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UTILIZATION OF BLACK SOLDIER FLY (*HERMETIA ILLUCENS*) AS A PROBLEM SOLVING OF ORGANIC SOLID WASTE

ABSTRACT

Organic solid waste is a type of waste that has the largest amount in Indonesia. If it is not managed properly, organic solid waste can cause various problems. To overcome this problem, it is necessary to make an effort to utilize organic solid waste which also has high economic potential. One solution to this is the use of Black Soldier Fly larvae (*Hermetia Illucens*) as decomposers of organic matter. The purpose of this study was to analyze the effect of the type of organic waste on the bioconversion of domestic waste using Black Soldier Fly larvae (*Hermetia Illucens*). This research was done using Black Soldier Fly (*Hermetia Illucens*) larvae of 7 days old. Two hundred larvae were used for every feeding treatment and placed in a growing cage. The feed types and feeding frequencies were varied. The feed types were three different food waste materials, were mainly composed of vegetable waste, fruit waste, and food waste. The larvae were fed with 40 mg of dry weight food waste/ larvae/ day. The feeding frequency was varied to once per day and once in four day periods. The weight of 10% of larvae per feeding treatment was measured every four days. At the end of the experiment, the residual feed material and characteristics were measured. The level reduces vegetable waste, fruit waste, and food waste respectively 52 %; 51 %; 55 % on the frequency of feeding once in four days. At the frequency of feeding once a day, the results were 50 %, 62 %; 67%. The C/N ratio of vegetable waste, fruit waste, and food waste residue was 8,8; 10,1; and 11,9 for the frequency of feeding once in four days, and 8,3; 9,2; and 10,6 at the frequency of feeding once a day. The moisture content in the residue of vegetable waste, fruit waste, and food waste were 92,1% respectively; 74,7%; and 77,2% at the frequency of feeding once in four days and 95,2% respectively; 72,6%; and 82,7% at the frequency of feeding once. The pH value of vegetable waste, fruit waste, and

food waste is 5,54 respectively; 4,21; and 4,18 for the frequency of feeding once in four days, and 5,47 each; 5,00; and 4,16 for the frequency of feeding once a day. The suggestion for further research is that further research is needed on the effect of the acidity of the food on the mortality rate of the larvae so that the optimum pH for the growth of Black Soldier Fly (*Hermetia Illucens*) larvae can be found.

Keywords: black soldier fly, biodegradable organic solid waste, larvae, reduction

INTRODUCTION

Along with the rapid population growth and urbanization, as well as the increasing consumptive behavior of the community, the government is facing challenges regarding waste management[1]. Waste is the remains of human daily activities and/or natural processes in solid form. Meanwhile, waste management is a systematic, comprehensive, and sustainable activity that includes waste reduction and handling[2]. Solid waste is solid or semi-solid waste material resulting from human and animal activities that are discarded because it is no longer needed or no longer used[3]. Waste management is one of the problems, both in developed and developing countries, which has not been resolved until now, including in Indonesia[4].

The Indonesian Ministry of Environment and Forestry states that the amount of waste generation in Indonesia has reached 175,000 tonnes/day or the equivalent of 64 million tonnes/year with 69% of which is transported and dumped in landfills, buried 10%, composted and recycled 7%, burned 5%, and the remaining 7% unmanaged, besides that the type of organic waste in Indonesia has the largest percentage, which is 60%. Based on these data, current waste management is still concentrated in landfills without going through the 3R (reduce, recycle, reuse) process at the source involving community participation. This condition is a major factor in landfill loads becoming heavy and their useful life is getting shorter[5]. One of the technologies in dealing with this type of waste is composting. This method is used because it is open so it can reduce the appearance of pungent odors, is easy and cheap to do, and does not require a too difficult process. The decomposition of the material is carried out by microorganisms in the material itself with the help of air[6].

To overcome this problem, it is necessary to make an effort to utilize organic solid waste which also has high economic potential. One solution to this problem is the use of Black Soldier

Fly larvae (*Hermetia Illucens*) as decomposers of organic matter. Black Soldier Fly (*Hermetia Illucens*) has been researched to degrade organic solid waste by utilizing its larvae which extract energy and nutrients from vegetable waste, food scraps, animal carcasses, and feces as food ingredients[7]. Besides, Black Soldier Fly (*Hermetia Illucens*) larvae are easy to breed with their resistance to seasons, although Black Soldier Fly (*Hermetia Illucens*) larvae are more active in warm conditions, so making them suitable for the Indonesian climate. Black Soldier Fly (*Hermetia Illucens*) larvae have the best decomposition ability compared to other organisms or microorganisms[8].

Based on the report from the Agency for the Assessment and Application of Technology of the Republic of Indonesia in 2010, the percentage of organic waste reached 65.05%[9]. A total of 60% of municipal organic waste is vegetable waste and 40% is a combination of garden waste, fruit skins, and food scraps[10]. Based on the above percentages, it will be obtained the amount of food waste is very high if it is directly disposed of into the landfill without prior processing. Supported by these factors, the use of Black Soldier Fly (*Hermetia Illucens*) larvae to reduce food waste is feasible to develop.

MATERIALS AND METHODS

This research is experimental research carried out with laboratory-scale experimental methods in the Research Workshop and the Composting Area of PT. Waste 4 Change Jemundo Village, Taman District, Sidoarjo Regency, East Java, Indonesia. The research was conducted within 2 months (60 days) with a research running time of 24 days and with 3 (three) replications. The final result to be achieved from this research is to know the percent reduction of organic solid waste through the use of Black Soldier Fly larvae (*Hermetia Illucens*). The reduction percentage obtained was then used to see the potential utilization of Black Soldier Fly larvae (*Hermetia Illucens*) as an effort to reduce organic solid waste.

Research Framework

The research framework is an overview of the implementation of the research, which is arranged in order based on the stage of the implementation of the research to achieve the desired final goal. The research framework is based on literature studies conducted both from scientific

journals, textbooks, and final project reports, which support research on the use of Black Soldier Fly (*Hermetia Illucens*) larvae to reduce organic solid waste. The research framework in this study can be seen in Figure 1.

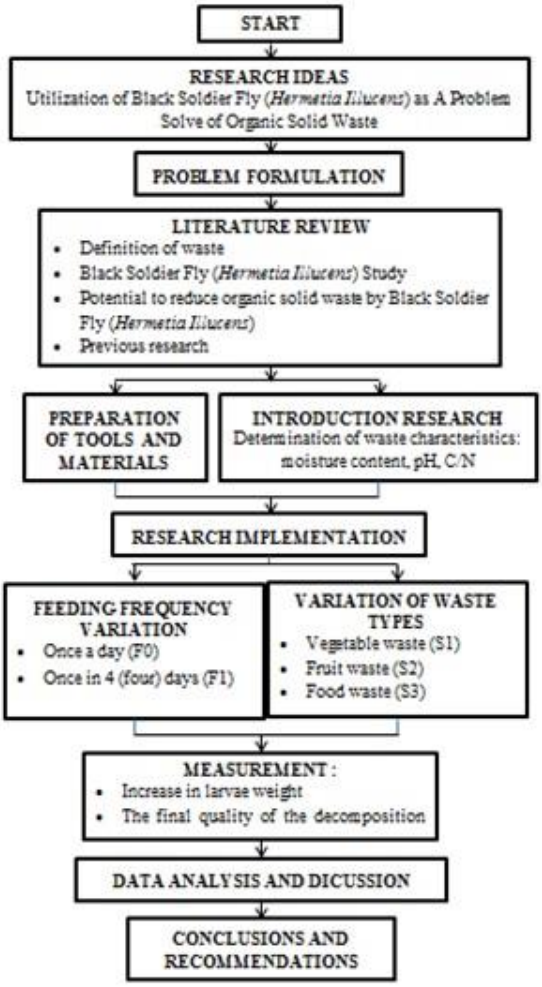

Figure 1.

The Research Framework of Utilization of Black Soldier Fly (*Hermetia Illucens*) as A Problem Solve of Organic Solid Waste

Data Analysis Methods

The data is presented in tables and graphs, the characteristics of the waste decomposition results by Black Soldier Fly (*Hermetia Illucens*) larvae were analyzed based on the water content

test, pH test, and C/N content test from the resulting residue. Data analysis and discussion must be adjusted to the literature study that has been carried out to support and compare the results obtained. All factors that have a significant or insignificant influence during the research implementation must be discussed in detail to obtain the best analysis results and conclusions.

RESULTS AND DISCUSSION

The results of the research and discussion will be presented as follows :

The Level Reduce of Organic Solid Waste by Black Soldier Fly (*Hermetia Illucens*)

Table 1.

Percentage The Level Reduce of Organic Solid Waste by Black Soldier Fly (*Hermetia Illucens*) With Various Feeding Frequencies

Waste	Percentage The Level Reduce of Organic Solid Waste	
	Frequency 1 x 4	Frequency 1 x 1
Vegetable	52 %	50 %
Fruit	51 %	62 %
Food	55 %	67 %

The effectiveness of the utilization of Black Soldier Fly (*Hermetia Illucens*) larvae in reducing food waste can be seen from the large percentage of waste reduction that has been successfully carried out. The percentage of waste reduction is calculated based on the ratio of the final weight of the decomposition residue to the total weight of the sample added[11]. The largest percentage reduction was achieved for food waste samples with a frequency of feeding once a day by 67%. The lowest percentage reduction was obtained in vegetable samples, namely 50% for the frequency of feeding once a day.

Based on the results of the research that has been done, the three types of samples produced a fairly good percentage reduction, reaching more than 50% for each type of waste. In several previous studies, the average percentage of reduction achieved was around 50%. The results of previous studies conducted on cow dirt were 56%[12], 50% human dirt[13], and 50% for some types of dirt[14]. Based on the frequency of feeding, two of the three types of waste tested showed a better percentage reduction compared to feeding with a frequency of once in 4 (four) days, reaching 67%. In addition to the type of food provided, the portion of food also affects the

percentage of reduction obtained[13].

C/N Ratio of Residual Organic Solid Waste

Table 2.

C/N Ratio of Organic Solid Waste Residue From Feeding Black Soldier Fly (*Hermetia Illucens*)

Waste	Final C/N Ratio	
	Frequency 1 x 4	Frequency 1 x 1
Vegetable	8,8	8,3
Fruit	10,1	9,2
Food	11,9	10,6

At the frequency of feeding once a day, there was a decrease in the C/N ratio for all samples. The degradation process by the Black Soldier Fly (*Hermetia Illucens*) and also by the microorganisms present in each sample as an energy source also causes a decrease in the C/N ratio[15]. This increase or decrease in total N levels is due to the formation of ammonia gas in the sample during the degradation process of waste protein by microorganisms[3]. The activity of the Black Soldier Fly (*Hermetia Illucens*) larvae and bacteria in the organic solid waste provided also reduces the N content which is converted into biomass[1]. Utilization of Black Soldier Fly (Hermetia *Illucens*) larvae is also known to reduce nitrogen levels from cow dirt by up to 55%[12] and for several other types of dirt by up to 80.5%[1].

The difference in protein content for each sample resulted in differences in total N levels. Proteins with the help of heterotrophic bacteria will be converted to ammonia[16]. Thus, the greater the total N content will be proportional to the protein content. As an effort to utilize the residue from the Black Soldier Fly (*Hermetia Illucens*) degradation process, the residue can be used for composting or for biogas[1]. However, because the composting and biogas processes still require time for the process, efforts to use the residue as organic fertilizer can be an option. The C/N ratio for organic fertilizer is 10-15 with C-organic content > 12%, so the residue from the decomposition of Black Soldier Fly (*Hermetia Illucens*) larvae for food and fruit waste is suitable for use as organic fertilizer. The results of decomposition using vegetable waste still need to add carbon sources, such as by adding garden waste to increase the C/N ratio. Garden waste has a high carbon content of 46%, with a nitrogen content of 2.2%[3].

Water Content in Organic Solid Waste Residue

Table 3.

Water Content in Organic Solid Waste Residue From Feeding Black Soldier Fly (*Hermetia Illucens*)

Waste	Final C/N Ratio	
	Frequency 1 x 4	Frequency 1 x 1
Vegetable	72,1 %	73,2 %
Fruit	74,7 %	76,2 %
Food	79,2 %	82,7 %

The determination of the sample water content at the beginning of the experiment was carried out by heating at a temperature of 105 ° C for 24 hours. The water content in the initial sample is needed to determine the wet weight of waste that will be used during the study[1]. The water content in waste needs to be known before giving it to larvae because it is known that water content also affects the growth of Black Soldier Fly (*Hermetia Illucens*)[13].

Table 3 shows that food waste has the highest water content, namely 82.7%, and vegetable waste with the lowest water content, namely 72.1%. Then each sample is weighed based on the required portion which is packed in zippered plastic and stored in the freezer to maintain its quality and to prevent insects or other flies from laying eggs in the prepared waste[11]. The dry weight of the average portion of food given is 40 mg/larvae/day, with variations every eight days, namely 15 mg/larvae/day, 35 mg/larvae/day/50 mg/larvae/day, and 60 mg/larvae/day. The higher the water content of the waste, the more waste is prepared. The optimum water content for larvae food is 60-90%[17].

The pH Value of Organic Solid Waste Residue From Decomposition Result

Table 4.

The pH Value of Organic Waste Residue Resulted From Feeding Black Soldier Fly (*Hermetia Illucens*)

Waste	pH Residue	
	Frequency 1 x 4	Frequency 1 x 1
Vegetable	5,54	5,47
Fruit	4,21	5,00
Food	4,18	4,16

The final pH measurement results show an increase in pH for all samples. The high activity of microorganisms in the waste can result in an increase and decrease in the pH value[18].

The ability of most microorganisms to live in anaerobic conditions is to utilize the energy that comes from the fermentation process of organic compounds. Sugar substances will be converted into several products, including acidic organic compounds. These organic acid compounds will come out with the body cells of microorganisms and cause a decrease in the pH value.

The process of releasing protein, peptide, and amino acids from the degradation process also results in a decrease in the pH value[18]. Deamination, which is an amino acid process as NH_3, will form ammonium hydroxide (NH_4OH) when NH_3 is released[18]. The use of anions, such as nitrates from $NaNO_3$, results in a decrease in the pH value. Conversely, the use of cations such as the ammonium ion from $(NH_4)2SO_4$ will increase the pH value. The presence of water in the tested waste will create a reaction between NH_3 and H_2O. This reaction will form NH_4 and OH- ions which cause a decrease in pH in the sample[19]. So it can be stated that the increase in NH_3 is directly proportional to the increase in pH value.

CONCLUSION

Based on the results obtained in this study, the following conclusions can be drawn :

1. The level of removal of vegetable waste, fruit waste, and food waste each 52%; 51%; 55% on the frequency of feeding once in four days. At the frequency of feeding once a day, the results were 50% each; 62%; 67%.
2. The C/N ratio of vegetable waste, fruit waste, and food waste residue is 8,8; 10,1; and 11,9 for the frequency of feeding once in four days, and 8,3; 9,2; and 10,6 at the frequency of feeding once a day.
3. Water content in vegetable waste, fruit waste, and food waste is 72,1% respectively; 74,7%; and 79,2% on the frequency of feeding once in four days and 73,2% respectively; 76,2%; and 82,7% at the frequency of feeding once a day.
4. The pH value of vegetable waste, fruit waste, and food waste is 5,54 respectively; 4,21; and 4,18 for the frequency of feeding once in four days, and 5,47 each; 5,00; and 4,16 for the frequency of feeding once a day.

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