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Biogas Production from Tofu Processing Waste and Rice Straw with the Addition of Beef Bone Lime

Riki Jaswandi and Sulastri Panggabean

Agricultural and Biosystems Engineering Study Program, Agriculture Faculty, Universitas Sumatera Utara, Medan, 20155, Indonesia
*Corresponding Author: sulastripanggabean@usu.ac.id

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ABSTRACT

The waste processing of tofu and rice straw can be used as the basic material for making biogas. The acidic pH of the waste will cause a non-optimal biogas production. This research was conducted using NaOH and the variations of beef bone lime 3 replications. The purpose of this study was to obtain the value of volume, pressure, biogas production rate and flame quality. The result showed the best quality of flame with a blue color (for 64.48 seconds) and 962 ml/day of biogas production rate was obtained by adding 3% of beef bone. The highest volume was obtained by adding 3% of beef bone lime (2210.33 ml) and the highest pressure was obtained by adding 2% and 3% of beef bone lime (1.0159 bar).

Keywords: biogas, NaOH, beef bone

1. Introduction

Energy is one of the most important needs in human life. The dense population can affect the energy needs in a country. The industries are the sectors that use the most energy. The increase of these industries will directly encourage an increase in national and world energy consumption. Therefore, it is necessary to carry out a technology which help improve energy production, especially from environmentally friendly energy.

Biogas also known as fuel that does not produce smoke, has the potential to be developed as a substitute for natural gas or fuel oil[4]. Raw materials to produce biogas are relatively easy to obtain such as agricultural waste, industrial waste, human waste, and animal waste.

The tofu processing industry produces 2 types of waste, namely liquid waste and solid waste that cause pollution because they still contain high organic matter such as BOD and COD. Thus, a suitable waste treatment technology is needed to deal with this waste [1].

The addition of NaOH [11] can increase biogas production and biogas can be formed within 14 days compared to without the addition of NAOH. The rapid of biogas formation will affect the amount of biogas that produced.

Rice straw waste in Indonesia reaches 180 million tons every year and as much as 36-62% is burned which will certainly cause pollution. Therefore, straw waste needs to be processed so that it does not pollute the environment, One way is through processing this waste into biogas [8].

Based on [6] the best quality of biogas was obtained in the addition of NaOH 2.5 N (108.5 Watts). While the lowest quality in the addition of NaOH 1.25 N (25.67 Watts). In [5] the addition of CaCO3 (2.5%) produced a larger volume of gas and the rate of biogas production was very good. In the study of [9] the pressure of biogas obtained from the addition of 0.3% lime higher (with a pressure of 90 mmHg) then the addition of 0.6% lime (with a pressure of 75 mmHg).

In this study, experiments was carried out to discuss the effect of adding NaOH and adding cow bone lime on biogas production from tofu industrial waste and rice straw. The cow dung was using as starter in this experiment.

The purpose of this study is to obtain the pressure value, volume, and rate of biogas production on the addition of NaOH and cow bone lime during the production of biogas from industrial waste processing of tofu and rice straw.

2. Materials and Methods

The materials used in this study are tofu liquid waste, tofu dregs and rice straw (as main materials), NaOH and cow bone lime as acid neutralizers, plasticine to avoid leaks, cow dung as a starter, aquades as solution to make a 3% (w/v) of NaOH.

The digester that used in this study are 19 liters of mineral gallons, inner tubes as gas storage bins, 2 pipes as inlets and outlets material, plastic hoses, pH meters, room thermometers, gas faucets, funnel, manometer, a bucket, a tarpaulin, a pressure board, and camera. Schematic view of digester can be seen in Figure 1.

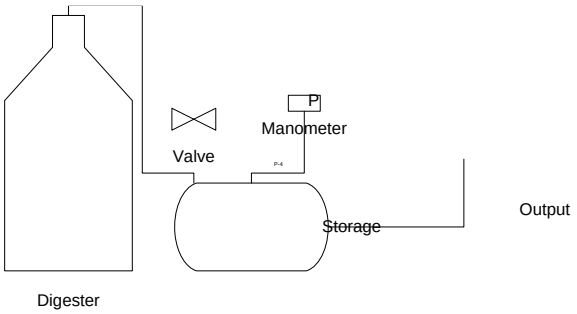

Figure 1. Schematic view of digester

2.1 Research Procedure

2.1.1. Material preparation

- Calculating the initial C/N ratio of the mixture by Equation (1):

$$C/N = \frac{\text{C Content (Liquid waste+ dregs+straw)}}{\text{N content (Liquid waste+ dregs +straw)}} \quad (1)$$

- Prepare rice straw material.
- Taking tofu dregs materials and liquid waste from tofu factory.
- Weighing the materials according to the required mass (Equation (1)).

2.1.2 Determining of 3% NaOH solution (w/v)

- Weighing 4.5 gr of NaOH.
- Adding 150 ml of aquades to NaOH.
- Stirring the NaOH solution
- Store the NaOH solution that has been made into a 200 ml bottle.

2.1.3 Biogas production

- Preparing materials (tofu liquid waste, tofu dregs, rice straw, 3% NaOH solution, cow bone lime and cow dung).
- Put 200 gr of rice straw, 500 gr of tofu dregs and 11,000 ml of tofu liquid waste into the bucket.
- Mixing cow dung with water as much as 1170 gr with the ratio of 1: 1.
- Put cow dung and water mixture in a bucket.
- Adding NaOH solution and cow bone lime according to the treatment.
- Stirring the mixture until homogeneous for approximately 20 minutes.
- Put the mixture of the above ingredients into the digester.
- Observe the volume, pressure of the digester and temperature of the environment around the digester during the fermentation process.
- Analysis of the data obtained

3. Results and Discussion

3.1 Biogas Volume

The biogas volume is the gas produced in gas storage over a certain period of time. The measurement of biogas volume in this study used a [7] method. The principle used in the measurement is the archimedes principle. According to [12] the principle of archimedes is that an object that sinks completely or partially in a container filled with water will get an upward lifting force equal to the weight of the fluid being moved. Data on the volume of biogas measured over 21 days can be seen in Figure (2).

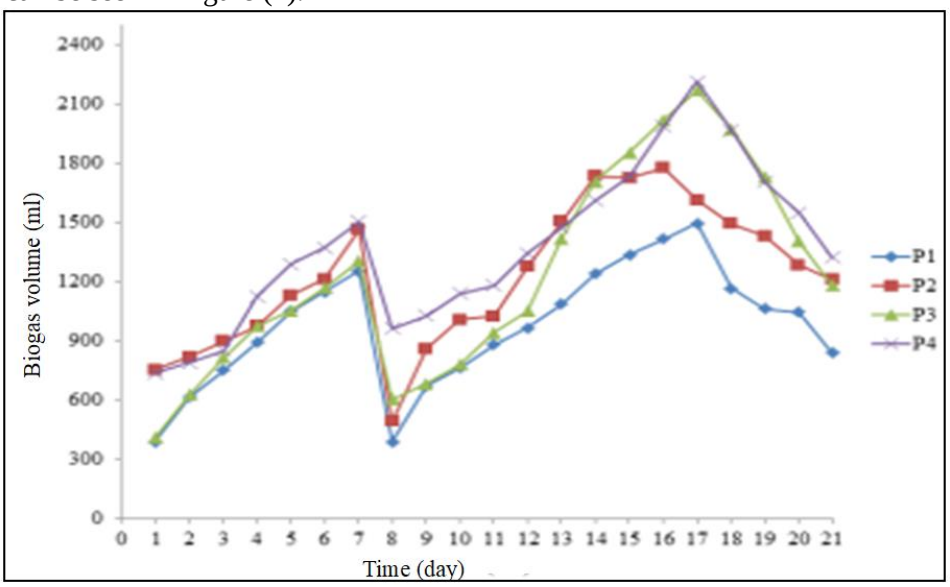

Figure 2. Biogas volume

From Figure (2), it can be seen that the biogas of the four treatments began to form from the first day and experienced a decrease in volume on the 18th day. The highest number of biogas produced from all treatment (P1,P2, P3, P4) was obtained when entering the third week (17th day). On this day, the highest biogas volume was obtained in treatment 4 which reached to 2210.33 ml, and the lowest biogas volume from the 4 treatments in the same day was obtained in treatment 1 which 1492.33 ml.

The differences of biogas formations peak point due to treatment 1 only using 3% NaOH while treatments 2, 3, and 4 also used cow bone lime as much as 1%, 2%, and 3%. This can be seen from the highest volume of biogas produced in treatment 4 with the addition of 3% cow bone lime, because cow bone lime contains calcium which is able to neutralize the acidic formation during biogas production (pH before added cow bone lime about 3.6 and after added cow bone lime before fermentation about 6.5-7 and after fermentation was 5.6 – 6.7). According to [10] cow bone lime has a content of 97% calcium. Therefore, the volume of biogas produced in treatments 2, 3, and 4 was higher than the use of 3% of NaOH.

3.2 Biogas Pressure

The measurement of biogas pressure in this study was obtained using a manometer. The gas pressure obtained during 21 days of fermentation can be seen in Figure (3).

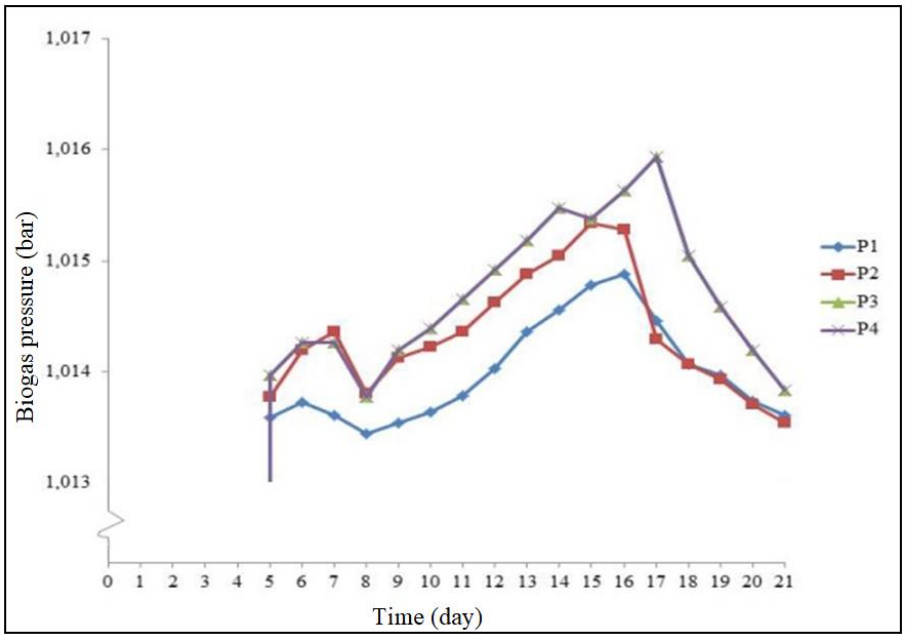

Figure 3. Gas Pressure

From Figure (3) can be seen that the biogas pressure of all treatments begin to form from the fourth and fifth days and decrease in the third week of fermentation. The highest biogas pressure was in treatment 3 and 4, which was 1.0159 bar (on the 17th day of fermentation) and the lowest was in treatment 1, which was 1.0149 bar on the 16th day of fermentation.

The difference in biogas pressure from each treatment is due to the fact that the optimal point of each bacteria on decomposing organic matter into biogas is different. This is because the mixed ingredients used in each treatment are different. Where the use of 3% NaOH and the use of cow bone meal 1% have a peak point on the 16th day of fermentation. In contrast to the use of cow bone meal, 2% and 3% have a peak point on the 17th day of fermentation. This means that the content the number and of materials to neutralize the solution during fermentation from each treatment affects the work of bacteria in decomposing organic matter into biogas, so that it affects the production of biogas obtained. According to [3] the decrease in bacterial activity is characterized by the decrease in biogas production, it also affects the pressure as it is directly proportional. The higher the volume of biogas produced, the higher the pressure of the biogas produced and vice versa.

The first pressure drop occured on the 8th day of fermentation. Based on [2] the gas produced on day 1 to day 7 of fermentation is still a CO_2 gas. So it is necessary to carry out gas removal on the 7th day of fermentation. The pressure drop also occured during the third week of fermentation, which is from the 17th to the 21st day of fermentation. According to [3] bacterial activity will decrease in line with biogas production. This means that if biogas volume is decreased, then pressure also decreased, the same as bacteria that work to decompose organic matter will decrease and use the remaining organic matter to maintain life instead of forming biogas.

From the results obtained, it can be seen in (Figure (2)) that biogas volume increase, then biogas pressure will also increases significantly (Figure (3)). According to [13] the production of biogas produced will affect the pressure of the biogas obtained as well, because it will affect the water level obtained on the manometer, and the more biogas pressure will also indicate the more biogas volume.

3.3 Biogas Production Rate

The rate of biogas production is a comparison between the volume of biogas with time. According to [2] the gas produced on the 1st to the 7th day of fermentation is still a CO_2 gas, so it is necessary to remove the gas because it will affect the quality of the methane gas from biogas during combustion. Methane gas is formed at week 2 of fermentation. The rate of CO_2 production in the first week of fermentation can be seen in Figure 4.

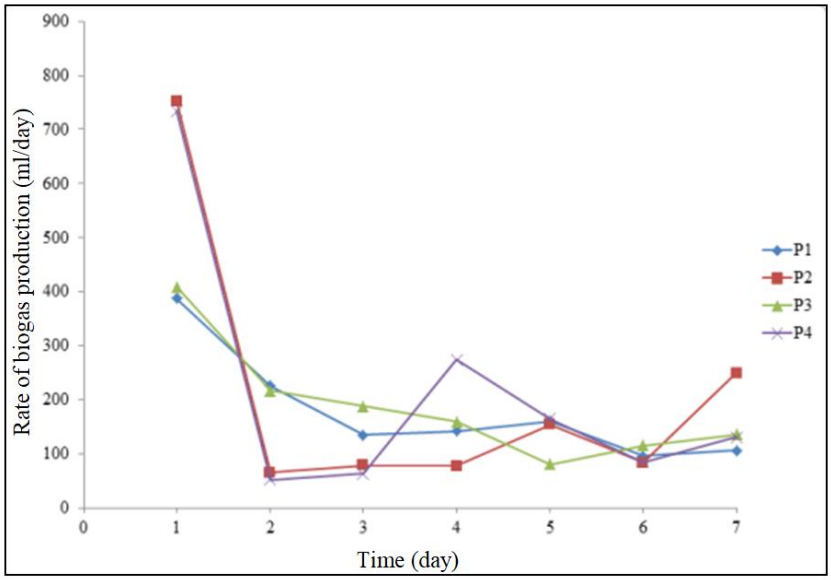

Figure 4. Biogas production rate on 1st week

From Figure (4) it can be seen that the highest gas production rate for 7 days of fermentation was obtained in treatment 2 of 753 ml / day and the lowest was obtained in treatment 1, which was 387.67 ml / day. The gas production rate of the second week and the third week can be seen in Figure (4).

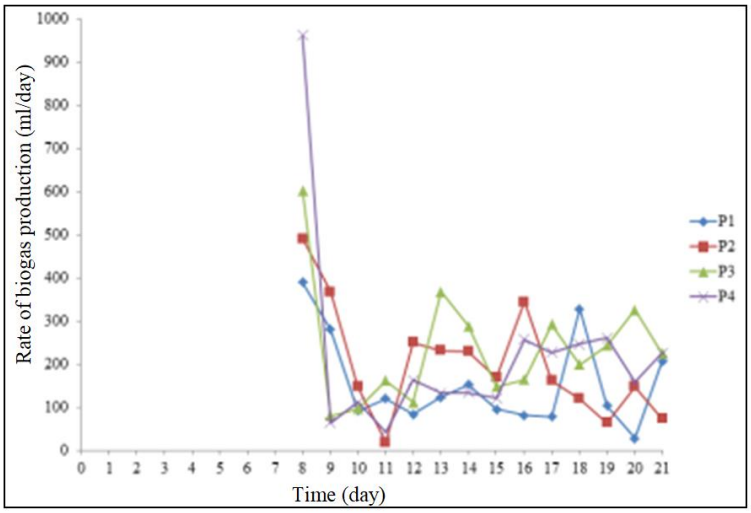

Figure 5. Biogas production rate of the 2nd week and the 3rd week

From Figure (5). it can be seen that the highest production rate (starting from the second week to the third week of fermentation) was obtained in treatment 4, which was 962 ml / day on the 8th day of fermentation. This also can be seen from the biogas volume (Figure 1) obtained at the beginning of fermentation after gas removal (on the same day). The rate of biogas production decreased on the 11th day and produced the lowest biogas production rate of 17.67 ml / day. According to Firdausy [3] bacteria will actively work to convert organic matter into biogas and will decrease along with the decrease in biogas production produced.

4. Conclusion

The highest biogas volume was obtained in treatment 4, which was 2210.33 ml in 3 weeks of fermentation, with 1.0159 bar of pressure and 962 ml / day production rate.

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