Potential the Black Soldier Fly (*Hermetia illucens*) in Feed Formulation for Growth of Common Carp (*Cyprinus carpio* L.)

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**Abstract** The utilization of maggot as larvae from black soldier fly is an alternative substitution of fish meal as the primary protein source in fish feed. Maggot is cultivated in 3 different cultivation, the medium used is organic waste, tofu waste, and wheat pollard. The method that used in this research is Completely Randomized Design (CRD) with 3 treatments and 3 replication. This study aims to determine the effect of various types of maggot growth media, 1) with maggot biomass parameters, containers, and growing media conditions maggot, 2) then, exact proximate composition, total amino acids content of the prepupae samples were determined. Based on the results of the analysis, each dose of treatment (media) has an influence on the different maggot biomass. The best media treatment results are pollard flour. The proximate analysis showed that BSF larvae had a protein content of 50.88% and also fat content of 15%.

**Introduction**

During this time, the source of protein for feed products for fish is very dependent on the fish meal while on the other hand, the problem of high production costs as a result of the high price of feed manufacturers is not comparable with the prices prevailing in the market, so economically the level of efficiency is still relatively low (Soebjakto, 2015). Proteins derived from insects are more economical, environmentally friendly, and have an important role naturally. Insects are reported to have high feed conversion efficiency and can be maintained and mass-produced (Huis, 2013). Using insect meals instead of fishmeal is becoming more common in the aquaculture sector of many countries. Not only is fishmeal not ecofriendly as a principal dietary protein source, but it is also becoming costlier. Issues such as the increasing global demand for fish protein, the impact of fishmeal production on the ecology of fishing grounds, its shortage, and its high price have brought attention to the need for alternative dietary protein sources (Moffitt and Cajas-Cano 2016; Pauly and Zeller, 2017).

Processed animal protein is considered a valuable alternative as it has a better EAA profile and is more digestible than plant proteins; nevertheless, within the Europe Community, restrictions on the use of certain processed animal proteins persist as protection against transmissible spongiform encephalopathies (Regulation 68/2013/-EC, 2013). Insects have recently attracted increasing attention as a sustainable nutrient source for feed, not only in Europe but also worldwide. Indeed, insects are a good source of EAA, lipids, vitamins, and minerals (Henry et al., 2015; Huis, 2013); they grow and reproduce quickly and easily on low-quality organic waste and manure (Huis, 2013) they have a small ecological footprint and high feed conversion efficiency (Makkar et al., 2014), and can reasonably foster a circular bioeconomy. Besides that, insect cultivation can reduce...
organic waste, which has the potential to pollute the surrounding environment (Li et al., 2011) where the waste pollution can lead to a negative impact on the environment (Islamy et al., 2017; Kilawati and Islamy, 2019) and develop a negative microorganism (Islamy, 2019). Another advantageous factor is that insect-based protein sources do not compete with humans, so it is suitable for animal feed ingredients, including poultry and fish (Veldkamp et al., 2012).

Maggot is one of the alternatives feeds chosen by farmers. The term maggot is the name shown for black soldier fly larvae. Black soldier flies or Hermetia illucens are a common type of fly family Stratiomydae and can be widely found in grasses and leaves; maggot works to convert organic waste into simpler biomass. Black soldier flies or Hermatia illucens are a common type of fly family Stratiomydae and can be widely found in grasses and leaves; maggot works to convert organic waste into simpler biomass. The black soldier fly larva can be used as a good source of nutrition because it contains proteins, lipids, and minerals (Spranghers et al., 2016). This type of insect has many benefits that can be utilized (Zheng et al., 2012). For their high protein content, BSF larvae/prepupae have been proposed to be used as feed for different species like fish, chicken, and pigs (Cummins et al., 2017; Newton et al., 1977) and as a portion of pet food (Bosch et al., 2014).

Cultivating maggots as a source of animal feed is now familiar. Maggot or larvae of the fly black soldier fly (Hermetia illucens) is one alternative feed that meets the requirements as a source of protein, with a high protein and fat content of 54% and 49%, these results can be obtained based on the substrate where it grows and in the cultivation process (Lock et al., 2016; Makkar et al., 2014). These larvae’ nutrient content can be used as natural feed raw materials, considering Indonesia still imports fish feed, especially a fish meal. Black soldier fly larvae can be used as feed for several fish species, carp’s (Barroso et al., 2014). The utilization of organic waste by H. illucens larvae is currently attracting the most attention due to the fact that the larvae have an extremely voracious appetite and can utilize, e.g., up to 73% of the DW (dry weight) of fecal sludge (Lalander et al., 2013). As an added value, fat- and protein-rich insect material can be obtained from it and used as a nutrient source (Purschke et al., 2017).

This study was conducted because it is the basis of research on the use of alternative feed sources of protein other than fish meal. The hope is to find out the right type of growing media to increase the biomass of the maggot population, nutrient content and is expected to reduce production costs, especially in the provision of feed.

**Materials and methods**

**Research Methods**

This study used an experimental method and a non-factorial Completely Randomized Design (CRD) with 3 treatments and 3 replications for each treatment with the weight of each medium growing was 1/2 kg. Treatment A: Organic Waste, B : Tofu Waste, and C : Wheat Pollard.

**Location and Time of Research**

The research was conducted from December 2018 to February 2019. This study was held at Reproduction Laboratory, Fisheries, and Marine Science, University of Brawijaya, Malang. Determination of percentage of amino acid in Saraswati Indo Genetech Laboratory, Jakarta

**Research Procedures**

**Container Preparation**

The containers used in this study were plastic jars of volume size 40 cm x 30 cm x 15 cm. The containers used in this study were first...
sterilized by washing them using detergent and water and then drying them. Then the containers are arranged randomly.

**Growth Media Preparation**

The growing media used in this study were: Organic waste, tofu waste, and wheat pollard which the growth media before use was dried first by spraying at a temperature of 60°C for 30 minutes, which aims to ensure there are no other animals in the media growing to be used and weighed according to a predetermined dose, the fermentation media grows using water with a ratio of 1:2. Growing media that has been mixed with water is put in a container and placed in a closed room.

**Maggot Culture**

The culture media that has been weighed as much as ½ kg is put in a container measuring 40 cm x 30 cm x 15 cm. After that, the media was placed in a closed room that has been provided. The available maggot eggs were weighed 0.1 g to be placed on dried leaves to make it easier for the hatched maggot larvae to walk into the cultivation medium. The duration of maggot growth was 25 days.

**Harvest**

After 25 days, harvesting was done by first separating the mangosteen from the growing media by splashing water into a container containing maggot. A maggot will separate from the growing media, and maggot can be taken and then weighed.

**Data Analysis**

Various data that were collected during the next study were statistically analyzed using diversity analysis (ANOVA), according to the design used, namely a completely randomized design (CRD). Suppose the variance analysis shows the results that the treatment gives an effect that is significantly (significantly) or very significantly different (highly significant). In that case, the LSD test (the Smallest Significant Difference) is carried out to compare the values between treatments. Orthogonal polynomial follow-up tests were carried out to determine the amount of different feeding to carp’s survival and growth.

**Proximate Analysis**

Proximate analysis of Black soldier fly larvae consists of protein (%), fat (%), ash (%), crude (%) crude fiber (%) were tested in the Food Nutrition laboratory, Agricultural Technology Faculty, University of Brawijaya, Malang.

**Amino Acid Analysis (UPLC)**

Testing amino acids using the Ultra Performance Liquid Chromatography (UPLC) method Analysis of amino acids using the UPLC consists of several stages. The sample was weighed as much as 0.1 g was crushed and put into a closed test tube. The sample solution was added with 6 N HCl as much as 5-10 mL, hydrolyzed in an oven at 110°C for 22 hours, then cooled at room temperature and transferred to a 500 mL measuring flask. Then, add distilled water to the boundary and filtered with a 0.45 μL filter and piped 10 μL, adding 70 μLAccQ Fluoric Borate. Then 20 μL of the Flour Adan reagent was added to be cooked and left to stand for 1 minute and added for 10 minutes at 55°C. then injected into the UPLC as much as 1 μL with chromatographic conditions using ACCQ-Tag Ultra C18 column, temperature at 49°C, phase of system motion PDA composition gradient detectors, flow rate 0.7 μL / minute and wavelength 260 nm.

**Results and Discussion**

Based on maggot biomass measurements found in each growth medium (organic waste, tofu waste, and pollard flour), there is a different amount of biomass in each container, even in the same media in each replication. The following are the average maggot biomass results in several media and containers listed in Table 1.
Table 1. Weight of maggot (Black Soldier Fly) biomass

| No | Media          | Dose  | Replication | Average (g) |
|----|----------------|-------|-------------|-------------|
|    |                |       | 1           | 2           | 3           |             |
| 1  | Organic Waste  | 500 g | 187.05      | 230.21      | 258.07      | 225.11      |
| 2  | Tofu waste     | 500 g | 201.1       | 253.12      | 300.11      | 251.44      |
| 3  | Pollard flour  | 500 g | 328.15      | 222.72      | 238.62      | 263.16      |

Table 1 shows that the use of different types of media as BSF growth media will give different results to the final weight of the larvae. The best results in this study are pollard flour media, which is indicated by the results of the average value of 263.16 g. In this treatment, the larvae can convert protein to body biomass better than other treatments, followed by tofu waste media 251.44 g and organic waste 225.11 g. This nutrient content stimulates the Black soldier to produce in the media provided. A maggot will convert protein and various nutrients into maggot biomass. Many factors influence the success of maggot cultivation. Things that affect maggot production on the media provided are maggot cultivation conditions and the nutrient content of the material.

**Proximate Analysis of Maggot**

Based on the proximate results of the maggot test, the following test results were obtained:

Table 2. Proximate result of maggot (Black Soldier Fly)

| No. | Media          | Water contain | Protein | Fat   | Ash   | Crude fiber |
|-----|----------------|---------------|---------|-------|-------|-------------|
| 1   | Organic Waste  | 11.93         | 43.87   | 13.01 | 11.93 | 10.49       |
| 2   | Tofu waste     | 4.86          | 39.87   | 28.01 | 15.71 | 10.36       |
| 3   | Pollard flour  | 6.36          | 50.88   | 15.00 | 9.36  | 10.14       |

The proximate test results in Table 2 show that there are differences in the proximate test results that differ from the 3 treatments. The proximate analysis of maggot protein content was highest in pollard flour treatment with a protein content of 50.88%. The protein contained by maggot Hermetia illucens comes from proteins found in growing media because maggot Hermetia illucens uses proteins present in the media to form body proteins. Suppose the quantity and quality of high media will positively affect the quantity and quality of the maggot protein Hermetia illucens. This maggot will reduce the media’s nutrients by 50-70% (Gary, 2009). These nutritional values indicate that maggot is very potent and can be used as an alternative source of protein instead of fish meal in the feed. Substitute or replace a fish meal with maggot as the primary source of protein in the feed where the maggot powder or structure used as the flour will facilitate the provision, preparation, storage, and processing of feed.

The quality and quantity of fly larvae media greatly influence the body's nutrient content and larval survival on each instar and subsequent metamorphosis stages (Gobbi et al., 2017; Makkar et al., 2014). De Haas et al. (2006) stated that the quality of larval development media was positively
correlated with larval length and adult flies’ survival rate. The number and type of media that contains less nutrients can cause the pupa's weight less than expected; thus, pupa cannot develop into adult flies (Wardhana & Muharsini, 2004).

Amino Acids of Maggot (Black Soldier Fly)
The results of cultivation on different media obtained the best amino acid maggot results in organic waste media. Amino acids result can be seen in Table 3.

| Amino Acids | Unit | Result    |
|-------------|------|-----------|
| Isoleucin   | mg/kg| 19.942.37 |
| Leucine     | mg/kg| 30.616.08 |
| Lysin       | mg/kg| 18.996.29 |
| Threonin    | mg/kg| 19.936.28 |
| Valine      | mg/kg| 26.602.14 |
| Phenylalanine| mg/kg| 25.588.87 |
| Thyrosin    | mg/kg| 34.750.21 |

The highest value of essential amino acids is found in leucine, 30.616.08 mg/kg. The determination of protein quantity from the nitrogen value produced by measuring proximate analysis while protein quality is generally calculated based on the amino acid profile it contains. Amino acids in animals, including fish, are free or related to proteins (connected in the peptide chain). Free amino acids have three forms of origin in which protein products are processed by hydrolysis from the results of intestinal absorption, synthesis of de novo and interconversion, and final hydrolysis of body proteins. Amino acids can also be used for high protein synthesis or other nitrogen components (nucleic acids, amines, peptides, hormones, and so on), provide a carbon source for intermediate metabolism, or become oxidized to provide energy (Guillaume et al., 2001). BSF larva flour is quite suitable as a feed ingredient because it contains amino acids, fats, and calcium needed for pig growth, although the ash content is relatively high. Rachmawati et al. (2010) said that larger larvae (prepupa) are ideal for use as a mixture of feed or raw material for pellets because they can meet production quantities.

Amino acids analyzed using UPLC include 15 types of amino acids. Amino acids that are not analyzed include tryptophan, proline, cysteine, asparagine, and glutamine. Hydrolysis that runs perfectly will produce hydrolysates consisting of a mixture of 18-20 kinds of amino acids. All hydrolyzed proteins will produce amino acids, but several proteins produce amino acids and produce protein molecules that are still bound (Annisa et al., 2017; Pratama et al., 2019).

Conclusions and Suggestion
The best results in this study are the use of pollard flour media, which is indicated by the results of the average value of 263.16 g. Where in this treatment the larvae are able to convert protein to body biomass better than other treatments. The proximate analysis of maggot protein content was highest in pollard flour (50.88%). The results of cultivation on different media obtained the best amino acid maggot results in organic waste media. The highest
value of essential amino acids is found in leucine (30.616.08 mg/kg). This shows that maggot flour can be used as an alternative source of the main protein in fish feed.

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