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Effectiveness of Water Hyacinth Bioconversion and Fermented Fruit Waste as a Growing Media Larvae of *Hermetia illucens*

Efektifitas Biokonversi Eceng Gondok dan Limbah Buah Terfermentasi sebagai Media Tumbuh Larva Hermetia illucens

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ABSTRACT

Black Soldier Fly (BSF) larvae have cellulosic activity in the presence of bacteria in their intestines. Generally, the organisms that play a role in bioconversion process are bacteria, and *Hermetia illucens* larvae as a bioconversion agent for fermented water hyacinth are combined with fruit waste and used as a growth medium. The purpose of this study was to determine the increase in larva mass weight, feed conversion efficiency, waste reduction index from water hyacinth bioconversion activity and fermented fruit waste by *Hermetia illucens* larvae. *Hermetia illucens* larvae are treated with feeding P0 = 100 % fruit waste, P1 = Fruit waste 25 % + 75 % fermented water hyacinth, P2 = 50 % fruit waste + 50 % fermented water hyacinth, and P3 = 75 % fruit waste + 25 % fermented water hyacinth. The larvae used were 6 days old, for all treatments 50 g used. The results showed that P3 = 75 % fruit waste + 25 % fermented water hyacinth produced the highest average final mass weight of larvae, namely 124.62 g, average feed consumption was 72.72 %, average ECD and WRI values were 10.98 % and 10.38 %, respectively. The mixing level of water hyacinth and fermented fruit waste in treatment 3 showed effective results as a medium for the growth of *Hermetia illucens* larvae.

Keywords: ECD, *Hermetia illucens,* larvae weight

ABSTRAK

Larva lalat tentara hitam *(Black Soldier Fly/BSF)* memiliki aktivitas selulotik dengan adanya bakteri pada ususnya. Umumnya, organisme yang berperan dalam proses biokonversi adalah bakteri, dan larva *Hermetia illucens* sebagai agen biokonversi eceng gondok terfermentasi dikombinasikan dengan limbah buah dan digunakan sebagai media tumbuh larva. Tujuan penelitian ini adalah untuk mengetahui pertumbuhan massa larva, efisiensi konversi pakan, indeks pengurangan sampah dari aktivitas biokonversi eceng gondok dan limbah buah terfermentasi oleh larva *Hermetia illucens*. Larva diberi perlakuan pakan P0 = Limbah buah 100 %, P1 = Limbah buah 25 % + Eceng gondok terfermentasi 75 %, P2 = Limbah buah 50 % + Eceng gondok terfermentasi 50 %, P3 = Limbah buah 75 % + Eceng gondok terfermentasi 25 %. Larva yang digunakan berusia 6 hari, untuk semua perlakuan menggunakan 50g bobot massa larva. Hasil penelitian menunjukkan bahwa P3= Limbah buah 75 % + Eceng gondok terfermentasi 25 % menghasilkan rata-rata berat massa akhir larva paling tinggi yaitu 124.62 g, rata-rata kosumsi pakan 72.72 %, rata-rata nilai *ECD* dan *WRI* sebesar 10.98 % dan 10.38 %. Tingkat pencampuran eceng gondok dan limbah buah terfermentasi pada perlakuan 3 menunjukan hasil yang efektif sebagai media tumbuh larva *Hermetia illucens.*

Kata kunci: Bobot Larva, ECD, *Hermetia illucens*

INTRODUCTION

Black Soldier Fly (BSF) larvae have cellulolytic activity in the presence of bacteria in their intestines (Supriatna & Ukit 2016). The presence of bacteria in the larvae's intestines helps the larvae in converting organic waste in their intestines. *Hermetia illucens* larvae are able to convert organic waste (manure) into fat and protein in their body biomass (Supriyatna & Putra 2017).

Nowadays, organic waste recycling activities are found using the bioconversion method, bioconversion as an overhaul of organic waste into biomass through a fermentation process involving living organisms. This process is usually known as anaerobic decomposition. Generally, the organisms that play a role in this bioconversion process are bacteria, fungi and insect larvae (family: Chaliforidae, Muscidae, Stratiomydae) (Suciati & Faruq 2017).

In animal husbandry, this process is often found, such as in the process of making fermented water hyacinth feed with the help of micro-organisms decomposers, and the process of decomposition of organic waste (making compost) which involves bacteria as decomposer organisms, while in animal waste decomposing agents are often found. are Musca domestica larvae and *Hermetia illucens* larvae. Bioconversion activity is an activity to convert organic matter carried out by *Hermetia illucens* larvae. Bioconversion carried out by a bioconversion agent, *Hermetia illucens* larvae or commonly called maggot, was able to reduce organic waste by up to 56% and as a bioconversion agent.

Previous studies have used agricultural waste containing lignocellulose and several nutrients that can be converted into useful products as materials for composting or animal feed. The process of bioconversion of agricultural waste without fermentation by *Hermetia illucens* larvae shows low yields. Bioconversion is low because rice straw has high lignocellulose content and low protein, while *Hermetia illucens* larvae do not have lignin-degrading enzymes (Supriyatna & Putra 2017).

Lignocellulose is also the main component of plants consisting of cellulose, hemicellulose, lignin and some extractive ingredients in water hyacinth so that it is necessary to do fermentation using bacteria contained in EM-4 to reduce crude fiber and increase the protein content in it (Nainggolan *et al.* 2018). Water hyacinth that has been fermented using EM-4 bacteria, then used in combination with fruit waste as a growth medium for *Hermetia illucens* larvae. The ability of the bioconversion process to take place during the larval stage before entering the prepupa stage. The purpose of this study was to determine the increase in larval mass weight, feed conversion efficiency, waste reduction index from water hyacinth bioconversion activity and fermented fruit waste by *Hermetia illucens* larvae.

MATERIALS AND METHODS

The equipment and materials needed include: a. Tools: Plastic tub, 20 cm × 13 cm jar 9 cm deep, tub for pupa migration container, caliper, spatula, cellphone camera, digital scale, and spoon, sieve, basin, stationery. b. Ingredients: Fermented water hyacinth, fruit waste, *Hermetia illucens* larvae.

This study uses an experimental method using a research design, namely a completely randomized design (CRD), with 4 treatments and 3 replications. The object of research using *Hermetia illucens* larvae aged 6 days as much as 50 grm/Treatment or spread using a container measuring 20 cm × 13 cm depth of 9 cm with the experiment of feeding water hyacinth with fermented fruit waste as follows. P0 = 100 % fruit waste, P1 = 25 % fruit waste + 75 % fermented water hyacinth, P2 = 50 % fruit waste + 50 % fermented water hyacinth, P3 = 75 % fruit waste + 25 % fermented water hyacinth, Source (Suciati & Faruq 2017).

Observation Variable

1. Increase in Larvae Mass Weight in the use of water hyacinth feed and fermented fruit waste.
2. The amount of feed consumed per treatment.
3. Efficiency of digested feed conversion (ECD) Larvae *Hermetia illucens*.
4. Waste Reduction Index (WRI) by *Hermetia illucens* Larvae on fermented water hyacinth substrate.

Data analysis

WRI is measured using the equation:

$$D = \frac{W-R}{W} \text{ x } 100\%$$

Where:
D = Weight percentage of degraded substrate
W = total dry weight of the substrate during the experimental time (t)
R = residual dry weight during the experimental time (t) (Supriyatna & Putra 2017)

WRI is an index that states the weight of the substrate digested by the larvae in a certain period of time. The WRI value is determined using the equation:

$$WRI = \frac{D \, x \, 100}{t}$$

Conversion efficiency is calculated using the equation (Diener 2009), namely:

$$ECD = \frac{B}{(I-F)} \text{ x } 100\%$$

Where:
ECD = Efficiency of Conversion of Digested-feed
B = Dry weight of biomass formed (g dw)
I = Weight of initial substrate (g dw)
F = dry weight of casting (food not consumed + excreta) (gr dw) (Supriyatna & Putra 2017)

Collected data The data were analyzed by analysis of variance (ANOVA) and if there were differences between treatments, it was continued with Duncan's test (Steel & Torie 1993).

RESULTS AND DISCUSSION

Larva Weight Gain

The maintenance period was carried out in uniform jars and kept at a temperature of 280-300 °C, humidity 60-70 %. *Hermetia illucens* larvae were separated from the hatching media by means of a sieve, the hatchery media using chicken feed facilitated the separation of the mini larvae from the media, then weighed 50 (g) per treatment and kept in the treatment tank. Weighing of larval mass was carried out once every 7 days along with changing feed according to the treatment. The amount of feeding treatment is as much as 300 (g)/week. Based on the results of research that has been carried out on the period of increasing the mass weight of *Hermetia ilucens* larvae, including the increase in larval weight and mass weight with experimental administration. Weighing data for 3 weeks during the research conducted at UPT. Agri Science Technopark Lamongan Islamic University.

The increasing mass weight in the first, second and third weeks showed that the highest and consecutive increase occurred in treatment 3, namely a mixture of fermented fruit waste and water hyacinth with a composition of 75:25 % having an average weight of 3 replications in weeks 1, 2, and 3. of 81.76 g, 101.49 g, 124.62 g. from the initial weight of 50 g. This is doe to the texture of feed and nutrients that were more fulfilled so that it shows maximum results. In accordance with research conducted by Muhayyat *et al.* (2016), stated that generally quality feed will produce more larvae because it can provide sufficient nutrients for growth and development of larvae. Diener *et al*. (2009). The growth of larvae during the active feeding phase depends on the type of organic waste provided. The results of the smallest weight gain of larvae for 3 weeks consecutively occurred in treatment 1 feed, namely the use of fermented fruit and water hyacinth waste at a composition of 25:75 % with an average weight gain of 1, 2, and 3 weeks of larval mass weight gain of 76.61, 90.61, 102.61 g. This was because the crude fiber content in treatment 1 was very high, causing the larvae to take a long time to decompose the feed, and the feed in treatment 1 for one week dries faster than the feed treatment 0, 2, and 3. So it is difficult for larvae to digest.

Tomberlin *et al.* (2002) and Gobbi *et al*. (2013) said that the quality and quantity of food digested by *Hermetia illucens* larvae had an important influence on the growth and development time of larvae, larval survival and mortality. Day 28 at this stage the larvae have entered the prepupa stage. The prepupa are no longer eating, there is a tendency during this prepupa stage, the weight of the larvae tends to be fixed or even slightly reduced (Fahmi 2015). At this stage the larvae will stop eating and the mouth will become a climbing tool and move out to find a dry and protected area for the process of becoming a pupa (Hall & Gerhardt 2002). The data for weighing the mass weight of larvae weeks 1-3 are presented in Table 1.

This optimal maggot growth was obtained due to the fulfillment of the life necessities for the larvae. Syahrizal (2014) explains that growth is influenced by internal and external factors. Internal factors that affect larval growth, namely larval mortality, while external factors that affect growth are the availability of feed and environmental temperature.

Feed Consumption

Feed consumption is the amount of feed consumed by larvae expressed in percent during the rearing period (Muhayyat *et al*. 2016). Feeding *Hermetia illucens* larvae resulted in a feed consumption value of 60.27-72.72 % (Table 2). The highest value in the P3 treatment with a value of 72.72 % and the lowest in the P0 treatment with a value of 60.27 %. This was thought to be possible due to the different content of fat, protein and water in the four types of feed. The quality of the feed media will influence on the provision of nutrition for larvae to breed (Katayane 2014).

Table 1. Average mass weight of larvae week 1-3

Treathment	Initial BB (gr)	Week 1 (gr)	Week 2 (gr)	Week 3 (gr)	Week 4 (gr)
P0	50	80.85	97.91	122.27	72.27
P1	50	76.61	90.61	102.61	52.61
P2	50	77.44	95.69	116.72	66.72
P3	50	81.76	101.49	124.62	74.62

Note: The results of the smallest weight gain of larvae for 3 weeks consecutively occurred in treatment 1 feed, namely the use of fermented fruit and water hyacinth waste at a composition of 25:75% with an average weight gain of 1, 2, and 3 weeks of larval mass weight gain of 76.61, 90.61, 102.61 gr. This was because the crude fiber content in treatment 1 was very high, causing the larvae to take a long time to decompose the feed, and the feed in treatment 1 for one week dries faster than the feed treatment 0, 2, and 3. So it is difficult for larvae to digest.This optimal maggot growth was obtained due to the fulfillment of the life necessities for the larvae

Table 2. Feed consumption

Parameter	Treathment			
	0	1	2	3
Feed Consumption (%)	60.27±4.28a	69.68±3.04b	68.47±3.12a-b	72.27±4.45b

Note : Based on the One-Way ANOVA analysis of feed consumption carried out by larvae on 4 different treatments, the results showed significantly different results ($P<0.05$). These results certainly affect the mass weight of the larvae. One of the factors causing the difference in the value of feed consumption is the water content in the feed media.

Table 3. Efficiency of Conversion of Digested-feed (ECD) and Waste Reduction Index (WRI)

Parameter	Perlakuan			
	0	1	2	3
WRI (%)	8.60±0.61a	9.95±0.43b	9.43±0.44a	10.38±0.63b
ECD (%)	11.74±3.53	8.90±2.88	10.27±2.53	10.98±2.44

Note : The highest WRI value was in the treatment (P3) of 10.38±0.63 % and the highest ECD was in the treatment (P0) of 11.74±3.53 % The ECD value for each feeding was not statistically significant, meaning that each treatment had the same effect on the value of ECD (P>0.05). The WRI value for each feeding was statistically significantly different, meaning that each treatment had a different effect on the WRI value (P<0.05). WRI indicates the efficiency of larvae in reducing the feed given, and shows the effectiveness of the time required to reduce the feed.

Based on the One-Way ANOVA analysis of feed consumption was carried out by larvae on 4 different treatments, the results showed significantly different results (P<0.05). These results certainly affected on the mass weight of the larvae. One of the factors causing the difference in the value of feed consumption is the water content in the feed media. *Hermetia illucens* larvae can only grow in media with low water content (Lalander *et al.* 2020), thus high water content will only inhibit the proliferation of *Hermetia illucens* larvae. Hakim (2017) stated that the high water content of the media was the cause of the difficulty of larvae reducing feed. The same thing was also expressed by Lalander *et al.* (2020) which states that the water content of the larval culture media must be low because the larvae cannot grow in media with high water content.

Waste Reduction Index (WRI) and Efficiency of Conversion of Digested-feed (ECD)

To determine the level of effectiveness of bioconversion by larvae, the digested substrate efficiency (ECD) and waste reduction index (WRI) were measured. The measurement results can be seen in Table 3.

The highest WRI value was in the treatment (P3) of 10.38±0.63 % and the highest ECD was in the treatment (P0) of 11.74±3.53 % The ECD value for each feeding was not statistically significant, meaning that each treatment had the same effect on the value of ECD (P>0.05). The WRI value for each feeding was statistically significantly different, meaning that each treatment had a different effect on the WRI value (P<0.05). WRI indicates the efficiency of larvae in reducing the feed given, and shows the effectiveness of the time required to reduce the feed. The greater the WRI, the better the feed reduction efficiency produced (Supriyatna & Putra 2017). Waste reduction value shows the projected waste reduction in a certain period.

The difference in WRI values were caused by the water content in the feed media. *Hermetia illucens* larvae can only grow with low water content in the media (Lalander *et al*. 2020), so high water content can inhibit the breeding of *Hermetia illucens* larvae. Hakim *et al.* (2017) stated that the high water content in the media was the cause of the difficulty of larvae reducing feed. As stated by Lalander *et al.* (2020), stated that the water content of the media when cultivating larvae should be low because the larvae cannot grow in the media when the water content is high. Ingested Feed Conversion Efficiency (ECD) indicates the amount of feed consumed by *Hermetia illucens* larvae during the study period. The quality of the feed media will have an influence on larval growth (Suciati & Faruq 2017).

CONCLUSION

The mixing of fermented water hyacinth and fruit waste as a growth medium for *Hermetia illucens* larvae showed significantly affected the increasing larval mass weight, feed consumption, Waste Reduction Index (WRI) and Efficiency Conversion of Digested-feed (ECD) values. The mixing rate of fermented water hyacinth 25 % and 75 % fruit waste, were effective as a growing medium for *Hermetia illucens* larvae.

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