

Effect of Different Organic Wastes on the Growth of Black Soldier Fly (*Hermetia illucens*) Larvae

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ABSTRACT

Black soldier fly (BSF) is one of the most promising bioconversion agents for organic wastes and potential nutrient-rich food source for the poultry and aquaculture industries. For these purposes, it is essential to produce edible quality larvae of BSF. This study tested the effect of the oil palm dregs (oil palm shreds after the oil is squeezed out), soybean curd residue, and restaurant waste as food on the survival and growth of BSF larvae. About 25 BSF larvae age of six to seven-days-old were placed on each treatment substrates (oil palm dregs, soybean curd residue, and restaurant waste). At 5, 12, and 19 days after treatments were started, all larvae on each treatment were collected for measurements. Results after 19 days showed that the restaurant waste, a mixture of food from West Sumatran food restaurants (RM Padang) and Javanese food restaurants (RM Tegal), produced significantly ($P < 0.05$) longer body length and width, along with heavier body weight compared to the larvae fed with the other two treatments.

Keywords: black soldier fly larvae, BSF, oil palm dregs, soybean curd residue, restaurant waste

1. INTRODUCTION

In many cities and municipalities, decision-makers are facing a severe challenge in the management of accumulated daily solid wastes. In Indonesia, about 175.000 tons of solid wastes are generated daily, which is about 64 million tons per annum [1]. The accumulation of these wastes is due to large population in cities/municipalities, and lack of technology to process these wastes [2]. Furthermore, the failure to manage waste causes significant negative consequences, including massive environmental pollution of land as well as marine bodies which has caught global attention, for example, the accumulated plastic wastes in Bali and the polluted Citarum River, West Java [3, 4]. The health issue is another impact of solid waste pollution and needs serious actions that have an immediate effect on addressing the problem [5, 6].

Wastes could be divided into two groups; inorganic and organic wastes. Among the 64 MT/annum of wastes, about 40% are inorganic wastes consisting of ~15% plastic, ~10% paper, and ~15% metals, glasses, clothes, etc. The rest or about 60% of the wastes are organic wastes [1]. Unlike inorganic waste, organic waste contains a high amount of food and nutrition available to many decomposing organisms, including insects, fungus, and bacteria. Many studies found that the end products of decomposition processes by these organisms could be beneficial for humans [7]. The use of black soldier fly (*Hermetia illucens*, BSF) to manage organic solid wastes

was introduced in the 1990s, and since then has been getting increased attention until today [8].

The use of BSF larvae to manage waste has significant advantages over other methods. This method uses simple and affordable technology with faster and more reliable results that make it suitable for low to middle-income countries [9]. Another approach to this is the decomposition by bacteria, which needs higher cost in technology to operate and to maintain. This particular technique suffers from significant draw-back in the implementation front in different countries due to budget issues. The BSF larvae are found to be efficient in suppressing *Drosophila melanogaster*, which minimizes the development of bacteria, and reduces health threat to humans along with the better odour of the waste materials [10]. Another benefit is that BSF can colonize and consume a wide variety of resources, ranging from cow manure, animal carcasses, and even human to animal feces [11], which indicate that the BSF can be used to manage a variety of organic wastes. Besides, the residue of BSF larvae is used for organic fertilizer, and the larvae themselves are used as an animal feeder, for example, for fish in aquaculture, or chicken in the poultry industry. As a food source, indeed, the quality of larvae is essential to the animal fed with it, and many studies were reported that the quality of food affects the quality of larvae produced [6].

There are three solid organic wastes produced daily in higher volumes in Indonesia: soybean curd residue, oil palm dregs, and restaurant food wastes.

Soybean curd residue contains about 23-24% protein and about 4.6% fat, are generally used as animal feed for pig, cow, etc. The oil palm dregs (oil palm shreds after the oil is squeezed out) contains about 15.9 % protein and 7.8% fat [12]. Organic food waste from the restaurants includes a variety of proteins and fat types that are beneficial for the larvae. Due to the continuous generation of these three solid wastes in high volume in Indonesia, this experiment was designed to test whether BSL larvae can be used to decompose these wastes.

1.1. Materials and Methods

1.1.1. Research location and materials

This experiment was carried out at the laboratory of the Research Institute for Ornamental Fish Culture (BRBIH), Ministry of Marine Affairs and Fisheries of the Republic of Indonesia. Materials used in this experiment were a plastic container (40cm x 30cm x 10cm) to house the flies attractant, wooden shelf where the plastic container containing fly attractant was placed, black plastic bowl (diam. 20cm) to be filled with food substrates and where the BSF larvae were cultivated during bioconversion process. A digital camera was used for the documentation, while digital scale and digital caliper were used to measure the larvae dimensions. BRBIH provided oil palm dregs and soybean curd residue, and restaurant food waste was collected from 10 restaurants, a mixture of Javanese food restaurants (RM Tegal/ Warteg) and West Sumatran food restaurant (RM Padang).

The black soldier fly colony used in this experiment has been reared in BRBIH facility for several generations. The media in which BSF females oviposit their eggs were in the form of porridge. The porridge was prepared from a mixture of palm oil residue, coconut dregs, oil palm dregs, soybean curd residue, and water. The prepared blend was kept fermenting for 2-3 days. After three days, about 2 kg of the fermented material was poured into the 40cm x 30cm plastic containers. Female BSF was attracted to the prepared material for oviposition on the surface of the substrate. Several wooden sticks (2cm x 2cm x 15cm) were placed on the top of the container as oviposition sites. Eggs laid by BSF female (about 300 eggs) on the surface of the wooden sticks were collected using a bamboo stick. The collected eggs were placed in a petri dish containing a weighing paper. Eggs were weighted with a digital scale, and about 1 g of eggs was sowed on the surface of the prepared media (treatments).

1.1.2. Experimental Set-Up

The treatments were different types of food for BSF larvae: 1) oil palm dregs (4 kg), soybean curd residue (4 kg), and 3) shredded restaurant solid organic wastes 4 (kg). The soybean curd residue and oil palm dregs were prepared by

breaking them into small pieces by hand. Each substrate was mixed thoroughly using a small shovel and metal spoon to reach target homogeneity and then poured into the plastic bowl. For restaurant organic waste, buckets of solid waste from the restaurant were separated from inorganic waste, if present. The final prepared treatment media were placed in each designated bowl. There was no repetition of food treatment. The BSF larvae with the age of 6-7 d old were placed on each surface of the treated substrate. The number of larvae that were placed on the substrate was about 25 larvae and weighs about 1 g (larvae were collected and weighed). The size of all larvae was measured with a digital calliper before placing them on each treatment substrate. At the 5, 12, and 19 d after treatment began, all larvae on each substrate treatment were collected for measurements. To imitate field conditions, the substrate in each treatment during this experiment was left as it was without additional treatment to the substrate, including watering, until the experiment completed. Statistical analysis for this experiment used one-way analysis of variance (ANOVA) followed by Tukey's HSD test to analyse differences between treatments ($P < 0.05$).

1.2. Our Contribution

This paper presents additional information about the ability of organic waste such as oil palm dregs, soybean curd residue, and restaurant waste to be used as feed media for BSF larvae. The results show that the administration of all three types of waste can influence the growth of BSF larvae, so the use of BSF larvae as a waste reduction can be applied and able to overcome the problems caused by organic waste

1.3. Paper Structure

This paper is organized as follows. Section 1 introduces the introduction in this paper, which reviews the background and purpose of the observations. Section 2. Then, the results and discussion of observations are in Section 3. Finally, Section 4 discusses the paper and provides suggestions for further research.

2. RESULTS AND DISCUSSION

2.1. Physiochemical Characteristics of the Treatment Substrates

The characteristics of each food treatment used in this experiment are presented in Table 1. Restaurant wastes had the highest temperature among the three food treatments. The highest humidity found in Soybean curd treatment.

Table 1 Characteristics of Soybean curd residue, Oil palm dregs, and Restaurant solid organic wastes

Parameters	Treatment		
	Soybean curd residue	Oil palm dregs	Restaurant solid organic wastes
Temperature	26.7-28.9°C	27.4-28.8°C	30-36°C
pH	4 – 7	7	6
Humidity	70-90%	70%	70%
Texture	Wet from the beginning to the end of the experiment	Dry from the beginning to the end of the experiment	Wet in the beginning, drier at the end of the experiment
Colour	White in the beginning, turned brown at the end	Brown in the beginning, turned black at the end	White, green, and red in the beginning, turned brown at the end
Size of particle	Fine	Small to fine	Large
Odour	Sour in the beginning, getting stronger at the end of the experiment	Slightly sour in the beginning, getting less sour, becoming odourless at the end of the experiment	Slightly sour in the beginning, becoming less sour at the end of the experiment

2.2. Effect of Food Treatments to BSF Larval Growth

Larvae of BSF were found to be capable of living and decomposing all three kinds of food (oil palm dregs, soybean curd residue, and restaurant waste) used in this experiment, which means that these wastes can be managed by using the larvae of BSF.

Food types have a significant effect ($P < 0.05$) to growth parameters of BSF larvae (Table 2). The longest larval body length and width were observed on larvae fed with restaurant waste followed by soybean curd residue-fed larvae (Table 2). The highest total larval body weight is observed in restaurant waste fed larvae (34.77 g), followed by oil palm dregs fed larvae (29.84 g) and soybean curd residue fed larvae (4.82 g) (Table 2).

These results were consistent with previous research, which found protein as the most crucial macronutrient needed by insect larvae [13]. Among the three food treatments used in this experiment, restaurant wastes had the highest protein content at 39% [6], followed by soybean

curd residue at 23% [14], and oil palm dregs at 16% [10]. Besides, restaurant wastes may have a better attraction to larvae due to the various food components it contained, such as meat, fruit, vegetable, fish, etc.

Low total larval weight of larvae fed on the soybean curd residue may be caused by the high mortality of BSF larvae on this substrate treatment as a result of the high moisture content of the substrate. The high moisture content of the soybean curd residue induced nutrient dilution and provided a favourable condition for pathogenic bacteria that may have caused higher larval mortality in this treatment compared to the other two treatments [15, 16].

3. CONCLUSION

This research has shown the potential of black soldier fly larvae as bioconversion agents of these three wastes that are produced daily in high volume in Indonesia. Higher and variety of protein, fat, and another nutrition source in restaurant solid organic waste could be the determining

Table 2 Average larval length, width, and total larval weight on Soybean curd residue, Oil palm dregs, and Restaurant wastes

Parameters	Unit	Treatment		
		Soybean curd Residue	Oil palm dregs	Restaurant wastes
Length (n=12)	mm	20.51±0.21 ^c	21.38±0.26 ^b	23.04±0.19 ^a
Width (n=12)	mm	4.88±0.06 ^b	5.11±0.10 ^b	5.46±0.07 ^a
Total weight*	g	4.82	29.84	34.77

*Total weight of BSF larvae on each treatment substrate at day 19. Low body weight indicates low larval survival rates in the treatment. Means±SE with different letters are significantly different statistically ($p < 0.05$)

factor that supports the best growth of BSF larvae feed with this food compared to the other two wastes. Further research on the potential use of BSF larvae in aquaculture and poultry industries should be explored.

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