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Biogas Production from Tofu Liquid Waste with Cow Manure Mixture

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ABSTRACT

Biogas is a mixture of several gases produced from the process of overhauling organic materials by microorganisms in a state without air or anaerobically. This study aims to analyze the production and quality of biogas produced from tofu liquid waste with a mixture of cow dung. The study was conducted with 4 treatments, namely 80% liquid waste tofu and water + 20% cow dung (T80K20), 70% liquid waste tofu and water + 70% cow dung (T70K30), 60% liquid waste tofu and water + 40% dung cattle (T60K40), and 50% tofu liquid waste and water + 50% cow dung (T50K50). Each was replicated 3 times with data analysis using a completely randomized design (CRD). The highest methane gas production in the T50K50 treatment was 64,986.97 ml and the highest methane gas content in the T50K50 treatment was 43% in the sixth week.

1. INTRODUCTION

The problems faced by society today, including the environment and energy. The scarcity of non-renewable natural resources has started to cause many concerns. There needs an effort to encourage the use of alternative energy sources such as biogas. Biogas is produced from organic materials such as animal waste, human waste or organic waste through a fermentation process in a biodigester (Sanjaya *et al*., 2015). The livestock sector, especially ruminants, is a contributor to methane gas in the atmosphere (Pusiptasari *et al*., 2015). Livestock waste contributes to methane gas (CH_4). Based on data from Ministery of Environment and Forestry (KLHK, 2020) for each adult beef cattle aged more than 4 years it produces 55.89 kgCH_4/year while dairy cows are 77.14 kgCH_4/year. If we accumulated with the total cattle in Indonesia, this amount is sufficiently big. The high production of cow manure resulted from cattle fattening increases every year, most of which is disposed in landfills or applied to land without processing (Tampio *et al*., 2018).

Not only from livestock waste, tofu industrial waste is currently also polluting the environment. Tofu industrial waste consists of solid and liquid waste. Tofu liquid waste comes from immersing water, tofu water that does not clot, pieces of tofu that are cloudy and light yellow turn white (Budyrahman *et al*., 2014). Tofu liquid waste contains high organic matter with BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) ranging from 7,000 – 10,000 mg/L and has a low pH, namely pH 4 – 5. If this liquid waste is directly disposed of in water bodies, it will result in decreasing environmental quality (Sato *et al*., 2015). Therefore, the liquid waste from tofu industry really needs a treatment that aims to reduce the risk of pollution loads in the waters.

Tofu waste, in liquid or solid form, contains high organic matter and nutrients. Tofu solid waste contains organic material in the form of 24.77% protein, 25.46% carbohydrate, and 23.58% crude fiber. Meanwhile, tofu liquid waste contains 90.72% water, 1.8% protein, 1.2% fat, 7.36% crude fiber and 0.32% ash (Susetyo *et al*., 2019). These materials are the raw materials for making biogas. Biogas is a technique that can be used to process livestock waste, industrial waste, agricultural waste, and household waste to produce energy (Wahyudi *et al*., 2019).

Utilizing livestock waste, namely cow manure and tofu industrial waste, as biogas can be a solution for renewable energy sources and certainly has an impact on improving environmental quality due to reduced waste. Biogas has several advantages namely reducing odors, reducing the greenhouse effect, preventing the spread of disease, as a source of fuel and electrical energy, inactivating pathogenic bacteria, recycling of nutrients in waste and the potential for a versatile demand-driven energy supply making it a valuable means of contributing and encourage the production of renewable energy (Kumar, 2021). This study aims to determine the optimal composition of the mixture of tofu liquid waste and cow dung to produce good biogas production and quality.

2. MATERIALS AND METHODS

The research was conducted at the Animal Husbandry Waste Management Laboratory, Faculty of Animal Husbandry, IPB University, from January to March 2022.

2.1. Materials and Equipment

The materials used in the research were tofu liquid waste, water, and cow dung. Materials in the form of tofu liquid waste, water, and cow dung. Tofu liquid waste is obtained from the tofu industry in Bogor district. Fresh cow dung was taken from the beef pen in the field laboratory of the Faculty of Animal Husbandry, Bogor Agricultural University. Cow manure is then mixed with tofu liquid waste according to each treatment. After that, the mixture of tofu liquid waste substrate, water, and diluted cow dung is stirred evenly and then put into the digester.

The tools used in this study were digesters, alcohol thermometers, pH meters, analytical scales, measuring cups, aluminum foil, bubble wrap, 100 ml glass bottles, matches, furnaces and ovens.

2.2. Design of Experiment

This research was conducted with four treatments, namely 80% tofu liquid waste and water + 20% cow dung (T80K20), 70% tofu liquid waste and water + 30% cow dung (T70K30), 60% tofu liquid waste and water + 40% cow dung (T60K40), and 50% tofu liquid waste and water + 50% cow dung (T50K50) and three replications each. The treatment is based on the total input volume of the material, namely 15 liters with a 20 liter jerry can capacity used in the production of biogas. The research begins with preparing research tools such as making an anaerobic digester. The biogas digester design can be seen in Figure 1.

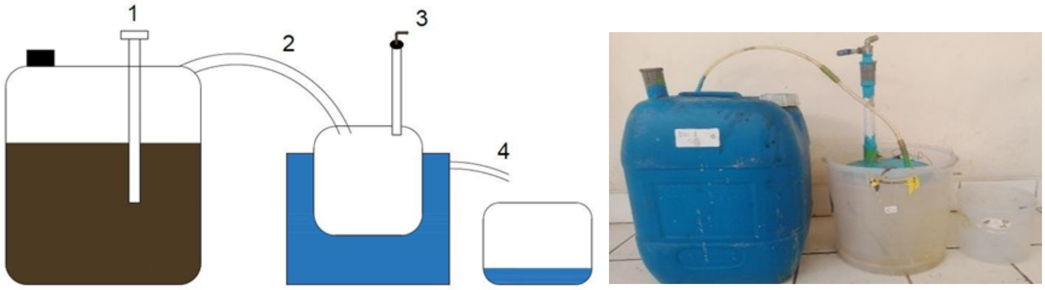

Figure 1. Digester for biogas production: design (left) and real digester (right). (Note: 1 = Sampling pipe, 2 = Gas flow hose, 3 = Gas outlet faucet, 4 = Water flow hose, 5 = Container for biogas production)

2.2. Measurement

Measurements of pH, temperature and biogas production were carried out every day, analysis of C/N ratio, VFA, TS and VS at weeks 1, 3 and 6. Analysis of methane and carbon dioxide every week until the sixth week.

2.2.1. Organic Materials TS (Total Solids) and VS (Volatile Solids)

TS analysis aims to determine the dry component of the material, while the VS is carried out to determine the amount of organic components in the material. This analysis was carried out at the 1st, 3rd, and 6th week of biogas observation. The TS measurement was carried out by measuring the fresh weight of each ingredient, namely tofu liquid waste and cow manure which were then put into the oven for 24 hours at 105⍰.

2.2.2. Digester Temperature

Measuring the temperature in the digester uses a tool, namely an alcohol thermometer by inserting the thermometer into the pipe hole at the top of the digester. Measurements are taken every day at 10.00-11.00 WIB. The temperature measured is the temperature inside the digester with the unit used is ^{o}C.

2.2.3. C/N Ratio

Measurement of the C/N ratio was carried out at the beginning, middle and end using the Walkey and Black method for organic C and the Kjeldhal method for total N.

2.2.4. Substrate pH

The pH measurement was carried out using the potentiometric method, namely by using a pH meter. Measurements were made before and after the study. The first pH measurement method is to calibrate the pH meter using a buffer solution then dry the electrode with tissue paper then with distilled water, prepare the sample in a 500 ml measuring cup, fill it half full, dip the electrode into the sample until the pH meter shows a fixed reading. and record the numbers on the pH meter display.

2.2.5. Methane and Carbon Dioxide

Analysis of methane gas (CH_4) and carbon dioxide (CO_2) was carried out in the first week, second week, third week, fourth week, fifth week and sixth week. The gas was put into a 100 ml glass bottle using a syringe and then labeled. The gas sample is then packaged using bubble wrap and then sent to the BALINGTAN Pati Laboratory using a Gas Chromatography (GC) (CP 4900 variant).

2.2.6. Volatile Fatty Acids (VFA)

Measurement of VFA concentration was using steam distillation method (General Laboratory Procedures 1966). The procedure for measuring VFA, first prepares the distillation apparatus by boiling water and flowing the condenser or cooling water. Then put 5 ml of sample and 1 ml of 15% H_2SO_4 into the distillation apparatus. The resulting VFA was captured with 5 ml of 0.5N NaOH which was put in an Erlenmeyer flask. The VFA concentration was presented in milimol (mmol)

2.2.7. Biogas production

Biogas production was measured every day from the day after filling the material up to 42 days of observation. Daily gas production is measured by measuring the volume of water in the reservoir. The water is obtained from a jar filled with water where there is a smaller jar upside down connected by a small hose to the digester as a bridge for gas transfer so that the water in the jar is pressed by the gas and enters the container jar. The biogas production observed was daily and cumulative biogas production.

2.2.8. Flame test

The flame test is carried out by releasing gas through a pipe that is above the jar and lit with a match. The flame test is carried out after the gas starts to be produced, this aims to determine whether the biogas produced contains enough methane or not.

2.3. Data Analysis

The experiment used was a completely randomized design (CRD) with four treatments namely: addition of 80% tofu liquid waste and water + 20% cow manure (T80K20), 70% tofu liquid waste and water + 30% cow dung (T70K30), 60% tofu liquid waste and water + 40% cow dung (T60K40), 50% tofu liquid waste and water + 50% cow dung (T50K50) each level got three repetitions. The data was analyzed using ANOVA with a general mathematical model:

$$Yij = \mu + Ai + \varepsilon ij \qquad (1)$$

where: Yij: results of observations on the j-th repetition of the treatment of the addition of tofu liquid waste and cow manure level i.

- μ : general average value.
- Ai : treatment of addition of tofu liquid waste and cow dung i.
- εij : experimental error of the addition of tofu liquid waste and cow dung level i in the jth repetition (1, 2, 3,).
- i : level (concentration) of addition of tofu liquid waste and cow dung.
- j : repetition (1, 2, 3).

The data obtained in the form of temperature and pH were not tested by ANOVA, while biogas production, methane gas content, carbon dioxide gas, C/N ratio, VFA, TS and VS were analyzed by analysis of variance (ANOVA) at 95% confidence level, to determine the effect of the treatment and if the treatment has a significant or very significant effect, a Duncan test is performed (Steel & Torrie, 1995).

3. RESULTS AND DISCUSSION

3.1. Total Solids and Volatile Solids

The process of making biogas requires organic materials, namely total solid (TS) and volatile solid (VS) which are useful as food sources for bacteria. Volatile solids are part of the solid (total solid) which turns into the gas phase during the acidification and methanogenesis stages as in the organic waste fermentation process and the number of initial indications of methane gas formation so that substrates with high VS content will produce more biogas (Widarti *et al*., 2012). The total solid and volatile solids in the form of slurry output of the biodigester decreased due to the process of degradation of organic compounds into biogas (Ni'mah, 2014). The results of measurements of organic matter content are shown in Table 1 and Table 2.

Table 1. Development of total solid of different substrate composition

Week	Total Solid (%)			
	T80K20	T70K30	T60K20	T50K50
1	8.86±0.46	8.96±0.20	10.67±1.48	11.91±1.63
3	6.46±1.28	4.58±1.58	5.64±0.28	4.37±0.65
6	3.51±0.24	3.44±0.33	3.82±0.51	3.06±0.80

Table 2. Development of total solid of different substrate composition

Week	Volatil Solid (%)			
	T80K20	T70K30	T60K20	T50K50
1	7,59±0,10	7,84±0,37	9,37±1,39	9,44±0,76
3	5,54±1,36	3,79±1,41	4,55±0,24	3,91±0,46
6	2,71±0,19[a]	2,78±0,26[a]	2,85±0,52[a]	2,10±0,36[b]

Note: Numbers accompanied by different letters in the same line show significantly different results ($P<0.05$)

There was no significant difference in the total solid organic matter content of all treatments at week 1, 3 and 6. There was a decrease in the value of the total solid content in all treatments indicating that organic matter had been degraded by microorganisms in the biogas formation process.

The solid volatile content of the 6th week in the T50K50 treatment showed significantly different results ($P<0.05$) compared to the T80K20, T70K30, and T60K40 treatments. Solid volatile content in the 1st and 3rd weeks showed results that were not significantly different. According to Felix (2012) the total solid content for producing optimal biogas is 8-10%. The T50K50 treatment had a higher initial TS (11.91%) and initial VS (9.44%) compared to the T80K20, T70K30, and T60K40 treatments. The content of TS and VS in each treatment decreased from the first week to the sixth week. This is due to the process of decomposition of the substrate by microbes during fermentation, so that the substrate changes to gas or water (Fairuz *et al*., 2015). The decrease in VS content shows that in the digester there is a process of degradation of organic compounds. The more organic matter digested by microorganisms, the more biogas is produced (Haryanto *et al*., 2019). The highest decrease in VS content was found in the T50K50 treatment, namely 9.44%, decreasing to 2.10% in the 6th week. The more mixture of cow dung in the biogas, the lower the VS content. This is because there are many microorganisms in the cow dung that degrade organic matter for the formation of biogas. Changes in total solid and volatile solid levels tend to decrease during the biogas production process. The decrease in total solids and volatile solids correlated with an increase in the levels of methane gas produced. The mixture of 50% tofu liquid waste and 50% cow manure is a substrate that contains high organic matter (high volatile solids) with simple carbohydrates and sugars which allows bacteria to consume the mixture of tofu liquid waste and cow manure more quickly to become biogas.

3.2. C/N Content of Biogas Substrate

The analysis carried out on cow manure resulted in a C/N ratio of 23.96%, while in tofu liquid waste it was 11.01%. The C/N ratio of materials calculated in Table 3.

Table 3. Development of C/N ratio of different substrate composition

Week	Average C/N Ratio (%)			
	T80K20	T70K30	T60K40	T50K50
1	16,83±0,33[c]	19,49±0,19[b]	20,21±0,63[b]	21,89±0,57[a]
3	15,40±0,46[c]	16,29±1,27[bc]	18,19±0,01[a]	17,82±0,78[bc]
6	13,42±0,58[b]	14,00±0,74[ab]	15,32±1,14[a]	15,14±0,86[a]

Note: Numbers accompanied by different letters in the same line show significantly different results (P<0.05)

The C/N ratio in the first week showed significantly different results (P<0.05), namely the T50K50 treatment produced the highest C/N content of 21.89%, compared to other treatments. There was a decreasing trend in the content of the C/N ratio in all treatments from the first week to the sixth week. The C/N ratio in the 6th week showed significantly different results (P<0.05) in the T60K40 and T50K50 treatments which yielded higher values compared to the T80K20 treatment which was lower in the sixth week of 13.42%. The decrease in the content of the C/N ratio is due to reduced organic matter in the substrate utilized by microorganisms in the biogas formation process. If the C/N ratio is very high, nitrogen will be consumed quickly by bacteria, on the other hand, if C/N is low, a lot of nitrogen is free. To ensure everything runs smoothly, the nutritional elements needed by microbes must be available in a balanced way. The results of research on biogas production with the T50K50 treatment containing a high C/N ratio also resulted in higher production of methane gas.

3.3 Temperature of Biogas Formation Process

Temperature is an important factor in the process of decomposing organic materials in the formation of biogas. The efficiency of anerobic digestion depends on the intensity of bacterial activity which is influenced by several factors: environmental temperature, digester material temperature, loading rate, retention time (Budyrahman, 2014). Biogas daily temperature conditions in each treatment can be seen in Figure 3.

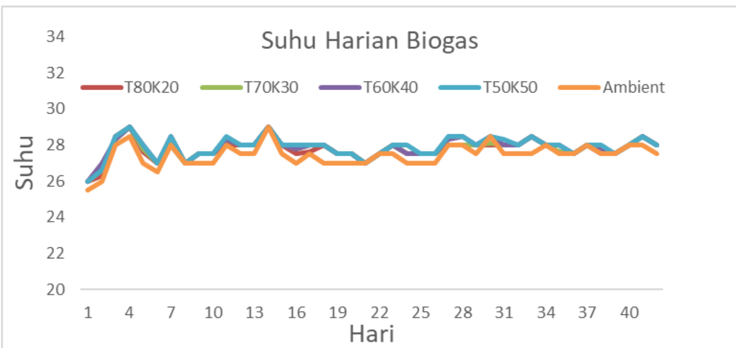

Figure 6. Biogas digester temperature

Changes in biogas temperature that occurred from day 1 to day 42 seemed to fluctuate not too much, either up or down. This happens because the temperature around the digester or room temperature greatly affects the temperature inside the digester. The temperature value used in this study fluctuated following changes in room temperature. The temperature inside the digester is slightly higher due to the decomposition reaction by microorganisms which releases heat in the digester. This temperature condition is maintained in mesophilic conditions, so that microorganisms can survive and grow optimally, so that the decomposition process of organic matter can run optimally. If the temperature during the fermentation process is too low (cold) it can result in a longer biogas formation time. This is related to the statement of Utami *et al.* (2021) that temperature is one of the factors that affect the productivity of methanogenic bacteria that produce methane gas.

3.4 pH of the Biogas Formation Process

The pH factor plays a very important role in anaerobic decomposition because at an inappropriate pH range, microbes do not grow optimally and can even cause death. According to Saputra *et al.* (2010) pH conditions affect the growth of anaerobic microbes in producing biogas, especially methane. Biogas daily pH conditions in each treatment can be seen in Figure 4.

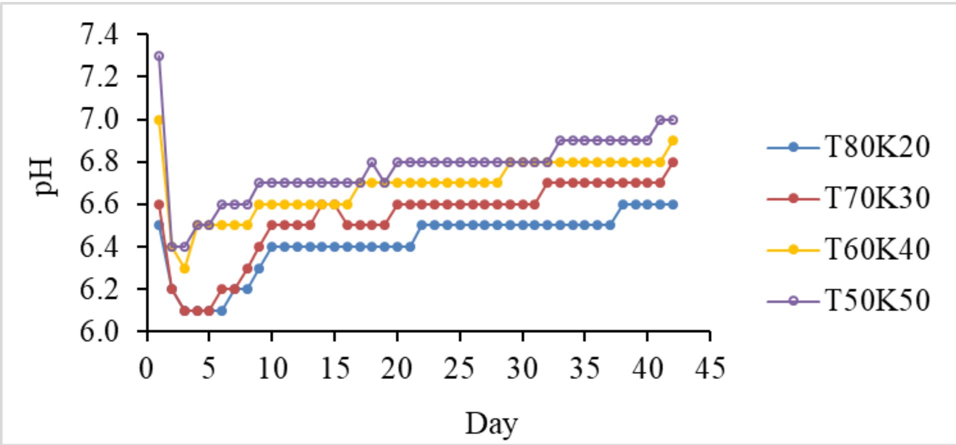

Figure 4. Daily pH during biogas production process

Figure 4 shows that the pH of each treatment is in the ideal pH range. T50K50 and T60K40 had a higher initial pH ranging from pH 7 - 7.3 compared to the pH at T70K30 and T80K20 which resulted in an initial pH ranging from 6.5 to 6.6 indicating that an increase in the amount of cow dung in each treatment caused an increase Biogas substrate pH. The pH conditions in the four treatments were still able to produce biogas with the resulting pH range of 6.1 to 7.0. There was a drastic decrease in pH during the first week of residence after filling the substrate. Initial pH ranged from 6.5 to 7.3 decreasing to 6.1 to 6.4. This happens because in the biogas reactor there has been a process of overhauling organic materials in the hydrolysis and acidogenic stages which produce short chain fatty acids so that the pH drops. The pH at the residence time of the second week to the sixth week began to slowly rise to approach the normal pH, namely pH 7 at the end of the study. This indicates that in the biogas reactor there has been a process of methane gas formation. Methanogenic bacteria start working by consuming acetic acid produced in the acetogenic process to produce biogas so that the pH continues to increase.

Week	Average VFA (mmol)			
	T80K20	T70K30	T60K40	T50K50
1	47,00±2,13^{b}	49,85±1.23^{b}	56,97±3,26^{b}	76,20±10,75^{a}
3	56,97±2,46^{c}	65,52±2,46^{b}	75,49±5,38^{a}	81,18±2,13^{a}
6	86,88±3,26^{b}	97,57±8,89^{ab}	91,16±3,26^{ab}	109,67±14,22^{a}

Note: Numbers accompanied by different letters in the same line show significantly different results (P<0.05)

3.5 Content of VFAs

The process of forming methane, a volatile fatty acid (VFA) is an important indicator. This is because Syntrophomonas and Syntrofobacter convert VFA into acetic acid and hydrogen which will later be used by methanogens to form methane (Harlia *et al*., 2019). Table 4 displays the content of volatile fatty acids in each treatment.

Table 4. Development of VFA content during biogas production

Based on Table 4, it can be seen that the average production of volatile fatty acids in the study from observations in the early, middle and late weeks has increased. There was an increase in VFA production in all treatments from the first week to the sixth week. VFA production in the first week ranged from 47.00 to 76.97. The increase in VFA production occurred continuously to produce the largest production in the sixth week with a production range of 86.88 to 109.67. During the anaerobic process, there are variations in the increase in VFA production. In the T80K20 treatment there was an increase in methane production from 47.00 in the first week to 86.88 in the sixth week. In the T70K30 treatment, an increase was found from 49.85 to 97.57. In the T60K40 treatment, an increase in VFA production was found from 56.97 to 91.16 and in the T50K50 treatment an increase from 76.20 to 109.67. The results of the ANOVA analysis showed that biogas from tofu liquid waste with cow dung had a significant effect on VFA production ($p<0.05$) in the first, third, and sixth weeks. This shows that the addition of cow dung produces high production of volatile fatty acids.

3.6. Biogas Methane and Carbon Dioxide

Methane gas is an important component of biogas to be used as fuel. The methane analysis test aims to see the production of methane gas produced in biogas. Methane production is affected by the growth of methanogenic bacteria which convert volatile acids into methane, carbon dioxide and other products. An increase in the addition of the composition of cow manure to the biogas substrate indicates an increase in the methane gas content produced because cow manure contains many methanogenic bacteria which are produced during digestion in the rumen of cattle. The T50K50 treatment resulted in high methane production. So that the rate of formation of methane is in line with the growth rate of methanogenic bacteria to produce biogas production.

Pure methane is colorless and odorless. The main components of biogas are methane (54-70%) and carbon dioxide (27-45%) (Budyrahman et al., 2014). The formation of methane occurs through several stages, namely hydrolysis, acidogenesis, acetogenesis, and methanogenesis. Methane gas production can be seen in Figure 5. It can be seen that there is a pattern of methane gas production. The optimal dilution ratio between tofu liquid waste and cow dung is in the T50K50 treatment, at this ratio the production of methane gas is higher because the content of solids used as nutrients for bacteria is higher which can support the development of microbes properly. There was an increase in the second week and a decrease in the sixth week, due to the degradation of the nutrients in the biogas substrate so that the nutrients for the methane-producing microbes began to decrease.

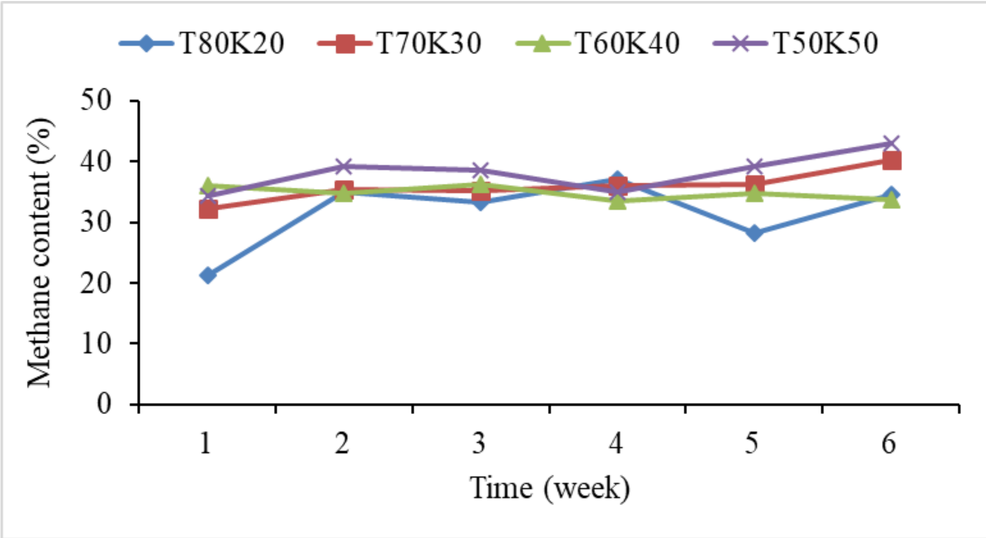

Figure 5. Development of methane (CH_4) content in the biogas

Figure 6 shows a graph of carbon dioxide gas production during the study. Graphs of carbon dioxide gas production tend to be stable from the beginning to the end of the study. In general, there is a tendency for low carbon dioxide gas production in the T50K50 treatment. Carbon dioxide gas production in the third to sixth weeks did not show a significant difference. According to Apriadi *et al.* (2013), the CO_2 content in biogas has a fairly large percentage (ranging from 25-45%).

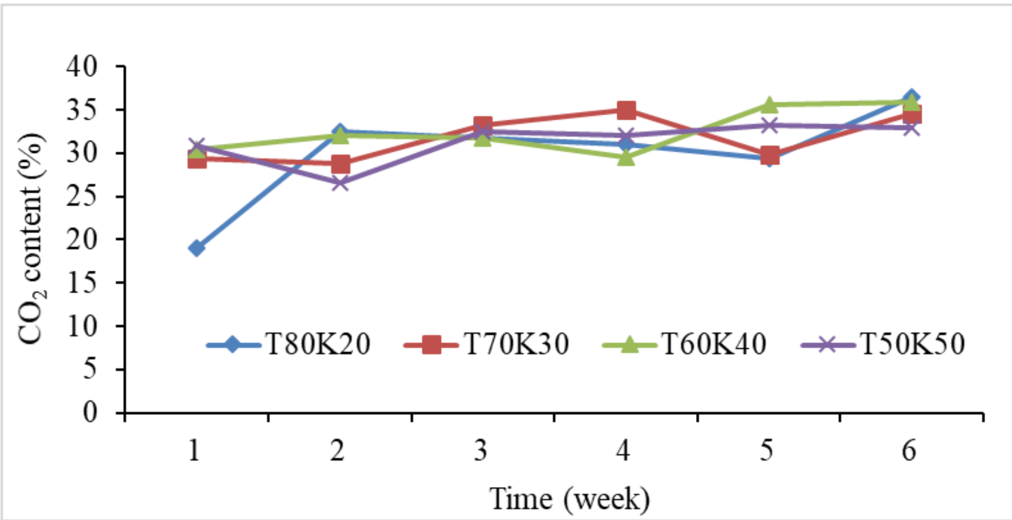

Figure 6. Development of carbondioxide (CO_2) content in the biogas

3.7. Total Biogas Yield

The factors that influence the anaerobic process are temperature, pH, temperature, substrate concentration, C/N ratio, and toxic substances. The C/N ratio and pH play an important role in the process of anaerobic digestion. Substrates with low C/N ratio and high pH need to be balanced to be treated in an anaerobic reactor. Combined processing by mixing more than two ingredients in the form of water, tofu liquid waste and cow dung can balance the value of the C/N ratio and pH. Biogas production of tofu liquid waste with a mixture of cow dung is presented in Table 5.

Table 5. Total production of biogas

Treatment	Total Biogas Yield (ml)
T80K20	20,416.67 ± 15,421.47^{b}
T70K30	35,066.67 ± 27,021.31^{ab}
T60K40	33,170.00 ± 8,225.77^{ab}
T50K50	64,986.67 ± 21,594.34^{a}

Note: Numbers accompanied by different letters in the same line show significantly different results (P<0.05)

The results of the ANOVA analysis of variance showed that there was a difference in the production of biogas from tofu liquid waste with a mixture of cow dung which had an effect on the gas production (P<0.05), namely the addition of 50% tofu liquid waste and 50% addition of cow dung resulted in a higher production of 64,986.97 ml compared to the treatment. So that the addition of cow dung has a significant effect on the resulting gas production. In addition to the conditions of the digester, the characteristics of the substrate, and the growth of organisms that affect biogas production, the influence of the starter is also important, namely to accelerate the reaction, a starter containing methane bacteria is required. Methane bacteria include: methanobacterium, methanobacillus, methanosacaria and methanococcus (Ni'mah, 2014).

The C/N ratio which is considered to function well in the biogas process varies according to Esposito *et al.* (2012) between 10-30, with optimal between 15 and 30. The content of the initial C/N ratio in all treatments ranged from 16.83 to 21.88. So that the C/N ratio can still be used as a nutrient for the growth and development of microorganisms in the formation of biogas. Entered the first week on the second day the gas started to produce. pH is an important factor for the growth of biogas-forming microbes (Afrian *et al*., 2017). The T50K50 and T60K40 treatments produced a suitable pH for biogas formation, namely a pH close to 7 so that biogas formation was faster. There are various kinds of bacteria in cow manure that act as decomposers, such as hydrolytic bacteria, acetogenic bacteria, and matanogenic bacteria (Nurjuwita *et al*., 2021). All of these bacteria play an important role as decomposers in the degradation of organic matter to produce biogas. Seeing the difference in the amount of each composition of tofu liquid waste and cow manure and the difference in the yield of biogas produced, shows that the composition of the addition of tofu liquid waste greatly affects the productivity of bacteria in producing biogas. Adding 80% of tofu liquid waste results in the decomposition process requiring longer residence time The time and development of bacteria will take longer in the formation of biogas due to the low pH and disrupting the process of decomposition of organic matter by microorganisms.

Biogas daily production can be seen in Figure 6. It shows that biogas production has been formed the first two days of research. Treatment T50K50, T60K40 and T70K30 biogas formation started on the second day while in treatment T80K20 it started on the fourth day. The addition of 50% cow dung resulted in the highest production of 2200 ml. The increase in biogas production occurred from the 10th to the 25th day. Biogas production was at a high production level. The T50K50 treatment showed the highest biogas production compared to other variables.

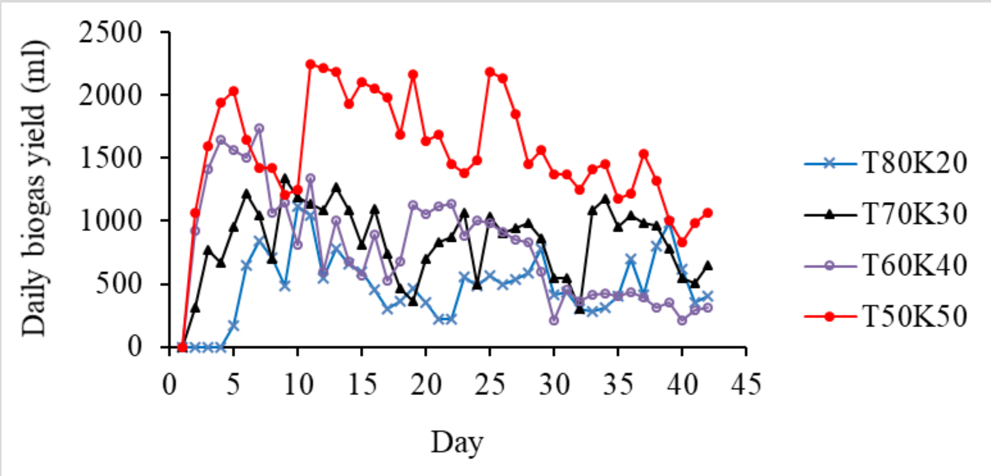

Figure 7. Daily biogas production from different treatment

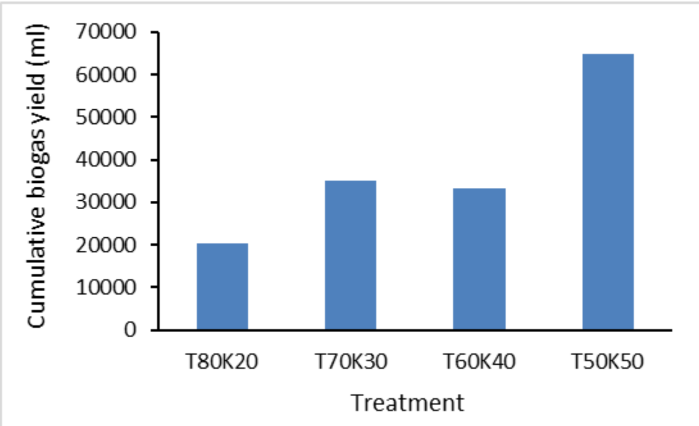

Figure 8. Cumulative biogas production of different treatment

The effect of adding cow dung to the digester is directly proportional to the increase in biogas production and the T50K50 treatment gives maximum biogas production results (Figure 8).

3.8. Biogas Flame

High methane content is an indicator of the quality of the biogas produced and the success of the fermentation process in biogas. The results of the observation of the biogas flame test are shown in Figure 9. It can be seen in Figure 9 that the flame of the reactor in the T80K20 treatment produced a yellowish blue flame and the flames of the reactors T70K30, T60K40, and T50K50 produced a blue flame. The color of the fire shows the heat level of the fire and the contents of the burning contents. Biogas with a high CH4 content will give a large blue flame (Haryanto et al., 2019). According to Uwar *et al.* (2012) CO_2 levels affect the burning of CH_4. Combustion of materials without CO_2 will produce a blue flame while a yellow flame indicates that the CO_2 content contained in the biogas is quite high. The T50K50 treatment so that the resulting flame color is also blue.

Figure 9. Biogas flame resulted from different substrate composition: (a) T80K20, (b) T70K30, (c) T60K40,dan (d) T50K50

4. CONCLUSION AND SUGGESTION

The composition of 50% tofu liquid waste and 50% cow dung produces higher biogas and CH4, produces a faster peak production and produces a blue biogas flame quality. Biogas production of tofu liquid waste with cow manure can be developed in biogas production by adding buffers to the biogas production process to increase the pH to produce better biogas and to conduct research over a longer period of time to determine optimum biogas production.

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