Effect of maggot (*Hermetia illucens*) flour in commercial feed on protein retention, energy retention, protein content, and fat content in tilapia (*Oreochromis niloticus*)

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Abstract. Nile tilapia is a fish with a nature of breeding throughout the year and has a high adaptation. Feed is one of the most important factors that will affect the growth and the sustainability of fish. Maggot is one of the alternative feeds which has function as source of protein. The aim of this research is to ascertain the influence of maggot (*Hermetia illucens*) flour substitution on commercial feed which affect the retention of energy, retention of protein, and also rough fat and protein of Nile tilapia flesh. The treatment was to substitute the commercial feed with different doses of maggot flour. In this study, the amount of maggot flour substituted on commercial feed is as follows: treatment P0 (0 %), P1 (12 %), P2 (14 %), P3 (16 %) and P4 (18 %). The parameter observed in this study is an effect on to protein retention, energy retention, and also rough fat and protein in Nile tilapia flesh. The result showed the highest protein content was gained from the treatment P4 with 17.267 %. The lowest protein content was 16.344 % obtained in the treatment P0. There was an increasing protein content in Nile tilapia along with the increase of the maggot flour addition in each treatment.

1. Introduction
One of the freshwater fish commodities favored by consumers considerably is Nile tilapia (*Oreochromis niloticus*). Nile tilapia (*Oreochromis niloticus*) is a fish with a nature of breeding throughout the year and has a high adaptation [1]. The production of Nile tilapia fishery has enhanced significantly from year to year, from 567.078 tons in 2011 to 695.063 tons in 2012 and 909.016 tons in 2013 [2]. Nile tilapia is a freshwater fish that contains high protein and has a preeminence of breeding rapidly. Nutritional content of Nile tilapia are 16-24 % of protein, 0.2-2.2 % of fat, carbohydrate, minerals, and vitamins [3]. According to Venugopal [4], fish is a good source of nutrients to fulfill nutritional needs of humans since fish contains protein, vitamins, minerals, calcium, taurine, and it is a source of good fats such as omega 3 (EPA and DHA) and omega 6.
Feed is one of the most important factors that will affect growth and sustainability of fish life [1]. Maggot is one of the alternative feed which has a function as a source of protein, maggot contains about 45.01% protein [5]. Maggot has amino acids, 44.26% protein, 29.65% fat, and 0.7% linoleic acid and 2.24% linolenic acid as the source of EPA and DHA [6]. Maggot can be given in fresh form to the fish and also in a pellet form. It can be processed as maggot flour before it is formed as a maggot pellet. The maggot which is made into a pellet must be steamed with a certain time where the time of maggot steaming process could affect the nutritional content of the maggot pellet [5].

To improve the quality of the fish meat, one thing to do is the application of feed with a balanced nutrition. Protein is one of the important nutrients for fish and it needs to be fulfilled to achieve optimal growth. On the other side, according to Diana [7], protein inside the body is the main source of energy other than carbohydrates and fats, it also functions as building substance, and as regulatory substance. Proteins regulate metabolic processes in the form of enzymes and hormones, as well as the defense mechanism of the body against various microbes and other toxic coming from outside the body, along with retaining cells and body tissue.

The inclusion of maggot flour in commercial feed is expected to be an alternative feed for Nile tilapia farmers to yield efficient feed cost, and high retention of energy, retention of protein, protein content, and fat content of Nile tilapia flesh.

2. Methodology

2.1. Maggot flour making process
Maggot (Hermetia illucens), which was cultivated for 17 days, was obtained from Puspa Agro Sidoarjo. The maggot flour making process was as follows: (1) 17 days old maggots were harvested, then it was cleaned to remove dirt, (2) clean maggots were boiled for 5 minutes, and subsequently squeezed using muslin cloth to reduce water and fat content, (3) afterward, maggots were steamed for 20 minutes at 80 °C, (4) after steaming, the maggots were put into the oven at 50° C for 2-3 days, and (5) dried maggots were mashed with a blender and sieved to obtain maggot flour which was ready to use as feed ingredients.

2.2. Feed making preparation
The first step of feed making process is to calculate the composition of each feed ingredient in every treatment. The Second step was mixing the ingredients gradually starting from the lightest weight to the heaviest weight into a tub and stirred until it mixed well before added with water. The third step was, after the feed ingredients were evenly mixed, they were put into the pellet maker machine. After the pellet feed had been shaped with the diameter of 1-2 mm, they were either chilled or sun-dried. Lastly, the pellet feed was ready to be given to Nile tilapia.

2.3. Data analysis
Data was analyzed using Analysis of Variance with Completely Randomized Design. When there were any differences, then Duncan’s Multiple Range Test was used with a degree of confidence 0.05 to know the differences among treatments [8].

3. Results and Discussion

3.1. Protein retention
The results showed that protein retention of Nile tilapia (Oreochromis niloticus) flesh ranged between 58.217% - 91.505%. The average data of protein retention of Nile tilapia fish flesh can be seen in table 1.
Table 1. The average of Nile tilapia fish flesh protein retention.

| Treatments | Protein Retention ± SD | Transformation($\sqrt{y + 0.50}$±SD) |
|------------|------------------------|--------------------------------------|
| P0 (0 %)   | 89.322b± 13.439         | 9.456b± 0.727                        |
| P1 (12 %)  | 73.840ab± 14.978        | 8.587ab± 0.897                       |
| P2 (14 %)  | 91.505b± 22.274         | 9.538b± 1.165                       |
| P3 (16 %)  | 61.322a± 11.295         | 7.837a± 0.722                       |
| P4 (18 %)  | 58.217a± 14.210         | 7.621a± 0.920                       |

Note: Different superscripts in the same column are indicated (p<0.05) differences

The highest protein retention (91.505 %) was obtained from the Treatment P2 with 14 % of maggot flour substitution. The lowest protein retention was 58.217 % that was found in Treatment P4 with 18 % of maggot flour substitution. Treatments P1 and P3 showed an enhancement in protein retention of Nile tilapia fish flesh, yet the protein retention in P0 (89.322 %) was still greater than P1 and P3. The treatment P2 showed the highest protein retention (91.505 %) compared to other treatments (P0, P1, P3, and P4). The results of the Analysis of Variance (ANOVA) showed a significant difference (P<0.05) between each treatment.

Protein retention indirectly describes the amount of feed protein consumed and used to build the body's protein tissue (beneficial for growth) [9]. Based on the results of statistical analysis, it indicated that maggot substitution on commercial feed significantly affected (P<0.05) protein retention in Nile tilapia. This occurred because the proteins in the feed with high biological values will lead the protein in the body to have good biological value as well [10].

The highest protein retention rate was found in treatment P2 with 14 % maggot flour that contained 9.538% feed protein. This exemplifies that feeding Nile tilapia fish with 29.8677 % protein in resulted in 9.538% protein retention.

3.2. Energy retention

Energy retention in Nile tilapia fish flesh (Oreochromis niloticus) ranged between 26.312 kcal/kg - 47.672kcal/kg. The average data of energy retention can be seen in table 2.

Table 2. The average energy retention of Nile tilapia fish flesh.

| Treatments | Energy Retention ± SD | Transformation($\sqrt{y + 0.50}$±SD) |
|------------|------------------------|--------------------------------------|
| P0 (0 %)   | 47.672± 14.926         | 6.876± 1.084                         |
| P1 (12 %)  | 30.112ab± 4.274        | 5.522ab± 0.397                       |
| P2 (14 %)  | 42.485bc± 10.692       | 6.517bc± 0.826                       |
| P3 (16 %)  | 27.217± 4.567          | 5.251± 0.433                         |
| P4 (18 %)  | 26.312a± 6.163         | 5.152a± 0.590                         |

Note: Different superscripts in the same column are indicated (p<0.05) differences
The highest energy retention was produced from the control treatment (P0), which was 47.672%. The lowest energy retention was 26.312% found in treatment P4 with 18% maggot flour substitution. Treatments of P1 and P3 showed an enhancement of energy retention, yet the energy retention in P2 (42.485%) was still higher than P1 and P3. Treatment P0 showed the highest energy retention by 47.672% compared to other treatments. Analysis of Variance (ANOVA) showed significant difference (P<0.05) among treatments.

The use of energy in Nile tilapia is influenced by the amount of feed consumed. Energy is obtained from reshuffling the chemical ligament through the oxidation reaction process towards feed components, specifically on proteins, fats, and carbohydrates to produce simpler compounds (amino acids, fatty acids, and glucose), so that it can be absorbed by the body to be either used or saved. Energy retention is a depiction of the amount of energy stored in tissues in the fish’s body divided by the amount of energy in the feed consumed [11].

Average energy retention ranged from 26.312 kcal/kg – 47.672 kcal/kg, with the highest energy retention found in control treatment (P0). Analysis of Variance (ANOVA) showed significant differences (p<0.05) among treatments. This signifies that the energy content in feed comes from proteins, causing it to be used to synthesize proteins in the body instead of as energy storage.

3.3. Crude fat

Crude fat of Nile tilapia fish flesh ranged from 3.572% - 4.779%. Analysis of Variance (ANOVA) showed a significant difference (P<0.05) among treatments. Average data of fat content can be seen in table 3.

**Table 3.** The average of crude fat content of Nile tilapia (Oreochromis niloticus) flesh.

| Treatments | Rough Fat Content ±SD | Transformation $\sqrt{y + 0.5}$±SD |
|------------|------------------------|------------------------------------|
| P0(0 %)    | 3.574± 0.288           | 2.017± 0.071                       |
| P1(12 %)   | 3.572± 0.305           | 2.016± 0.075                       |
| P2(14 %)   | 3.898± 0.301           | 2.096± 0.071                       |
| P3(16 %)   | 4.772± 0.137           | 2.295± 0.029                       |
| P4(18 %)   | 4.779± 0.321           | 2.296± 0.069                       |

Note: Different superscripts in the same column are indicated (p<0.05) differences.

The highest crude fat content was obtained from treatment P4 with 4.779% with 18% maggot flour substitution. The lowest crude fat content was 3.572% that was found in treatment P2 with 12% maggot flour substitution. The Duncan test results showed that substitution of maggot flour in commercial feed had increased crude fat content in Nile tilapia, but the substitution of 14% maggot (P1) had decreased the crude fat content which was not significantly different with P0 and P2. It can be seen that the substitution of maggot flour in commercial feed can increase the crude fat content of Nile tilapia fish flesh between 3.572% - 4.779%. Nile Tilapia is a low fat type of fish with 2.54% fat content [12]. The increase in crude fat of Nile tilapia was caused by high content of fat in maggot flour that was 13.945%. The commercial feed ration substituted with maggot flour yield a crude fat content of 11.242% - 11.709%. A proper growth will be generated when the fat content in the fish ration is between 4 – 8%, but the content of 10 – 11% of crude fat in the feed is still tolerable by the fish in general [13]. The decrease of the crude fat content in treatment P1 was caused by the low temperatures during the maintenance. Fat content decreases at low temperatures and increases at high temperatures. Water temperature greatly affects the
activity of the digestive tract of Nile tilapia [12]. Nile tilapia is a type of thermopile animal whose feeding ability will rise according to the increasing of the water temperature [14].

3.4. Protein
Protein content of Nile tilapia fish ranged between 16.344 % - 17.267 %. Analysis of Variance (ANOVA) showed a significant difference of (P<0.05) among treatments. Protein content of tilapia fish can be seen in table 4.

| Treatments | Protein Content ± SD | Transformation $\sqrt{y+0.5}$ ± SD |
|------------|----------------------|-------------------------------------|
| P0(0 %)    | 16.344 ± 0.252       | 4.104 ± 0.030                       |
| P1(12 %)   | 16.876 ± 0.518       | 4.168 ± 0.061                       |
| P2(14 %)   | 17.061 ± 0.270       | 4.190 ± 0.032                       |
| P3(16 %)   | 17.094 ± 0.647       | 4.194 ± 0.077                       |
| P4(18 %)   | 17.267 ± 0.093       | 4.215 ± 0.011                       |

Note: Different superscripts in the same column are indicated (p<0.05) differences

The highest protein content was gained from the treatment P4 with 17.267 %. The lowest protein content was 16.344% obtained in the treatment P0. There was an increasing protein content in Nile tilapia along with the increase of the maggot flour addition in each treatment. maggot flour substitution in commercial feed can increase the protein content of Nile tilapia fish with the range between 16.344 % - 17.267 %. Nile tilapia is the type of fish which has a low protein (16 %) [3]. The increase of protein content in Nile tilapia found in this study was caused by the high content of protein in the maggot flour (29.8 %). The commercial feed that was substituted with maggot flour gained 29.22 % - 29.29 % of protein content. Protein in the Nile tilapia flesh indirectly represented the amount of protein in the feed consumed and used to build tissues in the body and for growth [9]. Fish proteins is influenced by the feeding quality and their energy rate. the right balance of protein energy with the right amount of feeding will produce the best growth, feed conversion, and feeding efficiency. The amount of protein in the feed will affect the feed consumption leading to the level of protein absorption in the fish flesh [15].

4. Conclusion
The current study has demonstrated that the addition of maggot flour can improve protein retention, energy retention, protein content, and fat content in Nile tilapia. The treatment P4 with the addition of maggot flour 18% has effect on increasing the fat and protein contents of 4.779% and 17.267%, respectively.

5. References
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