UNIVERSITAS MUHAMMADIYAH SIDOARJO
ISSN 2528-3723 (online)
REM JURNAL
(REKAYASA ENERGI MANUFAKTUR)

Juni 2021
Vol 6 No 1 (2021)

Desember 2020
Vol 5 No 2 (2020)

Juni 2020
Vol 5 No 1 (2020)

Desember 2019
Vol 4 No 2 (2019)

ISSN

ISSN 2528-3723 (online)

ISSN 2527-5674 (print)

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UNIVERSITAS MUHAMMADIYAH SIDOARJO

ISSN 2528-3723 (online)

REM JURNAL
(REKAYASA ENERGI MANUFAKTUR)

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ISSN

ISSN 2528-3723 (online)

UNIVERSITAS MUHAMMADIYAH SIDOARJO
ISSN 2528-3723 (online)
REM JURNAL
(REKAYASA ENERGI MANUFAKTUR)

DOI: https://doi.org/10.21070/r.e.m.v5i2

Published: 2020-12-30

Articles

ISSN

ISSN 2528-3723 (online)

ISSN 2527-5674 (print)

R.E.M. (Rekayasa Energi Manufaktur) Jurnal / Vol.5 no.2/2020 / ISSN online (2528-3723)

Quality of Fuel Liquid Waste Biogas Tofu Using Starter Composition Variation

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Abstract. *Fossil fuels are a primary energy source. Fossil fuels that are widely used are in the form of fuel oil, gas fuel, and coal. Along with technological developments, the need for fossil fuels is increasing, which is followed by the depletion of supplies. Therefore, renewable energy is needed which is cheap and easy to use on a household scale such as biogas. Therefore, renewable energy is needed, which is cheap and easy to use on a household scale such as biogas. The materials used as biogas are tofu liquid waste with a yeast starter, EM-4, and horse manure. Tests on the quality of tofu liquid waste biogas conducted in this study include; Gas volume, temperature, degree of acidity (pH), C/N ratio, and gas content, namely methane (CH4), hydrogen sulfide (H2S), carbon monoxide (CO), and oxygen (O2). In the test results, it was found that the increase in the quality of tofu liquid waste biogas by using horse dung starter was producing a volume of 513.6 ml, a temperature of 31.7oC, a C/N ratio of 5.336, a CH4 content of 69%, and H2S content of 5 ppm, a CO content of 9 ppm and an O2 content of 16.3%.*

Keywords- *Yeast, EM-4, Horse Manure, Liquid Waste Biogas Tofu*

How to cite: Nely Ana Mufarida[1] ,Asroful Abidin[2] (2020) ,Quality Of Fuel Liquid Waste Biogas Tofu Using Starter Composition Variation. R.E.M. (Rekayasa Energi Manufaktur) Jurnal | Vol.5 no.2. doi: 10.21070/rem.v5i2.1001

INTRODUCTION

Fossil fuel sources are primary energy. Fossil fuels that are widely used are in the form of fuel oil, gas fuel, and coal. Along with technological developments, the need for fossil fuels is increasing, which is followed by the depletion of supplies. Moreover, fossil fuel utilization tend to pollute our environment triggering global warming [1]. Therefore, renewable energy is very suitable to be used as an environmentally friendly alternative energy. One of the environmentally friendly alternative energy is biogas. Biogas is a gas resulting from the fermentation activity of anaerobic microorganisms from organic materials [2]. Tofu liquid waste is one of the organic materials with high organic compound content [3]. Livestock waste such as horse manure can also be used as a substrate for producing biogas. The substrate in horse manure contains methane-forming bacteria [4]. Tape yeast contains various microbes, especially Saccharomyces cerevisiae which can accelerate the anaerobic process [5]. EM-4 (Effective Microorganisms-4) contains 90% of Lactobacillus sp [6]. These bacteria can optimize the use of organic materials to become biogas. This paper will discuss the quality of tofu liquid waste biogas by using variations in the composition of the starter.

METHODS

In this research, to collect data using experimental methods. Experimental research is research that is conducted by manipulating the object of research and the existence of control. Tests are carried out to obtain the required data. The research process carried out was to test the quality of the tofu liquid waste biogas fuel with the parameters of gas volume, temperature, C/N ratio, CH4 gas content, H2S gas, CO gas, and O2 gas. There are three variables used in this study, namely variations in the composition of horse dung starter, yeast, and EM-4. The composition of the starter can be seen in Table 1 below.

Table 1. Percentage of variation in starter composition

Variable	Horse Manure (%)	Tofu Liquid Waste (%)	Yeast (%)	EM-4 (%)
B1	75	25	0	0
B2	65	25	0	10
B3	68	25	7	0

Tofu Liquid Waste Biogas Design

The following components are needed in the manufacture of tofu liquid waste biogas as shown in Figure 1 below.

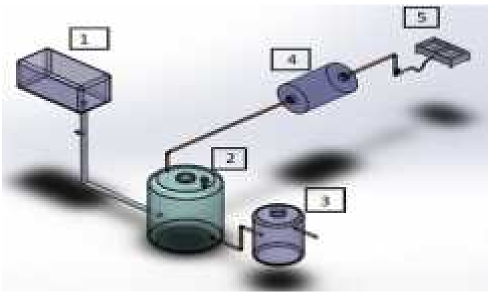

Figure 1. Tofu liquid waste biogas design

http://doi.org/10.21070/rem.v5i2.1001

Caption:
1. Tofu liquid waste
2. Biogas reactor
3. Outlet
4. Gas storage
5. Gas stove

Tools and Materials

Before the biogas formation process is carried out, the following are carried out first:

Mixing Starter
1. Prepare horse manure and tofu liquid waste according to the starter mixture in table 1.
2. Adding water to horse manure in a ratio of 1: 1
3. Adding tofu liquid waste, then stirring until dissolved.
4. Repeating the above steps 3 times to obtain 3 variables.

Addition of starter composition
1. Adding 150 ml of diluted yeast to variable B3.
2. Adding 700 ml of EM-4 solution to variable B2.

Fermentation Process
1. Adding NaOH solution to each variable little by little until the pH value is at 8.
2. Then check the C/N ratio for each variable.
3. Close the digester tightly so that the air cannot escape.
4. The fermentation process lasts for 21 days.

Testing the biogas quality of tofu wastewater

1. Measuring the volume of biogas.
2. Measure the temperature found on the digester surface using an infrared thermometer.
3. Measuring the content of methane gas (CH4), hydrogen sulfide gas (H2S), carbon monoxide gas (CO), and oxygen gas (O2) using a gas analyzer.

RESULTS AND DISCUSSION

Obtaining data in this study is data on the value of gas volume, temperature, degree of acidity, C/N ratio of methane gas content (CH4), hydrogen sulfide (H2S), carbon monoxide (CO), and oxygen (O2).

pH

Tofu liquid waste has a relatively low pH. This means that tofu liquid waste has acidic nature. The recommended value for the degree of acidity to obtain optimal biogas quality is between 6.8 to 8 [7]. Therefore, tofu liquid waste needs to be added with a solution that has an alkaline character, namely sodium hydroxide (NaOH).

C/N Ratio

C/N ratio is a quantity that states the ratio of the number of carbon atoms divided by nitrogen atoms [8]. In the reactor, there is a microbial population that requires carbon and nitrogen. Data on the C/N ratio value of each variable can be seen in Table 2 below:

Table 2. Value of C/N ratio for each variable

Variable	B1	B2	B3
C/N ratio (%)	5,336	4,795	4,832

The optimum C/N ratio range for carrying out the anaerobic digestion process is between 25-30 [9]. Based from the data above, the C/N ratio value of variable B1 has the greatest value among the other two variables. This indicates that the microorganisms in variable B1 are easier to carry out the anaerobic digestion process.

Digester temperature value

The temperature measured in this study is the temperature in the digester which can be seen in Figure 2 below:

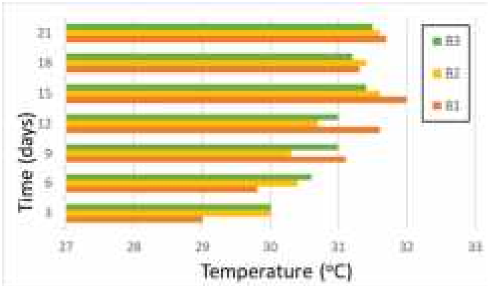

Figure 2. The temperature value in the digester

Based from the data above, the temperature of the three variables on the 3rd day is in the 29-30oC interval. Then on the 6th to 9th day, the temperature of the three variables increased, namely at 30-3oC intervals. On the 12th day to the 15th day the temperature value has increased again, namely at the interval 31-32oC. However, on the 18th to 21st day, the temperature value actually decreased, namely in the 31-31.5oC interval.

The best temperature for the growth of mesophilic microbes is 30oC or slightly higher [9]. Based from the data above, the three variables have an average temperature of 31oC. However, the temperature value in variable B1 can reach 32oC on the 15th day of the fermentation process. This means that microbial growth in variable B1 is more optimal than other variables.

The temperature value in this study has an erratic increase and decrease. This is caused by the temperature factor in the environment around the digester.

Biogas volume value

The volume of biogas measured in this study was calculated every 3 days until the 21st day of the fermentation process. The resulting change in biogas volume data can be seen in Figure 1 below:

http://doi.org/10.21070/rem.v5i2.1001

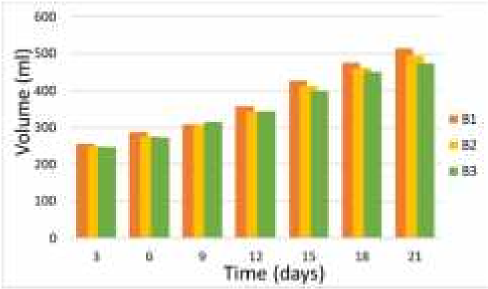

Figure 3. Biogas volume versus fermentation time

The volume of biogas produced from day 3 to day 21 continues to increase because the temperature in the digester can affect the biogas production. The best temperature for the growth of mesophilic microbes is 30oC or slightly higher [10]. The measured temperature that acts on the digester occurs at intervals between 28 - 32oC during the fermentation process. This shows that the volume of biogas has increased with increasing fermentation time.

Methane gas (CH4) value

Methane gas measured in this study was calculated every 3 days until the 21st day of the fermentation process. The data on changes in the resulting CH4 gas levels can be seen in the following graph 3:

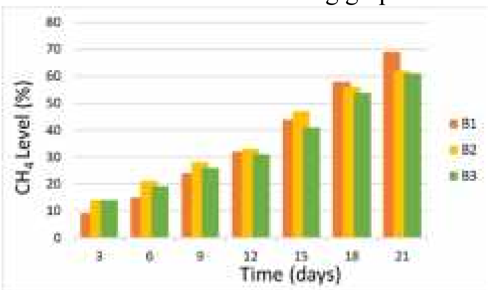

Figure 4. CH_4 levels against fermentation time

Based from the data above, it can be seen that CH4 levels continue to increase from day 3 to day 21. The highest CH4 levels produced on the 3rd day were B2 and B3 variables at 14%. Then on the 6th day, most CH4 levels were generated in variable B2 with a value of 21%. On the 9th day, the highest level of CH4 was generated in the B2 variable with a value of 28%. Then on the 12th day, the highest CH4 levels were found in variable B2 with a value of 33%. On the 15th day, variable B2 had the highest CH4 level, namely 47%. Then on the 18th day, the CH4 content of variable B1 had the largest value, namely 58%. On the 21st day, most CH4 levels were generated by variable B1 with a value of 69%.

The levels of CH4 gas produced on the 21st day of each variable were 69% B1, 62% B2, and 61% B3. The ideal CH4 gas content in biogas is around 60-70% [11]. This shows that the variation in the composition of the three starters can be used as biogas fuel with the highest CH4 content value owned by B1 at 69%.

Based on the graph above, it can be seen that the most biogas volume produced on the 3rd day is 254.6 ml in B1. Then the three variables experienced an increase in the amount of volume on the 6th day, namely 287.5 ml, 277.4 ml, and 273.2 ml. The increase in the amount of volume produced in the fermentation process for the three variables continues to increase until the 21st day. The largest volume of biogas is found in B1 with a value of 513.6 ml.

Hydrogen sulfide (H2S) gas value

Hydrogen sulfide gas measured in this study was calculated every 3 days until the 21st day of the fermentation process. The resulting change in H2S gas levels can be seen in Figure 4 below:

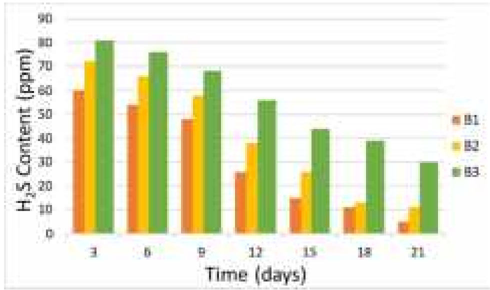

Figure 5. H_2S levels against fermentation time

Based from the graph above, it can be seen that the H2S levels of the three variables produced on the 3rd day are 60 ppm, 72 ppm, and 81 ppm. Then the H2S levels from B1, B2, and B3 on the 6th day decreased, namely by 54 ppm, 66 ppm, and 76 ppm. The decrease in the amount of H2S levels produced in the fermentation process continued to decrease until the 21st day, which was 5 ppm at B1, 11 ppm at 2, and 30 ppm at B2.

The increase in CH4 gas levels was caused by the absorption of CO2 gas and H2S gas contained in the biogas. Furthermore, CO2 gas will break down into one C atom and two O atoms, while H2S gas will break down into two H atoms and one S atom [12]. This shows that the less H2S gas levels, the CH4 gas levels will increase.

Carbon monoxide (CO) gas value

The carbon monoxide gas measured in this study was calculated every 3 days until the 21st day of the fermentation process. The resulting change in CO gas levels can be seen in Figure 5 below:

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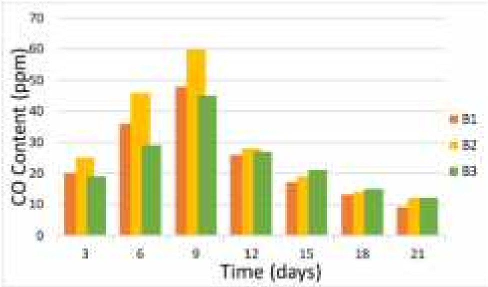

Figure 6. CO levels on fermentation time

Based on the graph above, it can be seen that the CO levels of the three resulting variables have increased from day 3 to day 9. The B2 variable has the highest CO levels on day 3 to day 9, which is 25 ppm on day 3 and 60 ppm on day 9. Then the levels of CO in the three variables on the 12th day experienced a significant decrease, namely B1 by 26 ppm, B2 by 28 ppm, and B3 by 27 ppm. The decrease in CO levels continued until the 21st day. Variable B1 has the smallest CO content, which is 9 ppm. The smaller the CO gas content in the fermentation process, the more efficient the microorganisms are in forming CO2 gas so that the air pollution produced by the digester is getting smaller [13].

Value of oxygen gas (O2)

The oxygen gas measured in this study was calculated every 3 days until the 21st day of the fermentation process. Data on changes in the resulting O2 gas levels can be seen in Figure 6 below:

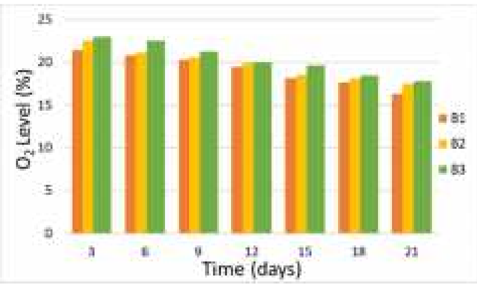

Figure 7. O_2 levels against fermentation time

Based from the graph above, it can be seen that the third O2 levels produced on the 3rd day are B1 of 21.4%, B2 of 22.5%, and 3 of 23%. Then the three variables experienced a decrease in the amount of O2 on the 6th day. The value of O2 levels on the 6th day of B1 was 20.8%, B2 was 21.1% and B3 was 22.5%. The decrease in the amount of O2 levels produced by the three variables in the fermentation process continued to decrease until the 21st day. The value of O2 levels is at least in variable B1, which is 16.3%. Biogas production will be more optimal if anaerobic fermentation is carried out completely in conditions without oxygen (O2) [14]. This shows that the increase in the quality of tofu liquid waste biogas can be identified by the oxygen content produced.

CONCLUSION

1. From the research results obtained, the effect of using variations in the composition of the starter on variable B1 has increased the quality of biogas fuel, marked by an increase in the volume of 513.6 ml, the temperature of 31.7oC, C/N ratio of 5.336, CH4 content of 69%, and decreasing H2S content of 5 ppm, CO of 9 ppm, and O2 of 16.3%.
2. From the research results obtained, the effect of using variations in the composition of the starter on the B3 variable has decreased the quality of biogas fuel, marked by an increase in the volume of 473.2 ml, temperature 31.5oC, C/N ratio of 4.832, CH4 content of 61%, and decreasing H2S content of 30 ppm, CO of 12 ppm, and O2 of 17.8%.

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Conflict of Interest Statement:

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Article History:

Received: 2 Oktober 2020| Accepted: 25 November 2020 | Published: 30 Desember 2020

http://doi.org/10.21070/rem.v5i2.1001