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REVIEW

Review on Using of Housefly Maggots (*Musca domestica*) in Fish Diets

Hamed H.E. Saleh*

Aquaculture Division, National Institute of Oceanography and Fisheries (NIOF), El-Fayoum, Egypt

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ABSTRACT

The main animal protein ingredient in fish diets is most often fishmeal because of its nutritional quality. However, the limited availability and increasingly cost of fishmeal has lead to investigations of either lowering or replacing the fishmeal content with more economic protein sources of animal and/or plant origin. The research for appropriate and cheap cost alternative sources of protein to use in commercial fish diets will be the most important factor in intensive fish culture development. Insect meals are healthy and nutritious alternatives to fish meal due to their rich nutritional values, particularly protein, fat and minerals. Housefly maggots (*Musca domestica*) meal is also rich in B complex vitamins, trace elements and phosphorus. From the results of previous studies, Housefly maggots meal can be used successfully to replace the fish meal portion partially or completely in the fish diets. Also, the results observed that not physiological stressful was introduced in the fish by feeding Housefly maggots meal diets. This indicates that Housefly maggots meal were well utilized by the fish thus resulting in good growth of fish. In other study, observed a best growth performance with fish feeding on diets containing maggot's meal compared with fish feeding on fishmeal diet. This indicates the high nutritional quality and fish acceptance of maggot's meal.

1. Introduction

The limited availability and increasingly cost of fishmeal has lead to investigations of lowering or replacing the fishmeal content with more economic protein sources of animal and/or plant origin [1-4]. The efficiency of alternative animal protein sources has been evaluated in fish diets, e.g., poultry by-product meal [5-7], meat and bone meal [8], turkey meal [9], gambusia meal [10,11], tuna liver meal [12], sand smelt meal [13,14]. The need for cheap, protein rich feeds is a global requirement, relevant to large and small producers alike.

Insect-based diets have recently been identified and studied as one of the cheapest alternatives to fishmeal. Insects such as the meal worm beetle (*Tenebrio molitor*), the black soldier fly (*Hermetia illucens*) and the house fly (*Musca domestica*) have been studied as alternative protein sources and alternatives to fishmeal in fish diets with promising results [15-18].

The common housefly, *Musca domestica*, (family: Muscidae) they can be found almost anywhere on earth including decaying matter, faecal matter and garbage heaps [19]. The housefly maggots have been shown to be of great benefits as a potential protein source for fish nutrition [20,21].

The observations indicate that maggot meal is well

**Corresponding Author:*
Hamed H.E. Saleh,
Aquaculture Division, National Institute of Oceanography and Fisheries (NIOF), El-Fayoum, Egypt;
Email: hhsaleh90@gmail.com

utilized by Nile tilapia (*Oreochromis niloticus*) fingerlings thus promoting good growth. Tilapia fingerlings feeding with maggot meal diets did not result in any form of physiological stress. Hence maggot meal can therefore completely replace fishmeal in diet of Nile tilapia fingerlings, because it is able to meet the nutritional requirements of this species [20].

With the increasingly demand for fishmeal globally, its cost is expected to continue to rise in the globle market. For eliminate this trend, researchers are conducting studies to determine cheaper alternatives with similar nutritional quality. It has been reported that Housefly maggot's meal is a possible alternative [22,23]. Therefore, the objective of this review was, to assess the effects of using of Housefly maggots (*Musca domestica*) in fish diets on growth performance, feed efficiency survival rate and physiological stress of fish.

2. Importance of Housefly Maggots (*Musca domestica*) in Fish Feeding

The development of fish production is adversely affected by high cost of fish feed. The rapid expansion and success of commercial fish farming is largely dependent on the availability of good quality and cheap feed. Using of nonconventional feedstuffs and by-products for aqua feeds would reduce unit cost of fish production.

The cost of processing and harvesting one kilogram of Housefly maggots meal is less than 20% of cost of one kilogram of fishmeal [20]. Based on availability, cost, feed conversion ratio and biological value, it can be said that, Housefly maggots meal is a viable alternative to fishmeal in fish diets. Using of maggot meal seems to provide a good opportunity to develop low-cost fish feeds, especially in the developing countries where the fishmeal is imported very expensively and therefore not readily available [20].

The nutritional value of the maggot's meal is equal to the value of whole fishmeal [24]. The percentage of crude protein ranges from 43 to 62% [25,26]. Also, Sheppard and Newton [27] revealed that maggot oil is high in monounsaturated fatty acids, rich in B-complex vitamins, phosphorus and trace elements [28]. Atteh and Ologbenla [29] mentioned that the amino acids for the maggot's meal are similar to the amino acid found in fishmeal.

Housefly maggot's meal is of good nutritional value, and it is cheaper and less in production than other sources of animal protein. Also, it is produced from wastes, which can be an environmental nuisance. Thus, the production system serves the dual purpose of providing a nutrient-rich resource as well as a source of waste diversion and reduction [30].

3. Methods of Housefly Maggots (*Musca domestica*) Meal Production

Maggot's are produced from the semi transparent larval stage of the housefly (*Musca domestica*) and are used to process maggot meal.

According to Hwangbo *et al*. [31] fresh maggots were grown in a medium containing a mixture of fresh layer droppings and powdered milk and sugar, and then dried in in the oven at 55°C for 24 hours.

According to Aniebo *et al*. [21] the substrate consisted of a mixture of twenty kilogram wheat bran and 100 kg of cattle blood. The substrate were mixed and spread over a floor area of 6 m^2 with a thickness of 3 cm. The smell of fermenting substrate and fresh blood attracted flies, which later laid eggs on it. The eggs hatched to larvae during 48 hours and allowed two days to develop more. The ripe maggot's were harvested, and then dried in the sun.

According to Saleh *et al*. [32] the maggots were produced from poultry droppings with added foods wastes. The substrate consisted of a mixture of 15 kg from poultry droppings and wastes of foods. The substrate were mixed and spread on three wood box (40× 40× 10 cm). The smell of fermenting substrate and fresh foods wastes attracted flies, which later laid eggs on it. The eggs hatched to larvae during 48 hours and allowed two days to develop more. The moisture in the poultry droppings in the wood box was kept high during the maggot's production. The ripe maggot's were harvested, and then stored in the freezer until used.

According to Okore *et al*. [33] the poultry droppings were placed in an open bucket and constantly wet with water to make it moist to attract flies to lay eggs in it. Maggots were created from the third to the fourth day. Portions of the maggot infested droppings were put in another bucket and enough water was added, and the maggot were sifted from the surface of the water and washed several times. After washing the maggot's, they were dried in the oven at about 35-45°C.

According to Emeka and Oscar [34] fresh poultry droppings was incubated in a rectangular rubber container measuring (43× 30× 32 cm) as a substrate for maggot's 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 3 to 7 days to allow the maggot to be completely grown before harvesting. The harvested maggot's were washed with warm water before it was used feeding the fish.

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According to Arong and Eyo [35] maggots were produced from poultry droppings by placing them in plastic bags, submerging them in water and keeping them out in the shade as a substrate for the development of maggot's. The bags were exposed to house flies for lay egg. The bags were watered twice in the morning and evening daily to maintain the continuous moisture needed to development for maggot. Maggots were appearing on the second day with a peak on the fourth and fifth days. The maggot were harvested from the bag by washing and sifting through a metal screen of 3 mm mesh size. The maggot's harvested were weighed, blanched in hot water, and then dried in the oven at 70 °C for 24 h before grinding to a powder for obtain the maggot meal.

According to Mustapha and Kolawole [36] the maggots were produced from poultry droppings where maggots were highly concentrated in a 50-litres bowl until it was filled up. The bowl was left for some times to allow the maggots to move and gather at the bottom of the bowl. This method provides space for collection of life and active maggot. An additional separation was performed by sifting and liberating them from waste particles. The maggots were thoroughly washed until they showed their characteristics whitish colour. They were killed by subjecting them to a low temperature at 5°C and kept in the refrigerator for further use.

According to Alofa and Abou [37] Housefly maggot's produced from chicken viscera. The substrates (5 cm) consist from chicken entrails spread over the sawdust for flies to lay egg. These substrates were watered twice in the morning and evening daily to maintain the continuous moisture required for the growth of maggots. Maggots appeared after 48 hours. Maggots were harvested, washed and killed in hot water during 15 minutes, and then dried in the oven at 60 °C for 24 hours before being processed to meal.

4. Chemical Composition of Housefly Maggots (*Musca domestica*)

The content of dry matter, crude protein, fat, crude fiber and ash in maggot meal has 92.7%, 47.6%, 25.3%, 7.5%, 6.25%, respectively, and the amino acid profile comparable to the fishmeal [21]. In other study, Hwangbo *et al.* [31] reported that maggot meal has 5.28% moisture, 63.99% crude protein, 24.31% ether extract, 5.16% crude ash and 1.25% carbohydrate.

Because of the difference observed in the chemical composition reported by many authors [21,26,38] and the cause off this difference concluded as being age at harvest (larvae versus pupae) [38,39], method of drying [26] and larval feed substrate [40]. Notable differences in chemical composition in Table 1, differences in amino acids in Table 2, fatty acids composition in Table 3, and mineral composition in Table 4, and it is relation to the feed substrate and age at harvest in Table 5, and the effect of the processing method are shown in Table 6. Comparison of amino acid and mineral composition of fish meal and magmeal in Table 7.

Table 1. Chemical composition of housefly larvae (on dry matter basis) receiving different feed substrates

Feed substrate	Poultry manure[1]	Poultry manure[2]	Cattle blood and wheat bran[3]
Harvest stage	Larvae, did not harvest stage	Larvae, did not harvest stage	3 days of larval formation
Crude protein, %	37.5	50.4	47.6
Crude fibre, %	--	1.6	7.5
Fat, %	19.8	20.6	25.3
Ash, %	23.1	11.7	6.25

Notes: 1- Ogunji *et al.* [20], 2- Sogbesan *et al.* [41], 3- Aniebo *et al.* [21]

Table 2. Amino acids of housefly maggots receiving various feed substrates

Feed substrate	Poultry manure[1]	Cattle blood and wheat bran[2]
Harvest stage	Larvae, did not harvest stage	3 days of larval formation
Amino acid (% Protein)		
Histidine	5.10	3.09
Arginine	4.60	5.80
Aspartic acid	4.50	8.25
Threonine	7.60	2.03
Serine	3.30	3.23
Glutamic acid	6.80	15.30
Proline	--	2.85
Glycine	0.90	4.11
Alanine	4.40	2.86
Cystine	--	0.52
Valine	1.30	3.61
Isoleucine	1.70	3.06
Leucine	5.60	6.35
Lysine	4.40	6.04
Tyrosine	2.50	2.91
Phenylalanine	10.20	3.96
Methionine	--	2.28
Tryptophan	1.50	--
Protein (% dry matter)	37.50	47.6

Notes: 1- Ogunji *et al.* [20], 2- Aniebo *et al.* [21]

Table 3. The fatty acid composition of housefly larvae [31]

Feed substrate	Layer manure, milk powder and sugar
Stage at harvest	Larvae (did not state age)
Fatty acid (% of Fatty acid)	
Myristic acid (C14:0)	6.83
Palmitic acid (C16:0)	26.74
Palmitoleic acid (C16:1n7)	25.92
Stearic acid (C18:0)	2.32
Oleic acid (C18:1n9)	21.75
Linoleic acid (C18:2n6)	16.44
Saturated fatty acid (SFA)	35.89
Unsaturated fatty acid (UFA)	64.11

Table 4. Mineral composition of processed housefly larvae

Feed substrate	**Poultry manure[1]**	**Layer manure, milk powder and sugar [2]**
Stage at harvest	Larvae harvested after 96 hours	Larvae (did not state age)
processing method	Hydrolysed oven dried	
Mineral analyzed		
Ash, % dry matter	13.20	5.16
Calcium (Ca), % dry matter	0.31	2.01
Phosphorus (P), % dry matter	--	1.32
Potassium (K), % dry matter	0.50	--
Sodium (Na), % dry matter	0.29	0.66
Magnesium (Mg), % dry matter	0.25	--
Manganese (Mn), mg/kg	47.38	56
Copper (Cu), mg/kg	25.71	34
Zinc (Zn), mg/kg	48.87	237
Iron (Fe), mg/kg	1317.34	604

Notes: 1- Fasakin *et al*. [26], 2- Hwangbo *et al*. [31]

Table 5. The average crude protein and fat (on dry matter basis) for the larvae according to the affect of age and drying method [42]

Method of drying	**The second day's harvest**	**The third day's harvest**	**The fourth day's harvest**
Drying in the oven			
Crude protein	59.6	54.2	50.8
Fat	22.4	23.9	27.3
Drying in the sun			
Crude protein	55.3	51.3	45.5
Fat	25.2	28.0	32.0

Table 6. Chemical composition of housefly maggots meal as affected by the processing methods [26]

Type maggots meal	**Moisture,%**	**Crude protein,%**	**Crude fat,%**	**Ash, %**
Hydrolysed oven- dried	8.06	45.60	13.28	13.20
Hydrolysed sun- dried	8.40	44.30	13.65	13.25
Hydrolysed/defatted oven-dried	7.56	46.70	6.28	13.30
Hydrolysed/ defatted sun-dried	8.10	45.65	6.30	12.32
Defatted oven- dried	9.20	45.75	7.00	13.35
Defatted sun- dried	9.65	45.10	7.40	13.45
Full fat oven- dried	8.25	43.45	14.30	14.35
Full fat sun- dried	8.55	43.30	14.35	14.65

Table 7. Amino acids and minerals contents of maggot's meal and fishmeal [36]

	Fish meal	**Maggot meal**
Amino acids		
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
Phenylalanine	4.35	6.95
Proline	4.35	3.66
Serine	4.55	4.51
Threonine	4.55	4.53
Tryptophan	1.33	1.45
Tyrosine	3.45	8.10
Valine	5.65	5.60
Minerals		
Calcium (Ca), %	0.40	0.36
Magnesium (Mg), %	0.02	0.21
Sodium (Na), %	0.55	0.31
Potassium (K), %	0.08	0.45
Iron (Fe), ppm	162	1129
Zinc (Zn), ppm	173	49.63
Copper (Cu), ppm	--	21.47
Manganese (Mn), ppm	86	15.41
Lead (Pb), ppm	--	1.08

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5. Effect of Using of Housefly Maggots (*Musca domestica*) Meal in Fish Diets on Growth Performance

The maggot's meal is acceptable and well used by fish [43,44]. Sogbesan *et al.* [41] postulated that the feed efficiency and good growth of fish fed on maggot diets stems from the high nutritional value. Incorporation of maggot meal in the Nile tilapia diets appears to have no oxidative stress generating effect on fish metabolism. It can be effectively used as an alternative protein source in the production of tilapia fingerlings [45].

Many researches have been carried out on the using of Housefly (*Musca domestica*) maggots meal as ingredient for fish diets for different fish species. For example but not limited to.

In Nile tilapia, Mustapha [46] the best growth rates of Nile tilapia fingerlings were recorded with fish feeding on diet containing 75% maggots meal, followed by diet containing 50% maggots meal, while the least growth rates of fingerlings were feeding on diet containing 100% maggots meal.

Moreover, Ajani *et al.* [24] revealed that maggots meal can replace up to 100% of fishmeal in Nile tilapia (*Oreochromis niloticus*) diets. The authors concluded that the biological value of the maggots meal was equal to the value of fishmeal and that the maggot did not contain anti-nutritional or toxic factors that are sometimes found in alternative protein sources of plant origin.

Also, Ogunji *et al.* [20] reported that, seven test diets formulated by replacing fishmeal with maggot's meal were fed to Nile tilapia fingerlings. Results of haematological parameters and stress indicators, growth parameters and protein utilisation observed no significant effect between all feeding groups. This shows that not physiological stressful was introduced in the fish by feeding maggots meal diets. The observation indicates that maggots meal can completely replace fish meal in the fingerlings diets of Nile tilapia and can meet the nutritional requirements of this species.

In other study, Ogunji *et al.* [17] reported that, Nile tilapia feeding on diets containing maggot's meal. Fish meal was partially replaced with maggot meal. The results noted that the fish in general were in good status with good growth, and survival rate for fish was 100%. These results demonstrate the suitability of the maggots meal in diets for Nile tilapia fingerlings.

Also, Mustapha and Kolawole [36] reported that the maggot's meal can be used to partially or completely replace a fish meal from 50 to 100% in the fingerlings diets of Nile tilapia for the highest growth and feed efficiency. The feed conversion ratio decreases as the maggots level increases from 25 to 100%, and protein efficiency ratio decreases with the increase in the level of dietary maggots inclusion.

Furthermore, Alofa and Abou [37] found that 200 grams fish meal per kilogram diet can be successfully replaced by 250 grams per kilogram of housefly maggot meal without negatively affecting on growth and feed efficiency of Nile tilapia.

On the other hand, Slawski *et al.* [47] observed that the Nile tilapia feeding on diets with maggots meal reduced growth rates and increased feed conversion rate compared with the fish feeding on the control diet.

In African catfish, Faturoti and Ifili [48] indicated that the African catfish (*Clarias gariepinus*) fingerlings feeding on maggots diets had a high survival. Moreover, Aniebo *et al.* [21] reported that the fish meal was replaced by the maggots meal at levels 0, 50, and 100 %. No significant effects with the growth indicators and feed efficiency. It was concluded that the maggots meals are an alternative protein source that a viable to fishmeal in the African catfish diet. Its use is expected to reduce the cost of feed significantly.

Furthermore, Okore *et al.* [33] reported that, *Clarias gariepinus* juveniles feeding on diets containing maggot's meal (*Musca domestic*). Maggots meal percentage to commercial feed were 30 to 70%, 45 to 55%, 65 to 35%, and 100% conventional feed. Result showed that the fish fed on 55% conventional feed with 45% maggots meal achieved the better growth rates and the best feed conversion ratio, and the highest survival rate. It was concluded that use maggots meal as supplementary feed for feeding of African catfish at the appropriate ration will enhance its haematological and growth performance.

In other study, Ipinmoroti *et al.* [49] reported that the African catfish juveniles were fed on diets containing on housefly maggots. Maggots was used in proportions (0, 25, 50, 75 and 100%) to replace fish meal. Results observed that the diet containing on 75% of wet maggots was recorded the best growth and feed efficiency and feed conversion ratio.

Also, Saleh [50] reported that the African catfish fry were feeding on three feeds (100% artificial diet, 100% fresh (wet) maggots, 50% artificial diet with 50% fresh (wet) maggots). The results showed that the final weight and specific growth rate were higher significantly in catfish feeding on 50% artificial diet with 50% fresh (wet) maggots, subsequently 100% fresh (wet) maggots, then 100% artificial diet. It was concluded that using 50% of fresh maggots with a 50% artificial diet in feeding of African catfish fry had positive effects on growth rates and reduce the cost of feed.

On the contrary, Arong and Eyo [35] reported that the African catfish were feeding on three feeds (100% commercial feed, 100% maggots meal, 50% commercial feed with 50% maggot meal). The result showed that the commercial feeds were recorded the better growth and feed conversion ratio and the highest survival rate. Although commercial feed was the better growth, using maggot meal as supplementary feed by 50% with commercial feed will reduce the cost of fish production.

In other species, Omoruwou and Edem [51] reported that the *Heteroclarias* hybrid fingerlings were fed on diets containing on housefly maggots. Maggots was used in proportions (0, 50 and 100%) to replace the fish meal. The fingerlings feeding on diet containing on 50% maggots recorded the highest mean weight, length, protein intake and feed conversion efficiency. Thus, the maggots meal can be successfully used to replace up to 50% of the fish meal in diets of *Heteroclarias* hybrid to achieve best growth and utilization of nutrients. Dong *et al*. [52] indicated that supplementing 390 gram per kilogram maggot meal protein to basal diet cause an enhancement of the antioxidant capacity in gibel carp (*Carassius auratus gibelio*). Lin and Mui [53] reported that the Housefly maggot meal at 100, 150, 200 and 300 gram per kilogram was supplemented in the basal diet to replace dietary fish meal protein. The results indicated that up to 300 g/ kg housefly maggot meal can be used to substitute dietary fish meal protein without negative effect on growth of juvenile barramundi, *Lates calcarifera*.

6. Conclusion

In this review, the results confirm the reported positive effects on enhanced growth performance and survival percentage of fish with the addition of Housefly maggots (*Musca domestica*) meal in fish diets. Using of Housefly maggots meal in fish diets may improves growth rates and feed utilization with no physiological stressful condition. Also, using of Housefly maggots meal in fish diets had positive effect on the growth rates and reduce the cost of feed. Depending on nutritional value, availability, growth and feed efficiency, maggot's meal is an alternative protein source that is applicable to fishmeal in fish diets. This is particularly in developing countries where fishmeal is imported at a great cost.

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