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Nutritive worth of differently prepared Housefly Maggot Substituted Diets for Nile Tilapia (*Oreochromis niloticus*)

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Abstract
In recent time, efforts of fish nutritionists have been directed toward searching for relatively low-cost fish feed ingredients that is of good quality and easily procurable as an alternative to the expensive feed ingredients in fish feeds. In this study housefly maggot was used as the protein source in the diets for *Oreochromis niloticus* juveniles. Five diets were compounded to substitute fish meal at 0%, 25%, 50%, 75% and 100% for each of the oven dried, sundried and fresh maggot diets and tested on the fish for 12 weeks. The data were analyzed using One-way Analysis of Variance (ANOVA) test for comparison among treatments. Analyses of various growth parameters revealed that diets substituted at 25% up to 75% maggot for both oven-dried and sundried maggot diets and 50% up to 100% fresh maggot diets were not significantly different in weight gained by fish fed with fish meal diets ($p > 0.05$). Water quality parameters showed that none of the differently prepared maggot substituted feeds polluted the water media. The studies showed that maggot substituted feeds irrespective of the method of preparation are suitable for the growth of *O. niloticus* for optimum growth and nutrient utilization.

Keywords: Fishmeal; Feedstuff; Juveniles; Diet; Weight gained

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Introduction

Several factors affect the efforts being made to develop and improve fish production in Nigeria in order to meet the increasing demand. Such factors include high cost of fish feeds. In Nigeria, many fish farmers are faced with the problem of cost-effective and high cost of standard fish feed that profit reduce and discourages many fish farmers. This has led to advocation for use of by-products and wastes that are less expensive but of good quality protein, not directly used by human being, readily and locally available as alternative that can replace completely or partially substitute the expensive fishmeal (Fagbenro, 1996). Fish feed is a factor that has much to do with the success of fish culture in Nigeria as it represents the greatest proportion of cost in aquaculture production. Maggots have only been associated with waste products, with decay and worthlessness in Nigeria (Adesulu and Mustapha, 2000). Maggot is among the alternative sources of protein that is being evaluated or that has potential to replace fishmeal in fish feeds. Maggot has been reported to have the potential of becoming a source of commercial fish feed within few years if correct technology is properly harnessed. There is a good potential for cultivating maggot from poultry manure and agricultural waste products, as it takes very short time raised them on continuous bases without any disturbance of the climate during the decomposition (Pillay, 1993). Maggot has been reported to contain very high amount of protein with a well-balanced essential amino acid spectrum. Amino acid composition of the maggots is about the same as that of fishmeal (Spinelli, 1978). The previous works on potentiality of maggot as protein source in fish feeds include those of Adesulu and Mustapha (2000), Idowu *et al* (2003), Olaniyi and Salau (2013), Sing *et al* (2014) and Ezewudo *et al*., 2015 and Emilie *et al.*, 2017.

The main purpose of the study is to find out how methods of preparation of housefly maggot meal affect growth and nutrient utilization of O. *niloticus* juveniles.

Materials and Methods

Collection of maggots and sources of another feedstuff

Maggots used were those of housefly (*Musca domestica*). Developed maggots were harvested using a modified floatation technique where manure impregnated with maggots was put in a sieved plastic bowl immersed in a basin of water. The manure was dissolved by gentle manual vibration of the sieved plastic bowl in the water and washed off leaving clean maggots. The maggots were thoroughly washed until they show their characteristics white colour and free from waste after being killed by subjecting them to low temperature. Yellow maize and dried fish for the fishmeal were obtained from market. The minerals -vitamin premixes and other ingredients were obtained from a livestock feed store.

Feedstuff Preparation

The maggot sample was divided into three parts. the first part was oven dried, the second part was sundried and the third part was kept as fresh maggot sample in refrigerator for further use. The sun-dried, oven dried and fresh maggot samples, dried fish and maize were milled and packed separately. Pearson square method (Pulin and Jhingran, 1985) was used to formulate a 35% crude protein diet for juveniles. The proportionate contribution of each of the feedstuff was determined and five diets containing 0%, 25%, 50%, 75% and 100% maggot meal (protein fraction) for each of the oven dried, sun-dried and fresh maggot meal were prepared. The mixtures containing oven dried and sundried maggot meal were pelleted and dried, but the one with fresh maggot was kept the refrigerator for dispensation as required. The diet containing fish meal as the only protein source (0% maggot inclusion) was taken as control (Table 1). Proximate analysis was carried out to determine moisture content, ash and crude protein of the different diets using (AOAC, 2012).

Experimental Set-up

The experiments were carried out in 39 indoor plastic bowls (240 litres each) at the Aquaculture Center Laboratory of Obafemi Awolowo University, Ile-Ife**.** Each bow was filled with 180 litres of water from Opa dam. 780 juveniles of *Oreochromis niloticus* with a mean weight of 0.52 ± 0.062 were acclimatized in the laboratory for one week, so as to ensure that the fish empty their gastro-intestinal tract before stocking. The fish that were still surviving after one week were weighed and randomly assigned to the bowls at a stocking of 20 fingerlings per bowl. There were three replicates for each diet treatment. The fish were fed 3% of their body weight with their respective diet twice daily for 12 weeks. The fish in each bow were weighed bi-weekly and the feeding rate adjusted according to the mean weight of the fish in each tank. The bowls were monitored daily, the dead fish number in each bowl was recorded and the percentage of survival was estimated. Water quality was controlled by replacing the water loss by evaporating, daily cleaning, changing of the water weekly and removal of uneaten food regularly. Water temperature, pH and dissolved oxygen were monitored weekly using standard methods (APHA, 1985).

Growth performance and nutrient utilization

Growth performance and nutrient utilization were determined from the data on weight gain**,** Specific Growth Rate (SGR), Conversion Ratio (FCR) and Protein Efficiency Ratio (PER)**.** Specific Growth Rate (SGR), Feed Conversion Ratio (FCR) and Protein Efficiency Ratio (PER) were calculated according to the method of Eyo (2005) and Olaniyi and Salau (2013) as follows:

$$SGR = \frac{W_1 - Wo}{T} \times 100$$

(where W_1 = final weight, Wo = initial weight, T = time in days).

$$PER = \frac{\text{Weight gain}}{\text{Protein fed}}$$

(where protein fed = $\frac{(\text{\% protein in diet x total diet consumed})}{100}$)

$$FCR = \frac{\text{Fish feed intake}}{\text{Weight of fish.}}$$

Data Analysis:
The data were analyzed using the One-way Analysis of Variance (ANOVA) test followed by the least significant (LSD) test for comparison among treatment mean of 5% probability (P = 0.05).

Results
The composition of the experimental diets and the proximate analysis of the diets including calorimetric energy termination are shown in Table 1 and 2 respectively. The water temperature range, the pH range and oxygen concentration range were 26.01 - 27.52 ^{0}C, 7 .40 -7.60 and 6.6 - 8.5mg/l respectively. Figure 1 illustrates bi-weekly growth performance of *O. niloticus* juveniles fed diet of different protein levels of maggots for 12 weeks and Table 3 shows growth performance of the young fish with respect to the mean weight gain, and specific growth rate, feed conversion ratio and % survival. Table 4 shows the initial and final carcass composition of *O. niloticus* fed different protein levels of inclusion of the maggot meal diet for 12 weeks and Table 5 shows the records of water quality parameter.

Table 1: Composition of Experimental diets (dry weight)

	A (Oven-dried maggot diets)				**B (Sun-dried maggot diets)**				**C (Fresh maggot diets)**				**D (Control)**
Feedstuff	**A_1**	**A_2**	**A_3**	**A_4**	**B_1**	**B_2**	**B_3**	**B_4**	**C_1**	**C_2**	**C_3**	**C_4**	D
	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%	
Fish Meal	28.63	19.09	9.54	-	28.63	19.09	9.54	-	28.63	19.09	9.54	-	38.17
Maggot	9.54	19.09	28.63	38.17	9.54	19.09	28.63	38.17	9.54	19.09	28.63	38.17	-
Maize	56.83	56.83	56.83	56.83	56.83	56.83	56.83	56.83	56.83	56.83	56.83	56.83	56.83
Vit. Premix	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Palm Oil	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Starch	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 2: Proximate composition of the experiment diet (% weight)

Feedstuff	A (Oven-dried maggot diets)				B (Sun-dried maggot diets)				C (Fresh maggot diets)				D (Control)
	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4	C_1	C_2	C_3	C_4	D
	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%	
Moisture	6.5±0.2	5.9±0.8	5.8±0.2	6.8±0.5	6.9±0.5	6.8±0.2	6.0±0.8	5.9±0.5	36.0±0.5	40.4±0.3	43.0±0.1	20.4±0.4	8.9±0.2
Protein	35.8±0.3	35.4±0.5	34.9±0.9	35.9±0.4	35.6±1.0	35.4±0.3	35.0±0.1	36.2±0.3	35.9±0.4	35.5±0.8	34.9±0.8	36.5±0.5	36.6±0.7
Ether Extract	9.0±0.2	10.5±0.3	12.2±0.6	15.8±0.5	9.8±0.2	10.0±0.2	11.0±0.8	15.8±0.6	4.3±0.2	4.9±0.6	5.6±0.4	18.1±0.4	10.2±0.1
Crude Oil	3.9±0.5	6.5±0.2	5.4±0.3	6.5±0.5	3.8±0.6	6.1±0.3	5.8±0.6	7.1±0.3	1.0±0.2	1.1±0.5	1.3±0.2	7.4±0.3	7.3±0.4
Ash	36.8±0.3	28.6±0.3	30.5±0.3	24.5±0.3	7.6±0.5	12.2±0.2	11.0±0.2	11.8±0.4	4.9±0.9	5.2±0.1	5.8±0.9	16.3±0.4	5.7±0.7
NFE	36.8±0.5	28.6±0.3	30.5±0.3	24.5±0.7	36.7±0.1	29.4±0.1	31.0±0.1	23.7±0.5	17.7±0.2	12.7±0.5	9.2±0.8	1.3±0.3	43.0±0.4
Energy Kcal/Kg	4908±0.4	4858±0.7	4798±0.4	4678±0.1	4764±0.1	4764±0.3	4708±0.5	4695±0.1	5272±0.7	5243±0.2	5243±0.6	5234±0.0	4562±0.3

*Values are mean of three replicates

Table 3: Growth performance of *O. niloticus* juveniles fed for 12 weeks

	A (Oven-dried maggot diets)				B (Sun-dried maggot diets)				C (Fresh maggot diets)				D
	A1	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**	D
IMW*	0.52±0.3^{a}	0.51±0.7^{a}	0.54±0.5^{a}	0.52±0.8^{a}	0.52±0.7^{a}	0.53±0.9^{a}	0.54±0.8^{a}	0.53±0.3^{a}	0.51±0.9^{a}	0.53±0.9^{a}	0.52±0.9^{a}	0.52±0.9^{a}	0.53±0.8^{a}
FMW*	2.13 ±0.2 ^{b}	2.20±0.9 ^{ab}	2.35±0.4^{a}	1.37±0.4^{b}	2.18±0.3^{a}	2.50±0.4 ^{a}	2.24±0.5 ^{ab}	1.15±0.5 ^{b}	1.26±0.6 ^{b}	1.94±0.1 ^{a}	2.05±0.4 ^{b}	2.38±0. ^{a}	2.55±0.5 ^{a}
MWG*	1.61±0.4^{a}	1.69±0.1^{ab}	1.87±0.2^{a}	0.85±0.4^{b}	1.66±0.2 ^{ab}	1.97±0.6 ^{a}	1.70±0.4 ^{ab}	0.98±0.2 ^{b}	0.75±0. 4^{b}	1.41±0. 2^{b}	1.53±0. 7^{ab}	1.86±0. 5^{a}	2.02±0. 3^{a}
SGR*	1.68±0.6^{a}	1.74±0.3^{a}	1.75±0.5^{a}	1.15±0.5^{b}	1.71±0.9 ^{a}	1.85±0.3 ^{a}	1.69±0.9 ^{a}	1.25±0. 9^{b}	1.08±0.2 ^{b}	1.54±0. 9^{a}	1.63±0.7 ^{a}	1.81±0.3 ^{a}	1.87±0.3 ^{a}
FCR*	105.8±0.8^{a}	100.6±0.4^{a}	100.2±0.1^{a}	116.5±0.8^{a}	102.0±0.6^{b}	94.2±0.5 ^{b}	102.3±0.3^{b}	135.5±0.5 ^{a}	159.9±0. 5^{a}	114.7±0.5^{ab}	108.4±0.9 ^{b}	94.9±0.5 ^{b}	93.1±0.5 ^{a}
PER*	1.83±0.6^{a}	1.99±0.6^{a}	1.60±0.9^{a}	2.05±0.0^{b}	1.94±0. 2^{a}	1.69±0.7^{a}	1.72±0.4 ^{ab}	2.10±0. 7^{b}	1.88±0. 9^{a}	1.74±0.5 ^{a}	1.38±0. 6^{ab}	1.63±0.8 ^{b}	1.61±0.7 ^{a}
%S	95.0±0.6^{a}	96.7±0.^{a}	100.0±0.^{a}	91.7±0.^{a}	98.3±0. ^{a}	98.3±0. ^{a}	100±0.^{a}	93.3±0. ^{a}	95.0±0.5 ^{a}	95.0±0. ^{a}	95.0±0. ^{a}	95.0±0. ^{a}	96.07±0 ^{a}

Figures in in the same row having similar superscript are not significantly different from one another ($p>0.05$)

*IMW=Initial Mean Weight; FMW = Final Mean Weight; MWG = Mean Weight Gain; SGR = Specific Growth Rate; FCR=Feed Conversion; PER = Protein Efficiency Ratio; %S= Percentage survival;

Table 4: Initial and final carcass composition of *O. niloticus* fed different protein of maggot diets

Nutrients	Initial	A (Oven-dried maggot diets)				B (Sun-dried maggot diets)				C (Fresh maggot diets)				D Control
		A1 25%	**A2** 50%	**A3** 75%	**A4** 100%	**B1** 25%	**B2** 50%	**B3** 75%	**B4** 100%	**C1** 25%	**C2** 50%	**C3** 75%	**C4** 100%	D
Protein (%)	19.42	21.7	21.9	22.9	20.4	22.6	23.3	22.2	20.9	20.3	21.0	21.4	23.0	23.8
Fat (%)	4.92	2.95	3.05	2.67	2.53	3.07	2.67	2.53	2.22	4.01	3.95	4.22	3.67	2.52
Crude fibre (%)	3.72	3.60	3.70	3.77	3.54	3.73	3.83	3.68	3.72	3.69	3.81	3.68	3.74	3.69
Ash (%)	3.72	3.60	3.70	3.77	3.54	3.73	3.83	3.68	3.72	2.48	2.67	2.63	3.31	3.69
Moisture (%)	2.95	2.80	2.85	3.10	2.57	2.87	3.10	2.91	3.13	70.9	69.7	69.8	68.4	3.22

Table 5: Records of water quality parameters in the experimental bowls

Physico-Chemical Parameter	Initial	A (Oven-dried maggot diets)				B (Sun-dried maggot diets)				C (Fresh maggot diets)				D Control
		A_1 25%	**A_2** 50%	**A_3** 75%	**A_4** 100%	**B_1** 25%	**B_2** 50%	**B_3** 75%	**B_4** 100%	**C_1** 25%	**C_2** 50%	**C_3** 75%	**C_4** 100%	**D**
Temp (^{0}C)	25.53	26.5	26.0	27.0	27.5	27.0	26.5	26.0	26.5	27.5	26.5	26.5	26.5	26.5
pH	7.63	7.42	7.60	7.53	7.58	7.52	7.50	7.60	7.50	7.60	7.56	7.51	7.54	7.50
Dissolved Oxygen	7.55	5.50	5.20	5.48	4.80	5.30	5.42	5.03	2.90	5.20	5.35	4.60	4.10	5.59

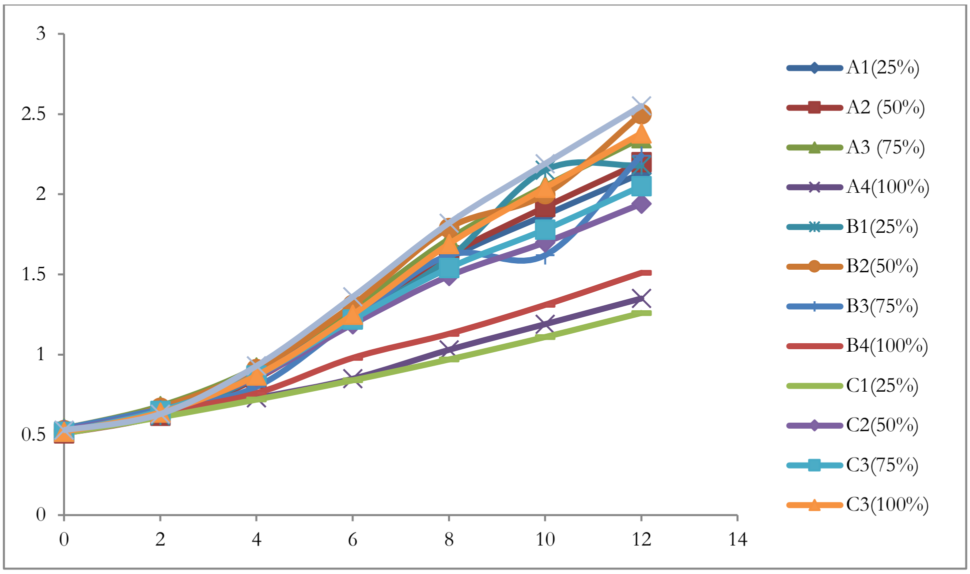

Fig. 1: Bi-weekly records of weight increment (g) of *O. niloticus* juveniles fed for12 weeks

Discussion

The physico-chemical parameters of the culture media were found suitable for fish. The water temperature range of 26.01 to 27.52^{0}C was within the range described by Komolafe and Arawomo (2008) for Osinmo reservoir. The pH range of 7.40 to 7.60 were within the range of 7 – 7 .69 recommended for *Tilapia* culture (Burn and Stickney (1980) and the range of 6.6 and 8.5 known for most streams and lakes of the world (Boyd, 1979). Oxygen concentration was found to reduce with time in the culture media with the value ranging from 4.10 to 5.50mg/l. A dissolved oxygen range of 1 to 4.99 mg/l makes fish survive but slows the growth on prolonged exposure of the fish to the condition and the value above 5mg/l is desirable (Huner and Dupree, 1988). The dissolved oxygen content recorded during the current study were however normal within the acceptable range of 1.75 - 11.20 mgl^{-1} obtained by Atobatele and Ugwumba (2008), which has been found to be suitable for fisheries resources development in the reservoir.

Results from this study show that housefly maggot meal is well utilized and is suitable as source of protein in fish feed. Dietary protein level of maggot substituted diets in this study falls within the suitable level reported by Idowu *et al* (2003) and Sing *et al* (2014). Rumsey (1998) had earlier reported that maggot meal helps to increase growth of fish. *O. niloticus* juveniles are capable of utilizing compounded diet effectively as shown by the general low feed conversion ratio in all treatment. The SGR, FCR and PER value for most of the maggot diets were indication of the acceptability of maggot-supplemented diet to *O. niloticus*. This study reveals that maggot meal can be successfully used to replace fishmeal in diet of *O. niloticus* fries and for optimum growth. *Oreochromis niloticus* like other cichlid is highly adaptable and can tolerate adverse condition. The results obtained suggest that maggot contains all the necessary growth promoting factors. According to Agbede and Falaye (1998) feed ingredient of 20% protein level and above could be regarded as good protein source. The dietary protein requirement *Oreochromis niloticus* were 35% (Santiago, 1985). Nwadukwe (1991) reported that tilapias require relatively low protein level. *O. niloticus* according to this experiment are capable of utilizing maggot-compounded diets at various substitution rate, but its best-feed conversion ratio was obtained at 75% oven dried, 50% sun-dried and 100% fresh maggot inclusion level. Maggot has been reported to contain the essential amino acid found in fishmeal. The use of maggot from ecological point of view according to Idowu et al (2003) appear to be cheaper means of reducing the population of adult housefly, *Musca domestica* thereby reducing the risk of disease transmission on the part of the insect vector. Proximate analysis of fishmeal and housefly maggot meal suggested crude lipid was higher in maggot meal, a finding consistent with a previous study (Ogunji *et al*., 2008) where the nutrient composition of housefly maggot meal was evaluated. The result of SGR indicated an increase in the weight gain and food utilization by the juvenile fish. The reason for the superiority of 100% fresh maggot diet over other diets was attributed to the relatively large amount of soft tissue contain in the whole diet. This is in accordance with Adesulu and Mustapha (2000) who reported that the superiority of maggot over other protein sources in fish was due to tender and easily digested nature of maggot.

The value of FCR and PER becomes better as the protein level increased. This is favourably compared with those obtained by Faturoti et al (1995) who found that fish fed 100% life poultry during maggot had the highest percentage mean weight gain, SGR and lowest FCR than those artificial diets. *O. niloticus* juveniles are capable of utilizing compounded diet effectively as shown by the low feed conversion ratio. The best-feed conversion ratio was obtained with 100% fresh maggot diets. This is in contrast to Olaniyi and Salau (2013) who reported that fingerling performed better when fed with diet containing 75% maggot protein inclusion level for fingerling of *Clarias gariepinus.* In another research conducted by Mustapha (2001), the best growth rate was recorded among fingerling fed with diet containing 75% oven dried maggot meal, followed by 50% maggot inclusion and the least growth was exhibited by the fish fed diet containing 100% oven dried maggot meal as the protein source. High levels of fishmeal replacement with housefly maggot meal have been associated with low body weight gain in both fish and chickens (Oyelese, 2007; Ogunji *et al*., 2008).

Previous studies showed that housefly maggot meal should only partially substitute fishmeal in the diets of omnivorous fish species such as catfish and Nile tilapia (Oyelese, 2007; Ogunji *et al*., 2008). Some researchers reported substitution of fishmeal with housefly maggot meal at 50% or less provided the optimum level in chicken feed (Awoniyi *et al*., 2003; Adenji, 2007). These earlier studies contrast with the present study which showed increased substitution of fishmeal by housefly maggot meal improved the growth, survival and feed efficiency of juvenile tilapia with the total replacement diet giving the optimal results with Diet C (fresh maggot diet) only. The results and the observations in the field indicated that there was no food rejection by the fish. High survival of fish was attributed to water quality parameters being within the optimum range for the fish. *O. niloticus* like other cichlids is highly adaptable and can tolerate adverse condition within their habitat. The mortality, though very insignificant, was attributed to stress encountered by the fish during the frequent sampling and waste removal.

The study revealed that oven-dried maggot could replace from 25% up to 75% of the protein component of O. *niloticus* diet, though diet containing 75% maggot meal as the protein source is the most suitable for optimal growth performance and feed efficiency. Fish diet containing 100% fresh maggot followed by Diet containing 75% maggot as crude protein (in the diets containing fresh maggot) is most suitable for optimal growth and performance and it showed a comparable growth parameter with the control diet. The study revealed that maggot meal is favourably compared with the fish meal in term of protein and nutrient content and that it could successfully replace fishmeal partially or wholly in the diet of *Oreochromis niloticus*. The study indicated that fish diets containing crude protein of fresh, oven dried and sun-dried maggot (irrespective of the method of preparation) are suitable for optimum growth and performance of *Oreochromis niloticus*. There was no significant ($p > 0.05$) difference between the maggot meals and the control diet. Optimum water quality and low mortality showed that maggot meal did not pollute the water media. Fish meal is expensive, less economically viable and not easily affordable by fish farmers whereas maggot meal is less expensive, economically viable and easily affordable. Maggot meal inclusion could be utilized in place of the fish meal for adequate growth and survival of Tilapia and it will be more profitable for use in large scale fish production.

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