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Production of Biogas with Two-Stage Fermentation of Cow Dung-Palm Oil Mill Effluent

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Abstract

In this research, biogas is produced from Palm Oil Mill Effluent (POME) by fermentation of cow dung using a stirred reactor and purified by various CO_2 and H_2S removal techniques. The variables in this study were: composition of cow dung (55%, 60%, 65%, 70%, 75%, 80% w/w), amino acid composition (0.5%, 1%, 1.5% w/w) and length of fermentation time (2, 6, 10, 14, 16 days). The fixed variables were stirring speed (100 rpm), temperature (30°C) and reactor volume (100 L). This research also investigated the effect of using a lime packed reactor on the purity of methane gas. From the results of first stage of fermentation, it was found that the optimum composition of cow dung-POME was at 60% and the fermentation time was 14 days. In the second stage of fermentation using optimum results at first stage compared to fermentation of cow dung without POME, the results of measuring the gas pressure produced in 60% cow dung-POME fermentation were 17.5 Psig greater than fermentation of cow dung without POME of 15 Psig.

Keywords: *Biogas; fermentation; cow dung; POME*

Introduction

Biogas is formed naturally when palm oil mill effluent (POME) is decomposed under anaerobic conditions. Without control, Biogas is a major contributor to global climate change. Biogas consists of 50-75% Methane (CH_4), 25-45% Carbon Dioxide (CO_2), and small amounts of other gases. If POME management is not controlled, Methane in the biogas is released directly into the atmosphere (Parinduri, 2018). As a greenhouse gas (GHG), methane has an effect 21 times greater than CO_2. Methane capture and conversion of biogas into energy offers one of the renewable energies (Irawan, 2016). The use of waste in the community environment is very important because the waste can cause various kinds of sustainable problems and will have a negative impact on society (Rahayu Sri, 2015).

One of the POME processing methods is thermophilic anaerobic and the end product of this process is biogas which can be used as fuel and this POME processing requires ingredients to convert POME into biogas, one of which is cow dung (Yahya, 2017). In cow dung, there are several bacteria that are useful in the POME fermentation process, the

type of bacteria that has been identified in mole cow dung include *Lactobacillus sp, Actinomycetes sp* (Sanjaya, 2015). POME processing has been widely carried out among scientists, however, not many people are able to have the facilities to produce biogas using POME and available source materials around the community environment (Sekao, 2021). POME fermented in two stages can produce biogas products with levels of more than 60%. The quality of biogas from POME also needs to be improved by increasing the selectivity of Methane gas (Sidik, 2010).

The two-stage fermentation method can produce methane products with high selectivity, which is 90-94% when compared to one stage which only produces a yield of 40-65% (Winanti, 2019). The study of combining the two-stage fermentation method with the addition of cow dung needs to be investigated properly. The novelty of this research is the modification of the use of two-stage POME fermentation using cow dung.

To improve efficiency and high-quality products, in this research, a two-stage fermentation biogas production process will be carried out with the addition of amino acids (Tippayawong, 2010). The objectives of the research were to evaluate the effect of the composition of addition of cow dung in fermentation based on the volume of biogas and the characteristics of the biogas produced, and to examine the effect of the addition of amino acids on the volume of biogas produced.

Methods

Tools and Materials

Reactor, gas sampling tube, thermocouple, palm oil mill effluent, cow dung, amino acids, aquadest

Production of Fish Amino Acids

The procedure for making fish amino acids was used as a basic ingredient of amino acid. The process of making amino acids was carried out by adding 2 kg of ground fish and mixing it with 2 kg of sugar or molasses, as well as 200 g of papain enzyme to accelerate the process of forming amino acids. After being thoroughly mixed, the material was fermented anaerobically in an 8 L jar for 10 days until a liquid was formed.

First Stage of Fermentation Process

POME from palm oil mills was mixed with cow manure (cow dung) 50%; 55%; 60%, 65%, 70%, 75% and 80% w/w. This mixing was carried out in a bucket with a small amount of POME liquid. After that, the mixture was put into the digester bioreactor. The variation of anaerobic fermentation time was 2, 6, 8, 10, 14, and 16 days.

Second Stage of Fermentation Process

The optimum results in the first stage were continued in the second stage. In the second stage, it was compared to fermentation of cow dung without POME.

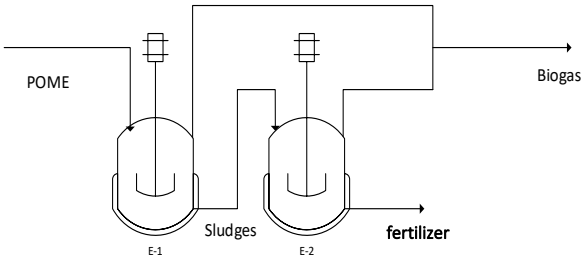

Figure 1. Two-stage fermentation process

Result and Discussion

In the initial research, experiments were carried out using variations in the composition of cow dung-POME as follows: 55%, 60%, 65%, 70%, 75%, and 80% w/w. The results can be seen in Figure 2.

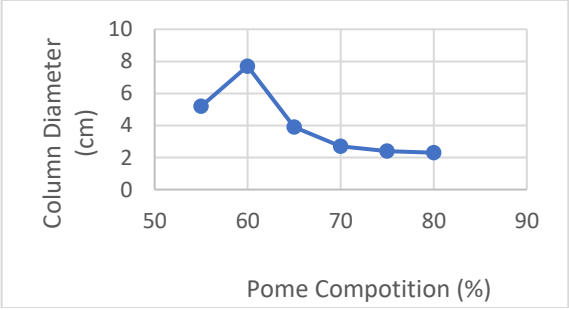

Figure 2. The effect of cow dung-POME composition on column diameter.

Based on the size of the resulting balloon, digester number 2, with a variation of 60% produces the largest volume of gas. In

digester 1 and digester 2, the volume of gas increased, however, in digester 3 to digester 6, the volume of gas decreased. This decrease in gas can be caused by the number of microbial decomposers that are not balanced with organic matter (POME). Cow dung contains microbes that function to decompose organic matter in POME and cow dung, namely *Lactobacillus sp* and *Actinomycetes sp.* (Rahayu, 2015). If there is an imbalance between decomposing microbes and organic matter, it will result in unstable chemical reactions and have an impact on the gas produced (Wahab, 2019), on the other hand, it can be due to technical errors such as leaky installations (Yahya, 2017).

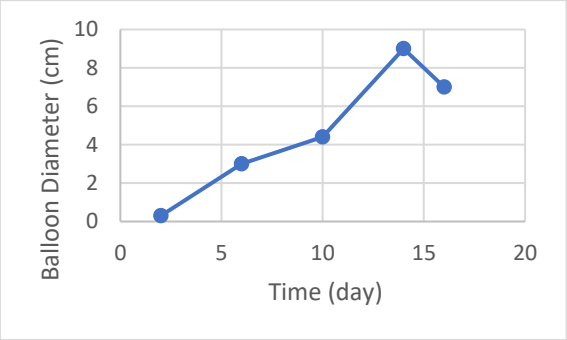

Figure 3. The effect of fermentation time on balloon diameter

After obtaining the optimum conditions of 60% cow dung-POME, further experiments were carried out on variations in fermentation time of the gas produced at a composition of 60% cow dung-POME. From Figure 3, it can be seen that the longer the fermentation time, the more gas produced up to a maximum time of 14 days, gas with a balloons diameter of 9 cm was obtained, but if the fermentation time was added, it turned out that the gas produced decreased due to the lack of nutrients by bacteria to continue the fermentation process.

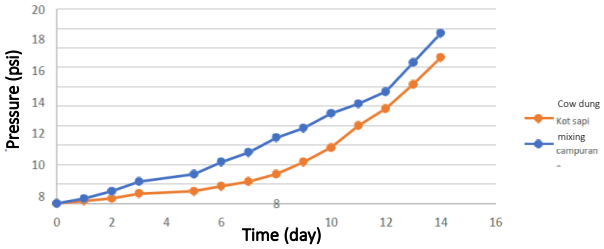

Figure 4. The effect of fermentation time on gas pressure

In the second stage, the results of the best variations in stage 1 were compared with biogas derived from cow dung without POME, with measurements based on the pressure produced by gas in mini gas cylinders (same volume). It can be seen that gallon 1 contained cow dung without POME had a pressure of 15 psi on day 14 and gallon 2 contained 60% cow dung-POME had a pressure of 17.5 psi.

This indicated that the addition of POME as a substrate has an effect on the gas produced in which the quantity of gas produced is greater (Rahayu, 2015). The pressure generated in gallon 2 was higher than gallon 1 indicating better decomposing bacterial activity, namely the addition of POME, whereas in gallon 1, POME was not added (Wahab, 2019). When viewed from the temperature on the 14th day, the temperature in gallon 2 was 30.2^{o}C, while temperature in gallon 1 was 28.8^{o}C. A higher temperature indicates a faster chemical reaction, due to faster and more frequent collisions between compounds (Aznury, 2018).

The fire produced in stage 1 was yellow, which is produced in a digester with a composition of 55% and 60%, and the biggest and the longest duration of flame was found in the composition of 60%. Digester 3 to digester 6 did not cause a fire because the gas volume was too small. Whereas in stage 2, the resulting fire was blue at the base of the fire and the rest was yellow. Based on the literature, the color of the flame in the biogas mixture of liquid palm waste and cow dung is slightly yellow, indicating that the Methane gas was produced.

Conclusion

Biogas with two stage of fermentation of cow dung and POME was achieved the optimum condition of the composition of 60% cow dung-POME and the fermentation time of 14 days. In comparison of a two-stage reactor using a mixture of POME and cow dung, and pure cow dung, it was found that the two-stage fermentation using a mixture of POME and cow dung produced gas with a higher pressure of 17 Psig. The color of the flame in the biogas mixed with palm liquid waste and cow dung was slightly yellow indicating that Methane gas was produced.

Suggestion

Clear regulation is needed for Industrial Cooperation in POME sampling. Besides, it is suggested to carry out a test to see the percentage of methane in the gas mixture.

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