The effectiveness combination of maggot (Hermetia illucens) flour with commercial feed on growth rate, feed conversion ratio, and feed efficiency of tilapia (Oreochromis niloticus)

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Abstract. Tilapia (Oreochromis niloticus) is a freshwater fish commodity that has high economic value. One way to increase tilapia production is to conduct intensive culture efforts by providing artificial feed. However, an important problem in tilapia farming is the high price of commercial feed. One way to reduce the cost of producing expensive commercial feed is by utilizing alternative raw materials that are easily available. Maggot flour is an alternative raw material that has high nutritional value ranging from 30-45% at a cheaper price. This study aims to determine the addition of maggot flour to commercial feed can increase the growth rate and feed efficiency, and reduce the feed conversion ratio of tilapia. The method was experimental with a completely randomized design (CRD) as an experimental design. This research used five treatments and four repetitions consisting of P₀ (0%), P₁ (24%), P₂ (49%), P₃ (74%) and P₄ (94%). The results showed that the addition of maggot flour to commercial feed had no effect (p> 0.05) on growth rate, feed conversion ratio, and feed efficiency of tilapia. The concentration of adding maggot flour which can produce values of growth rate, feed conversion ratio, and feed efficiency of tilapia is 24%.

1. Introduction
Tilapia (Oreochromis niloticus) is a freshwater fish commodity that has high economic value, because it has a delicious taste and relatively affordable prices, so that public demand is increasing. One way to increase tilapia production to meet consumer needs is to conduct intensive cultivation efforts by providing artificial feed [1]. However, an important problem in tilapia farming is the high price of commercial feed. One way to reduce the cost of producing expensive commercial feed is by utilizing alternative raw materials that are easily available [2]. Maggot flour is an alternative raw material that has high nutritional value ranging from 30-45% at a cheaper price [3]. Based on this, it is expected that there is an effect on the addition of maggot flour in commercial feed on growth rates, feed conversion ratio and feed efficiency of tilapia (Oreochromis niloticus).

2. Materials and methods
2.1 Place and time
This research was conducted in August until September 2016 at the Faculty of Fisheries and Marine Laboratory, Universitas Airlangga, Surabaya. Proximate analysis of feed ingredients was carried out
at the Feed Laboratory, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya. The method used in this study is an experimental method with a completely randomized design (CRD). The treatment in this study consisted of five treatments with four repetitions.

2.2 Tools and materials

The tools used in this research were 20 aquariums with a size of 30x30x35 cm$^3$ for the maintenance of tilapia (Oreochromis niloticus), hoses and aerated stones, aerators, water reservoirs, fish net, digital scales, rulers, gas stoves, pans, ovens, mill or blender, filter, pellet printer, measuring cup, sample bottle, bucket, pipette, filter paper, DO-meter, thermometer, ammonia test kit, and universal pH paper indicator. The materials used in this research were tilapia (Oreochromis niloticus) 5-7 cm long and 2-3 grams in weight obtained from UPTPB Freshwater Umbulan Pasuruan, PDAM water, commercial feed, bran, and maggot flour (Hermetia illucens) that obtained from Puspa Agro Sidoarjo.

2.3 Work procedures

2.3.1 Tools preparation
Before the research was carried out, clean the aquarium with liquid soap, then give chlorine as the disinfectant for 24 hours and dried in the sun. The water that used in this research is PDAM water that has been deposited. Tilapia (Oreochromis niloticus) is acclimatized first by preparing water that has been aerated for 1 day. The aquarium is filled with 10 liters of water with a density of 10 tilapia fish (Oreochromis niloticus) each and given aeration.

2.3.2 Preparation of maggot flour production
The process of making maggot flour are as follows: (1) maggot is boiled at a temperature of 80°C for 15 minutes, (2) the maggot is cleaned with clean water to remove dirt that is still stuck, (3) steamed maggot for 20 minutes at 80°C to reduce fat, (4) the maggot is oven at 50°C for 3 days so that the maggot is dry, (5) the maggot is mashed using a blender and sieved using a 100 mesh sieve so that maggot flour is ready to be used as a feed ingredient.

2.3.3 Preparation of feed production
The process of making feed are as follows: (1) the feed ration is calculated for each treatment in order to know the 30% protein requirement, (2) the ingredients that have been prepared and weighed are mixed gradually starting from the smallest to the largest weight into the tub, stirring until evenly distributed and adding enough water, (3) the feed ingredients that have been mixed are then put into the pellet making machine, (4) the printed pellet feed with a diameter of 1-2 mm is dried by drying it in the sun and the finished pellet feed is ready to give to tilapia (Oreochromis niloticus).

2.3.4 Research stage
The research was conducted with tilapia fish maintenance for 30 days with observations every 7 days. Feed was given to tilapia twice a day at 08.00 and 16.00 WIB with a feeding rate of 5%. The remaining feed contained in the aquarium is siphoned once a day in the morning before feeding. Water quality parameters temperature and pH were measured once a day in the morning and evening, while ammonia and DO were measured every week in the morning and evening.

2.4 Main parameter

2.4.1 Growth rate
The rate of growth was calculated with the formula proposed by Effendie [4]:

$$ GR = \frac{W_f - W_0}{t} $$
Information:
GR: Growth rate
Wt: Average weight of the seeds at the end of the study (g)
Wo: Average weight of the seeds at the beginning of the study (g)
t: The number of days during the trial

2.4.2 Feed conversion ratio
According to Djarijah [5], the feed conversion ratio is the ratio between the total amount of feed given during rearing with the total weight of fish at the end of maintenance and the total weight of dead fish reduced by the total weight of fish at the beginning of rearing. With the following formula:

$$ FCR = \frac{F}{(Wt + D) - Wo} $$

Information:
FCR: Food Conversion Ratio
Wo: Weight of tested animals at the beginning of the study (g)
Wt: Weight of tested animals at the end of the study (g)
D: Total weight of dead fish
F: The weight of the total feed that give during the study (g)

2.4.3 Feed efficiency
According to Djarijah [5], the value of feed efficiency can determine feed quality, feed efficiency, the more value of feed efficiency, the higher value of feed quality. Efisisiensi feed value can be calculated using:

$$ EF = \frac{(Wt + D) - Wo \times 100\%}{F} $$

Information:
EF: The efficiency of feeding (%)
Wt: Total weight of the fish at the end of the study (g)
Wo: Weight of tested animals at the beginning of the study (g)
Wt: Weight of tested animals at the end of the study (g)
D: Total weight of dead fish
F: The weight of the total feed that give during the study (g)

2.5 Supporting parameter
Supporting parameter in this study is the measurement of water quality parameters such as pH using universal indicator paper, DO using DO-meter, ammonia using the ammonia test kit, and temperature using a thermometer.

3. Result and discussion
3.1 Growth rate
The result showed the growth rate of tilapia ranges from 0.165 to 0.213 g / day. The average data of tilapia growth rate are shown in Table 1.

| Treatment | Growth Rate (g / day) ± SD |
|-----------|--------------------------|
| P0        | 0.166 ± 0.008            |
| P1        | 0.213 ± 0.041            |
Description: P0 = 90% commercial feed + 10% bran, P1 = 68% commercial feed + 24% flour maggot + 8% bran, P2 = 46% commercial feed + 49% flour maggot + 5% rice bran, P3 = 23% commercial feed + 74% maggot flour + 3% bran, P4 = 5% commercial feed + 94% maggot flour + 1% bran.

ANOVA statistical test results showed that the addition of maggot flour to commercial feed gave the growth rate of tilapia which was not significantly different (p > 0.05). Graph of the average growth rate of tilapia in each treatment can be seen in Figure 1.

Figure 1. Graph of the average growth rate of tilapia

Growth is the increase in length or weight over time [4]. Growth occurs due to the presence of protein that is absorbed by fish, the amino acid content contained in protein is used continuously to form new tissue during growth [6]. ANOVA statistical test results showed that the addition of maggot flour to commercial feed gave the growth rate of tilapia which was not significantly different (p > 0.05). There is no difference between treatments because the growth rate of tilapia is less susceptible or each treatment has the same amount of protein, so it has the same response. The growth rates of tilapia are P0 (0.166 g / day), P1 (0.213 g / day), P2 (0.192 g / day), P3 (0.194 g / day), P4 (0.165 g / day), so the growth rate of tilapia relatively equal in value.

The highest growth rate was obtained in the P1 treatment, adding 24% maggot flour. The highest growth rate in P1 treatment was due to the number of combinations of maggot flour with commercial feed that had a balanced nutritional value. This is in accordance with Murni and Early [7] research that the use of maggot as a combination of artificial feed for tilapia is recommended only up to 50%, because the more maggot is given, the growth will decrease. According to Murni and Early [7], the low growth rate of tilapia is due to the combination of the two feed ingredients that are not optimal and maggot contains chitin (shell skin) which is difficult for tilapia to digest so that growth is not optimal.

3.2 Feed conversion ratio
The results of the research ranged from 1.075 to 1.252 for the tilapia feed conversion ratio. The average data of tilapia feed conversion ratio is shown in Table 2.

Table 2. The average feed conversion ratio of tilapia

| Treatment | Feed Conversion Ratio ± SD |
|-----------|----------------------------|
| P0        | 0.166 ± 0.000             |
| P1        | 0.213 ± 0.050             |
| P2        | 0.192 ± 0.026             |
| P3        | 0.194 ± 0.018             |
| P4        | 0.165 ± 0.045             |
ANOVA statistical test results showed that the addition of maggot flour to commercial feed gave the tilapia feed conversion ratio which was not significantly different (p > 0.05). The graph of the average feed conversion ratio of tilapia can be seen in Figure 2.

Feed conversion ratio is the ratio between the total amount of feed consumed and the weight gain of fish produced. According to Rachmawati and Istiyanto [8], the ability of fish to consume a given feed will affect the size of the feed conversion ratio (FCR). The large number of at least the amount of feed left at the time of feeding can also indicate the high and low value of the feed conversion ratio, if the more amount of feed is left, then the feed conversion ratio value will be higher and vice versa.

ANOVA statistical test results showed that the addition of maggot flour to commercial feed showed the ratio of tilapia feed conversion was not significantly different (p > 0.05). It is assumed that there is a lot of fish feed left and the fish are less capable of consuming feed. Based on the calculation of the results, the lowest feed conversion ratio in P1 treatment was 1.075, which means that 1.075 kilograms of feed will increase the weight of tilapia by 1 kilogram. The highest feed conversion ratio in P4 treatment is 1.252, which means that 1.252 kilograms of feed will increase the weight of tilapia by 1 kilogram. The more feed conversion ratio values, the more feed is needed. According to Effendie [9], a good feed conversion ratio is less than 2, which means that providing feed less than 2 kilograms will produce 1 kilogram of fish meat.

3.3 Feed efficiency
The results of the research on tilapia feed efficiency ranged from 85.166 to 93.364%. Data on the average feed efficiency of tilapia are shown in Table 3.
The ANOVA statistical test results showed that the addition of maggot flour to commercial feed gave tilapia feed efficiency which was not significantly different (p>0.05). Graph of the average feed efficiency of tilapia can be seen in Figure 3.

![Figure 3. Graph of the average feed efficiency of tilapia](image)

Feed efficiency is the ability of fish to use feed optimally [10]. The main factor affecting the height and low efficiency of the feed is the source of nutrients in the feed. The more feed efficiency values so the fish will response better to the feed [11].

The results of the ANOVA statistical test showed that the addition of maggot flour to commercial feed gave tilapia feed efficiency which was not significantly different (p>0.05). The average value of feed efficiency for all treatments of tilapia ranged from 85.166 to 93.364%. The highest feed efficiency was obtained in the P1 treatment with the addition of maggot as much as 24% with an average of 93.364%, this shows that in the P1 treatment according to the needs so that the digestion and absorption of feed with the addition of maggot as much as 24% is more effective for increasing fish weight and feed presentation. While the lowest feed efficiency was obtained in the P4 treatment, the addition of 94% maggot flour with an average of 85.166%, this was due to the lack of feed absorption in the treatment, so that the feed efficiency was less effective and fish growth was also less than perfect. According to Rezi [12], the quality of feed determines the efficiency of the feed given. Low daily feed efficiency with a high amount of feed indicates that the level of feed consumption is small because the feed eaten is not for growth but for adaptation to environmental changes.

3.4 Water quality
The range of water quality for 30 days of maintenance can be seen in Table 4.

### Table 4. The data of water quality measurement

| Treatment | Feed Efficiency (%) ± SD | Transformation √Y ± SD |
|-----------|--------------------------|------------------------|
| P0        | 85.454 ± 4.048           | 9.242 ± 0.222          |
| P1        | 93.364 ± 3.898           | 9.661 ± 0.203          |
| P2        | 92.350 ± 3.704           | 9.608 ± 0.194          |
| P3        | 93.113 ± 5.483           | 9.646 ± 0.287          |
| P4        | 85.166 ± 12.558          | 9.208 ± 0.709          |
According to Centayana [13], water quality control needs to be treated so that the quality of the water remains in optimal conditions to match the fish habitat. The parameters observed during the study were dissolved oxygen (DO), temperature, pH, and ammonia.

During the 30-day study, the water temperature ranged from 27-30°C. This is in accordance with SNI 7550 [14], the optimal temperature for tilapia maintenance ranges from 25-32°C. The value of the degree of acidity (pH) during the study ranged from 6-7. This pH value is still in the optimal range for the growth of tilapia. This is consistent with the statement of Amri and Khairuman [14] that the pH range required by tilapia is 6-9. The pH value of a water can affect fish growth, and can even cause death [11].

Dissolved oxygen content during the study ranged from 3.24-5.92 mg / l. The dissolved oxygen content value is still in the optimal range for the growth of tilapia. This is in accordance with SNI 7550 [14] that the dissolved oxygen required for tilapia is a minimum of 3 mg / l. The optimal concentration of ammonia in tilapia cultivation according to SNI 6141 [15] is not more than 0.5 mg / l. The ammonia concentration in this study was not more than 0.5 mg / l. Ammonia concentration values ranged from 0.2 to 0.5 mg / l.

4. Conclusion
The addition of 94% maggot flour to commercial feed can increase the growth rate, feed efficiency, and decrease the feed efficiency of tilapia (*Oreochromis niloticus*). The suggestion in this study is that the addition of 24% maggot flour to commercial feed can increase the growth rate, feed efficiency and decrease the feed conversion ratio of tilapia (*Oreochromis niloticus*).

5. References

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