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Chemical Characteristic of Frass Fertilizer Derived from Black Soldier Fly (BSF) Larvae Culture using Leftover Fruits and Vegetables

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ABSTRACT
Toxic compounds such as chemical fertilizers have long been used in the agricultural and aquaculture sectors to improve soil fertility. Consequently, it adversely affects the soil, plants and aquaculture organism. Biodegradable waste can be converted into high-quality organic fertilizer. However, a proper candidate for treating biodegradable waste is required. A promising method for utilizing the black soldier fly (BSF, Hermetia illucens) larvae to derive the frass. The present study aims to determine the growth performance of maggots fed with leftover vegetables and fruit and its black soldier fly (BSF, Hermetia illucens) larvae frass chemical characteristic. The use of BSF larvae is to improve BSF frass fertilizer. A total of 3 experimental treatments were applied including; leftover vegetables (A), Fruit waste (B), Rice bran (C) as control treatment. Based on the results of the study, the type of food used as substrate affects the growth of larvae and the quality of the frass. In addition, there are differences in the length and weight of the larva produced by different types of food. This type of vegetable food provides the best maggot growth rate with an increase in length and weight. Several parameters of the chemical and biological properties of frass, the type of vegetable food suggest the highest N value.

INTRODUCTION

This Disposing of biodegradable waste has been considered a major threat to the environment. The use of biodegradable waste in maggot cultivation (black soldier fly larvae) is regarded as a sustainable practice to improve the quality of the organic fertilizer as well as the environment. Toxic compounds such as chemical fertilizer, perticides have been long used in aquaculture practice and agriculture for many purposes. Consequently, soil or water contamination with toxic compounds negatively impact the environment. Therefore, a great attention is required (Al-Taai, 2021).

A promising method for treating biodegradable waste is considered as the proper way to overcome the arisen challenges. The black soldier fly larvae (BSF, Hermetia illucens) have been identified as promising candidates for treating biodegradable waste (Gold et al., 2018). This insect-based treatment generates two valuable products; a larval of BSF rich in proteins and lipids (Scala et al., 2020). It has been used as fish meal and livestock. BSF larvae could alter food waste into safe fish feeds and high-quality (Huang et al., 2022). Furthermore, it is also used as antifungal and antimicrobial properties (Nigam & Wilson, 2022). BSF's ability is to efficiently produce protein-rich edible biomass which is more economical and

environmentally friendly (Van Huis & Oonincx, 2017). A by-product of insect breeding and the residues from production (decomposition residue) has been utilized for many purposes (Chavez, 2021; Gärttling & Schulz, 2022).

The frass derived from BSF residues production is locally known as “kasgot” fertilizer (Hernahadini, 2022). It is potentially used as organic fertilizer to fertile the soil (Pendyurin et al., 2021). It is noteworthy that frass emerge toward a considerable byproduct as the industry grows rapidly (Devic, 2016). The organic matter used varies in culturing BSF (maggot). Thus, maggot biomass and total frass depend on the quantity and quality of food during maggot cultivation. “Kasgot” fertilizer is considered to improve the fertile soil used in aquaculture for growing live feed or agriculture purposes. The full potential of frass should be thoroughly investigated due to its convincing indices in the biodegradable waste treatment method involving BSF culture (Smetana et al., 2021). Furthermore, if it is undertaken in the correct manner, it can be economically viable. The present study aims to determine the growth performance of maggots fed with leftover vegetables, fruit and the chemical composition of BSF frass.

Biodegradable waste management has become a critical issue worldwide due to the increasing accumulation of organic waste and its negative environmental consequences. Traditional waste disposal methods, such as landfilling and incineration, contribute to greenhouse gas emissions and soil contamination, posing serious threats to ecosystems. An alternative approach to addressing this challenge is the utilization of insects, particularly Black Soldier Fly (BSF) larvae (Hermetia illucens), to convert organic waste into valuable byproducts. This biological approach has gained popularity as a sustainable and eco-friendly solution to organic waste management. Among the key advantages of BSF larvae is their ability to rapidly decompose various types of organic waste while producing protein-rich larvae biomass and nutrient-dense frass fertilizer.

The use of BSF frass as an organic fertilizer has been widely explored due to its potential to improve soil fertility and enhance plant growth. Frass, which consists of insect feces and partially digested organic matter, is rich in nitrogen, phosphorus, and other essential nutrients. However, the chemical characteristics of frass can vary significantly depending on the type of organic waste used as a feeding substrate for the larvae. Understanding these variations is crucial to optimizing the application of BSF frass as a biofertilizer. Thus, this study investigates the impact of different organic waste sources, such as leftover vegetables and fruits, on the chemical composition of BSF frass and its potential as an organic fertilizer.

With the increasing global demand for sustainable agricultural practices and eco-friendly waste management solutions, the need to develop efficient organic fertilizers has become more pressing than ever. Chemical fertilizers, although widely used, pose significant environmental risks, including soil degradation and water contamination. Moreover, the rising cost of chemical fertilizers has made it imperative to explore alternative, cost-effective, and environmentally sustainable options. The utilization of BSF larvae for organic waste bioconversion presents a promising opportunity to reduce organic waste accumulation while producing high-quality organic fertilizer. Investigating the chemical composition of frass derived from different waste sources is crucial to optimizing its potential as a substitute for conventional fertilizers.

Several studies have examined the potential of BSF larvae in organic waste treatment and frass production. One study investigated the efficiency of BSF larvae in decomposing biowaste, emphasizing their ability to generate valuable byproducts, including protein-rich biomass and organic fertilizer. Another study highlighted the environmental sustainability of insect-based organic waste management, demonstrating the potential of BSF in reducing waste while producing nutrient-dense fertilizers. However, there remains limited knowledge regarding the impact of different organic waste sources on the chemical characteristics of BSF

frass. While previous studies have established the general benefits of BSF-based bioconversion, a comparative analysis of frass derived from different organic waste sources has not been thoroughly explored. This study seeks to fill this gap by examining how leftover vegetables and fruit waste influence the composition of BSF frass and its effectiveness as an organic fertilizer.

This study introduces a comprehensive analysis of the chemical properties of BSF frass derived from different organic waste sources, specifically leftover vegetables and fruits. Unlike previous research that focused solely on the general benefits of BSF larvae in bioconversion, this study provides specific insights into how waste composition influences the quality of the resulting frass. By analyzing key parameters such as nitrogen content, phosphorus levels, and organic matter composition, this research contributes to a more nuanced understanding of BSF frass as an organic fertilizer and offers practical recommendations for optimizing its use in agriculture.

The main objective of this study is to determine the chemical composition of BSF frass derived from different organic waste sources and evaluate its potential as a high-quality organic fertilizer. The findings of this research will benefit multiple stakeholders, including farmers, agricultural practitioners, and environmental policymakers, by providing evidence-based insights into the use of BSF frass as a sustainable alternative to chemical fertilizers. Moreover, this study contributes to the broader goal of reducing organic waste accumulation, promoting circular economy practices, and advancing sustainable agriculture.

RESEARCH METHOD

The present study was experimental research. This study was conducted in October 2022 at Maggot Cultivation Unit, Bosowa University, Makassar, Indonesia. “Kasgot” fertilizer and soil were analysed in the Chemistry laboratory at Pangkep State Polytechnic of Agriculture, South Sulawesi, Indonesia. This research consisted of two stages. Stage I, BSF larvae with initial size of 0.002 grams aged 4 days was rearing maggot for 2 weeks. Prior to the fermentation process, fruit and vegetables waste were ground using a machine or manually chopped. For fermentation process, microorganisms consisting of lactic acid bacteria (Lactobacillus sp), photosynthetic bacteria (Rhodopseudomonas sp), Actinomycetes sp, Streptomyces sp, and yeast, and cellulose-decomposing fungi were added into fermentation trays in which already added brown sugar (molasse), rice water. Vegetables and fruit waste were fermented for 24 hours. In addition, different type of food (leftover vegetables and fruit) was fed once in three days (Table 1). Food as a treatment in the form of vegetables and fruit waste were given as much as 250 grams with the addition of 30% bran intended to keep the media dry during rearing period.

RESULTS AND DISCUSSION

Absolute weight growth

The results showed a tendency to increase over time. The average value of absolute weight growth from the calculation of initial weight and final weight of the maggot can be seen in table 2. The availability of food sources with quality and quantity is needed by maggots to maintain their survival and growth rate. Maggot growth is very dependent on the amount and type of organic waste provided (Monita et al., 2017). When maggot is cultured in a medium, the media used must have sufficient nutrients to sustain the maggot production process. Maggot's body weight gain occurs from the digestive process of nutrients and proteins in the body

Specific growth rate

The specific growth rate of BSF larvae ranged from 0.231 to 0.365. The use of vegetables resulted in higher growth compared to using fruits and bran. However, from the standard

deviation (SD), it was shown that the use of rice bran had a lower value of SD between the two treatments. This suggested that the uniformity of growth among populations in the treatment of maggot feed using rice bran was better than vegetable and fruit feed. The nutritional content obtained by maggot highly affected by its substrates (Mokolensang et al., 2018). Furthermore, it will affect the nutritional content contained in maggot's body

Table 1. Maggot Weight Growth Performance

Treatments	Average weight (g)		Absolute Weight Growth (g)
	Initial weight	Final weight	
Vegetables (A)	0,002	0,71	0,69
Fruit (B)	0,002	0,60	0,58
Bran (C)	0,002	0,52	0,49

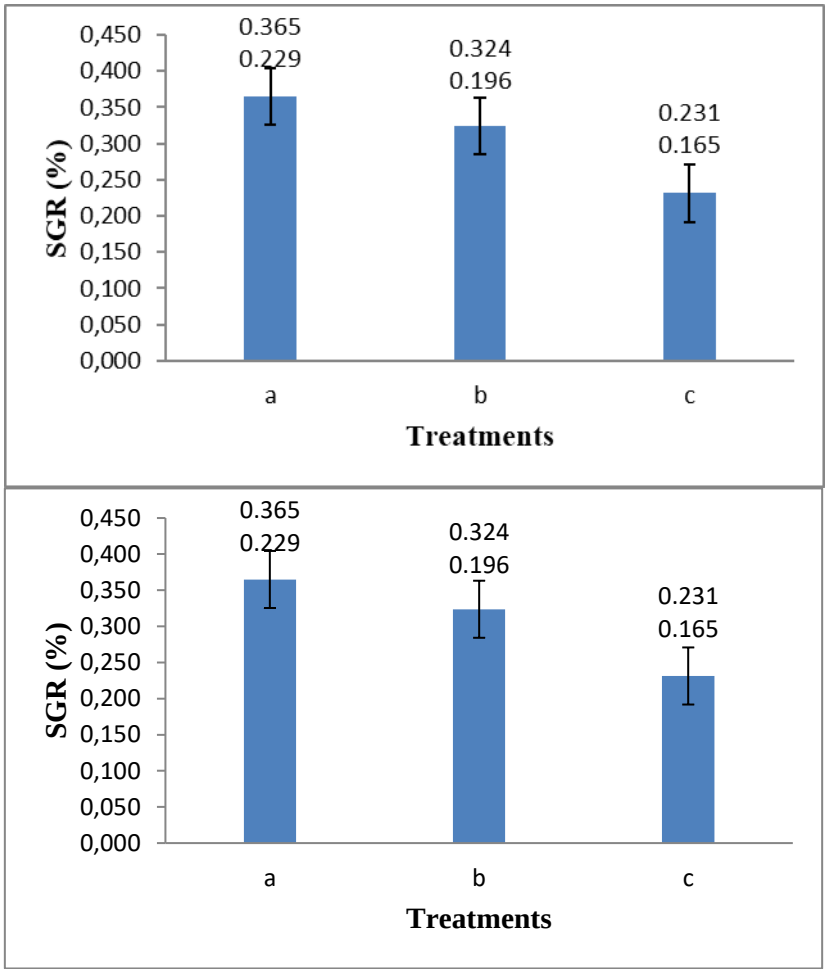

Figure 1. Specific growth rate of Maggots larvae

Table 2. Length growth performance of maggot larvae

Treatments	Average length (mm)		Absolute Length Growth (mm)
	Initial	Final	
Vegetables (A)	7,6	18,9	11,20
Fruits (B)	7,7	18,4	10,74
Bran (C)	7,7	18	10,33

Table 3. Proximate analysis of black soldier fly grown in different media (%)

No	Materials	Protein	Lipid	Carbohydrate	Moisture	Ash
1	Vegetables	31,03	10,67	31,56	73.42	4.42
2	Fruits	21,83	18,67	22,54	92,33	2,12
3	Bran	22,49	13,65	29,12	72.43	3,29

Table 4. Frass Fertilizer Content obtained from different feeding regimes (%)

No	Materials	Nitrogen	Carbon	P_2O_4	K_2O	N total	C/N	C organic
1	Vegetables	0.548	14.7	1.48	2,32	1,56	27,58	35,24
2	Fruits	0.329	16.7	1.58	1.12	1,52	32,37	30,26
3	Bran	0.332	19.47	1.59	1,03	0,94	31,17	21,13

Length growth

The results showed that the highest average length growth obtained from vegetable feed treatment for 14 days (11.20 mm). The detail of absolute length growth can be seen in table 3.

The table 3 illustrates that the use of vegetables as maggot feed provides the highest length growth compared to other treatments. This finding suggests that the nutritional content of vegetables has more influence on the growth of maggot length. The increase in body length of maggot is closely related to the conditions of the rearing media (Amran et al., 2021). The amount of protein contained in the body is closely related to the amount of protein received from consuming food. The decomposition of organic materials by bacteria in maggot living media will properly support the growth of maggot in this media (Mokolensang et al., 2018).

The length growth tended to increase gradually in all treatments. However, the higher length growth was obtained from vegetables treatment. The growth of maggot larvae is strongly influenced by the nutrient composition of the feed, especially macromolecules such as carbohydrates, fats and proteins (Purba et al., 2021; Tomberlin et al., 2009). In the present study, the highest percentage of protein content was derived from BSF grown in vegetables medium. Nonetheless, it showed a lower lipid content (Table 4). Maggot utilized the available nutrients from the medium (Katayane et al., 2014). Thus, the quality and quantity of the culture media affect the growth performance of maggot, particularly protein requirement for its body.

Proximate analysis

The amount of frass produced during the biodegradable waste treatment process with BSF larvae widely varies according to the physical-chemical characteristics of the waste (Table 4). The table 5 shows that the type of food and the length of time for rearing maggot significantly effects on the total N content of maggot frass. This type of vegetable food produces frass with a higher Total N content than vegetables and the longer the rearing of maggot, the higher total N content. Protein is a compound composed of groups of amino acids which are an important source of organic N. The higher N content in maggot manure is also caused by metabolic processes in the maggot body itself which also produce N. The availability of nitrogen in the soil is very dependent on C-organic, the higher the C-organic, the higher the population of N bacteria in the soil (Houben et al., 2020). It can be seen that C-organic frass meets the required standards. Thus, the deficiency of N in fertilizers in the growth process can be met by C-organic frass.

The results of the analysis of available phosphate in maggot decomposing organic waste can be concluded that the type of food and length of rearing of maggot affect the available phosphate content. The highest maggot frass phosphate content was obtained from vegetable food types. This can be connected with the results of an analysis of the phosphates contained in the maggot food, where the phosphate content in vegetables is higher than the type of fruit food. Phosphate is a macro nutrient that can be derived from organic waste. Thus, maggot fertilizer has the potential as a source of phosphate elements (Mashur et al., 2001). The

vermicompost or kasgot technique is compost obtained from the decomposition of organic waste carried out by maggot. Kasgot is a mixture of maggot manure with the rest of the media or feed in magot cultivation. Therefore, frass is an organic fertilizer that is environmentally friendly and has its own advantages compared to other composts (Yuwono, 2006).

Frass fertilizer meets the standards of organic fertilizer which about 3.1 x 108 CFU/gr of bacterial cell density. Free nitrogen fixing bacteria are abundant in nature which includes Rhodosprillum, Azotobacter, Pseudomonas, bacillus and Mycobacterium. Apart from containing almost all the nutrients needed by plants in the available quantities, maggot fertilizer also contains plant growth hormones. These hormones will spur plant growth, plant roots in the soil, spur the budding of new branches on tree trunks and branches, and spur leaf growth. These hormones will stimulate plant growth, plant roots in the soil, stimulate the budding of new branches on tree trunks and branches, and stimulate leaf growth.

In present study, the pH of frass fertilizer derived from experimental was 7.2. It appears that the characteristic of BSF frass in this study is slightly alkaline. However, the high variation of micronutrients is quite higher. Similarly, pH of BSF frass is 7.5. This finding indicates that the frass fertilizer has potential as basic standard of organic fertiliz

CONCLUSION

The type of food affects the growth performance of maggot (BSF, H. illucens) and the quality of the frass produced. A difference in the maggot weight produced by different types of food is found. The highest N value was obtained from the leftover vegetable treatment (0.548). However, the bran treatment had the highest phosphate value (0.159) compared to fruit treatment.

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