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(Research Article)

Utilization of dried dairy cow feces as biogas substrate and biogas sludge as organic soil conditioner

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Abstract

Utilization of farm waste as an alternative energy source is a form of farm waste management, but field applications are not optimal. The purpose of this study is to find out to what extent the dried dairy cow feces can function as a biogas substrate for an overview of the number of anaerobic bacteria, the volume of bio-gas, and the use of organic carbon-containing biodiesel mud so that it can be used as an organic soil fertilizer. This study uses an experimental research method and looks at the results of an independent T test with two treatments: sundry and dry oven. The tests were done on days 0 (after 4 hours), 7, 14, 21, and 28. The water level, number of bacteria, volume of gas, and pH and organic C content of the biogas sludge were all recorded. The study's findings showed that the number of anaerobic bacteria on days 0 (after 4 hours), 7, 14, 21, and 28 and the amount of biogas on days 14 and 21 did not change whether the samples were dried in the sun or in a furnace. However, on days 7 and 28, the amounts of biogas changed depending on whether the samples were dried in the sun or in a furnace.

Keywords: Dairy cow dung; Biogas sludge; Dried dairy cow feces; Soil conditions; Organic

1. Introduction

Fresh dairy cow feces are commonly used as a biogas substrate; wet conditions and odors are obstacles, so it is attempted by printing and drying it, known as Dried dairy cow feces. Feces from dairy cattle have the potential to be biogas substrates (F. Tufaner et al. 2016). Dried dairy cow feces have quite high economic value because their manufacture does not require high operational costs, they can be mass produced, and the availability of raw materials in Indonesia is quite abundant. Storing solid waste from dairy farms in wet form requires a large area, creates odors, attracts flies, and supports microbial growth, causing contamination of air, soil, and air (F. Tufaner, 2016; Logan et al., 2017; Prachi Pandey et al., 2021). Making Dried dairy cow feces is a solution for providing raw materials for making biogas from solid waste from dairy farms. Some breeders are reluctant to use feces as a biogas substrate, considering the high air content and requiring a large space, which is one of the obstacles to making livestock waste-based biogas. Cow feces drying technology helps reduce air content, odor, and pollution after the printing process, making it easier to store raw materials for biogas (M. Amin N. 2010; Horacio et al. 2019; Lilong Chai. 2022). Dried Dried dairy cow feces can be used as biogas substrates, as evidenced by the growth of anaerobic bacteria accompanied by the formation of gas after going through a biogas production process that involves microbial synthesis involving hydrolysis, acidogenesis, acetogenesis, and methanogenesis (Elijah et al., 2016). In making biogas using Dried dairy cow feces substrate, it produces waste known as biogas sludge. The content of biogas sludge is rich in nutrients needed by soil and plants. If biogas sludge is not managed properly, it will pollute water sources and the soil. One effort in managing biogas sludge

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is that it can be used as an organic soil conditioner. PTO (Organic Soil Improver) has simpler requirements to achieve. The main active ingredient of organic soil amendments is the element carbon (C); therefore, one of the requirements for a minimum organic C content of 15% is stated in Minister of Agriculture Decree 261/KTPS/SR.310//M/4/2019. The aim of this research is to utilize dairy cow feces through a drying process (Dried dairy cow feces) as an energy-producing biogas substrate with a by-product of organic soil conditioner biogas sludge.

2. Material and methods

2.1. Material

The materials used in this research were dairy cow feces, biogas sludge, $K_2Cr_2O_7$, $FeSO_4$, H_2SO_4, Aquades, and ferroin indicators.

Tools used: Plastic trays, pressing tools (Bio Press), dryers, molds with side lengths of 10 cm or 3.9 inches, rubber gloves, wooden trays,. Mask, cement spoon. Drums, Analytical Scales,

2.2. Methods

The research uses experimental and exploratory methods.

The experimental method uses the T test with 2 drying methods (sun drying and oven drying), with observation times on days 0, 7, 14, 21, and 28, and each observation consists of 4 repetitions. The parameters observed are the number of anaerobic bacteria and anaerobic gas volume. The explorative method observes the pH and organic carbon content in biogas sludge.

2.2.1. Observed Variables

The variables observed in this research are

- Dried dairy cow feces water content
- Number of anaerobic bacteria
- Volume of biogas in anaerobic fermentation produced by Dried dairy cow feces of dairy cow feces on observation days 0 (after 4 hours of fermentation), 7, 14, 21, and 28.
- pH
- Organic carbon content in biogas sludge

2.3. Research Implementation

2.3.1. Water Content Measurement

Water content of the sample by weighing a 5-gram Dried dairy cow feces sample in a cup where the dry weight has been measured. Then it is dried in an oven at a temperature of 105 °C until the weight is constant, then the sample in the cup is cooled in a desiccator and weighed again. The determination of water content was carried out in five repetitions. Calculation of water content:

$$\%\text{Water content } = \frac{b-c}{b-a} \text{ x } 100\% \ldots\ldots\ldots\ldots \ (1)$$

Information:
a = weight of an empty cup (g)
b = weight of cup + briquette sample (g)
c = weight of the cup + briquette sample after being oven-dried until the weight is constant (g).

2.3.2. Observation of the Number of Anaerobic Bacteria

- Put 0.2 ml of the sample resulting from the dilution into a Hungarian tube containing 10 ml of 98-5 liquid media, then release the gas contained therein using a syringe.
- Store the Hungarian tube containing the sample in the roll tube for the media. sticks to the side of the tube, and the medium becomes solid.
- Incubate the sample in an incubator at 39 °C for 48 hours.

- Perform calculations and record the total number of bacteria by looking directlyin the Hungarian tube above the colony counter on days 0, 7, 14, 21, and 28.

2.3.3. Biogas Volume Measurement

- Gas volume is measured using the water displacement principle (Anunputtikul). and Rodtong, 2004).
- Take out the gas trapped in the serum bottle using a 50-ml syringe.
- Observe the amount of gas produced by inserting a needle. syringe on the rubber cap of the serum bottle, then the gas in the serum bottle will flow. Push it up so you can see the volume of biogas listed on it. syringe.
- Observations were made on days 1, 7, 14, 21, and 28.

2.3.4. Measurement of C-Organic Content

The C-organic content was found using the Walkley and Black method, which is based on the idea that dichromate can oxidize organic carbon in an acidic environment.

2.3.5. pH measurement

Biogas sludge with Dried dairy cow feces substrate and dairy cow feces were measured using a pH meter.

3. Results and discussion

3.1. Water Content

Dried dairy cow feces after sun and oven drying processes containing water content are shown in Table 1.

Table 1 Average Dried dairy cow feces water content after the drying process

Treatment	repeat	Water Content (%)	
		Sun Dry	Dry oven
Sun	1	12.92	11.68
	2	13.07	12.00
	3	12.78	11.82
	4	13.25	11.34

The high quality of dried dairy cow feces is that they have a maximum water content of 15% (Ministry of Energy and Mineral Resources, 2006), while SNI stipulates that the water content of briquettes is less than 8% (Norman Iskandar, 2019). The lower the water content of dry feces (dried dairy cow feces), the higher the quality. Dried dairy cow feces with a water content of less than 15% has several advantages, including easy storage and transportation. Oven-dried dairy cow feces Dried dairy cow feces have a lower water content compared to sun-dried Dried dairy cow feces. Dry feces (Dried dairy cow feces) containing organic carbon can be used as an energy source for microbial growth in the digester with the addition of water. In line with the opinion of Chiumenti et al. (2017, the water content in the digester is.82% with a solids content of 18%, which is optimal for the growth of biogas-producing microbes.

Sun drying is an economical and easy-to-carry out drying process (Winangsih ., 2013). Drying using the sun-dry method has disadvantages because ultraviolet rays from the sun can cause damage to the contents of the material being dried. Apart from that, sun drying also requires quite a long drying time. Oven drying is considered more profitable because there will be a large reduction in water content in a short time; however, the use of too high a temperature can increase production costs in addition to biochemical changes occurring, thereby reducing the quality of the product produced (Muller et al., 2006; Winangsih et al., 2013).

3.2. Number of Anaerobic Bacteria in Dried dairy cow feces

Data on the number of anaerobic bacteria in the anaerobic fermentation of biogas from the dried feces of dairy cows with different drying methods is presented in Table 2.

Table 2 Average number of anaerobic bacteria in dairy cow feces dried dairy cow feces

Observation Day	Repeat (4X)	Dry treatment	
		sun	Oven
		……… x 10^{10} Cfu/ml………	
0		34.75 ±25.3	56.5±20.1
Sig. (2-tailed)		0.227ns	
7		150.25±15.4	187.5±57.3
Sig. (2-tailed)		0.293ns	
14		157±39.1	173.5±9.4
Sig. (2-tailed)		0.360ns	
21		120± 20.9	113.5±18.7
Sig. (2-tailed)		0.692ns	
28		119±37.4	110.3±38.3
Sig. (2-tailed)		0.762ns	

Information: ns = non signifikan > 0.05

The results of the T test analysis showed that there was no significant difference (P > 0.05) between the sun drying method and the oven drying method, meaning that there was no difference in microbial viability between the Dried dairy cow feces dried in the sun and oven dried in terms of the number of anaerobic bacteria. The sun-dry method treatment showed that the number of anaerobic bacteria increased from day 0 to day 14 and decreased again on days 21 to 28. The oven-dry method treatment increased from day 0 to day 7 and decreased again from day 14 to day 28.

The number of bacteria produced tends to remain stable and has not decreased. shows that the nutrients in the media contained in the digester are still sufficient for the growth of anaerobic bacteria, so that biogas formation continues (Mahliza, 2016; Erika D. A. et al., 2020).

3.3. Biogas Volume in Dried Dairy Cow Feces

Data on the volume of biogas dried dairy cow feces treated with sunlight and oven-dried is in Table 3. Observation data on the volume of biogas produced was carried out for 28 days.

Table 3 Biogas Volume T Test Results on Dried Dairy Cow Feces

Observation Day	Repeat (4X)	Drying	
		Sun	Oven
		……… ml………	
0		0	0
Sig. (2-tailed)		0.000	
7		0.01± 0.008	17.0± 0.8
Sig. (2-tailed)		0.000*	
14		32.9 ±10.7	39.3±5.1
Sig. (2-tailed)		0.320ns	
21		61.0± 9.3	52.8±6.1
Sig. (2-tailed)		0.188ns	
28		168.8 ±11.6	114.0±4.3
Sig. (2-tailed)		0.000*	

Information: *= signifikan <0.05

The results of the T test analysis showed that on Days 7 and 28, there was a significant difference (P<0.05) between the sun drying method and the oven drying method, which means there was a difference in microbial life between the Dried dairy cow feces dried on the sun and oven in terms of biogas volume. Meanwhile, on days 14 and 21, there was no significant difference (P > 0.05) between the sun dry drying method and the oven dry drying method. There was no difference in microbial viability between sun-dried and oven-dried Dried dairy cow feces, as seen from the biogas volume. This is in accordance with the statement (Rahajeng et al., 2019), which states that the smaller the particles, the greater the number of particles digested by microorganisms, so that biogas production will be higher. Many factors influence biogas production, including temperature, substrate type, C/N value, degree of acidity (pH), ingredient content, and stirring. Adding water to the digester aims to meet the optimal water content for biogas formation, namely 91–93% (Adrian E.Cioabla, 2012).

3.4. C-Organic Content

The research results of the C-organic content in biogas sludge can be seen in Graph 1.

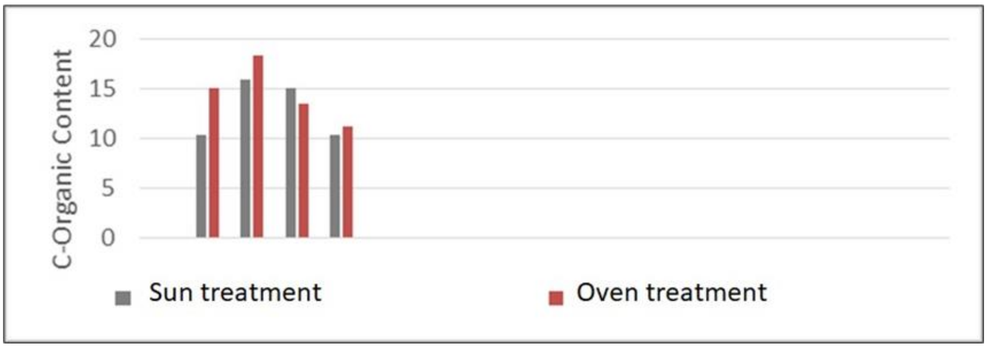

Figure 1 Carbon Organic Content

Graph 1. Dried dairy cow feces substrate biogas sludge can be used as an organic soil conditioner because the organic content in dairy cow feces ranges from 11.34% to 13.25%. This is in accordance with Norman Iskandar's (2019) statement that carbon content is also influenced by the drying process. The longer the drying time for briquettes, the lower the water content in the briquettes, so that the calorific value increases and the carbon content increases. The organic carbon content in biogas sludge is above 10% in accordance with Minister of Agriculture Decree No. 261 (2019). Biogas sludge containing at least 10% organic C can be used as an organic soil amendment, which can increase land fertility and productivity. One of the causes of the degradation of the C-organic content of biogas sludge is the breakdown of organic material by bacteria. Factors that influence the decomposition of organic C are the particle size of the organic material, the number and type of microorganisms, temperature, and pH. The process of decomposing organic material can take place under aerobic and anaerobic conditions. The decomposition process of organic matter is influenced by the presence of microorganisms, especially bacteria (M. Hakimi et al., 2023). .

3.5. pH

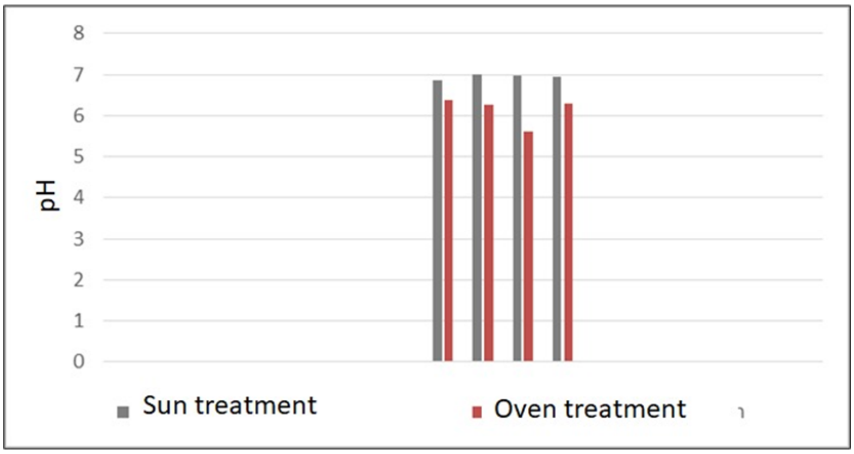

Figure 2 pH Value

The results of research on pH content in biogas sludge using different substrate drying methods obtained different results, as shown in Graph 2.

Based on Graph 2, it states that the pH value of each treatment ranges from 5.60 to 7.00. Based on the average value of each treatment, it produces an average that is in accordance with the minimum technical requirements for organic soil improver pH in Minister of Agriculture Decree No. 261 of 2019, namely 4–9, so it can be applied as an organic soil conditioner. According to the Department of Agriculture, in 2021, the neutral pH of the soil will range between 6.5 and 7.2. Soil with a neutral pH is the ideal pH in terms of the content of organic compounds, microorganisms, nutrients, and minerals under optimal conditions.

4. Conclusion

Based on the results of the research and discussion, the following conclusions can be drawn:

- Dairy cow feces that are dried using sunlight and an oven can be used as a biogas substrate which produces sludge which can be used as a soil conditioner based on the organic carbon content.
- The number of anaerobic bacteria and biogas volume showed the same results between drying using the sun and oven.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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