Efficiency utilization of protein and energy of maggot black soldier fly at different phase on chicks

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Abstract. This study aims to determine the use of protein and energy from the Black soldier fly (BSF) maggot with age differences in chickens. The research was conducted in the Animal Husbandry Department, Faculty of Agriculture, University of North Sumatra. Completely Randomized Design (CRD) with 4 treatments and 5 replications was used in this study. The treatments were BSF maggots aged 14, 21, 28, and 35 days. The parameters consisted of crude protein digestibility, nitrogen retention, and Apparent Metabolizable Energy (AME). The results showed that the treatment was statistically significant (P <0.01) on protein digestibility, nitrogen retention, and AME in chicks. Increasing the age of the BSF maggot decreases protein digestibility, but this shows an increase in AME. It was concluded that the BSF maggot was the most efficient according to the utilization of protein and energy at the age of 24 days.

1. Introduction
So far, to meet the protein needs of livestock, the commonly used animal protein feed source is fish meal, because of its protein content and easy of digestion. The problems faced in its use are inadequate availability and high price. The high price of fish meal is because Indonesia is still dependent on imported fish meal. Due to the high cost of fish meal, the price of feed is high, so that production costs increase which in turn increases the selling price of livestock products [1]. Based on the above problems, it is necessary to find other alternatives to feed as a source of protein. One of them is a feed source of protein derived from insects or insects. Insects that are rich in protein at each metamorphosis stage, with good and efficient protein quality, include the BSF.

The potential of insects as a protein source has been widely discussed for animal feed [2,3]. As feed raw materials, insect-based products must be safe from chemical contaminants. Maggot BSF can be used as an option for providing protein source feed because this fly is easy to find, breed, and is one type of natural feed ingredient that has high protein. Maggot is a BSF (BSF) fly larva or flower insect, has a chewy texture, and can release natural enzymes. Maggot is a high source of animal protein because it contains a protein range of 30-45%, and has been used as fish and poultry feed. Maggot also has antimicrobial and anti-fungal properties, which can increase the body's resistance to bacterial and fungal diseases. This shows that the BSF maggot has the potential to be used as an alternative feed. The life cycle of the BSF maggot starts from the egg, larva, prepupa, pupa, and then the BSF fly [4]. In the larval stage, prepupae and pupa can be used as feed ingredients. However, each phase has different nutritional content and quality, so it is necessary to do a digestibility study for the BSF maggot.
2. Materials and methods
The research was conducted in Pancur Batu Subdistrict, Deli Serdang Regency, North Sumatra and at the Feed Quality and Certification Testing Centre, Bekasi City, West Java Province. The research was conducted from August to October 2019. The tools used were 20 units of modified metabolic cages and 20 adult male chicks with fresh maggot flour of various ages, namely 14 days, 21 days, 28 days, and 35 days. The study consisted of 4 treatments and 5 replications, as follows:

- P0: Maggot flour with an age of 14 days
- P1: Maggot flour with an age of 21 days
- P2: Maggot flour with an age of 28 days
- P3: Maggot flour with an age of 35 days

The variables were observed including Protein Digestibility [5], while Nitrogen retention is measured by the force-feeding method [6] and Apparent Metabolizable Energy According to the Sibbald method [7]. Before excreta collection began, the chickens have fasted for 24 hours. After the chickens have fasted, it is followed by force-feeding to enter the treated feed directly into the crop. The feed that is entered is 40 grams per head. Drinking water is given ad libitum. The excreta were sprayed with 5% boric acid every 3 hours, then the excreta were collected for 24 hours, then stored in the freezer for 24 hours before drying. The stool sample is then dried, milled, and then its protein and energy content are analysed. The metabolic cage is equipped with a drink holder. Before chickens are put into the cage, the cage and equipment where food and drinks are placed are washed. Each cage is numbered to make it easier to record.

2.1 Preparation of BSF maggot flour
The maggot flour used comes from live BSF maggot or fresh maggot, of different ages. Fresh maggots used in this study were 14, 21, 28, and 35 days old of maggots. The process of making maggot flour has 3 stages, including boiling, Maggot BSF is boiled in boiling water for 5 - 10 minutes to sterilize maggot from pathogenic bacteria, so it is safe to use for livestock; then drying using direct sunlight; and Milling, the dry maggot is then milled or mashed using a grinder. The amount of maggot flour given to each livestock is as much as 40g. Before the maggot flour is given, it is analysed first to find out the crude protein and energy content in the maggot flour.

2.2 Data analysis
The data obtained after the study were analysed using analysis of variance. If it shows a difference, then further testing will be carried out using the Duncan method [8]

3. Results and discussion
Protein is one of the nutrients that are needed by a chick for basic maintenance, growth, or production [9]

| Treatments | Digestibility Protein (%) | Nitrogen Retention (%) | Apparent Metabolizable Energy (Kcal.kg) |
|------------|---------------------------|------------------------|-----------------------------------------|
| P0         | 72.67 ± 1.11              | 72.04 ± 1.58           | 3016.91 ± 64.64                         |
| P1         | 68.46 ± 0.96              | 66.23 ± 1.37           | 3402.10 ± 73.93                         |
| P2         | 63.74 ± 1.08              | 59.41 ± 1.55           | 3502.10 ± 58.52                         |
| P3         | 58.96 ± 1.50              | 52.40 ± 2.14           | 3597.69 ± 35.85                         |

Note: different superscripts on column showed differences (P <0.01)

The average value of BSF maggot protein digestibility can be seen in Table 1. The highest average value is in the P0 treatment of 72.67%, then followed by P1 treatment of 68.46%, then followed by P2 treatment of 63.74% and the lowest in treatment P3 amounted to 58.96%. The effect of giving BSF maggot flour on the digestibility of BSF maggot protein can be seen from the results of the analysis of
variance. The results of statistical tests showed that the use of BSF maggot flour had a highly significant effect (P <0.01). This study obtained the digestibility value of BSF maggot protein in the range of 58.96% - 72.67%

This range value indicates that the BSF maggot used in this study is of low, medium and high quality there are 3 categories of feed quality based on digestibility, namely: the digestibility value in the range of 50% - 60% is of low quality, between 60% - 70% of medium quality and above 70% of high quality [10] Further analysis of the orthogonal polynomial equation between BSF maggot age and protein digestibility Based on the orthogonal polynomial analysis, it shows that the equation follows a linear pattern, $Y = -0.655x + 82.00 (R^2 = 0.99)$, and indicated that the digestibility value of BSF maggot protein decreases at an older age. The results of this study indicate that the digestibility value of BSF maggot crude protein in treatment P0 has a higher value compared to treatment P1, P2, and P3.

The higher the age level of the BSF maggot, the higher the chitin content so that it can reduce digestibility. The high protein digestibility in treatment P0 was due to the BSF maggot used in treatment P0 which was a younger BSF maggot among other treatments. The low protein digestibility in the P3 treatment was because the BSF maggot used in the P3 treatment was the oldest BSF maggot among other treatments. The crude protein content in BSF maggot in treatment P0 has the highest value than other treatments, while P3 has a lower value among other treatments.

The decrease in protein digestibility is also influenced by the presence of chitin in the BSF maggot. Chitin is a polysaccharide compound found in the arthropod exoskeleton which cannot be digested by most monogastric livestock including quails [11], due to the absence of the chitinase enzyme [12]. Chitin can reduce the digestibility of protein and dry matter, but on the other hand, it has a positive effect on health because it can function as a prebiotic [13,14]. Based on research the chitin content of BSF larvae ranges from 2.7 - 96 g / kg of dry matter [15]. The older the maggot, the higher the dry matter and chitin content in the maggot body. Especially for BSF larvae and prepupae, the chitin content is 8.72% of the dry matter [16].

![Figure 1](image-url)

**Figure 1.** The relationship between age of BSF maggot, Protein Digestibility and Apparent Metabolizable Energy in chickens

Nitrogen retention shows the value of nitrogen used by the livestock body. This value is obtained from the difference between the value of crude protein consumption and the value of protein excreted after being corrected by the value of endogenous protein excretion. In other words, nitrogen retention is the difference between the value of crude protein consumption and the value of crude protein excreted after being corrected by the value of endogenous protein excretion [6].

The average retention value of BSF maggot nitrogen was around 52.40%-72.04% (Table 1). The nitrogen retention value, from the highest to the lowest, was obtained in treatment P0 of 72.04%, treatment P1 of 66.23%, treatment P2 of 59.41%, and P3 of 52.40%. Further analysis of the orthogonal polynomial equation between BSF maggot age and nitrogen retention in chickens indicated that the equation follows a linear pattern, $Y= -0.939x+85.52 (R^2=0.998)$ on figure 1 indicated that the nitrogen
retention value decreases in older maggots. The results of this study indicate that the retention value of BSF maggot nitrogen in treatment P0 has a higher value compared to treatment P1, P2, and P3.

High and low nitrogen retention is influenced by differences in the level of protein content in BSF maggots. Nitrogen retention depends on protein level in feed, nitrogen content retained is in line with feed protein content. Nitrogen retention is influenced by several factors, namely: ration consumption, protein consumption, and protein quality. The higher the ration consumption, the higher the nitrogen retention [17,18]. Nitrogen retention significantly increases with increasing protein in the ration. Will provide opportunities for the body to retain more food so that protein needs for growth are met [19].

Apparent Metabolizable energy (AME) is the gross energy of the feed minus the energy of excreta. This excreta energy comes from the energy of feedstuffs and comes from the body from the collapse of intestinal epithelial cells, digestive juices, unabsorbed bile, and the rest of the body's catabolism. The average apparent metabolic energy value of the BSF maggot is in the range of 3016.91 - 3597.69 kcal/kg (Table 1). The AME value from the highest to the lowest was obtained in treatment P3 of 3597.69 kcal/kg, treatment P2 of 3502.10 kcal/kg, treatment P1 of 3402.10 kcal/kg, and P0 of 3016.91 kcal/kg.). Based on the orthogonal polynomial analysis, it shows that the equation follows a linear pattern, $Y = 26.31x + 2734$ ($R^2 = 0.872$)

The high value of AME in P3 treatment is due to the high gross energy content in the BSF maggot P3 treatment. The high energy consumption illustrates that the energy level of metabolism is high. that the higher the energy consumption, the higher the metabolic energy [20]. The low apparent metabolic energy value in treatment P0 is due to the low gross energy content in treatment P0. Factors affecting are influenced by the gross energy feed and the amount of energy used by livestock [21]. Based on the linear equation (Figure 1), it shows that the BSF maggot with a linear equation for protein digestibility ($Y = -0.6552x + 82.01$ / $R^2 = 0.992$) and AME linear equation ($Y = 26.319x + 2734.9$ / $R^2 = 0.872$). From the two equations, it is found that that is most efficient in the use of protein and energy in chickens is BSF maggot at the age of 24 days

4. Conclusions
Increasing the age of the maggot Black soldier fly decreases protein digestibility but increases the value of metabolic energy. Based on a review of the use of energy and protein, it shows that the age of the maggot Black soldier fly is the most efficient at the 24-day-old larval phase. The use of protein and maggot energy from the Black soldier fly, it is recommended to use the maggot Black soldier fly in the 24-day larval phase.

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