The maggot flour substitution potency (*Hermetia illucens*) in artificial feed formulation on growth and survival rates of African catfish (*Clarias gariepinus*)

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Abstract. Catfish (*Clarias* sp.) is one of the important fish commodities, especially in the freshwater cultivation. The study aimed to reveal the substitution of maggot flour (*Hermetia illucens*) toward the growth and life sustainability of dumbo catfish. The treatments were different doses of flour maggot substitution: P0 dose (0%) P1 (4%), P2 (6%), P3 (8%) and P4 (10%). The data were analyzed using ANOVA in order to reveal the treatment impact. The differences among treatments were analyzed using Duncan’s multiple range test. After 30 days of cultivation, there were clear differences in the specific growth rate of the catfish after maggot flour substitution. The maggot flour substitution as artificial feeding cultivation of treatment P4 showed the highest growth rate for about 0.3075 g/day. Meanwhile, the specific growth rate of treatment P4 showed 3.4425 %/day. There was no significant difference (P>0.05) between treatments in the term of survival rate, among treatment P0-P4 which was 100%.

1. Introduction

The catfish (*Clarias* sp.) is one of important fish commodity, especially in the freshwater cultivation. Catfish dominates the cultivation of freshwater fish and earn third place after goldfish and tilapia [1, 2, 3, 4, 5]. The catfish cultivation is significantly increasing in 2015 about 719,619 ton, 764,797 ton in the next 2016, it increased into 1,771,867 ton in 2017 [6].

Feed is the most important aspect in the cultivation process that can support the growth rate and life sustainability of the fish. The feed consumes most of cultivation expense about 60-70% of the production cost that must be paid by fishermen [7]. According to Junda, [8] stated that one of the ways to increase the growth rate of *African* catfish in fulfilling the customer’s demand is by implementing cultivation by using an artificial feeding method. Unfortunately, one thing that must be noted in catfish cultivation is that the commercial feed is very expensive as the price increase of raw materials of the main proteins [9, 10, 11, 12, 13, 14].

Maggot flour is the raw material that contains high nutrition at cheaper price. It has many advantages to use flour maggots as raw materials of the artificial feed which are it could be found in any part of the world, reduces organic waste, it does not require high technology to get it [15].

Maggot could be cultivated by using media that contains organic material. Thus it can reduce organic waste pollution [16]. Maggot contains approximately 30-40% of proteins. This high concentration of proteins makes the material to be a candidate to be an alternative to artificial feed.
Moreover, it has anti-microbes and fungus essence, it will enhance the life sustainability for the fish if they eat it, they will be protected from any diseases caused by fungus and microbes.

2. Material and methods

The study started on September 8th to October 7th that takes place in B building backyard of Maritime and Fishery Faculty of Airlangga University of Surabaya.

2.1. Tools and materials

The tools used in the study are 20 aquariums within 50×30×30 cm dimension for fish cultivation, hose and aeration stone, aerator, siphon, water tank, digital scales, rulers, trays, gas stoves, pans, ovens, grinders, filters, pellet printing tools, buckets, DO meter, thermometer, pH pen, ammonia test kit, spoon, knife, and cutting board.

2.2. Research subject

The animal used for the test in this study is African catfish (Clarias gariepinus) within 8-10 cm in length, and weighing in 4-7 g which is collected from Fish Boster Center Gedangan, Sidoarjo Region.

2.3. Cultivation media

The cultivation media applied in the study uses PDAM (Local Water Utilities) water approximately 25 litters within the aquarium of 50x30x30cm³ of its dimension.

2.4. Feed material

The feed used in research is using fish flour, soybean meal flour, rice bran, tapioca flour and maggot (Hermetia illucens) which are granted from Puspa Agro of Sidoarjo Region.

2.5. Working procedure

2.5.1. Tools and material preparation

The preparation starts by cleaning the tools that are going to be used. The PDAM water, which later becomes cultivation media, must be tanked first by adding aeration in order to increase the oxygen substance and eliminate the unwanted chemical elements. The cultivation media which is the aquarium if washed by using soaps, cleansing it with clean water, and add some disinfectant in the form of chlorine for 24 hours and sun-dried it. The catfish is acclimatized. The twenty aquariums are each filled with 25 litter within 10 African catfish density for each aquarium, and aeration must be given.

2.5.2 Making the maggot flour

Maggot (Hermetia illucens) which is cultivated for a month is taken from the Puspo Argo Sidoarjo region. Next, maggots are cleaned and boiled in freshwater within 80°C for 20 minutes. In order to reduce the fat element, the boiled maggots are squeezed by using Mori cloth. The next step is placing the maggots in the oven within 50°C for about 2-3 days to make it dry. Grind the maggot and sieve them within 100 mesh size in order to get the maggot flour ready to be used as raw material.

2.5.3. The feed formulation

First of all, the raw materials are analyzed proximately and count the ration for each treatment based on every need of the raw materials' composition, the material is mixed from the heaviest to the lightest weight until they perfectly blend and add some water. The dough materials are moulded with 1-2 mm by using feed molder tools. After that, the feeds are dried under the sun and they
will be ready to be used.

Table 1. The nutrition list of raw materials.

|   | P0     | P1     | P2     | P3     | P4     |
|---|--------|--------|--------|--------|--------|
| DM| 94.4750| 94.5578| 94.5993| 94.6407| 94.6821|
| Ash| 10.1299| 9.9060 | 9.7941 | 9.6822 | 9.5702 |
| CP | 31.7334| 31.3552| 31.1660| 30.9769| 30.7878|
| EE | 13.2392| 13.4409| 13.5418| 13.6427| 13.7435|
| CF | 10.3398| 10.5623| 10.6735| 10.7848| 10.8960|
| NFE| 29.0326| 29.2934| 29.4238| 29.5542| 29.6845|
| GE | 3103.2341| 3115.2685| 3121.2857| 3127.3029| 3133.3201|

Note: DM = Dry materials, CP = Crude protein, EE = Extract ether, CF = Crude fiber, NFE = Nitrogen free extract, and GE = Gross energy.

2.6. Method
The study uses experimental mode, and experiment design which is used in this research, a completely randomized design applies 5 treatments and 4 repetitions.

2.7. Parameter

2.7.1. The growth rate
According to Amin et al. [18], the calculation of growth rate is displayed below, as follow:

\[ GR = \frac{W_t - W_0}{t} \]

Notes:
- GR: Growth Rate (gram/day)
- Wt: Average weight of fish seeds at the end of the experiment (gram)
- Wo: Average weight of fish seeds at the beginning of the experiment (gram)
- t: Total amount of days during the experiment

2.7.2. Specific growth rate
According to Amin et al [18], the calculation of specific growth rate is displayed below, as follow:

\[ SGR = \frac{\ln W_t - \ln W_0 \times 100}{t} \]

Notes:
- SGR: Specific Growth Rate (%/day)
- Wt: Average weight of fish seeds at the end of the experiment (gram)
- Wo: Average weight of fish seeds at the beginning of the experiment (gram)
- t: Total amount of days during the experiment

2.7.3. Survival rate
According to [18], the calculation of life sustainability is displayed below, as follow:

\[ SR = \frac{N_t \times 100}{N_o} \]

Notes:
- SR: Survival Rate (%)
- Nt: The number of an animal test at the end of the experiment (unit)
- No: The number of an animal test at the beginning of the experiment (unit)
2.7.4. Data analysis
The statistic analysis is using Analysis of Variance (ANOVA) to identify the give treatments by adding the maggot flours to show significant results. That is why the next calculation uses Duncan’s multiple range test.

3. Result and discussion

3.1. The growth of the seed of African catfish (Clarias gariepinus)
Growth is the development of an organism in weight and length in one significant time. The growing process requires over unused energy after the metabolism process [18]. The catfish seeds cultivated for 30 days shows the highest result of growth rate on treatment P4 (10%) (Table 2.)

According to the statistic calculation, it is revealed that the highest growth rate is on the treatment P4 shows the highest growth rate for about 0.3075 g/day within the substitution of maggot flour about 10%. Meanwhile, the lowest growth rate is found on the P0 treatment within an average value of 0.2550 g/day. According to the ANOVA test result, it shows that the clear differences between Dumbo catfish seed is about (P<0.05).

Table 2. The growth rate average and specific growth rate average of African catfish seeds.

| Treatment | GR (g/day) ± SD | SGR (%/day) ± SD |
|-----------|----------------|-----------------|
| P0        | 0.2550a ± 0.0129 | 3.0650a ± 0.1613 |
| P1        | 0.2725b ± 0.0050 | 3.1500a ± 0.1293 |
| P2        | 0.2775b ± 0.0050 | 3.2300a ± 0.0783 |
| P3        | 0.2975c ± 0.0050 | 3.4150b ± 0.1021 |
| P4        | 0.3075c ± 0.0095 | 3.4425b ± 0.0590 |

Notes: The different superscripts within the same column, shows the comparison among treatments that are different (P<0.05).

The next analysis is the result of Duncan’s multiple range test that the treatment of P0 clearly differs from P1, P2, P3, and P4. Meanwhile, the P1 treatment does not recognize the clear difference with P2 treatment, but it shows clear different with P0, P3 dan P4. The P4 treatment does not show a clear difference with P3 treatment, it shows clear different with P0, P1, and P2. The low growth rate value found in P0 which is 0.2550 g/day, the highest growth rate is found on the treatment P4 shows the highest growth rate for about 0.3075 g/day

The substitution of fish flour by using maggot flour as an artificial feed in catfish cultivation shows the highest growth rate is on the treatment P4 shows the highest growth rate within 10% substitution average. This is as a result of the contents of the materials of the artificial feed able to fulfill the requirement for the fish to grow, compared with the previous study conducted by [15] stated that the additional substitution of 10-20% maggot flour will show the highest growth rate for fish.

From the statistic calculation, it is revealed that the average specific growth rate of catfish seed on each treatment ranged from about 3.0650-3.4425%. The result of the average SGR declared that the highest value is taken by P4 treatment within 3.4425%. Meanwhile, the lowest specific growth rate is held by the P0 treatment within an average value of 3.0650 %. According to the ANOVA test result, it shows that the clear differences between Dumbo catfish seed are about (P<0.05).

The next data result is about Duncan’s multiple range test, the result shows that P0 treatment does not appeal a clear difference with P0 (0%), it does not have clear difference with P1, P2
which is substituted by 4% and 6% of maggot flour for each, meanwhile it is clearly different with P3 and P4. The P3 treatment does not clearly different from P4 treatment, but it shows a clear difference with P0, P1, P2. The P4 treatment, which is a substitution of 10% flour maggot, shows the highest specific growth rate, it is 3.4425%.

3.2. The survival rate of African catfish seed (Clarias gariepinus)
Life sustainability is one cultivation successfulness parameter. According to [19], stated that life sustainability is the comparison between living individuals at the end of and at the beginning of the experiment. The life sustainability of dumbo catfish seeds for 30 days of cultivation shows the result which the number of dead fish is zero (Table 3.). That is why the formulation of maggot flour as artificial feed substitution does not show a clear difference toward the life sustainability of Dumbo catfish seed. The level of life sustainability among all treatments shows 100 % from P0 to P4 treatment.

| Treatment | SR (%) ± SD          |
|-----------|----------------------|
| P0        | 100.0000 ± 0.0000    |
| P1        | 100.0000 ± 0.0000    |
| P2        | 100.0000 ± 0.0000    |
| P3        | 100.0000 ± 0.0000    |
| P4        | 100.0000 ± 0.0000    |

The life sustainability is affected by many factors, one of them are biotic and abiotic factors. According to [18], stated that life sustainability is affected by abiotic and biotic factors. The biotic factors consist of age, and adaptation ability, abiotic factors consist of feed and water’s quality.

3.3. Water quality
In order to measure and maintain the stability of the water tank during the experiment, the water’s quality needs to perform water quality measurement. The data of quality water consist of temperature level, pH, DO and ammonia. The quality of water used during experiments is measure on the optimum scale in cultivating the Dumbo catfish. The temperature level is approximately on 25–29 C, pH of 6.5-7.6, DO of 3.42-4.66 mg/l, and ammonia of 0.5-1 mg/L. The quality water is a supporting data in this study which is important as the quality of water affects the life sustainability of the fish and its growth. The parameter of water’s quality consists of the temperature level, pH. It must be checked daily at dawn and evening. Meanwhile, the ammonia and extracted oxygen checking are performed one in a week at dawn and evening before feeding time, after testing the quality of the water, the result shows, which is extracted from the variables, that the water is acceptable for catfish cultivation category. The temperature level during experiment is 25-29 C. The temperature level is still in acceptable condition where the catfish could grow in optimum size. It is inline with the statement from [20], he stated that the good temperature level for the growth of catfish is about 25-30 C. Next, the number of pH during the experiment shows 6.5-7.6. The result of pH level is still acceptable. [20] stated that the acceptable pH level for catfish ranged about 6.5-9. The pH level contributes in the decreasing rate of the growth of the fish, and in some cases, it could decrease the metabolism function of the fish and it will bring the fish to death.

The examination of dissolved oxygen during the experiment is 3.42-4.66 mg/l. The African catfish would still able to tolerate the number as supported by [21], he stated that catfish need at least 3 mg/l for them to survive. Meanwhile, the ammonia test results in 0.5-1 mg/l. It is still on the optimum number for Dumbo catfish to grow as the number must not exceed 1 mg/l [22]. The high concentration of ammonia in the water is caused by the fish feces and feed wastes that
could not be eaten by the fish [23].

4. Conclusion
Based on the results of study, there are some conclusions, as follow a) the substitution of maggot flour toward the formulation of artificial feed within 10 % dose is able to enhance the growth rate of dumbo catfish (clarias sp.) for about 0.3075 gram/day, b) the substitution of maggot flour toward the formulation of artificial feed within 10 % dose is able to enhance the specific growth rate of dumbo catfish (clarias sp.) for about 3.4425 %/day, and c) the substitution of maggot flour toward the formulation of artificial feed enhances the life sustainability of the dumbo catfish (clarias sp.) for 100 % result on each treatment from P0 to P4.

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