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WASTE REDUCTION PERFORMANCE BY BLACK SOLDIER FLY LARVAE (BSFL) ON DOMESTIC WASTE AND SOLID DECANTER

KEMAMPUAN REDUKSI LIMBAH OLEH LARVA LALAT TENTARA HITAM PADA LIMBAH DOMESTIK DAN SOLID DECANTER

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ABSTRACT

Organic waste was the potential to contaminate the environment. Hermetia illucens or black soldier fly larvae (BSFL) were insects that could decompose waste and produce larvae biomass. It had high efficiency for waste reduction. The kind of substrate could affect the waste reduction performance of BSFL. This study determined the effect of the kind of waste on the effectiveness of reducing waste by H. illucens. The larvae were reared on domestic waste and solid decanter. Each treatment (three replicates per treatment) contained 300 larvae seven days old with a daily food rate of 125 mg/larva/day. After instar fourth and fifth old, the larva was harvested using sterile forceps. The ratio of waste reduction (%WR), efficiency of conversion of digested feed (ECD), bioconversion rate (BCR), and biomass were calculated in the fourth and fifth instar. The results showed that larvae on domestic waste had a higher waste reduction performance than larvae on the solid decanter. The results showed that larvae could reduce domestic waste to 76.5% and 32.6% on the solid decanter. Larva on domestic wasted showed higher ECD, BCR, and biomass than larvae on the solid decanter. It showed that BSFL had higher waste reduction performance on domestic waste than on solid decanter. Therefore the kind of waste could affect the waste reduction performance of BSF larvae.

Keywords: *biomass, BSFL, bioconversion rate, ECD, waste reduction*

ABSTRAK

Sampah organik sangat berpotensi mencemari lingkungan. Hermetia illucens atau BSFL merupakan serangga yang dapat menguraikan sampah dan menghasilkan biomassa larva. Larva tersebut memiliki efisiensi tinggi untuk pengurangan limbah. Jenis substrat diketahui dapat mempengaruhi kinerja limbah dalam mengkonsumsi limbah. Penelitian ini bertujuan untuk mengetahui pengaruh jenis sampah terhadap efektivitas pengurangan sampah oleh H. illucens. Larva dipelihara pada limbah domestik dan solid decanter. Setiap perlakuan (tiga ulangan per perlakuan) mengandung 300 larva umur tujuh hari dengan takaran pakan harian 125 mg/larva/hari. Setelah berumur instar empat dan lima, larva dipanen dengan menggunakan forsep steril. Rasio reduksi sampah (%WR), Efisiensi konversi pakan tercerna (ECD), laju biokonversi (BCR), dan biomassa dihitung pada instar keempat dan kelima. Hasil penelitian menunjukkan bahwa larva pada limbah domestik memiliki kinerja reduksi limbah yang lebih tinggi dibandingkan pada solid decanter. Hasil menunjukkan bahwa larva dapat mereduksi sampah domestik hingga 76,5% dan 32,6% pada solid decanter. Larva pada limbah domestik juga menunjukkan ECD, BCR, dan biomassa yang lebih tinggi dibandingkan pada solid decanter. Hasil menunjukkan bahwa BSFL memiliki kinerja pengurangan sampah yang lebih tinggi pada limbah domestik daripada pada solid decanter. Oleh karena dapat disimpulkan bahwa jenis limbah dapat mempengaruhi kinerja reduksi limbah larva BSF.

Kata kunci: *biomassa, BSFL, tingkat biokonversi, ECD, laju umpan*

INTRODUCTION

Indonesia is one of the countries with a larger organic waste producer. Domestic and agro-industrial waste, such as a solid decanter, are some sources of organic waste. According to data from the waste processing information system in 2021, activities carried out by households produce 63.2% organic waste, while the palm oil industry produces solid decanters for 4%-5% of total production [1]. The amount of domestic waste and solid decanter has not been widely used, and it has the potential to contaminate the environment. One of the suitable methods uses black soldier fly larvae (BSFL) as a decomposition agent.

BSFL, or black soldier larvae (*Hermetia illucens*), is one type of insect that can degrade organic waste with high efficiency [2, 3]. These larvae are known to decompose various organic wastes in large quantities and produce BSFL biomass. Generally, BSFL biomass is widely used as animal feed [4] and feedstock for biodiesel

production [5]. It decomposes waste more effectively than *Drosophila melanogaster*, *Apis mellifera*, and *Bombyx mori* [4].

Diener et al. [6] showed that the effectiveness of BSFL in decomposing organic waste is 60-80%, with a biomass conversion rate of 20%. The effectiveness of larvae can also be known from waste reduction performance, including the ratio of waste reduction (WR) [6], efficiency of conversion of digested food (ECD) [7], and bioconversion rate (BCR) [8]. The kind of feed influences the waste reduction performance of BSFL. Hakim et al. [9] showed that BSFL with tuna heads as feed has a % waste reduction of 77.09%, ECD of 8.32%, and biomass of 72.59 mg. However, there has been no further research related to the waste reduction performance of BSFL on the solid decanter. Therefore, this study was conducted to determine the waste reduction performance of BSFL growth on the solid decanter and domestic waste.

METHODS

Biomass. *H. illucens* colony has been purchased from PT. Biomagg Sinergi Internasional. About 300 of 7 days old BSFL were inoculated in 37.5 g of waste by triplicates. The recommended feeding rate per larva per day was 125 mg (dry weight) [6]. The cultivation conditions were a temperature of 27ºC. After instar fourth and fifth old, the larvae were harvested using sterile forceps. The larvae were inactivated at 105ºC for 5 minutes after being washed with distilled water and then dried at 70ºC for 24 hours.

Waste materials. In this study, two types of organic waste were tested. Those wastes were domestic waste from household waste and solid decanter from PT. KIU, South Kalimantan. Prior to application, all wastes were kept in closed plastic bags.

Waste reduction performance analysis. The waste reduction performance was adopted from Diener et al. [6]. The parameters measured were the ratio of waste reduction or WR, efficiency of conversion of digested feed or ECD, bioconversion rate or %BCR, and larval biomass.

Ratio of waste reduction (WR). The amount of waste consumed throughout the larva development phase was used to determine the waste reduction ratio on a dry weight basis (Eq. 1).

$$WR\ (\%) = \frac{x-y}{x} x100 \qquad (1)$$

Where,
x : Initial weight (g)
y : Final weight (g)

Efficiency of conversion of digested feed (ECD). ECD was calculated to determine the ability of BSFL to digest the substrate. In this study, ECD was calculated using Eq. 2, 3 [7].

$$B = (I - F) - M \qquad (2)$$

$$ECD = \frac{B}{I-F} \qquad (3)$$

Where,
B : the assimilated food used for growth
I : the total food offered during the experiment
F : the residue in experimental boxes (undigested food+excretory products)
M : the assimilated food metabolized

Bioconversion rate (BCR). Bioconversion rate (BCR) indicates the efficiency of waste conversion by BSF larvae into usable energy. BCR was calculated using Eq. 4 [8].

$$\%BCR = \frac{Mpp-Mi}{Fin}\ x\ 100 \qquad (4)$$

Where,
Mi : The dry weight of the larvae at the start of experiment
Mpp: The final dry weight of larvae
Fin : The initial dry weight of the seven waste used at the start of experiment

Larvae biomass. Biomass is the total weight of organisms in a given area. Biomass was defined as organic compounds derived from living things. Biomass was calculated using Eq. 5.

$$Larva\ biomass = \frac{total\ weight\ of\ larvae}{number\ of\ larvae} \qquad (5)$$

Data analysis. Average of waste reduction, ECD, BCR, and larvae biomass were analyzed using one-way ANOVA ($P \leq 0.05$) with subsequent Tukey HSD Test. Calculations and statistical analysis were performed using SPSS Statistics IBM.

RESULTS AND DISCUSSION

Development time. Figure 1 showed a difference in the larvae's weight after being given domestic waste and solid decanter. Larvae with domestic waste showed an increasing weight from 5.4 g to 48.3 g, while larvae with solid decanter waste decreased weight from 16.1 g to 14 g in the fifth instar.

Figure 1 showed that BSFL was more effective in consuming and digesting domestic waste than a solid decanter. It was detected from the increasing larvae's weight on domestic waste. The food

quality consumed by BSF is one factor affecting increasing larval weight. Foods with good nutrients can increase the weight of the larvae significantly. According to Liu et al. [10], the minimum nutrients needed by BSFL in the substrate to support growth were carbohydrates, protein, and fat, while the lignin-rich substrate was not recommended because it was difficult for BSFL to digest, resulting in malnutrition.

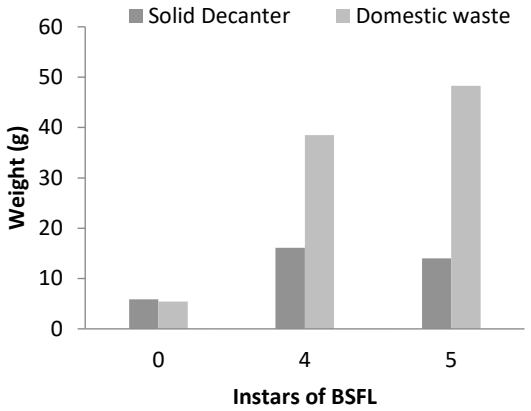

Figure 1. The weight of larva on domestic waste and solid decanter

Ratio of waste reduction. Figure 2 showed that the %WR of larvae on domestic waste at instar fifth (89%) was higher than instar fourth (76.5%). However, the %WR of larvae on solid decanter at instar fourth (32.6%) was higher than instar fifth (17.4%). The statistical analysis showed that the waste type and instar age significantly affected the waste reduction ratio BSFL (sig <0.05).

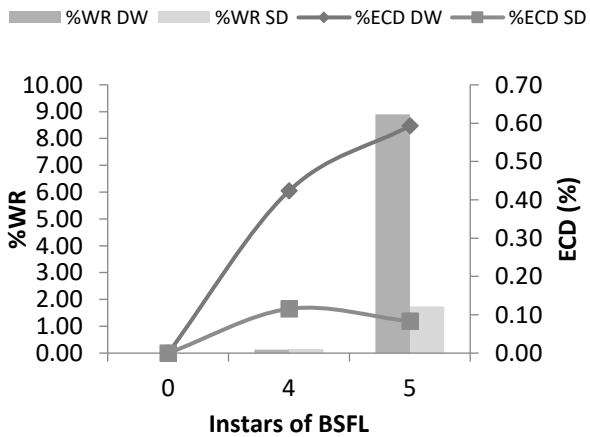

Figure 2. Ratio of waste reduction and efficiency of conversion of digested food (ECD) BSFL on domestic waste (DW) and solid decanter (SD)

The lower waste reduction ratio of BSFL on solid decanter was influenced by crude fiber and lignin compounds. Solid decanter was palm oil waste with a high organic matter. According to Sinurat [11], solid decanters have high nutrition and contain about 11.5-32.69% of crude fiber. Beesigamukama et al. [12] showed that rich-lignocellulose substrate, especially rich-lignin, can decrease the waste reduction ratio by BSF larvae.

The feed type and quality could affect the waste reduction ratio in BSF larvae. Liu et al. [10] showed that the substrate type or feed could affect the waste reduction performance of BSFL. Several studies showed that the effectiveness of BSF larvae in consuming waste was affected by waste type. Waste reduction of BSFL on animal waste was 56% [13], beer production waste was 38.69%, pig manure was 13.81% [10], and waste rice straw was around 24-34% [12]. In addition to the feed type, larval instar age also affected the waste reduction ratio. BSFL could consume large amounts of feed until the larval phase, about ±14 days. Feed consumption ability would decrease when the BSF larvae enter the pupa stage.

Efficiency of conversion of digested feed (ECD). The results showed that the ECD of larvae on domestic waste was higher than on solid decanter waste. ECD of larvae on domestic waste was 42.3% at the fourth instar and 59.3% at the fifth instar, while the ECD of larvae on solid decanter waste was 11.5% in the fourth instar and decreased to 8.3% in the fourth instar. Figure 2 showed the ECD and %WR proportionally. ECD was one of the parameters to determine larvae's ability to digest food. The high ECD indicated that larva was more effective for reducing waste into biomass [6].

According to Cammack & Tomberlin [14], the type of substrate given to BSFL could affect the ECD, while Kinasih et al. [15] showed that the substrate quality could affect the ECD value. Lower substrate quality could result in lower ECD. The use of solid decanter as a substrate in BSFL was not suitable. Solid decanter was palm oil waste with high lignocellulosic content. Maulana et al. [16] showed that solid decanter waste contained lignocellulose, mainly lignin 36.40%, cellulose 11.42%, and hemicellulose 18.77%. The lignocellulose, mainly lignin in the substrate, could inhibit the digestion of BSFL by impacting the lower ECD value. Liu et al. [10] showed that using semi-degradable grass as the substrate for BSFL was not recommended because it contained high lignin and was difficult for digestion by larvae.

Bioconversion rate (BCR) and larvae biomass. Waste reduction, ECD, and BCR were important parameters to evaluate the waste reduction performance of BSF larvae. Figure 3 illustrated the %BCR and larval biomass. The bioconversion rate represented the percentage of dry substrate converted into dry larvae biomass. In this study, the highest BSF were found for larvae reared on domestic waste (14.4% -14.6%), while the lower BSF were found for larvae on solid decanter (4.5% - 5.3%). The food type was one

factor that determined the BCR of larvae. Broeckx et al. [17] showed that the bioconversion rate of BSFL on food waste, corn meal, chicken manure, and beer draff was 20.71%, 15.61%, 15.43%, and 14.4%, respectively.

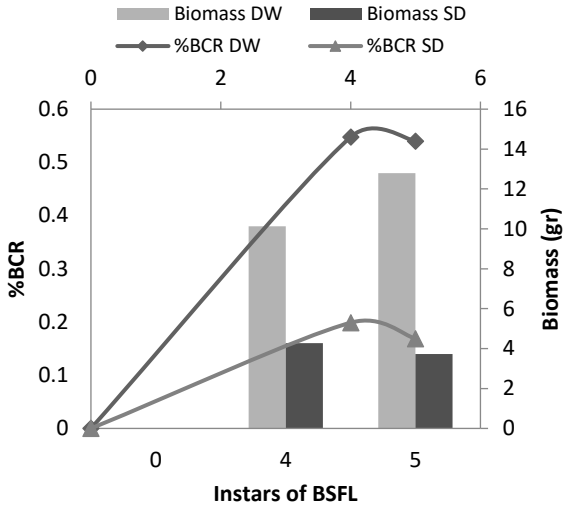

Figure 3. %Bioconversion rate and larvae biomass of BSFL on domestic waste (DW) and solid decanter (SD)

Figure 3 showed that the higher the %BCD value, the higher biomass produced. Biomass is an organic compound from living things. The ECD and BCR of BSFL determine the biomass produced from BSF larvae. Figure 2 showed that the biomass of BSFL on domestic waste has higher than on solid decanter. BSF on domestic waste produced biomass of 0.38 g or 380 mg at instar fourth and increased to 0.48 g or 480 mg at instar fifth. On the contrary, the biomass of BSFL on solid decanter showed 0.16 g or 160 mg at instar fourth and decreased to 0.14 g or 140 mg at instar fifth age.

The decrease in biomass value of BSFL on solid decanter was due to the lower waste reduction and digestion of BSFL. According to Supriyatna et al. [18], larval biomass was directly affected by substrate quality. High nutrition is one of the parameters of substrate quality. In this research, the solid decanter had high nutrition but had crude fiber and lignin, which made it difficult to digest by BSFL compared to domestic waste. Hakim et al. [9] showed that the substrate quality was determined based on the completeness of macronutrient elements.

CONCLUSION

BSF larvae were a good agent of degradation waste. The result showed that BSF larvae rearing on domestic waste had higher waste reduction performance than on the solid decanter. The BSF larvae on domestic waste had a WR of 89%, ECD of 59.3%, BCR of 14.6%, and biomass of 0.48 g, while BSF larvae on domestic waste had a WR of 17.4%, ECD of 8.3%, BCR of 5.3% and biomass of 0.14 g. Therefore, the kind of waste can affect the waste reduction performance. Furthermore, the kind of waste also affects the development of BSFL. BSFL on domestic waste has a better development than on solid decanter.

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