Study on Bioconvertion of Cassava Tuber Skin and Dry Rice Stalk By Black Soldier Flies (*Hermetia illucens*)

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***Abstract*— Recent report showed increasing production of rice and cassava due to demand for staple food and raw material of bioethanol. This condition increases post harvest waste in which 100 and 20.8 million tons originated from rice production and cassava production, respectively. Commonly, farmer burn this waste or use it as compost and ruminary fed which provide small amount of profit. Recently, another approach for post harvest waste management by bioconversion which believed could provide better profit to farmer has been proposed. Bioconversion defined as conversion of biomass of macromolecule into smaller molecule by biological processes. In this study, larvae of black soldier flies (*Hermetia illucens*) were used as bioconversion agent due to their simple biological system and short life cycle. Previous studies also confirmed their efficiency as bioconversion agents of various organic wastes but agricultural wastes.**

Conversion rate of waste for dried rice stalk and cassava tuber skin was 25% and 45% after 15 days (black soldier flies life cycle), respectively. Residue produced from bioconversion process maintained, on average, more than 50% of chemical composition of wastes with elevated water content. It can be concluded that *H. illucens* showed high potency as bioconversion agent of organic wastes with high lignin and cellulose content.

***Keywords*— agriculture wastes, bioconversion, black soldier flies, cassava, dried rice stalk**

I. INTRODUCTION

AGRICULTURE is one of human activities that produced significant amount of waste and increasing significantly due to increasing demand on agricultural products. In Indonesia, two agricultural products showed increasing pattern on production are rice and cassava. Production of dry rice stalk, as post harvest waste of rice, estimated 100 million ton [1] while cassava tuber skin, as waste of cassava, estimated 20.8 million ton [2], annually. All of these wastes have great potency as raw material of organic based product due to high content of cellulose, hemicellulose, lignin [3]-[6], small amount of protein [7][8], and significant amount of carbon [9]-[10].

Commonly treatment of dry rice stalk is pilling and burning while application as livestock feed not recommended due to low energy and protein content also low digestibility [11](Sitorus, 2002). On the other hand, cassava tuber skin usually applied as livestock feed [10]. Another common practice for organic wastes is composting which applicable for large amount of waste. Generally common practice of composting is application of bacteria and earthworm as composting agent [12] in which final product of this process is limited to fertilizer.

Recent developments showed development of composting into bioconversion. Bioconversion is a process of conversion of large molecules into smaller molecules by living organism. One of bioconversion agent is insect larvae such as Black Soldier Fly (BSF) (*Hermetia illucens*). Study on bioconversion by BSF showed the ability of BSF to convert organic wastes into protein and fatty acid in form of body mass [13]-[16] that could be used as replacement fishmeal which value of USD 1883 per metric tonne in February 2013 [17]. Even though BSF known for their ability as bioconverter, their application for converting agriculture with high cellulose content hardly known. Based on this information, purpose of this study is study the ability of BSF to converting dry rice stalk and cassava tuber skin.

II. METHODS

A. *Hermetia illucens egg collecting*

Eggs of *H. illucens* were collected by ovitraps filled with bait made of combination of shrewd coconut and manure (1:1). Ovitraps were kept in various places in Bandung. Collected eggs were reared at Laboratory of Toxicology, School of Life Sciences and Technology, Institut Teknologi Bandung at room temperature (24-28^{o}C), humidity 70-80%, and photoperiod 12:12.

B. *Dry rice stalk and cassava tuber skin*

Dried rice stalk abd cassava tuber skin originated from traditional farming of Soreang, Bandung Timur. Prior application, all material was crushed into powder by commercial food processor.

C. *Research methods*

Ten third instar larvae were kept inside plastic container filled with 30 g dry rice stalk and 10 g cassava tuber skin. As control group, dry rice stalk and cassava tuber skin was kept in similar container at same room without any larvae. Each treatment was replicated 20

times and carried out for 15 days. Mortality of larvae and conversion rate of each material by BSF were measured every 3 days. Conversion rate was defined based on formulae

$$\text{Conversion rate} = \frac{\text{weight of obs. n} - \text{weight of obs. (n+1)}}{\text{weight of obs. n}}$$

D. Data Analysis

Mean difference of conversion rate between treatment and control group was analyzed by Student's T-test. All statistical analysis was carried out with Statsoft Statistica ver. 8.

III. RESULTS

A. Conversion rate of dry rice stalk by BSF

Conversion dry rice stalk by BSF showed in Figure 1. This result showed that in average biomass of dry rice stalk was reducing higher when treated with BSF. By the end of experiment, biomass of dry rice stalk was reduced by 25% when treated with BSF while only 21% reduction when BST was omitted.

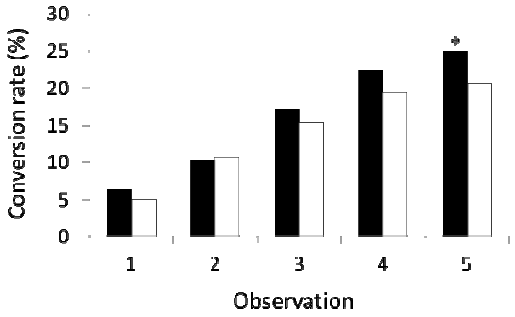

Fig. 1. Conversion rate of dry rice stalk for 15 days by BSF (closed bar) and without BSF (open bar). (*) indicated significant mean differences.

B. Conversion rate of dry rice stalk by BSF

Conversion cassava tuber skin by BSF showed in Figure 2. This result showed that in average biomass of cassava tuber reduced less when treated with BSF. By the end of experiment, biomass of dry rice stalk was reduced by 45% when treated with BSF while it reached 61% reduction when BST was omitted.

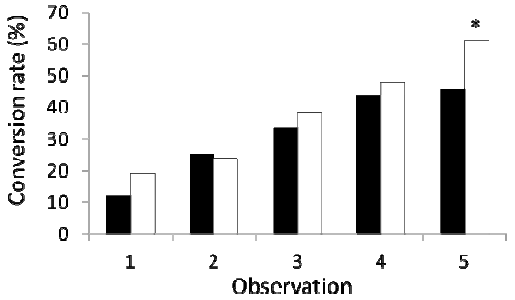

Fig. 2. Conversion rate of cassava tuber skin for 15 days by BSF (closed bar) and without BSF (open bar). (*) indicated significant mean differences.

C. Composition of organic waste material after conversion by BSF

Analysis on research material showed 1.92% reduction of fiber of dry rice stalk and 9.97% of fiber of cassava tuber skin by BSF. Along with reduction of fiber, we also recorded reduction on other material (Table 1).

TABLE 1
COMPOSITION OF RESEARCH MATERIAL AFTER CONVERSION

Composition	Dry Rice Stalk		Cassava Tuber Skin	
	Before	After	Before	After
Fiber (%)	19,76	17.84	17.95	7.98
Protein (%)	5,35	2.96	6.87	4.05
Water content (%)	9,61	39.80	10.63	23.84
Ash (%)	26,69	20.69	4.68	7.72
Carbon (%)	37,89	22.82	47.40	39.77
Nitrogen (%)	0,86	0.67	1.05	0.72
C/N ratio	44,18	34.05	45	55.23
Phosphor (%)	0,18	0.19	0.18	0.22
Potassium (%)	2.50	2.11	0.95	2.90

D. Composition of BSF at the end of study

Analysis on content of protein and lipid of BSF at the end of study showed that on BSF reared on cassava tuber skin produced higher content of protein and lipid (Table 2).

TABLE 2
PROTEIN AND LIPID CONTENT OF BSF AFTER TREATMENT

Composition	Percentage	
	Dry rice stalk	Cassava tuber skin
Protein (%)	11.66	13.14
Lipid (%)	2.03	7.25

IV. DISCUSSION

A. Conversion rate of dry rice stalk by BSF

Reduction of dry rice stalk biomass by BSF probably due to activity of some digestive enzyme inside salivary gland and digestive tract such as leucine arylamidase, α-galactosidase, β-galactosidase, α-mannosidase, and α-fucosidase. α-galactosidase [18]. However, conversion rate is relatively low which is probably caused by high content of lignin inside stalk structure. Further study is conducting to improve the conversion rate by application of addition decomposing agents.

B. Conversion rate of dry rice stalk by BSF

Result showed that BSF relatively less efficient in reducing biomass of cassava tuber skin. We believed this condition caused by fermentation of cassava tuber skin. Unlike rice starch, this material contain less lignin and much easier to undergo fermentation.

C. Composition of organic waste material after conversion by BSF

Reduction of fiber and other material showed the ability of BSF to digest both dry rice stalk and cassava tuber skin. This ability may possible due to availability of some microbe on their digestive system. Previous study had found *Bacillus substilis* inside digestive system of BSF [19]. This bacteria produced protease [20], lipase [21][22], and celulase [23]-[26].

D. Composition of BSF at the end of study

Compare with study by Rachmawati et al. (2010), protein content of BSF fed with dry rice stalk and cassava tuber skin lower than BSF fed with fermented starch and house flies artificial feed (14.6% and 15.3%, respectively). However lipid content of BSF fed on cassava tuber skin much higher than fermented starch and house flies artificial feed (0.03% and 3.8%, respectively). We suspect this related with original content of protein and lipid of feed and fermentation process.

V. CONCLUSION

This study is preliminary study on bioconversion of agricultural wastes by BSF. The result showed the ability of BSF to digest to material contains high cellulose and lignin also the potency as alternative protein and lipid source. Further study is conducting to improving the process of bioconversion.

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