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ANALYSIS OF THE EFFECT OF VARIATIONS IN ORGANIC WASTE COMPOSITION ON BODY WEIGHT GROWTH OF BLACK SOLDIER FLY LARVAE (HERMETIA ILLUCENS)

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ABSTRACT
The increasing amount of organic waste requires special attention in its management. Efforts to conserve and manage organic waste in bioenergy are one of the current intensive efforts through the cultivation of BSF maggots. This study aims to see the effect of variations in waste composition on body weight growth in maggot growth, analyze fat, protein, and water content based on variations in waste composition decomposed by maggot, and determine the Waste Reduction Index (WRI). This research is a quasi-experiment with the pre-and-post Group Design method, using 5 variations of a waste composition consisting of catering waste, vegetable and fruit waste with washing or chopping treatment. The growth of magot larvae body weight was best in the variation of catering waste with slurry treatment, with the final weight of magot reaching 3025 grams from the initial weight of larvae weighing 50 grams. Proximate analysis was carried out on a maggot that was 21 days old, namely water content ranging from 60.73% to 65.42%, and fat content from 47.29% - 51.24%. The protein content is 19.11% - 42.76%. The results of one-way Anova analysis obtained Sig value. (0.000) < α then H0 is rejected, it can be concluded that the five variations of waste composition in maggot feed have a different average weight gain of maggot, and have different weight gain. The WRI value obtained is 2.4 - 2.99.

Keywords: proximate analysis; body weight; black soldier fly maggot; organic waste

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INTRODUCTION
The old paradigm of waste management views waste as useless waste that tends to refer to the end-of-pipe approach. Law No. 18/2008 on Waste Management mandates that waste management shift to a new paradigm, which views waste as a resource that has economic value and is utilized with a comprehensive approach from upstream to downstream. Various ways of waste management began to be developed in order to utilize and process waste so that it has the by-product of increasing economic value. One of the developing waste management methods is utilizing Black Soldier Fly (BSF) maggot as an organic waste degradation agent (Auliani, Elsaday, Apsari, & Nolia, 2021; I. Utami, Putra, Khotimah, et al. Utami, Putra, Khotimah, & Pangestu, 2020). Organic waste accounts for 86% of Medan City's total waste, and 80% ends up in landfill (Khair, Putri, Dalimunthe, & Matsumoto, 2018). This significant amount of waste, if not managed properly, will cause problems such as an increase in greenhouse gases. According to the Ministry of Environment and Forestry (KLHK), organic waste in landfills is aerobically decomposed to produce methane gas, which is a greenhouse gas emission whose effects are more toxic than carbon dioxide gas. Maggot BSF can be used as one of the solutions as waste bioconversion and can reduce waste mass by 56% (Salman, Nofiyanti, & Nurfadhilah,

2019). Waste biomass is converted into maggot larvae and residue. Maggot has a crude protein content of 47.14% and crude fat of 27.30%. Thus, besides being useful in reducing the amount of organic waste, BSF maggot can also be used as an alternative feed for fish and poultry (Nur Ilham Natsir et al., 2020).

BSF larvae, also known as maggot, can be used as an alternative source of protein for animal feed, in addition to snails, indigofera leaf meal, and fishery residues. Alternative protein has more advantages than commercial feed (Wardhana, 2017). Fly larvae development media, both in quality and quantity, can affect the nutritional content of the maggot body in each metamorphosis (Gobbi, Martínez-Sánchez, & Rojo, 2013). Research states that larval performance in decomposing waste is influenced by the composition of nutrients contained in the waste (Gold, Tomberlin, Diener, Zurbrügg, & Mathys, 2018). Organic waste from households, vegetable and fruit waste and food waste, when mixed, contains 20% protein, 2% fat, and 69% carbohydrates. The nutritional content of the waste will affect the growth and nutritional content of the maggot larvae produced in converting waste (Cammack & Tomberlin, 2017). In addition, variations in the composition of waste provided as maggot nutrition affect body weight in maggot growth (Cicilia & Susila, 2018).

This study aims to see the effect of variations in waste composition on body weight growth in maggot growth by utilizing unutilized agricultural waste in Kabanjahe, Karo Regency as a producer of fruits and vegetables. Agricultural waste will be combined with food waste from catering activities. The more variety of nutrients in the waste component is expected to increase maggot body weight. Another objective of this research is to analyze the proximate body of maggot in the form of fat, protein and water content based on variations in the composition of waste decomposed by maggot. The results of the study stated that the addition of maggot as animal feed can help the growth of chicken body weight (B. Utami, Ari, & Huda, 2000). With the determination of good composition variations as maggot nutrition, it will increase protein and fat levels so that it can increase the body weight of livestock that utilize maggot as feed. This will be utilized by the community in increasing the yield of livestock.

METHOD

This research is a Quasi Experiment with the Pre and Post Group Design method with the intention of seeing whether or not there is an effect of variations in waste composition on maggot body weight growth. This study used 3 variations of waste composition including Variant A: catering waste, Variant B: catering waste and cabbage vegetables in a 1:1 ratio, Variant C: catering waste and papaya fruit in a 1:1 ratio. Observations of maggot body weight growth were replicated 9 times in each variation. The ratio of waste and larvae was 270 grams : 150 grams (Nofiyanti & Laksono, 2022), with a cross-sectional area of waste feeding of 30 x 40 cm (Budiyanto et al., 2019). Measurement of magot weight was carried out every day for 21 days. The waste given to the larvae was pulverized using a chopping machine (Salman et al., 2019).

RESULT

Table 1.
Research Design of Waste Variation and Sample Treatment

Waste Variation	Treatment	Sample Code
Catering waste	Enumerated	A
Catering Waste	Porridge	B
Catering waste + Pesticide farming	Enumerated	C
Catering + Agricultural waste with pesticides (washed)	Enumerated	D
Catering waste + Fatty fruits	Enumerated	E

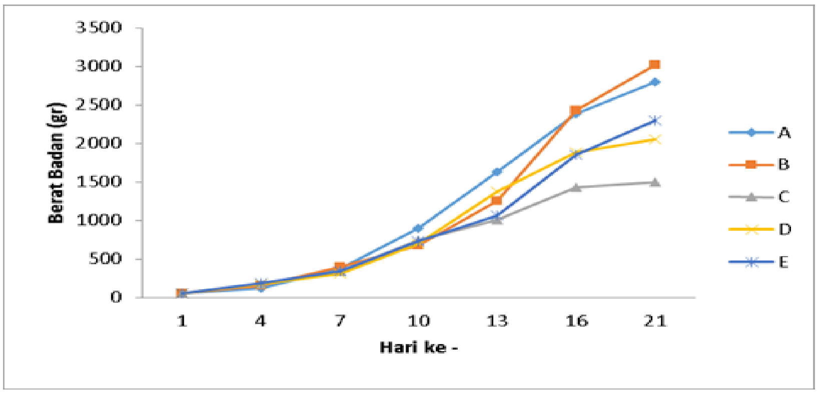

Figure 2. Larval growth graph with waste/feed variation

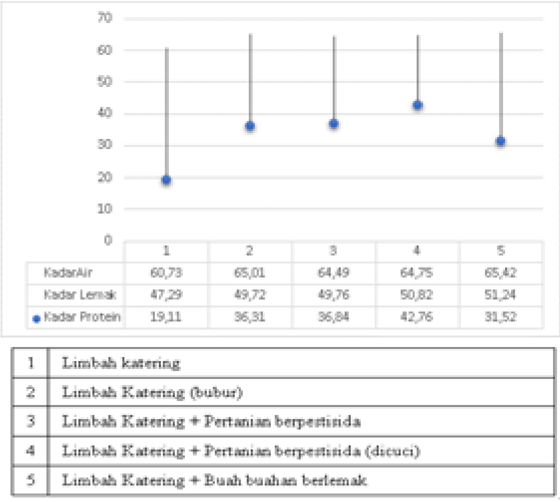

Figure 3. Proximate analysis results of BSF larvae based on feed variation

Table 3.
The amount of residual and digested feed to larval weight, and WRI value

Treatment	Total Feed (grams)	Total Feed Residue (gram)	Digested (grams)	Feed Consumption %	WRI	Final Magot Weight
A1	8820	3511	5309	60,19	2,87	2946
A2	8820	3747	5073	57,52	2,74	2612
A3	8820	3297	5523	60,62	2,88	2821
B1	8820	3420	5400	61,22	2,92	2851
B2	8820	3358	5462	61,93	2,95	3168
B3	8820	3280	5540	62,81	2,99	3056
C1	8820	4368	4452	50,48	2,40	1477
C2	8820	4277	4543	51,51	2,45	1505
C3	8820	4262	4558	51,68	2,46	1528
D1	8820	4232	4588	52,02	2,48	1934
D2	8820	4086	4734	53,67	2,56	2083
D3	8820	3665	5155	58,45	2,78	2153
E1	8820	4166	4654	52,77	2,51	2439
E2	8820	4107	4713	53,44	2,54	2400
E3	8820	3639	5181	58,74	2,80	2039

Table 3 shows that the higher the feed consumption value, the larvae are able to consume more feed given. The lowest feed consumption value is variation C with catering waste + pesticided vegetable waste at 50.48-51.68%. . The highest feed consumption value was in variation B with catering waste feed made into porridge at 61.22-62.81%.

DISCUSSION

The different variations of feed given to BSF larvae give differences in body weight gain for each sample variation. Maggot body weight gain can be influenced by feed consumption, where the higher the feed consumption value, the higher the maggot body weight gain. Based on Figure 1, it can be seen that the highest larval body weight is in sample B. Namely, the feed given is the remaining catering waste which is mashed (buried). The final body weight of the larvae reached an average of 3025 grams for 21 days. This is in line with research (Salman et al., 2019)), which states that the best body weight is from larvae that consume household waste and mashed. In addition, other studies suggest that to accelerate the process of decomposing organic waste in maggot, organic waste with a very small size or slurry is needed (Wahyudin, 2021).

Furthermore, the study looked at the growth of larval body weight with agricultural waste feed in the form of mustard, cabbage, and broccoli vegetable waste. In sample D, a washing treatment was made on the waste with the aim that the pesticides attached to the agricultural waste had disappeared when compared to sample C, which was without washing treatment of agricultural waste containing pesticides. The results obtained were the total body weight of larvae in the sample with washed agricultural waste reached 2057 grams after 21 days from 50 grams of baby larvae. While the unwashed agricultural waste feed did not experience unfavorable weight growth, namely on day 21 the body weight only reached 1503 grams. According to previous research, the growth and development of insects is influenced by the quality and quantity of food they eat. The addition of certain compounds to insect food can cause disruption to the growth and development of the larvae. Likewise, the pesticide content of the feed given to the larvae affects the growth of the larvae's body weight. Another study (Supriyatna, A., Putra, 2017) explained that if a larva consumes feed that has been exposed to active compounds, as a reaction, larvae that are not resistant will die, while larvae that are tolerant in this situation will experience growth and developmental obstacles. This is in accordance with the findings at the time of the study during the growth process, there was a "fainting spell" in baby larvae on days 5 and 6 in sample C containing pesticides. The larvae were weak and lethargic, not moving aggressively in contrast to the larvae on the other feed variations. This is thought to be due to exposure to pesticide content affecting the endurance of the baby larvae. However, the movement of the larvae returned to good and agile on day 10. However, body weight growth was not significant compared to other larvae. Other research suggests that pesticide residues cause insect feeding activity to decrease or even stop, so larvae show a decrease in movement activity. Furthermore, if the larvae are still able to survive and succeed in becoming pupae and then imago, the imago that is formed is usually small, deformed, has a shorter life span, and its egg-laying ability is reduced or sterile (Pliantiangtam, Chundang, & Kovitvadhi, 2021).

Proximate Analysis of BSF Maggot

Maggot body weight is largely determined by the feed media, the higher the nutritional content of the feed or media, the better the growth. To meet the needs of maggot feed, the quality of the media is influenced by the content of nutrients such as fat, protein, and carbohydrate content which affect maggot weight gain (Azizi, Purnamasari, & Syamsuhaidi, 2018).

Based on Figure 3 above, it can be seen that the highest moisture content was found in larvae fed with catering waste + fatty fruits such as mango and avocado, reaching 65.42%, while the lowest moisture content was found in larvae fed only with catering waste, reaching 60.73%. The need for high dietary moisture content can be attributed to the morphology of the mouthparts of BSF larvae, which resemble the characteristics of scavenging insects. This type of mouth apparatus allows BSF larvae to scrape food off the surface. By softening the feed solids, the increased moisture content of the food makes it easier for the larvae to eat. BSF larvae are also able to efficiently convert waste and by-products with high fiber content, thanks to the presence of gut bacteria in the digestive tract that are capable of degrading cellulose (Meneguz et al., 2018).

The highest fat content was in larvae fed a mixture of catering waste and fatty fruits such as mango and avocado, reaching 51.24%. The fat derived from the fruits successfully influenced the fat content of the adult larvae. This is also related to the fat requirement for larvae that will be used as feed for livestock. High fat requirements in animal feed will affect the body weight growth of livestock such as chickens and fish. The lowest fat content was found in larvae fed with catering waste at 47.29%. The highest protein content was in larvae fed a mixture of catering waste and pesticide-treated agricultural waste (mustard, cabbage, broccoli) that was washed before being fed to the larvae as feed, which amounted to 42.76%. In household waste, fruit and vegetable waste is also the most common type of waste, apart from food waste. According to Cammack and Tomberlin, fruit and vegetable waste generally contains about 20% protein, 2% fat, and 69% carbohydrates (Cammack & Tomberlin, 2017). Overall, larvae with other waste feed variations had protein contents ranging from 31.52 - 42.76%. Based on the results of research, the protein content of maggot larvae is good and has a high protein content (30-50%) which can be used as a source of fish feed (Amandanisa, A; Suryadarma, 2020). Based on this, larval feeding in the form of a mixture of catering waste with vegetables and fruits has met the expected protein levels in producing maggot larvae as fish feed.

Analysis of Differences in Maggot Weight Gain

The high level of organic waste production has the potential to be developed by increasing the benefits of organic waste in addition to compost as well as a feed medium for BSF maggots whose role is to convert organic waste into compost (kasgot or spent maggot) and the maggots that grow can be used as feed for poultry, birds, fish, and other pets. BSF maggot productivity is influenced by the type of organic waste media used, related to the nutrients contained in it. High nutrient content in organic waste can produce good production and quality in BSF maggot. Based on the research data, a homogeneity test was carried out to see whether the variance between data groups was homogeneous or not, so the homogeneity test results were obtained. Homogeneity test decision making guidelines are if the Sig. > α value, then the variance between data groups is the same (homogeneous). If the Sig. value < α, then the variance between data groups is not the same (not homogeneous). Based on the results of the Variety Homogeneity Test, it was found that in the average test of magot weight gain, the Sig value was obtained. (0.133) > α, then the variance between data groups is the same (homogeneous).

One Way ANOVA Test decision making guidelines: If the Sig. (significance) > α then H0 is accepted. If the value of Sig. (significance) < α then H0 is rejected. Based on the results of the one way Anova analysis, the Sig value is obtained. (0.000) < α then H0 is rejected, so the five variations of waste composition in maggot feed have different average maggot weight gain. The second result is obtained Sig value. (0.000) < α then H0 is rejected, so the five variations of waste composition in maggot feed have different maggot weight gain. If the Sig. value> 0.05 then the average difference in maggot weight gain and maggot weight gain is not significant. Based on the results of the Post Hoc test, it can be seen that variation A of chopped catering waste feed and variation B of buried catering waste feed obtained a Sig. (0.092) > 0.05, so the difference in average weight gain between feed variations A and B is not significant.

Calculation of Waste Reduction Index (WRI) Value

Environmental conditions and food sources affect the growth of BSF magot larvae. Based on field measurements, the growth temperature of BSF magot larvae ranged between 21oC - 25oC. The temperature and quality of the growth media affect the development time of the larvae. Tomberlin (2002) stated that H. illucens larvae with wheat growth media at a temperature of 24°C to 30°C. Larval development reached 18-25.9 days. While the growth of larvae developed in Kabanjahe, only ranged from 21oC - 25oC, followed by the rainy season when maggot larvae were bred. This of course affects the growth of maggot larvae body weight produced. If it is too hot, the larvae will leave their food source to find a cooler place. If it is too cold, the larvae's metabolism will slow down. As a result, the larvae eat less and thus grow slower (Dortmans, 2017).

Enzymes are a group of proteins that regulate and carry out chemical changes in biological systems. Enzymes are produced by organs in animals and plants that catalytically carry out various reactions, such as hydrolysis, oxidation, reduction, isomeration, addition, radical transfer, carbon chain breaking (Supriyatna, A., Putra, 2017). This enzyme will increase the metabolism of BSF magot larvae. The higher the temperature reaches the optimum temperature, the enzymes will increase and larval metabiolism will increase so that there will be many larvae to consume feed, leading to optimum body weight growth as well. While in the research area, Kabanjahe, the measured ambient temperature is in a mountainous area, the temperature ranges from 21oC - 25oC. This is not an optimum condition for magot larvae growth, and results in less than optimum weight gain compared to magot larvae growth in areas with warmer climate temperatures: the ideal temperature is between 24°C and 30°C.

Table 3, this is not in line with previous research (Gold et al., 2018) (Bonso, 2013; Diener et al., 2009; Li et al., 2011; Mutafela, 2015; Tran, Gnaedinger, & Melin, 2014), stating that in cultivating BSF, the moisture content of the media must be low because the larvae cannot develop well and cannot even grow (increase in weight) on media with high moisture content, which is > 70%. Similarly, Saragi and Bagastyo (2015) stated that growing media/feeding conditions with high moisture content will cause anaerobic conditions. The decomposition of organic matter in anaerobic conditions will produce NH_3 (ammonia) and CH_4 (methane) which can inhibit the process of feed consumption by larvae and affect their growth. The feed consumption value is then used to determine the Waste Reduction Index (WRI) value (Gold et al., 2018). The WRI value is used to calculate the ability of BSF larvae to consume feed by considering the time or period of feeding. A high WRI value implies a high ability of the larvae to reduce feed. The WRI values in Table 9 provide information that the highest value was 2.99 in treatment B buried catering waste and the lowest was 2.40 in C catering waste + pesticided agricultural waste. The amount of feed given in variation B can be consumed by the larvae optimally because it is in the form of a slurry that is easily digested by the larvae, compared to the other treatments. The WRI value is directly proportional to the feed consumption value. If the consumption value is high, the WRI value is also high. In the higher feed treatment, the WRI value tends to decrease. It is possible that the larvae are no longer able to consume the feed given because the feed is too much so that the percentage value of feed consumed to the total feed becomes lower. The WRI value obtained in this study is below the WRI value obtained (Respati, Hakim, & Kusuma, 2020), which uses fish offal and tuna head feed with a WRI value of 4.06. The type of feed given affects the ability of BSF maggots to consume feed.

CONCLUSION

The study focused on optimizing the growth of maggot larvae using different feed compositions and environmental conditions. It was found that the larvae showed the best weight gain when fed a combination of catering waste with slurry treatment, increasing from an initial weight of 50 grams to a final weight of 3025 grams. However, the ambient temperature of 20-25°C in Kabanjahe was determined to be unsuitable for the growth of Maggot BSF larvae. Proximate analysis of 21-day-old maggots revealed varying water content (60.73% - 65.42%), fat content (47.29% - 51.24%), and protein levels (19.11% - 42.76%). Statistical analysis using one-way ANOVA indicated significant differences in weight gain among different feed compositions, specifically highlighting that variation C (catering waste + unwashed agricultural pesticide) resulted in significantly higher weight gain compared to other variations (A, B, D, E). Conversely, variations A (chopped catering waste) vs. B (buried catering waste) and D (catering waste + washed agricultural pesticide) vs. E (catering waste + fatty fruits) did not show significant differences in weight gain. These findings underscore the importance of feed composition in optimizing maggot growth for potential applications in waste management and alternative protein production.

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