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Potentials of Fresh Housefly Maggot in the Diet of *Oreochromis niloticus* Fingerlings

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ABSTRACT: The study was designed to investigate the value of fresh housefly maggot diet as protein source and the level of inclusion for optimum growth in the diet of Nile Tilapia (*Oreochromis niloticus*) fingerlings. Five experimental diets, four fresh maggot substituted diets containing 25%, 50%, 75% and 100% fresh maggot meal and a control (0% maggot inclusion) were prepared and tested on triplicate groups of *O. niloticus* fingerlings (mean weight of 0.52g) for twelve weeks. The fish were fed twice daily at 3% of their body weight. The optimum water quality parameters were27^{0}C, 7.63 and 7.55 for Temperature, pH and Dissolved Oxygen respectively and the maggot did not pollute the water media. The best growth rate was recorded among the fish fed control diet and 100% fresh maggot inclusion as the only protein source and the least growth rate was showed by fingerlings fed 25% fresh maggot inclusion. Optimum Specific Growth Rate, Feed Conversion Ratio and Protein Efficiency Ratio of 1.8702, 159.92 and 1.8759 respectively showed that there was no significant difference in weight gained by the fish fed with the five diets except 25% fresh maggot substituted diet. The study indicated that fresh maggot meal can be successfully used to replace fishmeal partially or completely from 50% up to 100% in the diet of *O. niloticus* fingerlings for optimal growth and nutrient utilization. Based on these results, maggot meal is suggested as an effective and sustainable protein source to replace fishmeal in the diet of farmed tilapia.

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Fish production has a special role in enhancing food security and in alleviation poverty as fish is highly nutritious food that forms the essential part of the diet of a large proportion of the people in developing countries (FAO, 2000).The predicted shortage of animal protein in Nigeria necessitates the evaluation of all means of multiple water use and unconventional method of animal production. Scarcity and high cost of fishmeal are one of the several factors that contribute to the shortage of fish supply. The global supply of fishmeal has dwindled due to overexploitation of the natural fishery stock. With the predicted continuous growth of the aquaculture industry, Brugère and Ridler (2004) observed that, the demand for fishmeal will continue to increase, causing its price to soar. Various studies have been conducted with sustainable alternative protein sources to determine their effects on fish growth (Emilie *et al.,* 2017; Cabral *et al*., 2011; Silva *et al*., 2010) and these have shown contradicting results. The major constraint to rapid development of aquaculture in Nigeria is the inadequate supply of feedstuff at economic prices. There are many less expensive by-products and waste products of good quality protein that can eventually lead to reduced cost of production. Fish culturists have tried such products like rap seed meal, sunflower meal, cottonseed meal, parkia seed and blood meal as ingredients of fish feed. These products are locally available, inexpensive and readily easy to obtain.

Maggots have only been associated with waste product, decay and worthlessness in Nigeria. Insect-based diets have been recognized and studied in recent times as one of the cheaper alternatives to fishmeal. Insects such as the black soldier fly (*Hermetia illucens*), the meal worm beetle (*Tenebrio molitor*) and the house fly(*Musca domestica*) have been studied as alternative protein sources and as substitute for fish meal in fish diets with promising results (Emilie *et al.,* 2017;Ogunji*et al*., 2008; Zuidhof *et al*., 2003; Ng *et al*., 2001;).Interestingly maggot supplemented meal have been used successfully to feed *Oreochromis niloticus* fingerlings (Emilie *et al.,* 2017; Ezewudo *et al*., 2015; Ajani *et al*., 2004; Idowu *et al*., 2003;Fasakin*et al*., 2003; Akinwande *et al*., 2002; Adesulu and Mustapha, 2000;Faturoti*et al*., 1995).Housefly (*Musca domestica*) maggot meal was reported to contain 39-65% protein (Awoniyi *et al*., 2003; Atteh and Ologbenla, 1993), while the protein content of *Chrysomya megacephala* maggot meal

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ranged from 52-56% depending on the age of maggots at harvesting. Such variations in protein content could be attributed to the processing, drying, storage and protein estimation methods employed, or the substrate used for the production of housefly maggots (Ogunji *et al.*, 2008; Awoniyi *et al.*, 2003). Maggot has come to be known not only as safe food for fishes, but also as rich protein source for them. Maggots are produced from the semitransparent larval stage of the housefly, *Musca domestica* and are used to process magmeal. Studies have shown that magmeal is of high biological value. The percentage of crude protein of housefly maggot ranges from 39–61.4%, lipid 12.5–21%, and crude fiber 5.8–8.2%. Examination of the comparative minerals and amino acid contents of fishmeal and maggot meal showed that no essential amino acid was limiting (Adesulu and Mustapha, 2000). Spinelli *et al*., (1978) used magmeal protein in the diets of rainbow trout. The protein provided growth and feed conversion levels equivalent to fish meal at substitution levels ranging from 25-100 %.Fashina *et al.,* (1997) and Ajani *et al.*, (2004) reported that magmeal can replace up to 100 percent of fish meal in the diets of Nile tilapia *(O. niloticus).*

The high demand of *O. niloticus* has prompted countries such as China, Malaysia, Brazil, Thailand and the Philippines to invest in tilapia culture (Sing *et al.,* 2014; Watanabe *et al*., 2002), which in turn has elevated tilapia to second place amongst the farm-raised food fish in the world by volume (FAO, 2011).This present study was carried out to determine the best level of replacement of fishmeal with maggot meal in the diet of *O. niloticus* fingerlings.

MATERIALS AND METHODS

Collection of Maggot: Maggot used was those of housefly (*Musca domestica*). The main method adopted in the collection was the modified form of floating method (Atteh *et al.,* 1990**)**. The poultry droppings were collected from the part where maggots were highly concentrated into a 50 litres bowl until it was filled up. The bowl was left for some times to allow the maggots to move and congregated at the bottom of the container. The method gives room for collection of life and active maggot. Further separation was done by sieving and freeing them from waste particles. The maggots were thoroughly washed until they showed their characteristics whitish colour. They were killed by subjecting them to low temperature at 5^0C and were kept in the refrigerator for further use

Source of other feedstuff: Starch, minerals and vitamin premix were obtained from a livestock feed store and yellow maize were obtained from the local market. The fish used for the fishmeal were freshly caught from pond.

Feedstuff Preparation: The fresh maggot and sun-dried yellow maize were milled separately using a grinding machine, packed separately and stored for use. The fish after being degutted and descaled was boiled for ten minutes and then pressed to remove the water and oil. It was then oven dried at 95^0C for 12 hours, milled and packaged for use. The various ingredients were weighed and thoroughly mixed together and kept in the refrigerator for dispensation as required**.**

Feed Formulation: Pearson Square Method described by Pearson (1976) was use to formulate a 35% crude protein diet for the fingerlings. Prior to formulation of the experimental diets, the proximate nutrient composition of fishmeal and maggot meal was determined using **(**AOAC, 2012) method. Five diets with increasing levels of substitution of fishmeal by maggot meal D1 (25%), D_2 (50%), D3 (75%), D_4 (100%) and D_5(0%) maggot meal in the protein fraction were prepared. The diet containing fishmeal as the only protein source (0% maggot inclusion) was taken as control. Proximate analysis was carried out to determine the moisture content, ash and crude protein of the five diets (AOAC, 2012). Growth indices were determined to properly evaluate the performance of the fingerlings in the experimental diets.

Experimental Set-up: The experiments were carried out in 15 plastic bowls (240 litre each) in the aquaculture centre laboratory at Obafemi Awolowo University, Ile-Ife. Each bowl was filled with filtered water from Opa dam up to three-quarter of the volume. 300 fingerlings of *Oreochromis niloticus* with a mean weight of 0.52 ± 0.062 were acclimatized in the laboratory for one week**.** The survivors after one week were weighed and randomly assigned to the bowls at a stocking density of 20 fingerlings per bowl. Feeding commenced 48 hours after stocking, so as to ensure that all the stocked fish empty their gastro-intestinal tract. Each diet treatment was given in triplicates. Fish were kept in a natural photoperiod regime and the water temperature was 25±1.8°C. The fish were fed for 12 weeks at 3% body weight with their respective test diet twice daily**.** The entire population of each bowl was weighed bi-weekly and the feeding rate adjusted according to the mean fish weight in each tank. The bowls were monitored daily and dead fish number in each bowl was recorded and percentage survival was estimated. Water quality is controlled by replacing the water loss by evaporation, daily cleaning, changing the water weekly and removal of uneaten food. Water temperature, pH and dissolved oxygen were monitored weekly using standard method (APHA, 1985). At the end of the feeding trial, fish were fasted for 24h before the final body weight was recorded. Specific Growth Rate (SGR), Feed Conversion Ratio (FCR) and Protein Efficiency Ratio (PER) were calculated according to the method of Olvera- Novoa *et al*., (1990),Eyo (2005)Olaniyi and Salau (2013) as follows:

$$SGR = \frac{W1 - Wo}{T} \times 100$$

Where W_1= Final Weight, W_o= Initial Weight, t = Time in Days.

$$FCR = \frac{Total\ feed\ given}{Weight\ gained}$$

$$PER = \frac{Weight\ gained}{Protein\ fed}$$

$$Where\ protein\ fed = \frac{\%\ PD\ x\ TDC}{100}$$

Where PD = protein in diet and TDC = total protein consumed

Data analysis: Growth performance and nutrients utilization were evaluated from data on weight gain, SGR, FCR, PER and Carcass composition. The data were analyzed using 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 AND DISCUSSION

The physicochemical 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 Okayi (2003) for river Benue and, 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; Ross 2000) and the range of 6.6 and 8.5 known for most streams and lakes of the world (Boyd, 1979).

Table 1: Minerals contents of Maggot and Fish meal

Minerals	Fishmeal	Maggot
Ca(%)	0..40	0.36
Mg(%)	0.02	0.21
Na (%)	0.55	0.31
K(%)	0.08	0.45
Fe(ppm)	162	1129
Zn(ppm)	173	49.63
Cu(ppm)	-	21.47
Mn(ppm)	86	15.41
Pb(ppm)	-	1.08

Table 2: Amino acid contents of Maggot and Fish meal

Amino Acid	Fishmeal	Maggot
Alanine	6.34	6.15
Arginine	5.82	5.42
Asparagine	9.32	10.80
Cysteine	0.70	0.80
Glutamine	13.30	12.20
Glycine	5.90	5.40
Histidine	2.22	3.50
Isoleucine	4.36	4. 13
Leucine	7.35	6.95
Lysine	7.85	7.37
Methionine	2.84	2.24
Pheny-lalanine	4.35	6.95
Proline	4.35	3.66
Serine	4.55	4.51
Threonine	4.55	4.53
Trypto-phan	1.33	1.45
Tyrosine	3.45	8. 10
Valine	5.65	5.60

Oxygen concentration were found to reduce with time in the culture medium with the value ranging from 4.10ml/g to 5.50mg/l. Dissolved oxygen range of 1 ml/g to 4.99 mg/l make fish survive, but slows the growth on prolonged exposure of the fish to the condition and the value is within tolerance limits for tilapia (El-Sayed, 2006; Beveridge and McAndrew, 2000). High survival of fish was consequent of water quality parameter being within the optimum range for the fish. *Oreochromis 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 during frequent sampling and faeces collection (Bolivar *et al.,* 2004; MacNiven and Little, 2001).

Proximate and amino acid analyses of the maggot meal andtest diets were carried out. Minerals and amino acids contents of Maggot and Fish meal are shown in Tables 1, and 2respectively. The composition of the experimental diets and the proximate analysis of the diets including calorimetric energy termination are shown in Table 3 and 4 respectively. Bi-weekly weight gain by the fish fingerlings fed the experimental diets is shown in Fig 1. Table 5, 6 and 7 show the growth performance parameters, initial and final carcass composition of the fish and records of water quality parameters respectively. The best growth rate was recorded among fish fingerling fed with fishmeal as the only protein source (D_5) while diet D_4 (100% maggot meal) produced the second best growth response and nutrient utilization. Diet D_3 (75% maggot inclusion) was the third best growth rate, the forth D_2 (50% maggot inclusion) and the least growth was shown by fingerling fed diet (D_1) containing 25% fresh maggot meal as protein source.

Weight gain were not significantly different between treatments ($P < 0.05$). Specific growth rate increases up to 100% maggot inclusion level. The FCR decrease with increasing maggot level from 25% to 100% and Protein Efficiency Ratio (PER) decreased as the dietary maggot inclusion level increased. SGR and FCR were not significantly different between the five treatments except those fed Dt_1.

Table 3: Percentage Composition of Experimental Diets (% dry weight)

Diets	**Dt_1**	**Dt_2**	**Dt_3**	**D_4**	**Dt_5**
Dietary maggot inclusion	25%	50%	75%	100%	0%
Fish	30.54	26.72	22.90	-	38.17
Maggot meal	7.63	11.45	15.27	38.17	-
Yellow maize	56.83	56,83	56.83	56.83	34.95
Vitamin Premix	2.00	2.00	2.00	2.00	2.00
Palm oil	0.50	0.50	0.50	0.50	0.50
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50
Starch (Binder)	2.00	2.00	2.00	2.00	2.00
Total	**100**	**100**	**100**	**100**	**100**

Table 4: Proximate Composition of the Experimental Diets (% weight)

Diets	**Dt_1**	**Dt_2**	**Dt_3**	**Dt_4**	**Dt_5**
Moisture	36.05	40.43	43.01	20.40	8.90
Protein	35.90	35.50	34.90	36.50	36.67
Ether extract	4.32	4.98	5.60	18.10	10.28
Crude fibre	1.02	1.16	1.32	7.40	7.34
Ash	4.99	5.21	5.89	16.30	5.77
NFE**	17.72	12.72	9.28	1.30	43.04
Energy Kcal/Kg	5272.5	5259.3	5243.4	5234.3	4563.5

**Value are mean of three replicates; *NFE was obtained by difference*

Table 5: Growth performance of *O.niloticus* fingerlings fed for 12 weeks

Diets	**Dt_1**	**Dt_2**	**Dt_3**	**Dt_4**	**Dt_5***
Initial mean weight	0.51^{a}	0.53^{a}	0.52^{a}	0.52^{a}	0.53^{a}
Final mean weight	1.26^{b}	1.94^{b}	2.05^{b}	3.38^{a}	2.55^{a}
Mean weight	0.75^{b}	1.41^{b}	1.53^{ab}	1.86^{a}	2.02^{a}
Specific growth rate	1.0767^{b}	1.5547^{b}	1.6330^{a}	1.8107^{a}	1.8702^{a}
Feed conversion ratio	159.92^{a}	114.70^{ab}	108.38^{b}	94.98^{b}	93.06^{b}
Protein efficiency ratio	1.8759^{a}	1.7435^{a}	1.3840^{ab}	0.6317^{b}	1.6117^{a}
% survival	93.33^{a}	95.00^{a}	95.00^{a}	95.00^{a}	96.07^{a}

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

Table 6: Initial and final carcass composition of *OreochromisNiloticus fed*for12 weeks.

Diets	**INITIAL**	**Dt_1**	**Dt_2**	**Dt_3**	**Dt_4**	**Dt_5***
Crude Protein%	19.42^{c}	20.30^{c}	21.04^{b}	21.35^{b}	23.05^{a}	23.77^{a}
Ether extract %	4.92^{a}	4.01	3.95^{a}	4.22^{a}	3.67^{b}	2.52^{b}
Crude fibre	3.72^{a}	3.69^{a}	3.81^{a}	3.68^{a}	3.74^{a}	3.69^{a}
Ash	2.95^{a}	4.28^{a}	2.67^{a}	2.63^{b}	3.13^{a}	3.22^{a}

Table 7: Records of water quality parameter in the experimented bowls

	INITIAL	**Dt_1**	**Dt_2**	**Dt_3**	**Dt_4**	**Dt_5***
Temp. ^{0}C	25.0	27.0	26.5	26.5	26.5	26.5
Ph	7.63	7.60	7.56	7.51	7.54	7.50
Dissolved Oxygen	7.55	5.20	5.35	4.60	4.10	5.50

The improvement in growth and feed efficiency recorded in *Oreochromisniloticus* fed maggot-supplemented diet suggest that maggot contain all the necessary growth promoting factors. Agbede and Faleye (1998) reported that feed ingredient of 20% protein level and above could be regarded as good protein source. Tilapia requires relatively low protein level of about 25 – 30% as compared to the more carnivorous species (Kabaryk, 1980). Crucially, the values for maggot meal are similar and can readily substitute locally produced fishmeal (Kolawole and Ugwumba, 2018; Ezewudo *et al.,* 2015; Henry *et al.,* 2015; Barroso *et al*., 2014). 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 fish fingerling. 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 protein efficiency ratio, which decreased as the maggot inclusion level increase, was similar to the observance of *Sarotherodon mossambicus* (Jauncey, 1982). 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 dung maggot had the highest percentage mean weight gain, SGR and lowest FCR than those artificial diets. *O. niloticus* fingerlings 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 Kolawole and Ugwumba (2018), Ezewudo*et al.,* (2015), Olaniyi and Salau (2013) and Akinwande *et al*., (2002), who reported that fingerling performed better when fed with control diet and diet containing 60% and 75% maggot protein inclusion level for fingerling of *Oreochromis niloticus* and *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 fingerlings fed diet containing 100% oven dried maggot meal as the protein source. The concentration of K, Ca, Mg, Na, Fe, Zn analyzed for maggot meal were within the range of the value obtained for each of the element for *Sarotherodon galilaeus* by Olaleye and Akintunde (1991). This further confirms the suitability of maggot as Tilapia fishmeal. Spinelli (1978) had earlier shown that maggot contains the same number of amino acids found in fishmeal (including the ten essential ones for animals).This phenomenon is usually related to a deficiency or absence of one or more essential amino acids in those animal and plant protein sources. Moreover, insufficient amounts of certain essential amino acids in any given diet can cause fish to suffer cataracts (methionine and tryptophan) and scoliosis (tryptophan) (Cowey, 1994).

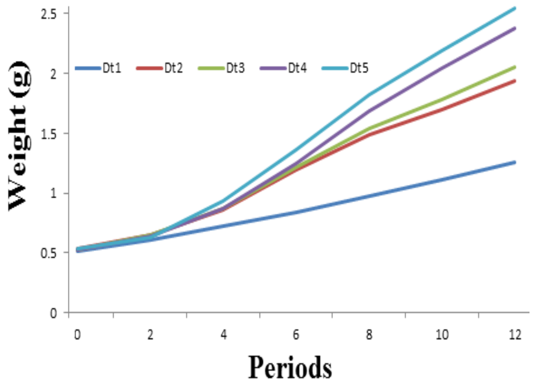

Fig 1: Bi-weekly records of weight increment (g) of *O. niloticus* fingerlings fed for12 weeks.

High levels of fishmeal replacement with housefly maggot meal have been associated with low body weight gain in both fish and chickens (Ogunji *et al*., 2008; Oyelese, 2007). Earlier studies indicated that housefly maggotmeal should only partially substitute fishmeal in the diets of omnivorous fish species such as catfish and Nile tilapia (Ogunji *et al*., 2008; Oyelese, 2007). Some authors reported replacement of fishmeal with housefly maggot meal at 50% or less provided the optimum level in chicken feed (Adeniji, 2007; Awoniyi *et al*., 2003). 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. Although palatability of the maggot meal was not directly tested, these results and the observations in the laboratory indicated that there was no food rejection by the fish.

*Conclusion***:** Housefly maggot meal contained all the essential amino acids needed by juvenile tilapia for normal growth and equivalent protein content to fishmeal. It is shown from this study that fresh maggot meal is favorable compared with fish meal in term of protein content and nutrient composition and has growth promoting ability. Low mortality and suitable water quality showed that fresh maggot diet did not pollute the water media. 50% to 100% level of replacement of fishmeal with maggot meal is recommended. Housefly maggot larvae can be produced enmass from agricultural waste. Therefore replacing of fishmeal with housefly maggot meal in *O. niloticus* feed should directly reduce the production costs.

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