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Comparative Study of Growth Performance, Food Utilization and Survival of the African Catfish *Clarias gariepinus* (Burchell, 1822) Fingerlings Fed Live Maggot (*Musca domestica*) and Coppens Commercial Feed

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ABSTRACT

A 70-day feeding experiment was conducted to determine the effect of live maggot and Coppens feed on the growth, food utilization and survival of African catfish (*Clarias gariepinus)*.Triplicate group of fish with a mean initial wet weight of 100.50 ± 2.03 g and length of 9.09 ± 0.11 cm were stocked in six glass aquaria (A_1, A_2, A_3, B_1, B_2 and B_3) measuring 96 cm x 50 cm x29 cm. Fish in A_1, A_2 and A_3 were fed live maggot and B_1, B_2 and B_3 were fed Coppens feed at 5% of their body weight. Growth performance of fish fed Coppens feed evaluated using weight gain (g), length gain (cm), growth rate, specific growth rate, mean growth rate, percentage weight gain and survival varied significantly form fish fed live maggot. Fish fed Coppens feed consumed significantly (P<0.05) more food (1266.77 ± 29.24 g) than fish fed live maggot (784.70± 16.97 g). Food conversion ratio and food conversion efficiency of fish fed Coppens feed (1.56 ± 0.02 and 64.03 ± 0.69 %) was significantly better (P<0.05) than fish fed live maggot (1.66 ± 0.03 and 60.30 ± 0.96%). Proximate analysis of the dry matter (mg/100 g) of maggot meal contained 82.25 ± 0.12 moisture content, 44.56 ± 0.02 crude protein, 5.48 ± 0.05 crude fibre, 24.00± 0.05 mean fat¸ 22.60 ± 0.04 mean carbohydrate and 5.00 ± 0.05 mean ash content while Coppens feed contained 9.00 ± 0.05 moisture content, 42.50 ± 0.42 crude protein, 4.00 ± 0.20 crude fibre, 12.50± 0.05 mean fat, 12.96 ± 0.08 mean carbohydrate and 9.40 ± 0.06 mean ash content. Percentage survival was higher (96.67 ± 5.80 %) in *C. gariepinus* fed Coppens feed than *C. gariepinus* fed live maggot (93.33 ± 5.80 %). Water quality parameters including water temperature, pH and dissolved oxygen were within the acceptable range for optimal fish growth and health. The implication of this results is that live maggot is incapable of providing *C. gariepinus* with all the nutrients required for optimal growth. It is therefore concluded that live maggot can be fed as a supplementary food and not as a complete ration or it can be further processed to maggot meal and used as supplementary protein source to replace or reduce the inclusion of fishmeal which is the most costly feed ingredient in fish feed.

Keywords: *Clarias gariepinus*, Live maggot, Supplementary protein, Coppens feed, Growth performance, food utilization

I. INTRODUCTION

Fish is an important animal protein source for Nigerians and as reported by FAO [1], fish production sector shows a fast growth worldwide with a growing percentage of the food fish demand being met by aquaculture. At the country level, Nigeria ranks first in Africa with almost 2 million people engaged in the fisheries and aquaculture sector, followed by Morocco (almost 1.4 million) and Uganda (almost 1 million) based on the figure indicated by FAO [2]. According to [3], consumption and demand for fish protein in Nigeria, is increasing due to its affordability and also due to the fact that fish is a good source of essential vitamins and minerals such as thiamine, phosphorus, riboflavin, vitamins A and D, calcium and iron. The African catfish (*Clarias gariepinus*) belonging to the family Clariidae is the most cultivated species in Nigeria due to its ability to tolerate a varying range of environmental conditions, high stocking densities under culture conditions, fast growth rate, disease resistance, acceptability of artificial feed, high fecundity, good taste and meat quality, ease of artificial breeding, high market value [4]. Although the culture of *C. gariepinus* in Nigeria tends to grow because a lot of awareness have been created on the need for fish culture by the Nigerian government and other Non-Governmental Organizations (NGOs), most Nigerian farmers are still facing serious challenges which hinders the success of their production.

In the submission of Jamu and Ayinla [5], growth of aquaculture in Nigeria is hindered by lack of high quality feed which accounts for at least 60% of the total cost of fish production. Eyo *et al.*, [4] explained that this present challenge on the unavailability of high quality feed in Nigeria has led farmer's reliance on imported foreign feed such as Aqua Aller, Coppens, Skrettings, Multifeeds, Podder feeds etc. The disadvantages of these imported foreign feed includes its expensive nature, inconsistency and instability in supply, especially in rural areas where most fish farms are located. However, commercial feed production industries utilize fish meal (FM) as the most desirable animal protein ingredient in aqua feed because of its high protein content, balanced amino acid profile, high digestibility and palatability, and richness in essential n-3 polyenoic fatty acids [6]. The continuous increasing demand for fish meal used in animal feed especially in aqua feed has resulted in fish meal becoming difficult to obtain and very expensive [7], posing another significant challenge to fish farmers in Nigeria. Therefore, to curb aforementioned challenges, farmers are constantly searching for cheaper protein sources as alternatives to fish meal without compromising fish growth and health.

The word Maggot means the larva from housefly (*Musca domestica*) belonging to the family Muscidae and Order Diptera [8].. Maggot which is creamy white in colour is a rich animal protein source that is not competed for by man. It has readily been accredited for its high quality protein with amino acids profile showing its biological value to be superior to soybean and groundnut cake [9]. Several studies on the use of housefly maggot meal (magmeal) as substitute for fish meal in fish diets have been conducted by fish nutritionist [10], [11], [12], [13], and [14] Spinelli *et al.* [15] included magmeal protein in the diets of rainbow trout, [16] and [9] used magmeal protein in the diets of Nile tilapia (*O. niloticus*), Sogbesan *et al.*, [12]; Omoruwou and Edem [17] used magmeal protein in the diets of *Heterobranchus longifilis* X *Clarias gariepinus* (*Heteroclarias*) hybrid fingerlings; Atse et al., [18] used magmeal protein in the diets of *Heterobranchus longifilis*. Interestingly, findings obtained from these previous studies indicated that maggot is a cheap and potential animal protein source that could be utilized by different fish species under culture conditions. The aim of this study is therefore to evaluate the effect of live maggot on the growth performance, food utilization and survival of the African Catfish *C. gariepinus* as a comparative study with Coppens feed which is a very popular imported feed in the Cross River State of Nigeria.

II. METHODS AND MATERIAL

Description of study area

This research work was carried out at the Institute of Oceanography (IOC) fish farm in the University of Calabar, Cross River State of Nigeria. The IOC fish farm is located within the University of Calabar staff quarters and geographically bounded within latitudes 04^o45^IN and 04^o55^IN longitudes 08^o20^IE and 08^o30^IE. The geographic location of the University, offers a land with potentials for sound aquaculture development with a total surface area of three hectares.

Experimental fish (*Clarias gariepinus*)

A total of sixty (60) healthy C. *gariepinus* fingerlings was collected from Hatchery Complex of the Institute of Oceanography, University of Calabar and used for this study.

Experimental design

The collected fingerlings were transported immediately in a plastic bucket to the Fisheries and Aquaculture Laboratory of the Institute of Oceanography. The fishes were acclimated for a period of two weeks in the experimental aquaria measuring (90 cm X 50 cm X 29 cm) and during this period, the fishes were fed Coppens feed to satiation. Prior to the beginning of the experiment, the fishes were starved for 24 hours before the start of the experiment. The 70 days experiment was set up in triplicate and six (6) aquaria labelled A_1, A_2, A_3, B_1, B_2 and B_3, was used. Ten fingerlings of C. *gariepinus* were stocked in each aquarium and fish in aquarium A_1, A_2 and A_3 were fed live maggot while fish in B_1, B_2 and B_3 were fed Coppens feed. Feeding was carried out twice daily at 5 % of their body weight at 8.00 am and 4.00 pm. Before the start of the experiment, the initial weight of the fish in grams was measured with METLAR MD-2000 electronic weighing balance while the initial length was measured using measuring board in centimetre. These measurements were repeated after every two weeks for 12 weeks.

Experimental Feed

Coppens feed (2 mm) was purchased from a fish feed store in Calabar, Cross River State, Nigeria and used for the feeding trial.

Production of live Maggot

Fresh poultry droppings was obtained from the University of Calabar poultry farm and incubated in a rectangular rubber container measuring (43 cm X 30 cm X 32 cm) as a substrate for maggot development. The poultry droppings in the container was moisture with water to prevent drying and exposed for two days to allow house flies to lay eggs on it. The container was covered and left for between 3 days to 7 days to allow maggot to be fully grown before harvesting. The harvested maggots were washed with warm water before it was used feeding the fish.

Determination of growth performance

Growth performance indices was evaluated according to protocols outlined in [3] and [19] as shown below:

1. Wet weight gain: Final weight (W_2) – initial weight (W_1)
2. Length increment: Final length (L_2) – initial length (L_1)
3. Growth rate: (Final weight, W_2 – initial weight, W_1) / (Number of days)
4. Specific growth rate: (Final weight, W_2) – (Initial weight, W_1) / (Number of days) X 100.
5. Mean Growth Rate (MGR) was calculated as the average weight gain in million gram per day.

   $$MGR = [(W_2 - W_1)/ 0.5 (W_2 + W_1)t] \quad x\ 1000$$

   Where W_2 = final weight (g)

   W_1 = initial weight (g)

   t = experimental period in days
6. Percentage Weight Gain (PWG): [(W2 –W1)/ W1)] x 100
7. Survival Rate (%): Survival rate (%) was calculated as total fish number harvested and divided by total fish number stocked, expressed in percentage as follows:

$$\text{Survival (\%)} = \frac{\text{Total fish no. harvested}}{\text{Total fish number stocked}} \times 100$$

Food Utilization Indices

Food Utilization Indices evaluated in this study include food consumed (g), food conversion ratio (FCR) and feed conversion efficiency (FCE) and these indices were calculated according to [3] and [19] as follows:

Food Consumed (g)

This is given as 5 % of fish bulk body weight X No. of days (Eyo and Ekanem, 2011)

Food Conversion Ratio

This is given as: Feed consumed (g)/ Weight gain (g)

Food Conversion Efficiency

This is given as: [Weight gain (g) / Feed consumed (g)]* 100

Proximate Analysis of Coppens feed and Maggot meal

Proximate analysis of the dry matter of Maggot meal and Coppens feed was performed according to [20] at the Department of Biochemistry, University of Calabar. Crude proteins (nitrogen x 6.25) was determined using micro-Kjeldahl method, crude fat was extracted (hexane extraction) by using the Soxhlet method. Crude fiber was quantified by acid digestion followed by ashing the dry residue at 550 °C in a muffle furnace for 4 hours. Ash content was determined by incineration at 550 °C in a muffle furnace for 24 hours, and moisture content was determined through a hot-air oven set at 105 °C for 24 hours.

Measurement of Water Quality Parameters

Water quality parameters measured in this study include pH, dissolved oxygen and water temperature. pH and dissolved oxygen was measured using pH and oxygen meter while water temperature was measured using mercury in glass thermometer.

Statistical Analysis

Data obtained for growth performance and food utilization indices including weight gain (g), length gain (cm), growth rate (g/day), mean growth rate (mg/day), specific growth rate (%/day), food conversion ratio (FCR), food conversion efficiency (%) and % survival of C. gariepinus fed Live Maggot and Coppens feed were subjected to T-test analysis to test for significant difference using Predictive Analytical Software (PASW) windows software program for statistical analysis (version 18.0). Effects with probability of (P< 0.05) were considered significant.

III. RESULTS AND DISCUSSION

RESULTS

Proximate composition of Maggot meal and Coppens feed

Mean proximate analysis (Table 1) of the dry matter (mg/100 g) of maggot meal and Coppens showed that moisture content was higher in maggot meal (82.25 ± 0.12) than Coppens (9.00 ± 0.05). Crude protein content was also higher in maggot meal (44.56 ± 0.02) than Coppens (42.50 ± 0.42). Mean crude fibre content was higher in maggot meal (5.48 ± 0.05) than Coppens feed (4.00 ± 0.20). Mean fat content was also higher in maggot meal (24.00± 0.05) than Coppens feed (12.50± 0.05).Mean ash content was higher in Coppens feed (9.40 ± 0.06) than maggot meal (5.00 ± 0.05). Mean carbohydrate content was higher in Coppens feed (12.96 ± 0.08) than maggot meal (22.60 ± 0.04).

Table 1: Proximate composition of Maggot meal and Coppens feed

Proximate indices (%)	Maggot meal	Coppens feed
Ash	5.00 ± 0.05^{a}	9.40 ± 0.06^{b}
Crude protein	44.56 ± 0.02^{a}	42.50 ± 0.42^{a}
Fibre	5.48 ± 0.05^{a}	4.00 ± 0.20^{b}
Fat	24.00 ± 0.05^{a}	12.50 ± 0.05^{b}
Moisture	8.25 ± 0.12^{a}	9.00 ± 0.05^{b}
Carbohydrate	12.96 ± 0.08^{a}	22.60 ± 0.04^{b}

*Mean values with the same superscript are not significantly different (P>0.05)

Growth performance indices of *C. gariepinus* fed live maggot and Coppens feed

Growth performance of *C. gariepinus* fed live maggot and Coppens feed (Table 2) evaluated in this study showed that length gain was higher in *C. gariepinus* fed Coppens feed (14.20 ± 0.66 cm) than *C. gariepinus* fed live maggot (9.70 ± 0.40 cm). Weight gain was also higher in *C. gariepinus* fed Coppens feed (811.00 ± 10.54 g) than *C. gariepinus* fed live maggot (373.00 ± 10.44 g). Growth rate (GR) was also higher in *C. gariepinus* fed Coppens feed (10.15 ± 0.16) than *C. gariepinus* fed live maggot (5.33 ± 0.15). Specific growth rate (SGR) was also higher in *C. gariepinus* fed Coppens feed (2.98 ± 0.04 %) than *C. gariepinus* fed live maggot (2.22 ± 0.04%). Mean growth rate (MGR) was also highest in in *C. gariepinus* fed Coppens feed (25.41 ± 0.06) than *C. gariepinus* fed live maggot (23.57 ± 0.11). Percentage weight gain was higher in *C. gariepinus* fed Coppens feed (705.71 ± 17.83) than *C. gariepinus* fed live maggot (371.88 ± 12.62). Percentage survival was higher (96.67 ± 5.80 %) in *C. gariepinus* fed Coppens feed than *C. gariepinus* fed live maggot (93.33 ± 5.80).

Table 2: Growth performance indices of *C. gariepinus* fed live maggot and Coppens feed

Growth Performance Indices	Treatment A (Live maggot)	Treatment B (Coppens feed)
Initia l Length (cm)	9.10 ± 0.10	9.07 ± 0.12

Final Length (cm)	18.8 ± 0,46	23.27 ± 0.56
Length Gain (cm)	9.70 ± 0.40 ^{a}	14.20 ± 0.66^{b}
Initial Weight (g)	100.33 ± 2.52	100.67 ± 1.53
Final Weight (g)	473.33 ± 11.24	811.00 ± 10.54
Weight Gain (g)	373.00 ± 10.44 ^{a}	710.33 ± 11.02 ^{b}
Growth Rate (GR)	5.33 ± 0.15 ^{a}	10.15 ± 0.16 ^{b}
SGR	2.22 ± 0.04a	2.98 ± 0.04 ^{b}
MGR	23.57 ± 0.04 ^{a}	25.41 ± 0.06 ^{b}
PWG	371.88 ± 12.62 ^{a}	705.71 ± 17.83 ^{b}
Number of Fish Stocked	10.00 ± 0.00	10.00 ± 0.00
Number of Fish Survived	9.33 ±0.58	9.67 ± 0.58
Survival (%)	93.33 ± 5.80 ^{a}	96.67 ± 5.80^{a}

*Mean values with the same superscript are not significantly different (P>0.05)

Food utilization indices of *C. gariepinus* fed live maggot and Coppens feed

Food utilization of *C. gariepinus* fed live maggot and Coppens feed (Table 3) evaluated in this study showed that *C. gariepinus* fed Coppens feed consumed more food (1266.77 ± 29.24 g) than *C. gariepinus* fed live maggot (784.70 ± 16.97 g). Food conversion ratio was better in *C. gariepinus* fed Coppens feed (1.56 ± 0.02) than *C. gariepinus* fed live maggot (1.66 ± 0.03). Food conversion efficiency was also better in *C. gariepinus* Coppens feed (64.03 ± 0.69 %) than *C. gariepinus* fed live maggot (60.30 ± 0.96).

Water Quality Parameters of Experimental Aquaria

Water quality parameters measured in this study (Table 4) including pH, dissolved oxygen (DO-mg/l) and temperature (°C) showed that in treatment A (Aquaria where fish were fed live maggot), mean pH ranged between 6.83 ± 0.06 in week 2 to 7.10 ± 0.00 in week 0, mean dissolved oxygen ranged between 3.33 ± 0.06 mg/L in week 6 to 3.90 ± 0.00 mg/L in week 0 and mean temperature ranged between 28.0 ± 0.00 °C in week 4 to 30.0 ± 0.00 °C in week 6. In treatment B (Aquaria where fish were fed Coppens feed), mean pH ranged between 6.83 ± 0.15 in week 2and week 4 to 7.10 ± 0.00 in week 0, mean dissolved oxygen ranged between 3.33 ± 0.06 mg/L in week 6 to 3.90 ± 0.00 mg/L in week 0 and mean temperature ranged between 28.0 ± 0.00 °C in week 4 to 30.0 ± 0.00 °C in week 6.

Table 3: Food utilization indices of *C. gariepinus* fed live maggot and Coppens feed

Food utilization indices	Treatment A (Live maggot)	Treatment B (Coppens feed)
Weight Gain (g)	373.00 ± 10.44	710.33 ± 11.02
Food Consumed (g)	784.70 ± 16.97a	1266.77 ± 29.24b
FCR	1.66 ± 0.03a	1.56 ± 0.02b
FCE	60.30 ± 0.96a	64.03 ± 0.69b

*Mean values with the same superscript are not significantly different (P>0.05)

Table 4: Water Quality Parameters of Experimental Aquaria

Period	Aquaria A (Fed Live maggot)			Aquaria B (Fed Coppens Feed)		
	pH	**DO (mg/l)**	**Temp. (°C)**	**pH**	**DO (mg/l)**	**Temp. (°C)**
Week 0	7.1 ± 0.00	3.90 ± 0.00	29 ± 0.00	7.1 ± 0.00	3.90 ± 0.00	29 ± 0.00
Week 2	6.83 ± 0.06	3.40 ± 0.10	29 ± 0.00	6.83 ± 0.15	3.37 ± 0.15	29 ± 0.00
Week 4	6.93 ± 0.06	3.53 ± 0.06	28 ± 0.00	6.83 ± 0.15	3.47 ± 0.06	28 ± 0.00
Week 6	6.87 ± 0.11	3.33 ± 0. 06	30 ± 0.00	6.90 ± 0.10	3.33 ± 0.06	30 ± 0.00
Week 8	6.87 ± 0.11	3.57 ± 0.06	29 ± 0.00	6.87 ± 0.86	3.53 ± 0.06	29 ± 0.00
Week 10	6.87 ± 0.06	3.43± 0.15	29 ± 0.00	6.87 ± 0.12	3.43 ± .06	29 ± 0.00

DISCUSSION

In aquaculture, feed represents 40-50% of the total production costs and is considered to be the major determinant of the farmer's profit margin. According to Oso *et al.,* [21] (2011), aquaculture is supported by development of new species-specific diet formulations especially, as it expands to satisfy increasing demand for affordable, safe and high quality fish and sea food products. Maggots and other non-conventional animals like winged termites, earthworms and garden snails have been explored to check their nutrient contents, relative abundance, use and conversion into processed meals, incorporation into formulated diets and subsequent development of technique for on-farm mass production [22], [23](Ugwumba et al., 2001; Ayinla, 1988). Results obtained from this study clearly indicate that C. gariepinus fed Coppens feed performed better than C. gariepinus fed live maggot in terms of growth which was evaluated using length gain, weight gain, growth rate, specific growth rate, mean growth rate and percentage weight gain. Length gain of 14.20 ± 0.66 cm obtained for *C. gariepinus* fed Coppens feed was significantly higher (P<0.05) from *C. gariepinus* fed live maggot. Weight gain of 811.00 ± 10.54 g obtained for *C. gariepinus* fed Coppens feed was also significantly higher (P<0.05) than 473.33 ± 11.24 obtained for *C. gariepinus* fed live maggot (about 41.63 % higher). According to Ekanem et al., [24](2012), fish like other animals, has a requirement for essential nutrients for growth and reproduction repairs. Findings obtained in this study showed that live maggot used in this study did not provide all the essential nutrients required by *C. gariepinus* for optimal growth as evident in the fish growth. Although proximate analysis of maggot showed that maggot contains crude protein (44.5 %), ash (5%), lipid (24 %), moisture (84 %) and fibre (5.5%), fish fed live maggot did not favorably compete with fish fed Coppens feed. This indicates that for fish to grow optimally, they must be fed with balanced diet containing all the required nutrients in the correct proportion. According to Eyo and Ekanem [3](2011), nutrients must be able to be digested and absorbed in a form that makes them available for providing energy and substrate for growth (bioavailability).Results obtained in this study is similar to Ekanem et al., [24](2012) and Eyo et al., [25] (2013) who reported that Coppens feed met the nutritional requirements of *C. gariepinus* in a culture system. Growth rate, specific growth rate, mean growth rate and percentage weight gain was significant (P<0.05) better in fish fed Coppens feed than feed fed live maggot. This findings indicates that growth rate, specific growth rate, mean growth rate and percentage weight gain of C. gariepinus is influenced by feed. This observation is similar to Ekanem et al., [24](2012) and Ekanem et al.,[26] (2013) who reported a better growth rate, specific growth rate, mean growth rate and percentage weight gain in C. gariepinus fed Coppens feed. Results obtained for fish fed live maggot in this study shows that live maggot can only be used as a supplementary food for fish and not a complete ration for fish. However, better result in terms of growth performance of fish can be obtained by further processing live maggot to maggot meal and used as supplementary protein source to replace or reduce the inclusion of fishmeal which is the most costly feed ingredient in fish feed. This suggestion is supported by the proximate composition of maggot obtained in this study which shows that maggot is composed of 44.5 % crude protein, 5% ash, 24 % lipid, 84 % moisture and 5.5%fibre. Several researchers such as Holm and Moller [27](1984), Eyo [28](1996), Ovie [29](1996) confirmed that maggot meal enhanced better growth of Catfish fingerlings as well as minimizing problems associated with artificial diets. According to Ekanem *et al.,* [25](2013), the amount of feed consumed is a crucial factor for calculating food conversion ratio (FCR)in fish nutritional studies. Eyo et al., [4](2014) reported that FCR is often used to evaluate the efficiency of a particular diet and as explained by De Silva and Anderson [19] (1995), a good feed will give a lower FCR value. Results of this study showed that FCR was significantly (P<0.05) better in fish fed Coppens feed(1.56 ± 0.02)than fish fed live maggot (1.66 ± 0.03) even though food consumed was significantly higher in fish fed Coppens feed (1266.77 ± 29.24 g) than fish fed live maggot (784.70 ± 16.97 g). Also, food conversion efficiency was significantly (P<0.05) higher in *C. gariepinus* fed Coppens feed (64.03 ± 0.69 %) than *C. gariepinus* fed live maggot (60.30 ± 0.96). However, food conversion ratio and food conversion efficiency obtained for fish fed both live maggot and Coppens feed falls within the range reported by Eyo and Ekanem [3](2011), Ndome et al., [30](2011), Ekanem et al., [24] (2012), Ekanem et al., [26](2013) and Eyo et al., [4](2014) to be optimal for C. gariepinus growth. Although percentage survival was insignificantly (P>0.05) higher in fish fed Coppens feed (96.67 ±

5.80 %) than fish fed live maggot (93.33 ± 5.80), it was not affected by either the live maggot or Coppens feed used in this study. Water quality parameters including water temperature, pH and dissolved oxygen were within the acceptable range for optimal fish growth and health as recommended by Boyd [31](1979) and Viveen et al., [32] (1986).

IV. CONCLUSION

Findings of this study has demonstrated that *C. gariepinus* fed Coppens feed performed better than *C. gariepinus* fed live maggot as evident in the growth indices and food utilization indices values which could be attributed to the nutritional quality of Coppens feed. Fish survival was not found to be affected by live maggot or Coppens feed used in this study. Although live maggot is rich in protein and other proximate indices, it is incapable of providing C. gariepinus with all the nutrients required for optimal growth. It is therefore concluded that live maggot can be fed as a supplementary food and not as a complete ration or it can be further processed to maggot meal and used as supplementary protein source to replace or reduce the inclusion of fishmeal which is the most costly feed ingredient in fish feed.

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