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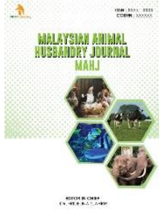

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RESEARCH ARTICLE

COMPARATIVE DEVELOPMENT OF JUVENILE CATFISH (*CLARIAS GARIEPINUS*) FED COMMERCIAL DIETS AND MAGGOT MEAL IN RECIRCULATING AQUACULTURE SYSTEM

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ABSTRACT

This study evaluated the comparative development of juvenile catfish (*C.gariepinus*) fed commercial diets (Skretting and Aqualis feed) and maggot meal at the Fishery unit, Federal College of Forestry Jos (FCF, Jos), Plateau State Nigeria. One hundred and twenty (120) *C.gariepinus* fingerlings were purchased at the Fishery unit, FCF, Jos for the experimental study. The experimental trial was conducted within 6 weeks (42days). The experimental set-up comprised three treatments; with each replicated. Data collected was evaluated using ANOVA and mean values were differentiated by the New Duncan Multiple range test at 5% ($p \leq 0.05$) probability level. Using the sack method, maggots were cultured from poultry waste and harvested using the floating method with mesh nets; then further processed into powdery form as the maggot meal. The commercial feeds and maggot meal had different proximate compositions; the maggot meal had better nutritional value and content. The *C.gariepinus* fingerlings in T3 indicated pre-eminent values for the growth parameters with regards to average length (6.90cm); width (6.95cm) and weight gain (0.047kg). Furthermore, the criterion of water quality in the RAS was significant and suitable for production of the juvenile catfish (*C.gariepinus)*. Also, there are variations in the comparative cost of experimental feeds consumed during the experimental trial. This study therefore recommends increased utilization of the maggot meal formulated at 35% crude proteins as the central diet for *C.gariepinus* fingerlings in RAS; intensification of maggot production and extensive research on maggot meals as fingerlings diets.

KEYWORDS

Comparative Cost, Fingerlings, Growth Parameters, Maggot Meal, Fish Feeds, Water Quality

1. INTRODUCTION

Fish are of global importance for food security, revenue generation, job creation and foreign exchange earnings (Abdelhamid, 2009). Food and Agriculture Organization report stated that, fish and seafood play an important role in the food sector of many developing countries (FAO, 2014). Fish are an excellent source of high quality protein as well as an essential source of micronutrients such as vitamins, minerals and omega-3 polyunsaturated fatty acids (Pillay and Kutty, 2005). Aquaculture has been perceived as a fast growing sector; with the greatest potentials to meet the increasing demand for fish (Rouhani and Britz, 2004). According aquacultures accounted for 42% of global fish production to (FAO, 2014). Sub Saharan Africa contributed just 0.68% to the gross output (Isyagi et al., 2009). Agriculture and aquaculture share the same goal; basically, to increase the levels of farm productivity. It is in their studies observed that the insignificant contribution to aquaculture productions from the region was attributable to problems like bad policies for developing aquaculture; financial barriers; inappropriate methods and technologies; absence of improved fish eggs; inaccessibility to feed; inadequate extension contact and a lack of synergy between research and development sectors (Bhujel, 2014; Hecht, 2005). Given that most of aquaculture's products are consumed by households, their significance cannot be overstated. In West Africa, catfish (*Clarias gariepinus*) are among the most prized freshwater and marine water species (He et al., 2001). Catfish is regarded to have high nutritive value. The nutrients derived from catfish include vitamins, calcium, phosphorus and unsaturated fat (Ayanda, 2003). They can withstand low dissolved oxygen levels and other adverse aquatic conditions, where most cultivable species cannot survive; due to their accessory air breathing organs. Catfish is one of the most prevalent aquaculture specie. However, feed plays a significant role in fish culture, particularly in the early stages. Different studies have found low survival rate and poor development as a significant obstruction in catfish production (Parker, 2012). Normally, fish fry grow in the wild where preys are readily available. In Recirculating Aquaculture System **(**RAS), most of the activities are artificial, their productivity depends on availability of adequate feed and the fry requires high protein food for survival and growth (Fernando, 2002).

According recirculating aquaculture systems (RAS) are utilized for fish production and home aquariums where water exchange is restricted and bio-filtration is required to reduce ammonia toxicity to (Timmons and Ebeling, 2013). In order to keep the water clean and provide fish with a suitable habitat, additional forms of filtration and environmental control are frequently required (Lawson, 1995). The ability to reduce fish's need for clean, fresh water while still providing a healthy environment is RAS's main advantage. To minimize cost commercial RAS should have high fish stocking densities and numerous scientists are at present directing examinations to decide whether RAS is a suitable type of concentrated hydroponics (Andrew, 2010). After mechanical and biological filtration, the technology known as RAS removes suspended matter and metabolites from water and recycles it. According to RAS works by filtering the water from the fish tanks so that it can be used again inside the tank (Stickney, 2005). This technique is used to cultivate numerous species of fish at high density with minimal land and water use. The fundamental hindrance of

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this framework is that it is more expensive to start up and have higher working expenses.

The most significant steps in aquaculture production are specifically seed production and fry rearing. In terms of their life history, the larval stage is thought to be crucial. Fruitful larval production at the initial phase of the juveniles depends significantly on the accessibility to suitable feeds that are promptly consumed, proficiently processed and provides the expected supplements to help development, wellbeing and good rearing conditions (Adewunmi, 2015). Success at this larval stage is mainly determined by fry feeding and nutrition (Orina et al., 2016). Overall, fish species like catfish, carps, salmon and trout have been raised effectively in hydroponics at larval stage. Live food is frequently required by larvae, particularly first-feeding larvae. Due to their lower concentration of nutrients, live foods are easy to digest (Conceifao, 2010). However, due to their small size and lack of a functioning digestive system, raising *C.gariepinus* larvae to juveniles has proven difficult (Olurin et al., 2012). As fry transition from yolk absorption to exogenous feeding, significant losses occur in the RAS (Adewumi, 2015). It has been challenging to obtain feeds that meet the nutritional requirements of the fry due to changes in their development-related nutritional requirements and digestion and absorption mechanisms (Haulihan et al., 2001). Subsequently, feed administration of has been perceived as the serious issue in the management of hatchlings to fingerlings (FAO, 2014). The most expensive part of aquaculture production is the feed, which is the most expensive cost component. According to fish feed costs a lot more than the feed for other cultured animals because fish diets contain more protein Adebayo and (Quadri, 2005). Studies have shown that African catfish needs around 40% crude protein in their feeding regimen and best outcomes have been accomplished with crude protein estimates between 35%-50% for all catfish species. In recent years, Nigeria has experienced an increase in major feed stuff shortages (FDF, 2008). Critical feed ingredients are becoming harder to come by for the aquaculture industry (Gao and Lee, 2012; Dadebo, 2009). Starter feeds, including live feeds like capsulated artemia and commercial starter feeds, are typically imported and costly in developing nations; hence, majority of farmers cannot afford the prices. Numerous incubation facility administrators alternatively use formulated diets for feeding of fry and larval production and as such mitigate the reliance on costly live feed (El-Sayed, 2006). Moreover, maggot meal is a protein source derived from poultry waste has been accounted for to be exceptionally nutritive (FAO, 2003; Williams and Brummett, 2000). When formulating feed, one important aspect to take into account is the cost. According to Webster (2002), it is also essential that the alternative diet contain all of the essential amino acids, fatty acids, vitamins, and minerals that the fish requires for rapid growth, good health, and economic profitability. As a result, substituting alternative protein sources for fishmeal, either in part or entirely, may provide significant financial advantages. Thus, the study evaluates the comparative development of juvenile catfish(*C. gariepinus*) fed commercial diets (Skretting and Aqualis feed) and maggot meal; it focused on the growth indices in *C. gariepinus* larvae subjected to different diets in recirculating aquaculture system (RAS). The findings thereof will help educate farmers on cost effective and highly dependable means of larvae feeding in order to enhance fish production and ensure food security. Specifically, this study sought to address the following research objectives:

i. determine the proximate composition of the commercial diets and maggot meal;
ii. evaluate the comparative growth performance of *C. gariepinus* larvae under different diets;
iii. ascertain the water quality parameters in the RAS over the experimental period.
iv. Estimate the cost effectiveness of the experimental feeds.

2. Materials and Methods

2.1 Study Area

The experimental study was conducted at the Fishery unit, Federal College of Forestry Jos (FCF, Jos), Plateau State Nigeria. The study site is at latitude of 9°55' and a longitude of 8°54' in the savanna of Northern Guinea; with mean elevation of 1,250m above sea level and rises about 600 meters above the plains around it. The average temperature is between 21 and 25 degrees Celsius. Due to its high altitude, the state has a cool climate. Rainy season is usually between April and September while the dry season is from October to March. According the average annual rainfall is 1,260mm to (FAO, 2014).

2.2 Experimental Fish

A total of 120 *C. gariepinus* fingerlings with average weight and age of 11.19 g and 2 weeks old were procured at FCF, Jos, Fish Farm. In the Fishery unit, the fish were acclimatized in the biological garden; for one week and fed with compounded feed formulated at 35% crude protein.

2.3 Preparation of Experimental units (*C. gariepinus* larvae)

Six (6) plastic bowls of 50lt capacity were erected at the biological garden in FCF, Jos. Instantly from acclimatization; the fingerlings were sorted, and 20 fish were randomly stocked into each of the six plastic bowls. The fish was famished for the time being to empty their gut and increment their craving and reception for the new diets. For six weeks (42 days), the fingerlings were fed the experimental diets twice daily at a weight of 5%.

2.4 Experimental Design

The experimental setup comprised three treatments and each replicated. The experiment was spread out in a randomized complete block design (RCBD) using three (3) treatments. Treatments were labeled as: T_1 D_1 D_2; T_2 D_1 D_2; and T_3 D_1 $D_2$for easy identification and monitoring. The catfish fingerlings were raised for a period of 6 weeks. The fingerlings were exclusively fed the formulated diets. They were fed twice daily; morning (8.00am-09.00am) and evening (6.00pm-7.00pm) for 42 days.

2.5 Experimental Materials

Bowl; Scope net; Skretting feeds; Aquilas feed; maggot meal; organic manure; bags; mesh net; *C. gariepinus* fingerlings; Water; Pellet Machine; plastic bowls.

2.6 Formulation and Preparation of Experimental diet

2.6.1 Commercial feeds

Two commercial feeds were used; they include Aqualis and Skretting feeds.

3. Culture and Harvesting of Maggot

3.1 Culture of Maggot

Maggots utilized for this experimental analysis were cultured from poultry waste involving sack technique as depicted by (Madu and Ufodike, 2003). One kilogram of fresh chicken manure was collected from Federal college of Forestry poultry farm in a sack. The dung was wet with water twice daily between6am-7amandbetween6pm–7pm.Thedungwasexposedtohousefly (*Musca Domestica*); during which they lay eggs on the dung. After the exposure time, the sack was sealed and placed under a shade to allow for development of maggots. The emergence of maggot starts after 24hours.

3.2 Harvesting Techniques

The harvesting method adopted was the floating method as described by (Sagbesan et al., 2006). The dung with Maggot was soaked in water in a basin, where the maggot floats and was sieved with 3mm-mesh size net.

3.3 Processing of Maggot Meal

The maggot collected was blanched in hot water; sieved and oven dried at 80oC for two hours, then grounded into powdery form as the maggot meal.

3.4 Measurement of Growth Performance

Total length, width and weight of the *C. gariepinus* fingerlings in each plastic bowl was calculated and recorded. Five (5) juveniles (*C. gariepinus*) per plastic bowl were selected randomly and measured weekly to assess the growth parameters (length, width and weight gain). Each fingerling was weighed using sensitive weighing scale, while the length was also measured using a measuring tape. At the conclusion of the experiment, mean parameter values were assessed and recorded.

4. Water Quality Analysis

Each treatment's water was tested weekly for pH, dissolved oxygen concentration, and temperature (Abdelhamid, 2009). A thermometer was used to measure the water's temperature in degrees Celsius. An electric digital pH meter (Jenway Ltd., model 350- pH meter) was used to measure the water's pH. Dissolved oxygen was evaluated weekly by utilizing an oxygen meter model (d-5509).

4.1 Comparative Cost of the Experimental Feeds

The comparative cost of the experimental feeds was estimated using farm budgetary techniques presented in equation 1 as:

$P_i * Q_i$.................. (1)

Where: P_i = unit price of i_{th} feed; Q_i = quantity of i_{th} feed used; * = multiplication sign

4.2 Statistical Analysis

ANOVA was used to analyze the collected data; and the New Duncan Multiple range test was used to separate mean values at 5% ($p \leq 0.05$) probability level. Excel 2010 and SPSS-23 were used for the analysis of all the data.

5. Results and Discussion

5.1 Proximate Composition of the Experimental Diets

The proximate analysis of commercial feeds of Skretting and Aqualis, as well as maggot meal, is presented in figures (1), (2) and (3). The commercial feeds and the maggot meal had distinct proximate compositional differences. The percentage crude protein (49%), crude Fat (14%), crude fibre (5.7) and Ash content (10.1%) of the Maggot meal indicated the highest vales than that of Skretting and Aqualis. This result suggests that the maggot meal had better nutritional value and content. The maggot meal is highly recommended as a very ideal and suitable diet for *C. gariepinus* fingerlings in aquaculture systems. This is in line with the study of who posited comparable results on the nutritive value of maggot meal diets (Odesanya et al., 2011; Sagbesan et al., 2006; Ajani et al., 2004).

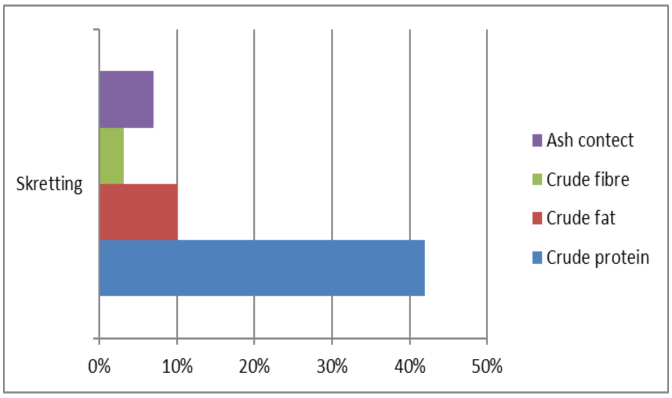

Figure 1: Proximate Composition of the Skretting Feed

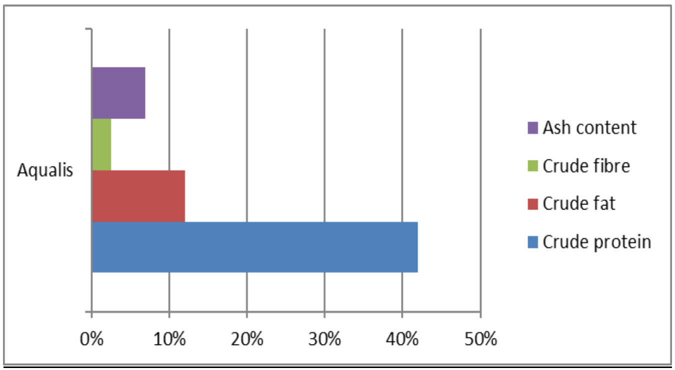

Figure 2: Proximate Composition of the Aqualis Feed

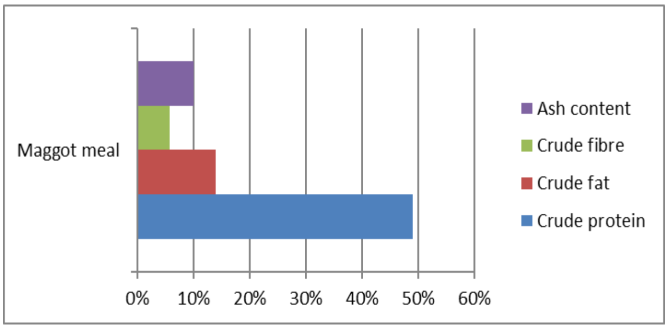

Figure 3: Proximate Composition of the Maggot meal

5.2 Comparative Effects of Commercial Feeds and Maggot Meal on Growth Parameters of fingerling Mean length of *C. gariepinus* fingerlings

Table 1 presents the results of the average length of *C. gariepinus* fingerlings for the experimental period (6 weeks) under different treatments. The result indicated that *C. gariepinus* fingerlings subjected to T3 recorded the highest mean length of 6.90 cm; T2 and T1 were 5.03cm and 4.74cm respectively. The cummulative values across weeks during the experiment shows progressive weekly increase in the average length of the *C. gariepinus* fingerlings. There was a significant difference between treatments observed in weeks 2, 3, and 4 at5% probability level; while no significant difference were noted in weeks 1, 5, and 6. This is in line with the study of who posited comparable results on the growth performance of *C. gariepinus* fingerlings fed different diets (Adewumi, 2015; March et al., 2011; Adewolu and Aro, 2009; Adewumi, 2015; March et al., 2011; Adewolu and Aro, 2009).

Table 1: Weekly Mean length of *C. gariepinus* Fingerlings for 42 days Experimental Period

Treatments/weeks	Initial width (cm)	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	Mean
Skretting(T1)	1.10	1.45	3.11[a]	4.75[a]	5.90[a]	6.25[a]	6.97[a]	4.74
Aqualis (T2)	1.10	1.57	4.02[a]	5.00[b]	5.97[a]	6.36[a]	7.23	5.03
Maggot (T3)	1.10	1.67	5.23[b]	7.75[b]	8.50[b]	8.90[b]	9.3	6.90
Sig. Level		NS.	Sig.	Sig.	Sig.	NS.	NS.	

Source: Authors computed results (2018); 5% (P<0.05) Sig. Level

5.3 Mean Width of *C. Gariepinus* Fingerlings

Table 2: Weekly Mean Width of *C. gariepinus* Fingerlings for 42days Experimental Period

Treatments/weeks	Initial width (cm)	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	Mean
Skretting(T1)	1.50	1.70a	2.75a	4.20a	6.70a	9.00a	12.25b	6.10
Aqualis (T2)	1.50	1.85b	3.30b	4.25a	7.30b	9.25b	11.70a	6.28
Maggot (T3)	1.50	1.95b	3.70b	5.30b	7.75b	10.70c	12.30a	6.95
Sig. Level		NS.	Sig.	Sig.	Sig.	Sig.	Sig.	

Source: Authors computed results (2018)

Table 2 presents the results of the average width of the juveniles (*C. gariepinus*) during the 42 days experimental trial under different treatments. The result indicated that *C. gariepinus* fingerlings subjected to T3 recorded the highest mean width of 6.95cm; T2 and T1 were 6.28cm and 6.10cm respectively.The cummulative values across the experimental period (6 weeks) shows progressive increase in the average width of the *C. gariepinus* fingerlings. There was a significant difference between treatments observed in week's 2 to 6 at5% probability level; while there was no significant difference in week 1. This corroborates the findings of Ayele (2015) and Dadebo *et al.* (2014) and Ebenso and Udo (2003) who posited related results on the growth performance of *C. gariepinus* fingerlings and their feeding habits

5.4 Mean Weight of *C. gariepinus* fingerlings

Table 3: Weekly Mean Weight of *C. Gariepinus* Fingerlings for 42days Experimental Period

Treatments/weeks	Initial width (cm)	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	Mean
Skretting(T1)	0.011	0.020a	0.028a	0.031a	0.036a	0.041a	0.053d	0.034
Aqualis (T2)	0.011	0.025e	0.030b	0.035b	0.041b	0.049b	0.050a	0.038
Maggot (T3)	0.011	0.027b	0.036c	0.039c	0.050c	0.063c	0.065b	0.047
Sig. Level		Sig.	Sig.	NS.	NS.	Sig.	NS.	

Source: Authors computed results (2018)

Table 3 presents the result of the average weight of the juveniles (*C. gariepinus*) during the 42 days experimental trial under different treatments. The result shows that *C. gariepinus* fingerlings subjected to T3 recorded the highest mean weight of 0.047kg; T2 and T1 were 0.038kg and 0.034kg respectively.The cummulative values across the experimental period (6 weeks) shows progressive increase in the average weight values. There was a significant difference between treatments observed in weeks 1, 2 and 5at 5% probability level; while no significant difference were noted in weeks 3, 4, and 6.This result is in conformity with the works of who posited related results on the growth performance of *C. gariepinus* fingerlings *and C. gariepinus* larvae diets (Tarekegn, 2015; Olurin et al., 2012; Ajani et al., 2004).

5.5 Water Quality Parameters

Table 4: Analysis of Water Quality Parameters in the Recirculatory Aquaculture System (RAS)

Treatments/weeks	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	Mean
Temperature	$23{\pm}0.002^{a}$	$0.25{\pm}0.021^{a}$	$27.0{\pm}0.043^{b}$	$24.0{\pm}0.028^{a}$	$23.0{\pm}0.032^{a}$	$23.0{\pm}0.042^{a}$	20.2
pH	$7.4{\pm}0.04^{a}$	$7.0{\pm}0.034^{a}$	$7.0{\pm}0.044^{a}$	$6.0{\pm}0.041^{a}$	$7.0{\pm}0.05^{a}$	$6.0{\pm}0.029^{a}$	6.73
dO_2	$6.0{\pm}0.047^{b}$	$6.0{\pm}0.041^{b}$	$4.0{\pm}0.05^{a}$	$6.0{\pm}0.027^{b}$	$5.0{\pm}0.049^{a}$	$5.0{\pm}0.033^{a}$	5.33
NH_3	$0.25{\pm}0.001^{a}$	$3.0{\pm}0.031^{b}$	$1.0{\pm}0.04^{a}$	$1.0{\pm}0.041^{a}$	$4.0{\pm}0.036^{b}$	$4.0{\pm}0.021^{b}$	2.21
Sig. Level	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	

Source: Authors computed results (2020); 5% ($P<0.05$) Sig. Level

Table 4 presents the water quality parameters of the Recirculatory aquaculture system (RAS) during the experimental period. The result shows that the average values of the water parameters; temperature (20.2°C), pH (6.73), dissolved oxygen (dO_2) (5.33) and ammonia (NH3) (2.21) were all significantat5% ($p<0.05$) level of probability. This result indicates that the water quality parameters in the RAS were very ideal and suitable for production of *C. gariepinus* fingerlings; hence better farm productivity was derivable thereof. This corroborates with who posited comparable outcomes on water quality in aquaculture systems (Boyd, 2012; Swann, 2006).

5.6 Comparative Cost of Experimental Feeds

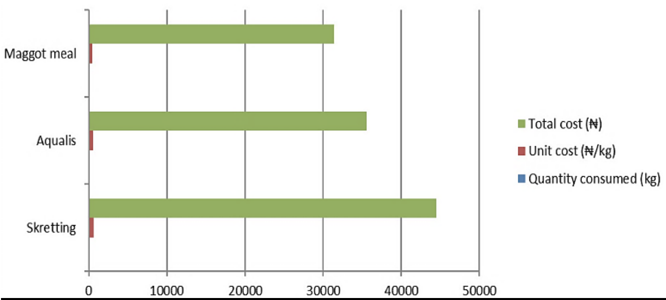

Figure 4: Experimental Feed Cost

Figure 4 shows the comparative cost of experimental feeds consumed during the period of the experimental trial (42days). The estimated total quantity per experimental feed consumed by the juveniles (*C. gariepinus*) for the period of the experimental trial (6 weeks) was 70.5kg; indicating that feed consumption is very germane in the production of *C. gariepinus* fingerlings in aquaculture systems. Also, the estimated unit cost per experimental feed consumed by the *C. gariepinus* fingerlings were; Skretting (₦630.70), Aqualis (₦505.20) and Maggot meal (₦445.50); suggesting that maggot meal constituted the lowest cost per unit *vis a vis* other commercial feeds (Skretting and Aqualis) and consequently this reduces total expenditure of feeding the juveniles (*C. gariepinus)* for the period of the experimental trials. Further, the estimated comparative cost of experimental feeds consumed by the juveniles (*C. gariepinus*) for the period of the experimental trial had variations; Skretting (₦44,464.35), Aqualis (₦35,616.60) and Maggot meal (₦31,407.75); implying that the cost of feeding *C. gariepinus* fingerlings in aquaculture systems with maggot meal as relatively lower *vis a vis* other commercial feeds (Skretting and Aqualis), hence this factor significantly affects total production costs. This corroborates with who posited comparable outcomes on costs and viability of fish farming (Asmah et al., 2008).

6. Conclusion and Recommendations

This study evaluated the comparative growth performance of *C. gariepinus* fingerlings fed commercial diets (Skretting and Aqualis feed) and maggot meal at the Fishery unit, Federal College of Forestry Jos (FCF, Jos), Plateau State Nigeria. The experimental trial was conducted within 6 weeks (42days) and the experimental set-up comprised three treatments; each replicated. The result shows that commercial feeds and maggot meal were differentiated by their proximate compositions; the percentage crude protein, crude fat, crude fibre and ash content of the maggot meal indicated the highest values than that of Skretting and Aqualis. The maggot meal (T3) had significant effect on the growth performance of *C. gariepinus* fingerlings in the RAS. Also, the water quality parameters in the RAS were very ideal and suitable for juvenile catfish (*C. gariepinus*) production. Further, the estimated comparative cost of experimental feeds consumed by the juveniles (*C. gariepinus*) for the period of the experimental trial had variations. This study therefore recommends increased intensification and utilization of the maggot meal formulated at 35% crude proteins as the central diet for *C.gariepinus* fingerlings in the RAS, particularly among smallholders to reduce cost, optimize profits and improve productivity. Also, policies directed towards increased intensification of maggot production should be implemented. Furthermore, research on the feed conversion ratio of *C. garieinus* fingerlings fed with maggot meal in aquaculture systems should be carried out.

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