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BIOGAS WASTE VEGETABLE GREEN (*BRASSICA CHINENSIS VAR. PARACHINENSIS*) AS ALTERNATIVE ENERGY SOURCES

Rini Kartika Dewi, Faidliyah Nilna Minah, Jimmy, Anitarakhmi Handraratri
Chemical Engineering Study Program, Malang National Institute of Technology, Malang, Indonesia
Email: rini_kartika_dewi@lecturer.itn.ac.id, nilnaminah@yahoo.com, jimmy.roring.kimia@gmail.com, anitarakhmi@lecturer.itn.ac.id

Abstract

Green mustard (*Brassica chinensis var. parachinensis*) waste has not been used optimally so it requires proper handling. The solution that can be done is to utilize the waste into biogas. Biogas is energy that can be used by vegetable farmers as lighting, a substitute for kerosene or LPG stoves and the rest of the biogas process can be used as fertilizer to fertilize plants. This research was conducted to determine the effect of the waste mass of *Brassica chinensis var. parachinensis* (0.5, 1, 1.5 and 2)kg and the length of fermentation time (0,5,10,15, 20) days on the pH and temperature values in biogas production and the mass ratio of vegetable waste and cow dung (1:0, 1: 0.5, 1:1 and 1:1.5)w/w to the volume of biogas produced. From the results obtained from each treatment for the pH value ranging from pH 6-7 and for the resulting temperature ranging from 25 C - 40 C. While the highest volume of gas produced was obtained from the mass of vegetable waste as much as 2 kg with a ratio of vegetable waste and cow dung 1:1.5 with a volume of biogas produced as much as 620 ml.

Keywords: biogas; energy; fermentati; waste; mustard greens

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Introduction

The increasing need for energy and the depletion of petroleum reserves, as well as the reduction in the impact of the greenhouse effect, have made alternative energy exploration more serious to be developed by various parties (Ellabban et al., 2014). Alternative energy that is widely researched and developed is energy that has renewable properties (renewable energy) (Sawyerr et al., 2019) as well as environmentally friendly. One of the renewable energies that is widely developed and utilized is biogas (Mayang et al., 2019; Szymanska et al., 2019).

Biogas is a product of anaerobic bacteria activity through a fermentation process with a material (substrate) containing carbohydrates, proteins, fats, cellulose, and hemicellulose. Biogas raw materials are generally from agricultural waste or organic waste (Annur et al., 2020; Kausar et al., 2016; Mayang et al., 2019; Rezeki et al., 2021), livestock waste such as cow manure, chicken and goat manure combined with

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additional materials in their processing (Arwindah et al., 2018; Pratiwi et al., 2019; Putri et al., 2014; Wardana et al., 2021; Yahya et al., 2018), as well as raw materials from microalgae which are very likely to be developed (Gultom, 2018; Ramaraj et al., 2015; Ramos-Suárez & Carreras, 2014; Zaidi et al., 2018). In this study, we used green mustard greens (*Brassica chinensis var. parachinensis*) because the amount was very abundant and farmers tended to just throw it away when the post-harvest was abundant, while the market price was not balanced with the cost of maintenance and fertilization. Biogas itself is thermodynamically has a calorific value that is not inferior to other non-renewable energy sources. Seeing the high calorific value, the utilization of biogas as an energy source is something that is possible to be developed. In this biogas process, in addition to the waste raw material, *Brassica chinensis var. parachinensis*, there is also cow dung. Cow dung is one of the most wastes from cattle farming activities, especially from dairy farms. For every kilogram of cow dung containing 65% water, biogas can be produced up to a volume of 0.8 m3 and the largest composition is methane gas (40% - 70%) (Tasneem et al., 2012). In cow dung there are microbes that function as decomposers and become catalysts to increase the production of methane gas (Agus et al., 2014; M.Nicko et al., n.d.). In addition to cow dung, there is also the addition of EM4 (Effective Microorganisms 4) which functions to help ferment organic matter (Irawan & Suwanto, 2017; Kinasih, 2020).

By mixing the vegetable waste *Brassica chinensis var. parachinensis* with cow dung in various treatments is expected to result in the formation of more biogas and can be used as alternative energy to replace fuel by farmers and at the same time help reduce the impact of the greenhouse effect caused by methane gas pollution from biogas.

Mechanism of Biogas Formation

Biogas is a product of the fermentation process carried out by a number of anaerobic bacteria through several stages, where in the fermentation process all conditions must be adjusted so that it can take place optimally. The whole fermentation process can be written in the form of a reaction equation as follows:

$$(C_6H_{10}O_5)_n + n\,H_2O \dashrightarrow 3n\,CO_2 + 3n\,CH_4 \qquad (1)$$

The whole biogas process is an anaerobic fermentation process or known as anaerobic digestion. The several types of bacteria involved in this fermentation process are Clostridium, Eubacterium, Lactobacillus, Syntrophobacter, Methanobacterium, Methanobrevibacter, Methanospirilum, and Methanosarcina.

In theoretical calculations, biogas will produce the same volume of methane gas and carbon dioxide gas volume, which is in the range (50% - 50%), however in implementation the volume of methane gas produced ranges from 50% to 70%. The range of methane gas volume varies due to the composition of the substrate (fermented organic matter), the composition of the group of microorganisms, and also the conditions in which the fermentation takes place (anaerobic digester) (Dieter & Angelika, 2008).

The volume of biogas produced is not only influenced by the process mechanism but also by nutrients and water. For the mechanism of the performance of microorganisms, especially methanogenic bacteria, there are several factors that influence and need to be considered, namely :

Composition of carbon and nitrogen (C/N ratio)

The ratio of carbon (C) and nitrogen (N) in organic matter (substrate) in the fermentation process to produce biogas is one of the most influential factors in achieving optimal microorganism activity. The ratio between C/N in general in the fermentation process to produce biogas in an anaerobic optimal way is 20-30. If the C/N ratio is too high, the methanogenic bacteria will consume nitrogen rapidly. This results in the low ability of these bacteria to convert carbon into methane gas, so that biogas production decreases. On the other hand, if the C/N ratio is too low, most of the nitrogen gas will be released from the substrate and accumulate to form ammonia gas (NH3). The higher the ammonia gas produced, the higher the pH value in the fermentation process and if the pH is more than 8.5, this condition will have a toxic effect on methanogenic bacteria. Cow dung has a C/N ratio of around 24, other substrate materials can have a C/N ratio of more than 7.2. To produce an appropriate level of C/N ratio value, one of the techniques can be done by mixing materials that have a low C/N ratio value with a high C/N ratio value.

Dilution (*Dilution*)

Substrate concentration will also affect the volume of biogas produced. The addition of water with a certain volume is very helpful for bacteria to carry out activities in the fermentation process. If the substrate solution is too dilute, the solid organic matter to be fermented will decrease and settle, this causes the fermentation process to take place not optimally. Vice versa, if the substrate solution is too concentrated with solid organic matter, the mixing process will not take place properly and the biogas product will be trapped in the solid. This resulted in the accumulation of the volume of biogas formed was not significant. In general, the optimal mass fraction in the fermentation process to produce biogas is in the range of 10 – 25% of the solid mass.

pH

In the fermentation process, the pH value also greatly influences during the process, this is because it involves the role of microorganisms in its decomposition. In the process of biogas formation, the optimal conditions for the fermentation process are between pH 6 and 7. Too low and high pH values can cause toxic effects on microorganisms because many microorganisms die.

Temperature

In addition to the pH value, the mechanism of performance of microorganisms, especially methanogenic bacteria, is strongly influenced by temperature during the fermentation process. In general, methanogenic bacteria can run optimally in three zones, namely: at 50oC – 65oC (thermophilic temperature), 20oC – 40oC (mesophilic temperature), and <10oC (psychrophilic temperature). Most of the mechanisms of the fermentation process in the formation of biogas occur at mesophilic temperatures, namely bacteria that can grow optimally at a temperature of 35oC. However, for the thermophilic temperature, the fermentation process can also be carried out, and it is usually more efficient than the fermentation process that takes place at the mesophilic temperature. The disadvantage of thermophilic conditions is that it is difficult to control the reaction that occurs and requires more energy to carry out the fermentation reaction in this zone.

Rate of comparison of incoming materials (*Loading Rate*)

The rate of feed intake ratio has a role too, if the biogas fermentation process is designed to run continuously. A high loading rate will result in a buildup of fatty acid concentrations. The build-up of these concentrations will result in microorganisms being more active in the process of acidification or acidogenesis, resulting in a decrease in the pH value of the system or in other words, an increase in the acidity level. At a pH value that tends to be acidic, it will cause toxicity to microorganisms, so that many microorganisms die before the methanogenesis process takes place.

Time to stay (*Retention Time*)

Residence time is the time required, where organic matter and microorganisms are in the biodigester or digester reactor equipment. And undergoes an anaerobic fermentation process. The shorter the "substrate retention time" required in the anaerobic reactor, the more efficient the digester reactor. In this retention time process, it can be grouped into two types, namely the first Hydraulic Retention Time (substrate retention time) and the other type is Solids Retention Time (retention time which refers to the length of time required for microorganism activity in the fermentation process).

Stirring (*Mixing/Agitation*)

Stirring is one way or method of mixing two or more substances that are used to produce a homogeneous mixture during the time the fermentation reaction process takes place. If the stirring is too fast, it will cause the colony of microorganisms to be disturbed so that it affects the time of the fermentation process. Vice versa, if the stirring is too slow, the level of homogeneity will not be achieved, resulting in the rate of the fermentation product formation process.

Research Methods

Tools and Materials

The equipment used to produce biogas products are analytical balance, mixer, anaerobic digester, beaker glass and barometer. While the material used is green mustard greens (Brassica chinensis var. parachinensis) with a mass of: (0.5, 1, 1.5 and

2) kg, dairy cow dung, aquadest, Microorganisms EM 4: 1.5 kg. The ratio between green mustard greens (Brassica chinensis var. parachinensis) and cow dung was 1: 0, 1:0.5 and 1:1, 1: 1.5 w/w
Mixing vegetable waste raw materials Brassica chinensis var. parachinensis (0.5, 1, 1.5, 2) kg and cow dung with the ratio between mustard greens and cow dung was 1: 0, 1:0.5 and 1:1, 1: 1.5 w/w. And add 10% EM4 into the anaerobic digester. Furthermore, the fermentation process is carried out for 20 days. Every 5 days temperature and pH were measured. The analysis is carried out to calculate the volume of biogas produced during the fermentation process through the ideal gas calculation formula.

Results and Discussions

One of the factors that affect biogas production is temperature as shown in Figure 1 below :

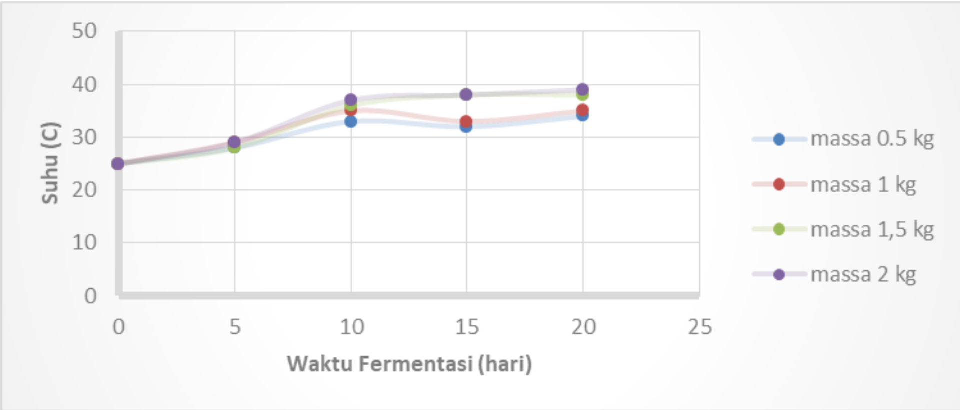

Figure 1
Effect of waste mass on temperature during biogas production process

Seen at the beginning of the fermentation process all have the same temperature, which is around 25 oC, after that the temperature increases and there are fluctuations ranging from 28 oC - 39 oC. This is because during the fermentation process the conditions are unstable, the thermometer is not patent for its placement so that when measuring the temperature, we slightly open the lid of the equipment. At mesophilic temperature conditions, the working temperature is in the range of 28-45 oC with optimal temperature conditions in the range of 35-45 oC.
The next factor that affects biogas products is pH, where the pH range that is allowed during the fermentation process is pH 6-7 .

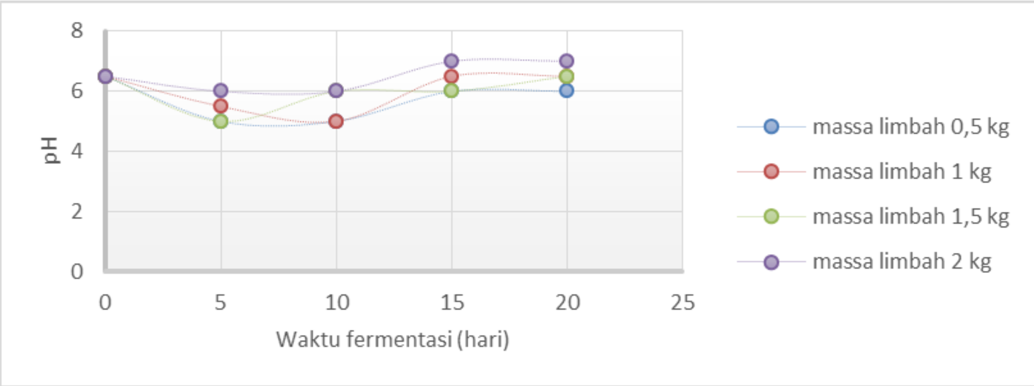

Figure 2
Effect of waste mass on pH during biogas production process

From Figure 2 it can be seen that almost all treatments ranged from pH 6-7, only in the fermentation process on day 5 to day 10 the pH ranged from 5-6, this was due to the formation of acidogenesis, where at this stage the bacteria produced acid which change the short chain in the hydrolysis process. Acid formation under anaerobic conditions is very influential for the formation of methane gas in the next process. If the pH is less than 6-7 or more, it will inhibit the growth of microorganisms which can result in a decrease in the biogas yield obtained.

Biogas is a flammable gas or flammable gas produced from the fermentation process of an organic material with anaerobic bacterial activity. The volume of biogas produced is influenced by the amount of organic waste in this study using green mustard (*Brassica chinensis var. parachinensis*) waste and the mass ratio of the amount of cow dung to vegetable waste. The function of cow dung is as a provider of methanogenic bacteria that can decompose acids in the asinogenesis process into methane gas products and can accelerate gas formation. In addition to bacteria obtained from cow dung in this study, EM4 (Effective Microorganise 4) was also added, which is a bacterium that has a function to accelerate the degradation process of organic matter. Waste *Brassica chinensis var. parachinensis* is included in organic waste which serves as a source of nutrition which will be broken down by anaerobic bacteria to produce methane gas. Vegetable waste mass *Brassica chinensis var. more parachinensis* can increase the biogas yield obtained. From the results obtained from the calculation for the volume of gas, it can be seen from the following figure :

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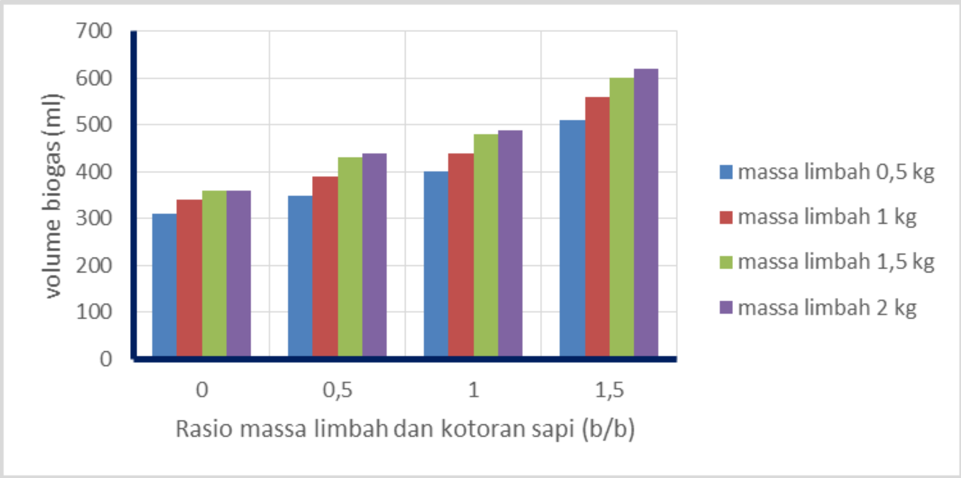
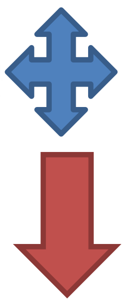


Figure 3

The effect of the ratio of vegetable waste mass and cow dung on waste mass to the volume of biogas produced

From Figure 3. It shows that there is an increase in the volume of biogas produced from the addition of cow dung. The highest biogas yield was found in the mass of vegetable waste as much as 2 kg in the mass ratio of vegetable waste and cow dung: 1:1.5 with a volume of 620 ml of biogas. More and more cow dung added will increase the number of anaerobic microbes forming biogas, so that with the increase in microbes they will be able to decompose existing organic matter into biogas. The biogas produced is still not optimal because the amount of organic waste used is still small.

For the overall process of the process of making biogas from mustard greens waste with various mass treatments of mustard greens and cow dung, it can be seen in Figure 5, below :



b. Mustard Waste

a. Cow Dung and EM4

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c. Mixing process

d. Measurement of biogas volume

Figure 5

Mechanism of Biogas Manufacturing Process from green mustard waste

Conclusion

Based on the results of the research conducted, it can be concluded that the more mass of vegetable waste Brassica chinensis var. parachinensis on the length of time of fermentation produces pH and temperature in the biogas production process which are relatively still in accordance with the specified conditions, namely pH ranging from 6-7 and temperatures ranging from 25-40 oC. Meanwhile, the highest volume of biogas produced is 2 kg of waste mass with a mass ratio of vegetable waste and cow dung at 1:1.5, which is 620 ml.

Suggestions for further research is the mass of vegetable waste Brassica chinensis var. parachinensis is increased so that the volume of biogas produced is high and the calorific value analysis is carried out. So that in the future it can be used as alternative energy.

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