

**THE EFFECT OF ORGANIC FEEDING ON THE GROWTH AND PRODUCTIVITY OF MAGGOT (HERMETIA ILLUCENS)**

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**ABSTRACT**

This study aimed to analyze the effect of organic feed on the growth and productivity of maggot (*Hermetia illucens*). Maggot is a decomposer organism with considerable potential to support organic waste management and provide an alternative protein source for animal feed. The study used an experimental design with four feeding treatments: household organic waste, vegetable waste, a mixture of vegetable waste and household organic waste, and a control treatment. One-day-old larvae were reared for 14 days, and growth was measured using body weight, body length, feed conversion efficiency, and the number of pupae produced. The results showed that the mixed organic feed produced the best growth performance, as indicated by faster increases in larval weight and body length than the control. Maggot productivity also increased under the mixed-feed treatment, with the highest number and better quality of pupae. These findings indicate that a balanced combination of organic feed materials can improve larval metabolism, biomass conversion, and production efficiency. Therefore, organic feed selection is an important factor in optimizing maggot cultivation for animal feed production and environmentally friendly organic waste bioconversion.

**Keywords:** Organic feed, growth, productivity, maggot, hermetia illucens

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**INTRODUCTION**

Organic waste management has become one of the major environmental challenges worldwide due to the continuous increase in municipal, agricultural, and agro-industrial waste generation. Rapid population growth, urbanization, and intensified agricultural activities have significantly increased the amount of biodegradable waste produced each year. According to recent estimates, organic waste constitutes more than half of the total municipal solid waste generated in many developing countries. However, a substantial proportion of this waste is still disposed of in landfills or unmanaged dumping sites without proper treatment. Such practices contribute to environmental pollution through greenhouse gas emissions, leachate production, unpleasant odors, and the contamination of soil and water resources. Furthermore, the accumulation of untreated organic waste creates favorable conditions for disease vectors and

negatively affects public health and ecosystem sustainability. Consequently, the development of environmentally friendly, economically feasible, and sustainable technologies for organic waste management has become an important priority in many countries, including Indonesia.

Indonesia, as one of the world's largest agricultural countries, generates enormous quantities of organic waste from households, food markets, restaurants, agricultural production, livestock farming, and food-processing industries. Vegetable residues, fruit peels, crop residues, and food leftovers account for a large proportion of this waste stream. Despite the abundance of biodegradable materials, waste management systems in many regions remain inadequate, resulting in low recycling rates and inefficient resource utilization. Instead of being treated as valuable biological resources, large amounts of organic waste are simply discarded, representing both an environmental burden and a loss of potentially useful biomass. Therefore, converting organic waste into valuable products through biological processes has become an increasingly attractive strategy within the framework of circular economy and sustainable agriculture.

Among the various biological waste treatment technologies currently available, the utilization of black soldier fly (*Hermetia illucens*) larvae has emerged as one of the most promising approaches for organic waste bioconversion. Black soldier fly (BSF) larvae possess an exceptional capacity to rapidly consume and convert a wide variety of biodegradable organic materials into valuable biomass. Unlike many other insect species associated with waste, adult black soldier flies do not feed on decomposing materials and are not considered vectors of human diseases, making them environmentally safe for waste management applications. During their larval stage, BSF efficiently reduce the volume of organic waste while simultaneously producing protein-rich and lipid-rich biomass suitable for livestock, poultry, and aquaculture feed. Chia et al. (2018) reported that BSF larvae can substantially reduce organic waste mass while producing high-value products such as insect protein, insect oil, and organic fertilizer. Consequently, BSF bioconversion technology has attracted considerable attention from researchers, policymakers, and industry as a sustainable alternative to conventional organic waste treatment methods.

The application of *Hermetia illucens* extends beyond waste reduction. The insect has become increasingly important in supporting sustainable food and feed production systems because of its ability to recycle nutrients that would otherwise be lost in organic waste streams. Larval biomass contains high concentrations of crude protein, essential amino acids, lipids, minerals, and bioactive compounds that make it an attractive ingredient for animal feeds. In addition, the residual substrate produced after larval feeding, commonly known as frass, can be utilized as an organic fertilizer capable of improving soil fertility and crop productivity. Therefore, the cultivation of BSF contributes simultaneously to waste management, nutrient recycling, feed production, and sustainable agriculture, making it an important component of integrated circular bioeconomy systems.

The efficiency of BSF bioconversion is strongly influenced by the nutritional characteristics of the substrate used as larval feed. Organic substrates serve not only as food sources but also as the primary determinant of larval growth, survival, development rate, and biomass production. Different types of organic waste vary considerably in their moisture content, protein concentration, carbohydrate composition, lipid levels, fiber content, and mineral availability. Consequently, substrate quality directly affects larval physiological performance and conversion efficiency. Nutritionally balanced substrates generally promote faster larval development, higher survival rates, increased biomass accumulation, and improved reproductive performance. Conversely, substrates deficient in essential nutrients may slow

growth, reduce feed conversion efficiency, prolong the developmental cycle, and lower the quality of the resulting larvae and pupae.

Various organic waste materials have been investigated as potential substrates for BSF cultivation, including household kitchen waste, vegetable residues, fruit waste, agricultural by-products, food-processing residues, brewery waste, tofu residue, and livestock manure. Many of these materials are abundantly available throughout Indonesia, providing an inexpensive and sustainable feed source for insect production. Among these materials, vegetable residues, fruit waste, and mixed kitchen waste are particularly attractive because they are continuously generated in urban and rural communities and contain relatively high concentrations of carbohydrates, vitamins, minerals, and moisture that support larval metabolism. Nevertheless, each waste type possesses distinct nutritional characteristics, and their suitability for larval development varies considerably depending on their chemical composition and physical properties.

Previous studies have demonstrated that substrate composition significantly influences biological performance in *Hermetia illucens*. Herwan et al. (2021) reported that nutrient-balanced organic substrates improved larval growth rate, pupation success, biomass yield, and feed conversion efficiency compared with nutritionally poor substrates. Similarly, Diener et al. (2011) explained that BSF larvae exhibit remarkable efficiency in converting organic matter into body biomass because of their highly active digestive system and rapid metabolic processes during the larval stage. Under favorable environmental conditions, larvae can complete their development within a relatively short period while producing biomass rich in protein, lipids, and essential nutrients. These characteristics have positioned BSF as one of the most promising alternative protein sources for the future livestock and aquaculture industries.

In addition to growth performance, the nutritional quality of the substrate also affects the quality of the pupae produced. Adequate protein and energy availability during larval development allow insects to accumulate sufficient nutrient reserves required for successful metamorphosis. Consequently, higher-quality substrates generally produce larger pupae with greater body weight and improved survival into adulthood. In contrast, nutrient-deficient substrates may reduce larval feeding activity, decrease biomass accumulation, delay pupation, and increase mortality. Makkar et al. (2014) emphasized that insects intended for animal feed should be reared on nutritionally appropriate substrates to maximize both biomass production and nutritional value. Therefore, optimizing substrate composition represents a key strategy for improving the productivity and commercial viability of BSF farming.

From an economic perspective, the utilization of locally available organic waste as BSF feed offers substantial advantages. Feed substrate represents one of the major operational costs in insect farming, and replacing commercial feed with organic waste can significantly reduce production expenses while simultaneously addressing waste disposal problems. Moreover, converting organic waste into valuable insect biomass supports sustainable resource utilization by transforming low-value waste into high-value products. This approach aligns with the principles of circular economy, in which biological resources are continuously recycled to maximize resource efficiency while minimizing environmental impacts.

Although the application of *Hermetia illucens* for organic waste bioconversion has been widely studied, considerable knowledge gaps remain regarding the combined utilization of different organic feed materials, particularly under local Indonesian environmental and waste-management conditions. Organic wastes available in Indonesia vary considerably depending on regional agricultural activities, seasonal availability, and household consumption patterns. Consequently, identifying appropriate combinations of locally available substrates capable of

maximizing larval productivity remains an important research objective. Furthermore, comprehensive evaluation of larval growth, pupa production, pupa quality, and feed conversion efficiency is essential for developing practical recommendations that can be implemented by farmers, waste management enterprises, and small-scale BSF producers.

Therefore, this study aimed to analyze the effect of different organic feed substrates on the growth and productivity of *Hermetia illucens*. Particular emphasis was placed on evaluating larval growth performance, pupa production, pupa quality, and feed conversion efficiency as indicators of substrate suitability. The findings of this study are expected to provide scientific evidence supporting the optimization of locally available organic waste utilization for BSF cultivation while contributing to sustainable waste management, alternative protein production, and the development of circular bioeconomy systems in Indonesia.

## **METHODS**

This study used an experimental design to examine the effect of organic feed on the growth and productivity of maggot (*Hermetia illucens*). The larvae used in the experiment were obtained from a laboratory culture and reared under controlled conditions. The feeding treatments consisted of four groups: household organic waste, vegetable waste, a mixture of vegetable waste and household organic waste, and a control treatment without organic feed. Each treatment was conducted in three replications to obtain more reliable data.

One-day-old larvae were used at the beginning of the experiment and reared for 14 days. Feed was provided daily according to each treatment. Uneaten feed from the previous day was removed before fresh feed was added to minimize spoilage and maintain the rearing environment. Larval growth was observed every three days by measuring body weight and body length.

Productivity was measured based on the number of pupae produced at the end of the rearing period. In addition, pupa quality was evaluated using pupa size and weight. Feed conversion efficiency was assessed to determine how effectively larvae converted organic feed into body biomass.

The data were analyzed using analysis of variance (ANOVA) to determine whether different organic feeding treatments produced significant differences in growth and productivity. When significant differences were identified, Duncan's multiple range test was used to determine the best-performing treatment. Descriptive analysis was also applied to explain the pattern of larval growth during the study period (Amin et al., 2017; Rahman et al., 2020).

## **RESULT AND DISCUSSION**

### **Growth Performance**

The results showed that maggot growth was influenced by the type of organic feed provided. Larvae fed with the mixture of vegetable waste and household organic waste showed faster increases in body weight and body length than those in the control treatment. On day 7, the average larval weight in the mixed-feed group reached 0.45 g, while the control group reached only 0.28 g. This indicates that a more diverse and nutrient-rich organic feed can support larval development more effectively.

Larvae fed only with household organic waste grew more slowly than those fed vegetable waste. The average body length of larvae in the household-waste treatment reached 3.2 cm after 7 days, whereas larvae fed vegetable waste reached 4.5 cm. Vegetable waste may provide higher moisture content and micronutrients that support larval metabolism. However, the mixture of vegetable waste and household organic waste still produced the best performance because it provided a more balanced nutrient composition.

### **Maggot Productivity**

Organic feed also affected maggot productivity, which was measured by the number of pupae produced at the end of the rearing period. The mixed-feed treatment produced the highest number of pupae, with 35 pupae recorded in the observed treatment unit. The vegetable-waste treatment produced 30 pupae, while the control treatment produced 22 pupae. The household-waste treatment produced fewer pupae, approximately 15 pupae, indicating that limited nutrient balance may reduce the capacity of larvae to complete development efficiently.

The increase in pupa production in the mixed-feed treatment suggests that combining different organic substrates can improve the availability of nutrients required for larval growth and metamorphosis. A more diverse nutrient supply can support metabolism, increase biomass accumulation, and shorten the development process. This result is consistent with the concept that black soldier fly larvae perform better when reared on substrates with adequate protein, carbohydrates, fats, and minerals (Li et al., 2017; Surendra et al., 2016).

### **Pupa Quality**

In addition to pupa quantity, pupa quality was also affected by the type of feed. Pupae produced from larvae fed the mixture of vegetable waste and household organic waste had larger size and higher weight than those produced from the control treatment. The average pupa weight in the mixed-feed group was 0.35 g, while the control group produced pupae with an average weight of approximately 0.20 g.

Higher pupa weight indicates that larvae received sufficient nutrients during their development. This is important because larger and denser pupae have greater potential as an alternative protein source for animal feed. Previous studies have also emphasized that BSF larvae and pupae can be valuable feed ingredients when reared on suitable organic substrates (Diener et al., 2011; Makkar et al., 2014). In contrast, larvae fed only vegetable waste or household waste produced smaller pupae, suggesting that limited nutrient diversity may reduce the quality of the final biomass.

### **Feed Conversion Efficiency**

Feed conversion efficiency describes how effectively larvae convert feed into body biomass. The mixed-feed treatment showed the best conversion performance, with an FCR value of 1.2. The vegetable-waste treatment showed an FCR value of 1.5, while the control treatment showed an FCR value of 1.8. A lower FCR value indicates better efficiency because less feed is required to produce larval biomass.

The better efficiency observed in the mixed-feed treatment indicates that larvae were able to use the available nutrients more effectively. Balanced organic feed may improve digestion, metabolism, and biomass accumulation. In treatments with less diverse feed, larvae required more substrate to achieve comparable growth, reflecting lower conversion efficiency. This finding highlights the importance of feed composition in optimizing maggot production systems.

## Implications for Organic Waste Bioconversion

Overall, the findings indicate that organic feed selection is a critical factor in maggot cultivation. The mixture of vegetable waste and household organic waste consistently produced better larval growth, higher pupa productivity, improved pupa quality, and more efficient feed conversion. These results show that maggot cultivation can simultaneously support organic waste reduction and the production of alternative feed biomass.

From an applied perspective, the use of mixed organic waste may help communities, livestock farmers, and waste-management actors develop a more efficient bioconversion system. By selecting substrates with balanced nutrients, maggot cultivation can become a practical strategy for reducing environmental burden while generating valuable products for agricultural and livestock purposes.

## CONCLUSION

Organic feed had a positive effect on the growth and productivity of maggot (*Hermetia illucens*). The mixture of vegetable waste and household organic waste produced the most optimal results, as shown by faster larval growth, higher pupa production, better pupa quality, and more efficient feed conversion than the control treatment.

The results indicate that balanced and nutrient-rich organic feed is essential for improving maggot cultivation performance. Single-source feed such as household organic waste or vegetable waste can support larval growth, but their performance is generally lower than that of mixed organic feed. Therefore, the selection and combination of organic substrates should be considered carefully in maggot production systems.

This study supports the development of maggot as an environmentally friendly bioconversion agent and an alternative source of animal feed. The use of appropriate organic feed can improve production efficiency, reduce organic waste, and contribute to more sustainable agricultural and livestock practices.

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