Fatty Acid Profile And Growth Performance Of Nile Tilapia Under The Influence Of 20%, 40% And 60% Fish Meal Replacement With Black Soldier Fly Maggot Meal In Diet

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Abstract
Fish meal is an important ingredient of fish feed that can be replaced by other protein sources in order to made fish feed more economically. In the present experiment, fish meal was replaced with black soldier fly (BSF) maggot meal in feed in different proportions to check out the growth performance and fatty acid profile of Nile Tilapia. Four glass aquaria were taken labelled as T0 (basal feed), T1 (basal feed+ 20% BSF) T2 (basal feed+ 40% BSF) and T3 (basal feed+ 60% BSF). The results of present study showed that substitution of fishmeal with BSF had significant effect on the growth performance of fish. The final weight (35.59±0.289) and weight gain (23.89±0.606) was maximum in T1 group and minimum in T3 group which were 29.47±0.388 and 18.81±0.742 respectively. FCR value of Nile Tilapia decreased with increased replacement level of fishmeal with BSF meal and T3 group showed lowest FCR. The T1 group showed the maximum value for final weight and weight gain. SGR showed non-significant difference in all experimental groups. The fatty acids profile of fish showed significant variation in experimental groups. The saturated profile of fish showed the significant difference in all experimental groups. The saturated fatty Lauric acid, Palmitic acid, Stearic acid and Arachidic acid) decreased significantly with increased BSF inclusion in diet of Nile tilapia. The Oleic acid, Linolenic acid and Docosahexaenoic acid are very important fatty for the proper growth and development of fish. The unsaturated fatty acids showed decreasing trend in experimental groups. The maximum value of unsaturated fatty acids is found in T1 group. The protein content of Nile tilapia showed the non- significant difference in all experimental groups. The fat and moisture content showed decreasing trend with increased inclusion level of black soldier fly. It is concluded that 20% BSF is best suitable for the growth, proximate body composition and fatty acid profile of Nile tilapia.

INTRODUCTION

The aquaculture field has been evolving and progressing day by day and is playing a significant role in developing countries by contributing to that country's economy and sustainability (FAO, 2016). The demand of aquaculture products has increased in the food sources due to its economic importance (FAO, 2014). Pakistan is basically aquaculture country and rich with natural water resources. The major aquaculture resources of water are freshwater and marine water. The area covers Rivers, Ponds, Lakes and water lodging area is 8,563,820 km^2 (Jarwer, 2008). For many years, aquaculturists have been looking for sustainable aquafarming and high-quality feed ingredients to meet the huge fish feed requirement (Rana *et al*., 2015). Currently, fish farming is expanding day by day. It has been growing at 8.6% annually (Ahmed and Diana, 2016).

Nile tilapia (*Oreochromis niloticus*) is a well-known fish of Africa that feeds on vegetation and herbivorous but sometimes shows omnivorous feeding behavior. Nile tilapia (*Oreochromis niloticus*) is the most popular cultured species in many countries (Akoll and Mwanja, 2012). Commercially, in wild-captured fishes tilapia is the second most important group after carps. Tilapia is a group of fishes which belongs to species of cichlid family. Tilapia is mainly freshwater and biparental fish species. It is generally known to be a mouth brooding aquatic plants fish species. Suitable optimum temperature for growth ranges from 22° C to 29°C (Lim and Webster, 2006).

Insects are considered a potential animal feed source so that insects have been attracted worldwide attention in recent years (Veldkamp and Bosch, 2015). There are rich source of lipids and proteins. Insects have many advantages of reproduction, growth, high feed conversion ratio, and ingesting biowastes. The major important factor is that some cultivated fish species easily ingest insects in nature (Khan and Panikkar, 2009). Currently, the exploitation of insects as feed does not compete directly with the production of food. Based on dry matter, BSF larvae contain approximately 35 percent fat and 42 percent protein. For the quality of protein, Black soldier fly contain high profile of essential amino acid that are very similar to fish compared to soy meal (Barroso *et al*., 2014).

Black soldier fly (*Hermetiaillucens* L.) is a significant species among insects used in aquaculture nutrition. Black soldier fly larvae are the most potential source of fish feed among the developing techniques. The additional benefit of this technique is that it offers organic waste utilization (Diener *et al*., 2009). On the basis of dry matter BSF larvae contained 30-35% fat, 40-45% protein, 4.8-5.1% calcium, 0.6% phosphorous, 11-15% ash. However, a small range of amino acid and minerals are also present in it. (Myers *et al*., 2008). Besides this, insect meal consist of high source of crucial amino acid, in particular leucine, methionine and lysine which do not contain nutritionally inhibitory elements (Basto *et al*., 2020; Baiano *et al*., 2020; Shumo *et al*., 2019). Black soldier fly larvae contain around 10 to 30 percent essential lipids, 30 to 58 percent protein and amino acid related to fish meal (Kourimská *et al*., 2016).

Fish meal replacement with Black Solider fly has been effectively confirmed in species of fishes such as, Salmon salad, Rainbow trout, Hybrid Tilapia, European sea bass and Japanese sea bass. However, little information on the impact of Black soldier fly maggot on hematology, growth and mucosa of Nile tilapia, which ranks second in the world with regarding to production because of fast growth, reasonable prices and high demand (Wang *et al*., 2019).

By growing dynamic sectors in several countries, Intensive farming of tilapia is also expanding in sub-Saharan Africa. Intensive fish farming primarily depends upon commercial feeds that increase economic production necessary for food conversion ratios. The limited access to high quality and locally produced ingredients of feed leads to a high demand of feed and commercially feed ingredients to ensure high performance and balanced diets (Hecht, 2007; Agbo, 2008).

Farmed insect meal has shown potential success in replacing fishmeal. African catfish (*Clarias gariepinus*) showed positive growth performance when reared with house fly larvae with an inclusion of 25–30% (Adewolu *et al*., 2010) (Idowu *et al*., 2013). Black soldier fly larval meal (BSFL) has been shown to be a promising substitute for fishmeal in the Pacific white shrimp diet with an inclusion level of less than 25%.

Several authors have reported results by using maggot meal as a substitute or additional raw material in feed formulations for livestock and fish meal. Some scientist concluded that in catfish feed, 75% maggot meal gave the best performance and the nutritional properties of meat in milking fish can be improved with a 100% inclusion of fishmeal. Maggot meal can replace fish meal for the best growth at a level of 25% (Rachmawati and Istiyanto, 2013). Compared to giving artemia in catfish feed, maggot administration can increase survival rates (Atse *et al*., 2014). For optimal growth in catfish breeding, the 40% addition of fresh maggot as an additional feed gave the best results (Bokau and Basuki, 2017).

Due to the importance of larvae meal as protein source, the current study is conducted to examine Nile tilapia (*Oreochromis niloticus*) growth, proximate body composition and fatty acid profile of fish by replacing fishmeal with Black soldier fly.

Experimental Design

An experiment of 60-days was performed in Fish Nutrition Laboratory, Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad. Nile tilapia fingerlings were collected from the fisheries farm of University of Agriculture, Faisalabad. In this trial, four glass aquaria of eighty-liter water capacity were used. Glass aquaria were labelled as T_0, T_1, T_2, and T_3 and ten fingerlings were kept in each aquarium with three replications of each treatment. Prior to experimentation, Nile tilapia fingerlings were acclimatized to laboratory condition for the period of one week and basal diet was given to fingerlings twice a day during acclimatizing period. T_0 was considered as control group, T_1 (basal diet + 20%BSF), T_2 (basal diet + 40%BSF) and T_3 (basal diet + 60%BSF). Fishes were fed with these diets @ of 6% of their body weight. Physico-chemical parameters were maintained at normal range and extra feed was removed by syphoning. Bodyweight (g) and length (cm) of fingerlings were assessed on weekly basis during the experimental period.

Feed Preparation

Four diets were prepared, labelled as T_0 (0% BSF+ basal feed), T_1 (basal diet + 20S% BSF), T_2 (basal diet + 40% BSF) and T_3 (basal diet + 60% BSF) respectively. Soybean meal, fish meal, Rice bran, starch, BSF-meal were used to prepare the fish feed. Fish feed containing 40% crude protein was also fortified with vitamins and minerals. All constituents were converted into fine powder and mixed in suitable quantity with the help of homogenizing and blending Enamel tray. After drying feed was labelled and packed into polythene bags (Table 1).

Table 1: Composition of experimental feed

Experimental Diets (g/100g dry diet)				
Ingredients	**T_0 0%**	**T_1 20%**	**T_2 40%**	**T_3 60%**
Fish meal	35.0	26.25	17.50	8.75
BSF larvae-meal	0.0	12.5	25	37
Soybean meal	39.0	39.0	39.6	41.0
Rice bran	14.0	13.25	10.90	5.75
Soybean oil	5	2	0	0
Vit Mix	2	2	2	2
Min Mix	1	1	1	1
Starch	2	2	2	2
Total	100	100	100	100

Table 2: Proximate composition of BSFM

Chemical composition (%)	Composition (mean ± SE)
Dry matter (%)	89.37 ± 0.12
Crude Protein (%)	41.74 ± 1.09
Crude lipid (%)	28.74 ± 1.44
44 Ash (%)	10.64 ± 0.04
Fiber (%)	12.50 ± 0.23

Culture and feed formulation of Black soldier fly

Black Soldier Fly (BSF) was reared in Fish Nutrition Research Laboratory, Department of Zoology, Wildlife and Fisheries. The matured larvae were harvested and dried at 50°C for 24 hours. 20%, 40%, and 60% FM replacement feed amounts were formulated using Win Feed software based on crude isonitrogen protein material.

Growth performance

Growth performance was assessed weekly by taking raw fish from each treatment, whereas feed conversion ratio (FCR), specific growth rate (SGR) and survival rate (%) were measured at the end of study period by their respective methods (AOAC, 1995).

Length Gain = Increase in total length (cm) = final length – initial length

Weight Gain = Weight gain (g) = final weight of fish – initial weight of fish

Specific Growth Rate (SGR) = $SGR = \frac{\ln(\text{final weight}) - \ln(\text{initial weight})}{\text{No. of days}} \times 100$

Feed Conversion Ratio (FCR) = $FCR = \frac{\text{dry weight of feed (g)}}{\text{Wet weight gain by fish (g)}}$

Crude protein analysis

The crude protein (CP) of the feaces, food ingredients, muscles and experimental diets samples were analyzed following the micro-kjeldahl method. S

3.4.2. Crude fat extraction

Soxlet method was used for extraction of crude fats.

Gas Chromatography:

Total lipids in fish feed were determined by the ISO standard method. Lipids were extracted from the fish feed with petroleum ether (boiling point ranged from 40 to 40 °C) after acid hydrolysis of the sample with hydrochloric acid. The extracts were collected, and the solvent was removed under a stream of nitrogen (Dionex Solvent evaporator 500, Sunnyvale, CA, USA), at 50 °C, until dryness. Fatty acid methyl esters (FAMEs) were determined by capillary gas chromatography on GC Shimadzu equipped with a flame ionization detector and capillary HP-88 column (100 m × 0.25 mm × 0.20 μm). The individual FAs were identified using the 37 Component FAME mix standard.

Body composition:

The samples of fish were used to examine the proximate composition. Fish were sedated with clove solution before being euthanized with a dissecting needle pierced through the skull. After the fins, scales, head and viscera were removed, just the muscles were used to determine the calculate composition of the fish body. The samples were maintained at -4°C until tested. The crude protein, total fats, moisture, and ash levels in the muscle sample were determined using standard techniques (AOAC, 1995).

Body composition was calculated by the formulas given below:

Crude Protein:

To determine the protein level of muscle sample the kjeldahl's method was applied.

$$\text{Nitrogen (\%)} = \frac{\text{Value of H2SO4 used} \times \text{Normality of H2SO4} \times 0.014 \times 250}{\text{Weight of sample} \times 10} \times 100$$

Where,

0.014 = Standard Volume of 0.1N H_2SO_4 used to neutralize 1ml of ammonia

250 = Dilution of digestion mixture

100 = Percentage of N_2

10 = Volume of digestion and diluted sample used

Crude protein in sample was calculated by the following formula

Crude Protein = N_2 x 6.25

Crude Fat:

The Soxtec HT2 1045 equipment along with the petroleum ether extraction was used to ascertain the total fat content of the fish samples. The total fat percentage was calculated using the formula below.

$$\text{Total Fat (\%)} = \frac{\text{Weight of empty extraction cup-Weight of extraction cup with fat after evaporation}}{\text{Weight of sample}} \times 100$$

Moisture:
A pre-weighed petri plate was used to collect a one-gram sample of muscle (W1), which was then kept there for 24 hours at 105 °C. The desiccated sample was weighed again after being kept in desiccators for five minutes. The sample was then put back in the oven for a further two hours, and the dehydration and desiccation process was carried out once more until the weight remained consistent (W2). The moisture percentage was calculated using the weight loss. The formula below was used to calculate the moisture percentage

$$\text{Moisture (\%)}=\frac{\text{Weight of Petri dish+Sample before drying-Weight of Petri dish+Sample after drying}}{\text{Weight of sample}}\times 100$$

Ash:
The sample was cremated in a crucible made of platinum or porcelain, both of which have their uses but are less suitable. Porcelain that had been well cleaned and dried was weighed out, and the sample's weight was recorded after adding around 4 g to the crucible. The meal sample was ruined by heat (hot plate or direct heat). After that, the crucible expended the next 3:30 hours at 600 °C in the muffle furnace. It was maintained at this temperature until a white or light grey remnant developed. Ash at that time was devoid of carbonaceous particles since such particles were not present. After 3:30 hours, the heating mantle was powered off and left unattended for an hour. The crucible was then placed in a desiccator, let to cool, and then immediately weighed. The results were as follows.

$$\text{Total Ash (\%)}=\frac{\text{Weight of ash(g)}}{\text{Weight of sample (g)}}\times 100$$

Statistical Analysis
The data were analysed using ANOVA, which is a one-way analysis of variance. Tukey's test was used to do multiple comparisons to determine the differences between treatments. All tests were carried out at a 0.05 significance level.

Results and discussion

Table 2: Statistical analysis of growth performance of Nile Tilapia under the influence of different treatments of BSF.

Parameters	T0	T_1	T_2	T_3
Initial weight (g)	12.266±0.352	11.7±0.321	10.803±0.254	10.66±0.354
F.W(g)	32.54±0.43	35.59±0.289	33.153±0.542	29.47±0.388
WG (g	20.27±0.282bc	23.89±0.606a	22.35±0.672ab	18.81±0.742c
FCR	1.72±0.11b	2.33±0.03ab	2.29±0.13a	1.99±0.10ab
SGR	0.6±0.115b	1.37±0.057a	1.53±0.049a	1.39±0.017a
Initial length (cm)	9.223±0.295	9.18±0.410	9.94±0.298	9.54±0.113
Final Length(cm)	11.91±0.194	12.76±0.324	12.26±0.075	11.58±0.422
Gain in Length(cm)	2.69±0.196ab	3.58±0.131a	2.31±0.264ab	2.08±0.532b
C.F	7.37±0.034a	6.47±0.011b	5.53±0.07c	6.41±0.057b

The results of this study showed that the average weight gain of T_0 and T_1, T2 and T3 were 20.27±0.282bc, 23.89±0.606a, 22.35±0.672ab, and18.81±0.742c grams. There was statistically difference between the means of control and experimental groups. Maximum weight gain was observed in T1(23.89±0.606a) and minimum growth was observed in T3 (18.81±0.742c). Statistically Means of length gain showed that significant difference between the treatments, and the maximum length gain was measured in T1(3.58±0.131a) and the minimum length was recorded in T3(2.08±0.532b) group. Feed conversion ratio (FCR) was highest in T_1 and T_2 groups which were 2.33±0.03 and 2.29 ±0.13, respectively and lowest 1.99 ±0.10 in T_3 and T_0 1.72 ±0.13. Statistical analysis showed significant differences among these treatments. The data recorded for specific growth rates showed non-significant variation among all experimental and control groups (Table 2).

Observations on Fatty Acid Profile of Nile tilapia (*Oreochromis niloticus*) under various treatments T_0 and T_1 T_2 T_3.

Fatty Acids	Name	T0	T1	T2	T3
Saturated Fatty Acids	Palmitic acid	0±0 c	1.8±0.057b	2.1±0.173b	4.46±0.409c
	Stearic acid	NIL	2.36±0.145b	2.66±0.088b	3.6±0.057a
	Arachidic acid	1.7±0.115d	7.033±0.120c	11.91±0.239b	13.56±0.643a
	Lauric acid	0±0d	14.27±0.085c	16.98±0.9b	22.49+0.279a
UUnsaturated Fatty Acids	Elaidic acid	1.66±0.072c	3.25±0.017a	0±d	1.90±0.008b
	Oleic acid	0±b	5.89±2.26a	2.28±0.092ab	0±b
	Linolenic acid	0±c	8.26±0.08a	8.31±0.254a	5.98±0.35b
	Docosahexaenoic acid	0±c	4.71±0.198b	5.83±0.233a	0±c

The fatty acid profile of Nile Tilapia showed the significant results. The maximum value of palimitic acid and Lauric acids found in T3 groups which were 4.46±0.409c and 22.49+0.279a resprctively and their minimum values were found in T1 which were .8±0.057b and 22.49+0.279a respectively. Steric acid Arachidic acid followed the trend as followed by palmitic acid and Lauric acids. Elaidic acid, Oleic acid, Linolenic acid and
Docosahexaenoic acid which were unsaturated fatty acids also showed the significant. The maximum values Linolenic acid and Docosahexaenoic acid were found in T2 group. While Elaidic acid and Oleic acid showed the maximum value in T1 groups.

Table4. Proximate analysis of Nile Tilapia under different levels of replacement.

Parameters	T0	T1	T2	T3
Protein	15.63±0.663a	16.03±0.400a	15.39±0.277a	14.65±0.197a
Fat	9.4±0.152a	9.13±0.01ab	8.72±0.100ab	8.62±0.241b
Moisture	72.07±0.324a	71.97±0.287a	70.69±0.519ab	70.30±0.097b
Ash	3.35±0.181ab	3.20±0.178ab	3.07±0.097b	3.843±0.080a

The crude fat percentage for the T_0 of *Oreochromis niloticus* was 9.4±0.152a %, for T_1 9.13±0.01ab %, for T_2 8.72±0.100ab %, for T3 was 8.62±0.241b %. These values indicated a significant increase in crude fat observed when T1, and values decreased in T2 and T3 with reference of T0. The results of Fat contents on the base of their means showed that it is possible to replace the fish meal with BSF meal. The crude protein percentage for T_0 of was 15.63±0.663a %, for T_1 16.03±0.400a %, for T_2 15.39±0.277a % and for T_3 was 14.65±0.197a %. These values indicated a non-significant difference in crude protein observed with different levels of replacement of fish meal with BSF meal was given to the Nile Tilapia.
The moisture content percentage for the T_0 of *Oreochromis niloticus* was 72.07±0.324a %, for T_1 71.97±0.287a %, for T_2 70.69±0.519ab % and T_3 was 70.30±0.097b %. These values indicated a non-significant difference in moisture level. The crude ash percentage for the T_0 of *Oreochromis niloticus* was 3.35±0.181ab %, for T_1 3.20±0.178ab %, for T_2 3.07±0.097b % and for T_3 3.843±0.080a.

Discussion

Fishmeal has balanced amino acid profile, high digestibility and unknown growth factors which make it most favorable protein source for aquaculture ((Biswas et al., 2020; Zamani et al., 2020). The rapid development of aquaculture industry has built pressure on fishmeal supply which is derived from forage fish species. So, It has become very important to replace fishmeal with other protein based sources such as animal proteins for the production of high quality fish, minimizing the feed cost and over fishing of forage fish for fishmeal production. (Halpern et al.,2021; Mmanda et al., 2020). Among the animal proteins, insects are most promising and suitable substitute for fishmeal (Gasco et al., 2020: Mousavi et al., 2020; Shafique et al., 2020). Among the insects, black soldier fly ((*Hermetia illucens*) has gained special attention on commercial level for being good substitute of fishmeal in aquafeed formulation (Cammack and Tomberlin 2017; Lock et al. 2015). Therefore, the present study was conducted for the evaluation of black soldier fly meal on the growth, proximate body composition and fatty acid profile of Nile Tilapia.
In present study the substitution of fishmeal with BSF had significant effect on the growth performance of fish. Maximum final weight, weight gain, final length, gain in length was recorded in T1 group. The replacement of fishmeal with 60 % BSF had detrimental effect on the growth performance of fish. However, SGR showed non- significant difference among all experimental groups. FCR value was also higher in all treatment groups when compared to control group. There are many studies which support this fact that inclusion of BSF in the diet of fish increases the FCR value. In our study maximum value of FCR was found in T1 (20%) group. Weththasinghe et al. (2021) reported that small inclusion of full fat black soldier fly meal (6.25 and 12.5 %) did not affect the FCR value, but 25% inclusion increased the FCR value in comparison to control group. Caimi et al. (2020) and Zarantoniello et al. (2021) reported the significant reduction in growth performance of Siberian sturgeon when fed with 37% and 23 % black soldier fly meal respectively. The reduction in growth performance of fish with the increase of substitution level might be due to the higher level of chitin in the black soldier fly meal. Several studies have reported that higher level of chitin can negatively affect the digestibility and growth performance of fish (Xiao et al.,2018; Barragan-Fonseca et al., 2017). Eggink et al. (2022) found that rainbow trout and Nile tilapia both has ability to digest the chitin but digestibility of chitin decreased with higher inclusion of chitin which support that chitin could act as anti-nutritional factor in both fish species. Kishawy et al. (2022) reported different results to our study that complete replacement of fishmeal with black soldier fly meal could be possible in Nile Tilapia without reducing the growth rate and feed efficiency.
The proximate body composition of fish also affected by inclusion of black soldier fly meal. The protein content showed the non- significant difference among all experimental groups. The T1 group showed the maximum fat and moisture content while minimum was observed in T3.Our findings are similar to the finding of Kishawy et al. (2022) who observed that as the inclusion of black soldier fly meal in fish diet (25%, 50%, 100%) increased there was reduction in fat content of Nile tilapia however the protein content remain unaffected by the inclusion level of black soldier fly meal. Black soldier lipid content is commonly constituted by lauric acid which is less stored in fish body due to its rapid oxidation (Liland et al., 2017; Williams et al., 2006) and this might be possible reason for reduction of fat content of Nile tilapia. The findings of our study are not parallel to findings of Devic et al. (2018) who reported that higher

inclusion level of black soldier fly meal (80%) had no effect on the proximate body composition of Nile Tilapia. There are different factors responsible for the variation of proximate composition of fish. These factor include the difference in fish species, growth performance, synthesis and deposition rate of protein and fat (Abdel-Tawwab et al., 2006).The nutritional value of diet can also be responsible for variation in lipid and protein content. Black soldier fly nutritional value depends upon the diet and processing methods which are used for making black soldier fly meal (Hua, 2021).

Long chain polyunsaturated play important role in maintaining the health of human beings and fish consumption can meet these dietary requirement as they are rich source of polyunsaturated acid (EPA, 20:5n-3, DHA, 22:6n-3 and ARA, 20:4n-6) (Xu et al., 2020). The synthesis of PUFA is greatly affected by species, diet and environmental factors (Teoh et al., 2011).

In present study, the fatty acid profile showed the significant results among all experimental groups. Saturated fatty acid showed the direct relationship with the inclusion level of BSF meal. Palmitic acid, Lauric acid, Stearic acid and Arachidic acid were the main saturated acid and there deposition level in Nile tilapia increased with the increase of inclusion level of BSF meal. The maximum value of saturated fatty acids is found in T3 group and minimum in control group. The most abundant fatty acids which are present in black soldier fly includes Lauric acid, Palmitic acid, linoleic acid and oleic acid (Belghit et al., 2019; Borgogno et al., 2017; Renna et al., 2017). The fatty acid profile of fish reflects the fatty composition of its diet. (Gasco et al., 2019). The unsaturated fatty acids showed the opposite trend to saturated fatty acids. The unsaturated fatty acids level decreased with the increase of substitution level of BSF meal. Elaidic acid, Oleic acid, Linolenic acid and Docosahexaenoic acid are very important unsaturated fatty acids which are very important for the fish as well as for human beings. The maximum level of Linolenic acid found in T1 which decreased significantly in T3 group. The maximum level of Oleic acid and Docosahexaenoic acid found in T1 and T2 groups respectively which decreased significantly in T3 groups. In accordance to our study, Devic et al. (2018) founded that as level of inclusion of black soldier fly in Fishmeal increased, the deposition of saturated fatty acid in the Nile tilapia also increased in the same manner and n-3 PUFA decreased in same manner. Similarly, Zhou *et al.* (2018) found that as the substitution level of fishmeal with black soldier fly increases the deposition of saturated fatty acid such as Lauric aci, palmitic acid increased while Linoleic acid, Eicosapentaenoic acid and Docosahexaenoic acid decreased in hepatopancreas,

Conclusion

It was observed that 20% fish meal replacement BSF maggot meal in diet was the most significant in terms of assessment of the fatty acid profile and growth performance of Nile tilapia (Oreochromis niloticus) because the fish under this diet composition showed enhanced growth in weight and length along with improved SGR, FCR, CF, and survival rate. Moreover, the use of BSF included fish meal will provide a more economical means for fish feeding; thus, leading towards a more sustainable fish farming.

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