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Recycling Oil Palm Industry Waste: Sustainable Solid Waste Treatment Utilizing Bioconversion Agent

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ABSTRACT
Oil palm is one of Indonesia's most important crops. Indonesia produces 47.180 million tonnes of CPO from an area of 14.858.300 hectares. When there are a lot of CPOs, it suggests there are a lot of wastes. EFB (Empty Fruit Bunch) is a significant biomass by-product of the oil palm industry. These cellulosic materials are relatively inexpensive feedstocks for ethanol synthesis and have no problem with the food supply because they are abundant and outside the human food chain. The principal by-product of the palm kernel oil extraction process is palm kernel meal (PKM). It's a high-fiber, medium-protein feed that's best suited for ruminant or rabbit consumption. EFB was once utilized as a fuel to generate steam at mills, whereas PKM was recycled into animal feed. Another option is to use bioconversion to control these wastes. The Black Soldier Fly (Hermetia illucens) larval (BSFL) is a worldwide insect whose larvae are notable for their capacity to eat a variety of organic wastes. The BSFL were housed in a container and fed EFB and PKM. There were two different treatment options (3 replication per treatments). Each treatment contained 200 larvae and 400 grams of food. The research lasted 18 days. The larvae were collected on the 18th day, and container were measured. Treatment 1 (EFB) have average 9,46% waste consumption, and Treatment 2 (PKM) have 23,14% waste consumption on average.

Keywords recycling, bioconversion, industry waste, oil palm, sustainable treatment
Paper type Research paper

INTRODUCTION

Indonesia produces the most CPO, with 47.180 million tonnes and 14.858.300 hectares [1]. The large oil palm growing area contributes to the massive amount of CPO produced, but it also generates massive amounts of waste. CPO processing generates a substantial amount of waste, including solid waste and liquid waste.

The oil palm business produces a lot of empty fruit bunch, which is a substantial biomass by-product. 1 tonne of oil palm Fresh Fruit Bunch yields 230 kg of Empty Fruit Bunch (EFB) on average [2]. Because EFB contains 37.3–46.5 percent cellulose and 25.3–33.8 percent hemicelluloses, it has a high efficacy as a basic raw material for fermentative synthesis. Being plentiful and not part of the human food chain makes.[3].

The principal by-product of the palm kernel oil extraction process is palm kernel meal (PKM). It's a high-fiber, medium-protein feed that's best for ruminant or rabbit consumption [4]. The majority of palm kernel meal is used for animal feed [5].

Because palm oil manufacturing generates a huge quantity of trash, numerous studies have been conducted to determine how to manage these wastes. Previously, EFB was commonly utilized to generate steam at mills [6]. EFB can also be used to make compost [7]. PKM, on the other hand, was recycled in animal feed. Another option is to use bioconversion to control these wastes. The Black Soldier Fly (Hermetia illucens) larval (BSFL) is a worldwide insect whose larvae are notable for their capacity to eat a variety of organic wastes.

Hermetia illucens L., also known as the black soldier fly, is a common Stratiomyidae fly. Composting and sanitizing trash is done with black soldier fly larvae (BSFL). Fresh manure, food waste, and numerous sorts of organic wastes can all be converted by BSFL. The adult and larvae of black soldier flies are not considered pests or vectors, and they are not attracted to human habitation or foods [8]. Black soldier flies may contribute to biological control of the environment by limiting house fly oviposition and reducing the number of house fly larvae [9]. The life cycle of black soldier is as follow:

1. Female black soldier fly lay eggs about 200-600 eggs. These eggs will be put into the gap of organic waste. They will hatch about four days later, and that is what we called maggot or larva.
2. Maggot can reach 27 mm in length and 6 mm in width. They have about 14 days of growth period. In this stage, maggot will not stop eating. This is actually the most powerful trait of black solder fly maggot. They will keep eating the organic waste throughout their growth period. When they became adult, they do not need food anymore, they make use of the reserve food when they were still in maggot stage. [10]
3. Pupa. At this stage, maggot will stop eating and self-cleansing their bowels. Their mouth will transform into climbing tools to help them moving around finding dry and protected place to become pupa. [11]
4. Adult. Black soldier fly cannot eat because their mouth already transformed and cannot function properly. Black soldier fly only purpose in life is to reproduce. [12]

METHOD

The larvae utilized in this investigation were 6 days old and fed EFB and PKM as a diet. There were two different treatment options. The containers were filled with the EFB and PKM.

The BSFL were placed in containers that were 17 cm x 17 cm x 08 cm in size and wrapped in soft fabric. Each treatment was reproduced three times with 200 larvae in each container.

The study took 18 days to complete. On the 18th day, each container were measured in order to find the waste reduction of EFB and PKM.

Table 1. Treatment of BSFL

NO	Treatment	Amount	Larvae
1	EFB 100 %	400 g	200
2	PKM 100 %	400 g	200

DISCUSSION

In this research, the development time was 18 days. The larvae were put in each of the container box. Each box contain 200 larvae. The larvae were collected on the 18th day and the waste consumption was measured for each treatment (three replications per treatment). The growth of larvae was impacted by the varied treatments. The nutritional contents in feeding material influenced the growth of BSFL, according to Tomberlin [12].

Table 2. Waste Consumption

***Waste Consumption* (%)**

Treatment	Replication			Average
	1	2	3	
Treatment 1	8,95	10,12	9,32	9,46
Treatment 2	24,05	23,00	22,39	23,14

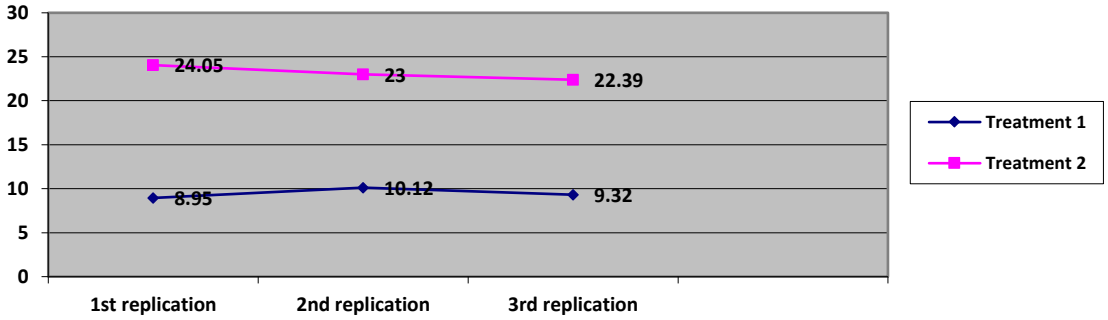

Figure 1 Waste Consumption of Larvae

It can be shown in Table 2 that Treatment 1 have 9,46 average waste consumption and Treatment 2 have 23,14 average waste consumption. From Figure 2 we can also see that Treatment 1 have a lesser waste consumption that Treatment 2. This is caused by the water content in EFB is higher than the water content in PKM. According to Tran [13] to cultivate BSFL require low water content, because BSFL cannot develop in high water content media.

Research by Diener [14], BSFL were given chicken feed, and it produce substrate consumption (waste consumption) approximately 26,2 – 39,7 %. Meanwhile, research by Supriyatna [15], BSFL produced 9,29 % - 36, 82 % substrate consumption.

EFB has a moisture content of 80% and a crude protein level of 3.7 percent [16] [17]. PKM, on the other hand, includes 8.26 percent moisture and 14.5-19.6 percent crude protein [18] [19]. To properly cultivate the BSFL, the moisture content of the feeding material must be low [13] [20]. According to Caruso [21], the ideal moisture percentage in feeding material for BSFL was 60%.

Substrate consumptions can be used as a benchmark in waste reduction [9]. Sheppard [22] utilized BSFL as a manure management system. With the ability of larvae to reduce waste by more than 40%, hermetia illucens larvae deserve to be used as bioconversion agents for organic waste, apart from the relatively low cost of production, the technology used can also be applied by most people. According to [9] and [22], hermetia illucens larvae are able to reduce animal waste by 42-56%.

CONCLUSION

In this research, BSFL is capable to reduce organic waste Empty Fruit Bunch (EFB) and Palm Kernel Meal (PKM) respectively 9,46% and 23,14% on average. EFB and PKM are not proper food for BSFL but they are still able to eat them, going by this logic, we can utilize BSFL to reduce many organic waste such as household waste and restaurant waste. Because they contain more nutritious food waste that will attract BSFL to eat more.

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