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Effect of Vegetable Feed on Protein Levels of BSF Maggots (*Hermetia illucens*)

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Abstract

Background: A BSF maggot (*Hermetia illucens*) is an organism that can live in waste media because maggots eat and decompose organic materials or waste for their growth. One innovative way to break down several types of organic waste, including vegetable waste, is to use maggots. This research aimed to analyze the effect of vegetable waste feed on maggots' mass, length, thickness, and protein content. **Methods:** This research experimented with a completely randomized design (CRD) with five treatments, three repetitions of each treatment with various feed varieties. Analysis of maggot protein levels using the Automatic Kjeldahl method. The parameters measured were the maggot's mass, length, thickness, and protein content. The variable in this research is the experimental variable for maggot samples with variations in the types of cabbage and mustard greens waste food. The number of samples used was 30 samples for each treatment. The data were analyzed using ANOVA, and a further BNT test was carried out to determine the natural effect of each treatment. **Results:** The results of the BNT and protein content test show that vegetable waste food significantly impacts the mass, length, thickness, and protein content of maggots. **Conclusion:** Feeding vegetable waste affects maggots' mass, length, thickness, and protein content.

Keywords: Growing media; Maggot growth; Maggot; Protein content; Vegetable waste

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Introduction

Black soldier fly larvae are a species of fly native to America that breeds in tropical areas known as maggots. The Latin name for the BSF maggot is *Hermetia illucens,* and it is included in the family Stratiomydae, order Diptera, genus Hermetia. (Siswanto et al., 2022). Maggots have good advantages/immunities, such as living in waste environments or media with high levels of salinity and acid. Maggots prefer warm environments. They do not move actively but do not die in icy environments or lack food. Larvae can survive in neutral environments like water and acidic environments like alcohol. The characteristics of maggots include their ability to reduce organic waste, resistance to high pH, absence of disease genes, high protein content, longer larval life, and ease of cultivation (Suciati & Faruq, 2017). The life cycle of this insect includes the egg, larva (maggot), pupa, and adult stages (Sholahuddin et al., 2021).

Maggots, as unique organisms, are decomposers of organic waste and a superior source of animal feed due to their ability to reproduce quickly and their high protein content, making them an excellent and appropriate choice for feed (Mudeng et al., 2018). Therefore, maggots meet the requirements and can be used as an alternative feed for poultry because they are a promising source of protein (Sholahuddin et al., 2021).

In their breeding, maggots need a growing medium that can be used for their growth. In addition to the growing medium, there is also a feed that will determine the quality of the larvae produced, namely the quality of mass, length, thickness, and protein content of the larvae. The high protein content in the media used as maggot feed has a positive effect on the protein content of maggots (Pratama & Angga, 2023). Media or organic waste feed positively affects the protein content of maggots by increasing protein levels by 18.52%. Maggots can live in waste media because maggots are organisms that eat and decompose organic materials or waste (Cicilia & Susila, 2018). The variety of organic materials that maggots can decompose includes fresh/rotten meat, vegetables, fruit, and restaurant waste (Hartati et al., 2022). Organic waste that can be used as a feeding medium for maggots is cabbage and mustard greens. Cabbage vegetable waste contains 1.3 grams of protein per 100 grams (Darmawan et al., 2017), while mustard greens contain 1.0 grams of protein per 100 grams (Atifa, 2023). By using waste as a maggot feed medium, on the other hand, we are also helping to solve the waste problem in the environment, especially in traditional market environments where the composition is primarily organic waste, one of which is vegetable waste (Arifin, 2018). Solid waste from vegetables is a source of water, soil, and air contamination and can cause disease. Lack of effective handling of this waste can cause environmental pollution, produce unpleasant odors, and become a habitat for flies and insects (Yayan, 2016). With the problem of waste in the environment, especially in traditional markets, efforts are needed to manage organic waste (Leonardo et al., 2023). Larvae are the organisms that play a role in the organic waste management process. Maggots, in their life journey from eggs to larvae, become irreplaceable agents in consuming various organic wastes. Thus, using maggots is an innovative solution and a dynamic approach to decomposing multiple types of organic waste, including vegetable waste, which is often a problem (Rojabi et al., 2021).

Figure 1. Maggot BSF *(Hermetia illucens)*

Based on the description above, it is indispensable to research the effect of vegetable waste feed on the protein content of BSF larvae (*Hermetia illucens*) as an effort to show that there is novelty between this research and previous research, so it is necessary to carry out evaluation and development regarding maggots because The researchers attempted to compare various variables (maggot samples with a variety of different types of feed used) and the results of research that had been carried out regarding maggots. We use organic waste as a growing medium or maggot feed for larvae's growth, and maggots will be used as poultry feed because they are rich in protein. This research aims to analyze the effect of vegetable waste feed on BSF maggots' mass, length, thickness, and protein content (*Hermetia illucens*). The type of vegetable waste used is cabbage and mustard greens. In the research, we compared the larvae's mass, length, thickness, and protein content and the effect of the feed used.

Methods

This study took place at the Ruyani Life Sciences Learning Resources (SBIH Ruyani) Informal Science Education, Bengkulu City, Lab. Bengkulu University FKIP learning, and for proximate (protein) analysis at the Integrated Research and Testing Laboratory (LPPT) Gadjah Mada University from September 2023 to January 2024.

Sample

The research tools used were maggot cages, containers, wires, cloth covers, digital scales, rulers, and screw micrometers. The materials used are BSF Maggot (*Hermetia illucens*) seeds and vegetable waste taken from the traditional markets of Bengkulu City, namely cabbage and mustard greens, rice bran, and wood powder.

Experimental Design

This research used a Completely Randomized Design (CRD) experimental method divided into five treatments with three repetitions in each treatment. The distribution of larvae in each treatment was 30 maggot samples, with 10 maggot samples for each repetition. The division of maggots into A1, A2, A3, B1, B2, B3, C1, C2, C3, D1, D2, D3, E1, E2, E3 each is 10 maggot samples.

Table 1. Percentage of Variation in Maggot Feed Types

Treatment Group	Percentage of Variation in Feed Types
A	100 % *Cabbage* (100 g *Cabbage*)
B	75 % *Cabbage* dan 25 % *Mustard* (75 g *Cabbage* dan 25 g *Mustard*)
C	50 % *Cabbage* dan 50 % *Mustard* (50 g *Cabbage* dan 50 g *Mustard*)
D	25 % *Cabbage* dan 75 % *Mustard* (25 g *Cabbage* dan 75 g *Mustard*)
E	100 % *Mustard* (100 g *Mustard*)

A B C D E

Figure 2. Maggot treatment groups with varying percentages of feed types

Procedure

Maggot maintenance is carried out uniformly, including its mass, length, and thickness. The research sample (maggot) was 3 grams per container for each treatment. The larvae used in the research were taken from maggot breeders in Bengkulu City three days after hatching and given pellet food for three days. After the larvae are six days old, they will be given different treatment for each feed. Vegetable waste, which is maggot food, is processed by cutting it into small pieces, making it easier for maggots to digest their food. Grubs 6 days old are kept in a container with growing media as different food for each treatment. In the container, rice bran is given. This aims to ensure that the maggot's living area remains in good condition (not too damp). Wood powder is also provided on the edge of the container, which ensures that the larva does not come out of the container where it lives. Maggot rearing with cabbage and mustard greens is carried out for 14 days, from 18 October to 1 November 2023 (until the larva enters the Pre-Pupational period). Maggot feeding is carried out every two days, namely in the afternoon at 16.00 WIB for ± 2 weeks according to the composition in Table 1—the percentage of variation in the type of feed. Maggot measurements were carried out twice (initial measurements for maggot mass, length, and thickness and final measurements after harvest for maggot mass, length, thickness, and protein content).

Measurement

Maggot measurements were performed by taking ten maggot samples in each repetition with 30 maggot samples in each treatment. The mass, length, and thickness of the maggot were calculated for each maggot sample, and then the overall average number of each treatment of the maggot sample was calculated. The process of measuring the mass, length, and thickness of the maggot can be seen in Figure 3.

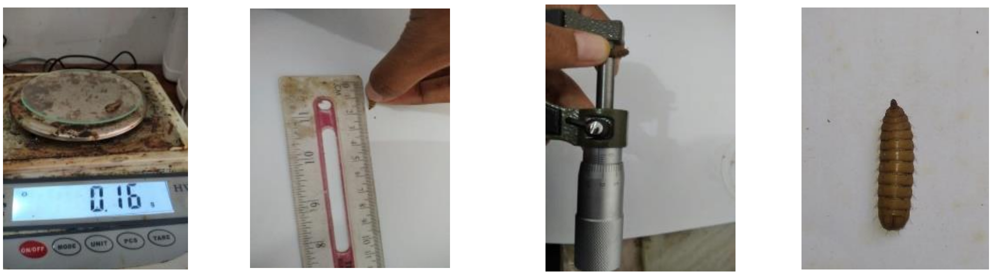

Figure 3. Process of measuring the mass, length, thickness of the larva, and documentation of the maggot at close range

Data Analysis

Data analysis in this study adopted the One Way Anova Test method to explore substantial differences in the effect of feed on each treatment. If the significance value shows a sig value <0.05, this indicates the existence of a significant difference. Furthermore, this research went further by using the Least Significant Difference Test (BNT) to identify significant differences in the effect of feed on the mass, length, and thickness of maggots in each treatment. Meanwhile, maggot protein levels are analyzed using the Automatic Kjeldahl method, where automatic digestion, distillation, and titration are carried out on maggot protein levels.

Result

Maggots Mass

Maggot Mass shows that the mass of maggots in treatment group C (50% cabbage and 50% mustard greens) showed the highest average, namely with an average mass of 0.185 g, followed by experimental treatments A, B, D, and E. Maggot mass in treatment group E (100% mustard greens) showed the lowest average, with an average mass of 0.142 g. From the analysis using the Least Significant Difference Test (BNT), it can be seen that feeding in vegetable waste significantly affects maggot mass. Treatment A shows a significant difference compared to treatments B, C, D, and E. Treatment B also shows a considerable difference compared to treatments A, C, and E. The same applies to treatment C, which is significantly different from treatments A, B, D, and E. Treatments D and E also show significant differences compared to all other treatments.

Table 2. Maggot Mass Measurement Results (g)

Treatment Groups	N	Initial Mass (g)	Final Mass $\bar{X}$ (g) ± SD
A	3	0,1	0.147 ± 0.004[a]
B	3	0,1	0.147 ± 0.002[ac]
C	3	0,1	0.185 ± 0.001[b]
D	3	0,1	0.147 ± 0.002[ac]
E	3	0,1	0.142 ± 0.002[c]

Information: A-E: experimental treatment group, N: number of repetitions of each treatment, $\bar{X}$: final average of each treatment, SD: standard deviation.

Maggot Length

Maggot length showed exciting results, where treatment group C (50% cabbage and 50% mustard greens) had the highest average length, reaching 19.23 mm, followed by treatments B, A, E, and D. Meanwhile, treatment group D (25% cabbage and 75% mustard greens) showed the lowest average length, namely 17.33 mm. Analysis using the Least Significant Difference Test (BNT) shows that feeding in the form of vegetable waste significantly impacts maggot length. Treatment A shows substantial differences compared to other treatments, including B, C, D, and E. Treatment B also shows significant differences compared to other treatments, including A, C, D, and E. Treatment C also shows significant differences. Significantly different from other treatments, such as A, B, D, and E. Treatment D, however, is substantially different from other treatments except treatment C. Treatment E also shows significant differences compared to all other treatments.

Table 3. Maggot Length Measurement Results (mm)

Treatment Groups	N	Initial Length (mm)	Final Length $\bar{X}$ (mm) ± SD
A	3	7,12	17.80± 0.34[ad]
B	3	7,12	18.56 ± 0.15[b]
C	3	7,12	19.23 ± 0.25[c]
D	3	7,12	17.33 ± 0.15[d]
E	3	7,12	17.63 ± 0.20[ad]

Maggot Thickness

Maggot thickness showed an exciting pattern, where treatment group B (with a combination of 75% cabbage and 25% mustard greens) showed the highest average thickness, reaching 4,567 mm, followed by treatments C, A, D, and E. On the other hand, treatment group E (with 100% mustard greens) showed the lowest average thickness, namely 4,256 mm. Analysis using the Least Significant Difference Test (BNT) revealed that feeding in the form of vegetable waste had a significant impact on maggot thickness. Treatment A shows substantial differences compared to other treatments, including B, C, D, and E. Treatment B also shows significant differences with other treatments, especially treatments A, D, and E. Likewise with treatment C, which shows differences which is substantial with other treatments, such as A, D, and E. Treatment D shows substantial differences with treatments A, B, C, and E. Treatment E also shows significant differences when compared with all other treatments.

Table 3. Maggot Thickness Measurement Results (mm)

Treatment Groups	N	Initial thickness (mm)	Final Thickness $\bar{X}$ (mm)± SD
A	3	2,1	4.468 ± 0.041[a]
B	3	2,1	4.567 ± 0.026[b]
C	3	2,1	4.562 ± 0.020[b]
D	3	2,1	4.373 ± 0.020[c]
E	3	2,1	4.256 ± 0.025[d]

Maggot Protein Levels

The protein content of maggots showed interesting variations in different treatments. Treatment A, which consisted of 100% cabbage as feed, showed the highest level of protein content with an average of 18.52%, with a sample mass of 0.5505 g out of a total sample mass of 7 g. Meanwhile, treatments B, C, D, and E also showed significant levels of protein content, although lower than treatment A. On the other hand, the protein content in Maggots from treatment E, which consisted of 25% cabbage and 75% mustard greens, showed the lowest level of protein content, with an average of 16.41%.

Tabel 5. Results of measuring maggot protein levels (% b/b)

No	Code	Spl Mass (g)	N HCI (N)	Blank HCL Volume (ml)	Vol HCI Spl (ml)	Fk*	N (%)	Protein (%)	Average (%)
1	A	0,5505	0,2680	0,046	4,391	6,25	2,963	18,52	18,52
2	B	0,5463	0,2680	0,046	4,299	6,25	2,922	18,27	18,27
3	C	0,5652	0,2680	0,046	4,459	6,25	2,931	18,32	17,75
		0,5350	0,2680	0,046	3,964	6,25	2,749	17,18	
4	D	0,5604	0,2680	0,046	4,230	6,25	2,803	17,52	17,52
5	E	0,5515	0,2680	0,046	3,889	6,25	2,616	16,35	16,41
		0,5668	0,2680	0,046	4,024	6,25	2,635	16,47	

Information: the analysis method uses the Automatic Kjeldahl test method
Source: Integrated Research and Testing Laboratory, Gadjah Mada University (No: 02792.01/I/L/LPPT/2024).

Discussion

After intensive observation for around 18 days, results showed various variations in values in each treatment. Based on Table 2, the results of measuring maggot mass using the BNT test show significant differences in the effect of feed on each treatment. This is because the nutritional composition of the mixed media is complete to cabbage alone or mustard greens. Cabbage feed media contains complete nutrition in calories, water, protein, fat, carbohydrates, fiber, calcium, potassium, carotene, and vitamin C (Rovi'ati et al., 2019). Mustard greens are rich in various essential nutrients, such as protein, fat, carbohydrates, calcium (Ca), phosphorus (P), and iron (Fe), as well as vitamin A, vitamin B, and vitamin C, which are essential for growth and maintaining maggot health (Ibrahim & Tanaiyo, 2018), so that a varied and complete diet can meet the nutritional needs of maggots. According to research Allagan & Ratni (2022), Vegetable waste affects the growth of larvae because the large amount of vegetable waste that enters can be easily digested by maggots. Maggot growth depends on our feed, which must be water-rich (Herlinda & Sari Puspita, 2021). Research supports the relationship between nutritional and nutritional completeness and maggot mass production (Muhayyat et al., 2016). Quality substrate tends to produce more abundant maggots because it can provide adequate nutrition for their growth and development. The presence of complete nutrition from cabbage and mustard greens has the potential to support optimal mass growth of maggots.

Based on Table 3, the maggot length BNT test measurements show significant differences in the effect of feed on each treatment. This is not much different from the results from Table 2. Maggot mass is best because the mixed media's nutritional composition is more than cabbage or mustard greens alone. The quality of nutrients in the medium significantly impacts maggot length. This is because the availability of adequate nutrients tends to result in optimal growth in maggots, which is reflected in their body length (Minggawati et al., 2019).

Based on Table 4, the results of the maggot thickness BNT test measurements show significant differences in the effect of feed on each treatment. The situation is similar to maggot growth in mass and length, influenced by the diversity of nutrients in the media mixture. This differs from conditions where the media only consists of cabbage or mustard greens. A good and complete nutritional composition in maggots can support good maggot growth, including maggot thickness.

In this research, protein content was also measured using the Automatic Kjeldahl method apart from measuring the maggot's mass, length, and thickness. In this study, only protein levels were measured and carried out with a combination of three repetitions due to the limited maggot research sample used. Based on Table 5, the results of measuring maggot protein levels show different results regarding the effect of feed on each treatment. The differences in results observed in each treatment were influenced by several critical factors, including feed consumption, the type of feed given, and the nutritional content of the feed. Feed consumption, in turn, is influenced by several factors, such as protein content, energy metabolism, and crude fiber in the feed. Previous research has confirmed this (Rivai et al., 2023). Protein intake is influenced by the amount of feed consumed, where the higher the protein content, the lower the feed conversion value required. Cabbage vegetable waste, with high humidity levels, tends to be susceptible to damage and is not durable. Therefore, it is likely that maggots will consume significant amounts of cabbage vegetable waste.

Additionally, cabbage vegetable waste contains around 1.3 grams of protein per 100 grams (Darmawan et al., 2017). The amount of media or feed consumed impacts the amount of other nutrients received, so the greater the amount, the more nutrients available. When the nutritional quality in the maggot growth medium is good, the resulting maggot feed will also have optimal nutritional quality (Polii et al., 2020). Quality and abundant media will positively impact the amount and quality of protein produced by the larvae. In general, the nutritional composition in the medium significantly influences the nutritional content in maggots, including protein, which is essential for their growth. The protein in the maggot's body comes from protein sources obtained from the growing media used to build its body (Aldi et al., 2018).

The results of Table 5, namely the results of measurements of maggot protein levels that have been carried out in research, this is in line with research that has been carried out by (Julia et al., 2023) on protein in maggots by feeding them waste vegetables and fruit with a maggot weight of 2,070 g with a protein value of 45.09%, (Aditama et al., 2023) protein in maggots by feeding 100% organic vegetables with a maggot weight of 268.90 g with a protein value of 36.30%, (Purnamasari et al., 2023) protein in maggots by feeding quail droppings with a maggot weight of 30 g with a protein value of 24.64%.

From several studies regarding the protein content of maggots, it can be seen that the protein content of maggots varies depending on the type of feed used. This is under the various feed formulations provided as a source of the required nutrients. A study Rivai et al. (2023) highlights the importance of feed in supporting health, growth, and providing energy, ensuring metabolic processes run optimally and supporting good growth. Data from other studies confirms that this approach can increase protein levels in maggots in the range of 18 to 45 percent.

The critical function of maggots is that in the future, maggots can continue to be used to decompose organic waste to overcome various organic waste problems in the surrounding environment. They can also be used as animal feed because of their high protein content.

Conclusions

Vegetable waste feed affects the mass, length, thickness, and protein content of BSF Maggots (*Hermetia illucens*). The variation in feed of 50% cabbage and 50% mustard greens had an influence on the mass and length of the maggot, the variation in diet of 75% cabbage and 25% mustard greens influenced the thickness of the maggot, and the variation in the diet of 100% cabbage influenced the protein content of the maggot.

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Declaration statement

The authors reported no potential conflict of interest

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