of African catfish, *Clarias gariepinus* fed on three levels of protein diets (30% CP, 35% CP and 40% CP) formulated from plant, animal and agro-industrial by-products were experimentally evaluated in recirculating tanks. A total of nine tanks, each with 1 m^3 volume were used in the feeding experiment. The experiment was conducted in triplicate tanks at a stocking density of 12 fish fingerlings per tank. Before the commencement of the actual experiment, stocked fish were left to acclimatize in their tanks for a week. All fish were fed 5% of their body weight per day, and the ration was given twice a day in the morning (10:00 am) and afternoon (4:00 pm) for all treatment groups. The initial total length (TL) and total weight (TW) of each fish was measured to the nearest 0.1 cm and 0.1 g, respectively. Similarly, monthly TL and TW of all fish were measured to compute the growth rate and adjust the daily ration accordingly throughout the experiment period (January 2019 to July 2019). Some physico-chemical parameters of the tank water including dissolved oxygen, water temperature, pH, conductivity as well as level of ammonia were recorded. The results of the experiment showed very significant variations on the growth of fish between the treatment groups ($p<0.05$). Fish fed with 40% crude protein showed the highest daily growth rate (0.52 g/day) followed by fish fed with 35% CP and 30% CP. Similarly, the lowest feed conversion ratio (FCR=2.1) was recorded in fish fed with 40% CP, indicating its suitability for African catfish fingerlings than the other test diets. The overall survival rate varied from 85.2%–92% per treatment. The physico-chemical parameters of the rearing tanks were close to the lower limits of DO and water temperature required for the growth of African catfish. The low daily growth rate of *C. gariepinus* observed in this study might be attributed to the combined effects of low quality of the test feeds and poor water quality recorded in rearing tanks.

Key words/phrases: African catfish, *Clarias gariepinus* formulated feeds, Plant and animal ingredients, Tanks.

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INTRODUCTION

The African catfish, *Clarias gariepinus* is commercially one of the most important indigenous fish in Ethiopia. It is widely distributed in nearly all rivers, lakes and reservoirs and contributes a lot to the capture fishery nationwide (Redeat Habteselassie, 2012; Gashaw Tesfaye and Wolff, 2014). This species is regarded as important candidate culture fish species due to its fast growth in captivity at high stocking density, disease resistance, tolerance to a range of extreme environmental conditions (de Graaf *et al*., 1995; Demeke Admassu *et al*., 2015).

The African catfish, *C. gariepinus* feeds on a wide array of food including plant matter, insect larvae, zooplankton, mollusks, fish etc. The species can be regarded as an opportunistic, omnivorous or predator fish (Tesfaye Wudneh, 1998; Zenebe Tadesse *et al*., 1998; Elias Dadebo, 2000). It has the ability to utilize and/or switch efficiently between alternative food sources such as plants and detritus when prey animals become rare and scarce (Almázan-Rueda *et al*, 2004; Potts *et al*., 2008; Abdelhamid *et al*., 2010; Dienye and Olumuji, 2014). Fish feed is one of the major inputs required for semi intensive type of cultured fish production in addition to water quality and suitable culture environment. Fish feed alone constitutes 40–60% of the running cost of semi intensive fish production. Therefore, research should focus on the production of cheap but nutritionally better fish feed which enhance the growth and production of fish.

The carnivorous feeding habit of *C. gariepinu*s indicates the high dietary protein requirement of the fish (van Weerd, 1995; Agung, 2004; Hecht, 2007). The biology of African catfish focusing on the reproductive biology and spawning season have been reported from Lake Awassa, Langano and Babogaya and determined the fecundity and breeding months of the fish (Zenebe Tadesse *et al*., 1998; Elias Dadebo, 2000; Leul Teka, 2001; Lemma Abera *et al*., 2014). Similarly the feeding habits and diet composition of adult African catfish have shown the omnivorous to carnivorous feeding habit of the fish in natural water bodies (Elias Dadebo, 2000; Demeke Admassu *et al*., 2015).

However, studies on growth experiments based on artificially formulated feeds under controlled culture system is comparatively better documented for Nile tilapia, *Oreochromis niloticus* in Ethiopia (Zenebe Tadesse *et al*., 2012; Abelneh Yimer *et al*., 2015; Mesay Eniyew *et al*., 2016). However, similar studies focusing on controlled culture systems on *C. gariepinus* are extremely scarce and started very recently (Alayu Yalew, 2018). The main objective of the present study was to evaluate the growth performance and survival rate of African catfish, *C. gariepinus* fed on three levels of protein diets in recirculating tanks under greenhouse condition.

MATERIALS AND METHODS

The experiment was conducted at Sebeta National Fisheries and Aquatic Life Research Centre (NFALRC), which is located about 23 km south-west of the capital city, Addis Ababa at 2200 metres above sea level. The area is characterized by a moderately warm climate with a mean annual temperature of about 20°C.

The three experimental diets used in the study were prepared by mixing different proportions of the four ingredients including wheat bran, brewery waste, noug cake soya bean and earthworm. The different ingredients were purchased from local markets (except earthworm), sun dried, grinded to powder to be included in the diets. The three diets formulated were then manually pelleted using meat mince and then dried before feeding the fish. Feed I was exclusively composed of plant ingredients whereas the other two feeds (Feed II and Feed III) constituted a mixture of animal and plant ingredients (Table 1). Since the fish are grown in recirculation tanks, the water is reused regularly in dark tanks so the growth of natural plankton in tanks was almost negligible. Therefore, the fish depended mainly on the daily feed ration throughout the experimental period.

Table 1. Chemical composition and proportions of each ingredient used to formulate for the three feeds used in the experiment.

Feed ingredients	% Crude protein	Proportion of feed ingredients		
		Feed I	Feed II	Feed III
Earthworm	55.2	-	20	25
Soya bean	44	25	14.3	39.3
Brewery waste	29	68.6	65.7	35.7
Wheat bran	18	6.4	-	-
Total protein		30%	35%	40%

The growth and feeding experiment was conducted in dark plastic tanks each holding 1 m^3 water. A total of nine tanks were used for the three feeds run in triplicate tanks on a completely randomized design. The experiment was carried out in recirculation tanks kept in plastic green house for a period of six months between January 2019 and July 2019 (Plate 1). Each tank was stocked with 12 fish and left for one week to acclimatize with the tank condition. As much as possible fish fingerlings were distributed to the nine tanks following their size gradient to make the initial size nearly uniform (9.0–9.4 cm mean TL and 5.1–6.6 g mean TW).

Plate 1. Photo showing the experimental setup of recirculating tanks in green house at NFALRC.

C. gariepinus fingerlings raised artificially in the centre were used for the feeding experiment. The feeding trial consisted of three treatment groups; fed with three feeds of protein diets containing 30% CP, 35% CP and 40% CP. Twelve fish fingerlings having similar sizes were stocked per tank. At the beginning of the experiment total length and total weight of all fish were measured to the nearest 0.1 cm and 0.1 g, respectively. Similarly monthly TL and TW of all fish were recorded and the daily ration was adjusted accordingly. Fish were fed with test diets at 5% of their total body weight for six days a week, except Sundays. The daily ration was given twice a day by hand casting, in the morning (10:00 am) and in the afternoon (4:00 pm). The daily ration was calculated and adjusted regularly following the monthly weight gain of the fish. Mortality of fish was monitored and recorded continuously throughout the experiment.

Growth performances of fish were determined in terms of final mean weight gain, daily growth rates (DGR) and specific growth rates (SGR) and survival rates (%), were computed in the experiment. Growth parameters were calculated following standard equations given below (Adebayo *et al*., 2004):

- Daily growth rate DGR (g/day) = Final weight (g) – Initial weight (g)/culture period
- Weight gain (g) = Final weight (g) – Initial weight (g)
- Percent weight gain (%WG) = $\frac{(Wf - Wi)}{Wi} \times 100$

– Specific growth rate (SGR) = $\frac{(\ln Wf - \ln Wi)}{T}$

Where Wf = final weight of fish; Wi = initial weight of fish; T= growth period in days.

– Feed conversion ratio (FCR) = $\frac{\text{Feed offered for fish (g)}}{\text{Weight gain by fish (g)}}$

– Survival rate (%) = (Number of fish harvested/Number of fish stocked) x100

Water temperature of each tank was measured twice a day, in the morning and afternoon, with a thermometer. Other parameters such as pH, dissolved oxygen, water conductivity were measured *in situ* using portable digital multiline probe. Ammonia was determined from water samples collected from each tank using the indo-phenol blue method (APHA, 1995).

A one-way ANOVA was used to test the effect of supplementary feeds on the growth performance of cultured fish. Duncan's multiple range test was applied to separate means of the different treatments considered. Differences were considered significant at $p<0.05$. All data were analyzed using the SPSS software program of statistical analysis (Mead *et al*., 1993).

RESULTS

The initial size of the fish stocked at the beginning of the experiment was nearly uniform with mean total length of 9.0–9.4 cm TL and mean total weight of 5.1–6.6 grams in all treatment groups. However, the final size of the fish at the end of the experiment varied significantly ($p<0.05$) between the treatment groups (Table 2). This indicates that the supplemental feeds given for the fish brought better growth of the fish irrespective of the protein level. Fish fed with 30% CP showed the least daily growth rate (0.23 g/day) and the highest daily growth rate (0.52 g/day) was observed in fish group supplied with 40% CP. Fish given 35% CP showed medium growth rate (0.28 g/day). This indicates that the growth rate of the fish followed the level of protein supplied for the fish. However, the growth of individual fish varied remarkably as it can be noticed from the size range and large standard deviations observed at the end of the experiment. This variation was more pronounced in fish fed with 40% CP and ranged from 25 g TW to over 359 g TW.

The size range in fish at the beginning of the experiment was comparatively lower than the final size range of fish measured at the end of the study (Fig. 1; Table 2). The size difference was more pronounced in fish fed with 40% CP than fish fed with 35% CP (14.7–163 g) and 30% CP (5.9–113.6 g). Similar to the daily growth rate, the highest specific growth rate was observed in fish fed with 40% CP followed by fish fed with 35% and 30% CP. The feed conversion ratio (FCR) recorded in this study ranged from 2.14 to 3.66 and varied significantly ($p<0.05$) between the test diets. Feeds III which contains higher proportion of animal ingredient was consumed better by the fish than the other two test diets.

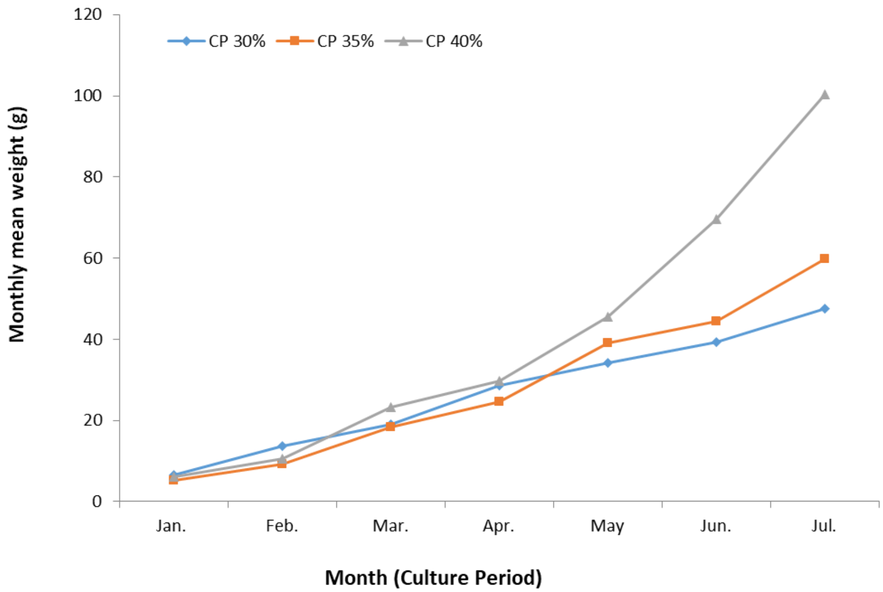

Fig. 1. Monthly trends on the growth of *C. gariepinus* fingerlings fed on three levels of protein diets between January and July, 2019.

Table 2. Growth performance of *Clarias gariepinus* (mean±SD) fed on three level protein diets. Values in the bracket indicate the fish size range.

Parameters	**Treatments**		
	Feed I (30% CP)	**Feed II (35% CP)**	**Feed III (40% CP)**
Initial TL (cm)	9.37±2.15 (6.3–16.3)	9.0±1.61(6.5–13)	9.4±1.57 (6.5–12.6)
Final TL (cm)	18.83±4.0[a] (9.5–25.0)	20.1±4.3[b] (13–30)	23.38±5.76[c] (16–37.5)
Initial TW (g)	6.60±4.95[a] (2.7– 25.8)	5.10±2.88[a] (3.6–14.7)	6.0±2.99[a] (1.9–13.5)
Final TW (g)	47.60±29.66[a] (5.9–113.6)	59.90±42[b] (14.7–163)	100.40±89.83[c] (24.9–358.5)
Change in weight (g)	40	50.9	94.6
Percent weigh gain (%WG)	606.1	998	1576.7
Daily growth rate (g/day)	0.23[a]	0.28[a]	0.52[b]
Specific growth rate (SGR) % day	3.851	4.083	4.598
Feed conversion rate (FCR)	3.66[c]	2.95[b]	2.14[a]
Survival rate (%)	85.2	86.7	92

Values with similar letters are not significant at 5% level.

During the experimental period some physico-chemical parameters of the tank water was recorded as shown in Table 3. Important parameters like water temperature, dissolved oxygen, conductivity and pH were found to vary between months (Table 3). The level of dissolved oxygen was generally low in all months showing slight variation between months. Comparatively, higher oxygen level was measured in the afternoon than in the morning (Fig. 2). Similarly, the water temperature varied between months ranging from 24.3°C to 30°C (Table 3). The water temperature was relatively lower in the morning and increased in the afternoon in all months. Similarly, the level of DO and temperature showed diurnal variations over 24 hours (Fig. 2). Generally, the DO level increased with decrease in water temperature and vice versa indicating the inverse relationship between solubility of oxygen and temperature. The level of oxygen recorded in all tanks was low (4.3–6.7 mg/L) which is close to the minimum limit required for the growth of catfish. This indicates that DO in rearing tanks was below the optimum required for fish growth. The pH of the tank water in most cases was between 4.5 and 6.5 which were slightly acidic throughout the experimental period. The level of ammonia recorded in the tanks varied between 365 ppb and 384.1 ppb which is much less than the level toxic for the fish (Table 4).

Table 3. Monthly and diurnal variations (mean±SD) in some physico-chemical parameters recorded in the experimental rearing tanks.

Parameters	**Dissolved oxygen (mg/l)**		**Temperature (°C)**		**pH**		**Conductivity (µs/cm)**	
Time	**10:00 am**	**4:00 pm**	**10:00 am**	**4:00 pm**	**10:00 am**	**4:00 pm**	**10:00 am**	**4:00 pm**
Jan. 2019	4.3±0.4	5.1±0.2	24.6±0.1	27.1±0.1	4.5±0.1	5.4±0.2	151.6±5.5	154.3±3.9
Feb.	5.5±1.3	6.7±0.5	24.3±0.2	28.3±0.2	4.9±0.3	5.5±0.1	171.5±5.2	173.2±5.9
Mar.	4..9±1.9	5.6±0.7	25.2±0.6	29.7±0.5	5.3±0.0	6.5±0.1	184.9±6.7	194.6±6.0
Apr.	5.1±0.8	6.4±0.7	25.3±0.2	29.1±0.4	.4.8±0.3	5.8±0.2	201.7±8.7	208.7±7.5
May	5.4±0.6	6.7±0.3	25.3±0.1	.30.±0.1	5.0±0.0	6.0±0.1	207.4±4.9	208.9±4.1
Jun.	4..0±0.3	5.3±0.4	25.2±0.2	29.0±0.3	6.2±0.1	7.4±0.2	212.2±10.	221.3±2.5
Jul.	5.2±1.7	5.4±0.6	24.1±0.2	27.0±0.2	7.0±0.0	8.4±0.0	192.0±6.7	202.6±6.6

Table 4. The level of N-ammonia recorded in two occasions from experimental rearing tanks.

Treatment tanks	**N-Ammonia (ppb)**	**N-Ammonia (ppb)**
Feed I	381.5	384.1
Feed II	378.8	380.7
Feed III	365.5	365.9

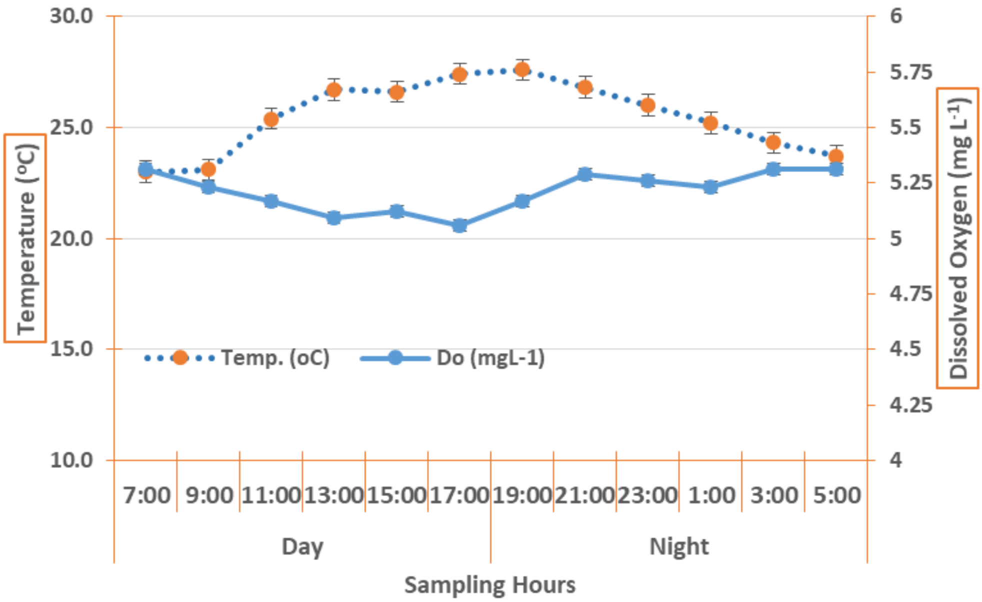

Fig. 2. Diurnal variation in water temperature and dissolved oxygen in rearing tanks.

DISCUSSION

Determination of the optimum level of protein diet is one of the most critical factors for the success of aquaculture operations. In this study growth performance of *C. gariepinus* was compared between treatments fed with three levels formulated diets containing 30% CP; 35% CP and 40% CP.

Results of the growth experiment also showed that highest daily growth rate (0.52 g/day) was recorded on fish fed with 40% CP followed by 35% CP (0.28 g/day) and the lowest was recorded in fish given 30% CP (Table 2). The growth difference observed between the treatments was found to be statistically ($p<0.05$) significant. All treatment groups showed change in growth rate indicating the importance of supplementary feeds on the growth and production of fish. From this study it can be concluded that the African catfish, *C. gariepinus* fingerlings require at least 40% CP for better growth and survival rate.

In general the growth rate of *C. gariepinus* recorded in the present experiment was found to be lower than similar growth studies reported earlier by Alayu Yalew (2018), who reported daily growth rate of 1.12 g/day to 1.64 g/day for different stocking density. The apparently lower growth rate of the fish in our experiment might be due to the composition of the ingredients which are either exclusively or predominantly composed of cereal or agro-industrial by-products which are less in terms of nutrient content and digestibility than ingredients of animal origin.

Feed conversion ratio (FCR) is an important indicator of the excellence of fish feed. A lower FCR indicates better utilization of the feed by the fish (Mugo-Bundietal, 2013). In this experiment the FCR values ranged from 2.14 to 3.66 and varied significantly ($p<0.05$) between treatments (Table 2). However, comparatively lower FCR value (FCR=2.14) was recorded in fish fed with 40% CP indicating that the fish utilized the feed better than the other test feeds. The low FCR might be due to the high proportion of protein derived from animal ingredients which are easily digestible. On the other hand, comparatively higher (FCR=3.66) values were recorded in 30% CP diet which was composed of only plant materials which are less digestible. Generally, the formulated diets tested in this experiment showed poor growth rate. Unlike our results comparatively lower FCR values of 1.61 have been reported for *C. gariepinus* reared in tanks under greenhouse (Ogunji and Awoke, 2017). Generally FCR values of 1.2–1.5 have been reported as normal range for fish reared with properly compounded diet (Ogunji *et al*., 2008). Thus, quality feeds containing more animal ingredients should be formulated and tested which give higher growth rate of fish in the future.

The overall survival rate of the fish was high ranging from 86–92% per tank indicating the high tolerance of the fish in confined system. Our results agreed well with previous study conducted on the feeding rate of *C.*

gariepinus which reported survival rate ranging from 80% to 96% (Marimuthu *et al*., 2011). Cannibalism is common phenomenon in this species when substantial difference in size occurs (Baras and Jobling, 2002). Thus the mortality of the fish in this experiment is likely due to the vast size difference recorded as the fish grows bigger and ranged from 25 g to over 359 g as observed in 40% CP tanks (Fig. 1; Table 2). Similar values ranging from 80% to 96% survival rate was reported for *C. gariepinus* fingerlings reared in tanks (Marimuthu *et al*., 2011). It is, therefore, recommended to regularly sort bigger fish and keep them in separate tanks to enhance growth of smaller fish and reduce bullying of bigger fish in commercial catfish production system.

The African catfish can tolerate and adapt to a range of environmental conditions such as water temperature, low oxygen level and pH. However, *C. gariepinus* showed high growth rates between 25 and 33°C, with optimum growth recoded at 30°C (Britz and Hecht, 1987). Therefore, temperature of water in rearing tanks is crucial for ensuring existence, production and normal metabolic activities in fish (Marimuthu *et al*., 2011). When the water temperature in tanks remains between 16 and 26°C feed intake reduces and growth rate declines and this results in high FCR and stresses the fish. In this experiment the temperature in most months was below 26°C during morning time and this might have lowered the feeding rate and stressed the fish.

Similarly, the minimum concentration of DO should be at least 5 mg/L for normal growth and production of fish (Ogunji and Awoke, 2017). The DO level measured in this study was around the lowest limit indicating that the fish was stressed by low level of DO in rearing tanks. pH is also another important factor affecting the physiology and metabolic activity in culture fish. An acceptable pH for satisfactory growth and production ranges from 6.5 to 8.7 (Ogunji and Awoke, 2017). On the other hand, fish are stressed and experience slow growth rate, poor feed intake and high FCR when the pH lowers between 4 and 6. Fish also showed retarded growth at higher pH between 9 and 11 which enhances the production and accumulation of unionized ammonia which is toxic for fish. The pH measured in this study in most months ranged from 4.5–6, which was slightly acidic and inhibits the production and accumulation of unionized ammonia (NH_3) (Ndubuisi *et al*., 2015). Thus, the level of toxic ammonia recorded in the rearing tanks was much lower than the minimum limit (0.1 mg/l) affecting the growth and activity of the fish (Table 4). The low level of toxic ammonia in the water tanks might be due to the acidity of the water in nearly all months except

June and July.

In general, analysis of physico-chemical parameters of the rearing tanks was crucial in explaining the feeding regime and growth of the fish stocked. Favourable water environment enhances fish growth and production. Optimum growth and production of fish in culture systems can be achieved when both the feed quality and the rearing environment of the water is maintained suitable for the fish. Thus, the low growth rate of catfish observed in this study might be due to the combined effects of low quality feed ingredients and poor water management of the culture system.

CONCLUSION AND RECOMMENDATIONS

The African catfish, *C. gariepinus* is one of the indigenous candidate culture fishes in Ethiopia. It was selected as culture fish due to its fast growth, tolerance to wide range of environmental conditions and ability to consume exogenous feed easily in confined environment. Our knowledge on the growth of African catfish under controlled system is very scarce and limited. Thus, the results and conclusions obtained in this study can serve as base line information for the culture of the species in Ethiopia. From the present study the following points can be concluded and recommended.

Fish fed with 40% CP showed the highest daily growth rate (0.52 g/day) as compared to fish supplied with 35% (0.28 g/day) and 30 % CP (2.1 g/day), and the growth rate varied significantly between treatments. The high FCR values (>2.0) observed in all treatments might be due to the quality of feed ingredients and less favourable water quality parameters. The survival rate of the fish was variable and ranged from 86%−92% between treatments. Cannibalism was believed to be the main reason for the observed mortality of fish resulting from the huge size differences recorded between individual fish. The physico-chemical parameters such as DO, water temperature and pH recorded in the experimental tanks were generally found to be close to the lower limit required for growth and production of African catfish. Thus, the poor water quality in the rearing tanks could be one factor for low growth rate of the fish in this study. The low daily growth rate of *C. gariepinus* fry in the present study might be attributed to the combined effects of poor quality feed ingredients and unfavourable physico-chemical water parameters. Thus, similar feed experiments based on high quality compound feeds and management should be carried out to obtain better growth and production of fish. Future studies should include determination of cost benefit analysis, digestibility rate, daily feed ration and stocking density of the fish.

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