



Biogas Production from a Mix of Cow Manure with Odor Grass (*Pennisetum purpureum* cv. Mott)

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ABSTRACT

Biogas is one of the alternative energy sources that can be updated because it uses raw materials derived from livestock manure. The research aims to analyze biogas production from a mixture of odor grass and cow manure. The study was conducted with 3 treatments namely 100% cow manure (control), 70% cow manure + 30% odor grass, and 50% cow manure + 50% odor grass. The parameters are temperature, degree of acidity, total solid and volatile solids, volume biogas, flame test, and C and N content measurement. The research design used was a Completely Randomized Design (CRD) Each treatment was repeated three times. The results showed that the mixture of cow manure biogas with odor grass was very real ($P < 0.05$) against the production of biogas produced successive production values for M_{100G_0} , $M_{70G_{30}}$, and $M_{50G_{50}}$ 191.3500 mL; 99,0067 mL and 0.0000 mL. The C/N ratio of each treatment is 27.52; 25.32 and 23.85. The average daily temperature is about the same for all treatments which is 27-29°C. The pH value of each treatment is 5.90-7.27; 5.00-7.00 and 4.77-6.70. The content of TS, VS the initial and final of each treatment is the initial TS of 11,014; 11,007; and 11,195; final TS 6,960; 6,794; and 6,714; initial VS 8,838; 8,965; and 9,309; final VS of 5734; 5,728; and 5,831. Biogas flames with a mixture of odor grass (M_{100G_0}) dan ($M_{70G_{30}}$) produce blue biogas flames ($M_{50G_{50}}$) do not produce flames. A mixture of odor grass and cow dung as a substrate did not produce high levels of biogas, compared to the non-odor grass mixture, which produced higher biogas production

Keyword: Biogas, Cow manure, Fermentation, Odor grass, Production



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1. Introduction

Most Indonesian livestock farmers raise livestock traditionally on a small scale. Cattle are typically raised using either extensive (grazing) or intensive (stall-keeping) systems. Intensive livestock farmers must provide forage (HMT) to meet their livestock's feed needs. Grass is obtained through HMT cultivation and foraging for wild grass (harvesting). Odor grass is one of the forages commonly fed to livestock. Cattle farming has been passed down through generations.

Farmers still have minimal knowledge of animal husbandry. Information on technology and innovation in the field of animal husbandry is very limited. Farmers need adequate management of livestock husbandry,

feed processing, health care, and waste management to improve livestock productivity and quality [1]. Livestock farming is often associated with environmental pollution, both through ozone layering and water and soil pollution. Cow manure also pollutes the air with an unpleasant odor. Farms that do not process cow manure into biogas or fertilizer often allow the manure to accumulate in one location, polluting the environment. One cow produces 8-10 kg of manure per day, or 2.6-3.6 tons per year.

Biogas is a gas produced from organic materials such as animal waste, human waste, or organic waste through a fermentation process in a biodigester. Biogas is a type of energy that can be made from organic materials such as waste, garbage, livestock manure, straw, water hyacinth, and many other materials. A 5 m³ digester with two cows produces 3 m³ of biogas, enough for cooking and running a 400-watt generator for 6 hours [2]. This biogas can replace the cost of 2 liters of kerosene or 10 kg of firewood per day.

Sunaryo reported that to boil 1 liter of water, 0.04 m³ of biogas is needed in 10 minutes, and to cook 0.5 kg of rice, an average of 0.15 m³ of biogas is needed in 30 minutes [3]. Daily household use requires an average of 3 m³ of gas. This study aims to determine the effect of adding odor grass and cow dung on biogas production.

2. Method

2.1 Place

This research was conducted at the Waste Laboratory, Field Laboratory and Integrated Laboratory of the Faculty of Animal Husbandry, Bogor Agricultural University, located on Jalan Agatis, IPB Darmaga campus.

2.2 Materials

The tools used in the study included a digester, an alcohol thermometer, pH meter, an analytical balance, measuring cylinder, furnace, and oven. The materials used in the study were odor grass, leftover animal feed, cow dung, and water. The digester was made from 35-liter jerry can, small hose, jar, pipe, Aibon glue, and No-Drop paint.

2.3 Procedure

This research began with the preparation of tools for making a digester. These tools were assembled into an anaerobic digester. Organic materials in the form of odor grass and fresh cow dung were obtained from the Field Laboratory of the Faculty of Animal Husbandry, Bogor Agricultural University. A total of 12 kg of odor grass was roughly chopped to ± 5 cm to make it easier to insert the material into the digester. 33 kg of cow dung was diluted with water according to each treatment. After that, the chopped odor grass and the diluted cow dung were mixed evenly and then added to the digester.

2.3.1 Treatment

The treatment in this study was a mixture of cow dung with odor grass, namely a control of 100% cow dung without odor grass (M₁₀₀G₀), a mixture of 70% cow dung and 30% odor grass (M₇₀G₃₀) and a mixture of 50% cow dung and 50% odor grass (M₅₀G₅₀) each repeated three times with a composition of odor grass, cow dung, and water.

Table 1. Composition of Filling Ingredients

Treatment	Composition of Filling Ingredients		
	Odor Grass (Kg)	Cow Manure (Kg)	Water (Liter)
M ₁₀₀ G ₀	-	5.00	10.00
M ₇₀ G ₃₀	1.50	3.50	10.00
M ₅₀ G ₅₀	2.50	2.50	10.00

2.3.2 Temperature

Temperature was measured daily after the material was loaded. The temperature inside the digester was measured using an alcohol thermometer, inserted into the pipe hole at the top of the digester. Measurements were taken three times daily: morning, afternoon, and evening. The morning measurement was taken between 7:00 and 8:00 a.m. Western Indonesian Time (WIB), the afternoon measurement was taken between 12:00 and 1:00 p.m. Western Indonesian Time (WIB), and the afternoon measurement was taken between 4:00 and 5:00 p.m. Western Indonesian Time (WIB).

2.3.3 Degree of Acidity (pH)

The pH measurements were performed using the potentiometric method, using a pH meter. Measurements were taken daily during the study in the morning. The pH meter was first calibrated with

standard buffer solutions of pH 4 and 7. Prepare a 500 ml measuring cylinder and fill it halfway. The pH meter probe was inserted into the sample. The pH value will be read on the pH meter display.

2.3.4 Total Solids (TS) and Volatile Solids (VS) Organic Matter

The characteristics of the substrate materials were analyzed, namely TS (total solids) and VS (volatile solids). TS analysis aims to determine the dry components of the material, while VS is carried out to determine the number of organic components in the material. This analysis was carried out at the beginning of the digester filling and at the end of the biogas observation. Measurements were carried out at the Integrated Laboratory of the Department of Animal Production Science and Technology, Faculty of Animal Husbandry, Bogor Agricultural University. Initial TS measurements were carried out first by measuring the fresh weight of each material, namely odot grass and cow dung, which were then placed in an oven for 24 hours at a temperature of 104°C. After the material was dry, the mass of the material was measured to obtain the water content value. After the water content value was obtained, the TS value of the material was calculated. VS calculations were carried out by measuring the mass after being dried in an oven and then ashed in a furnace for 2 hours at a temperature of 550°C. The material that had become ash was then measured and calculated. The following are the calculations for water content, total solids, ash content, and volatile solids.

2.3.5 Volume Biogas

Measurements were conducted daily from the day after filling the material for 42 days of observation. Daily gas production was measured by measuring the volume of water in the reservoir. The water was obtained from a jar containing water, where a smaller jar, upside down, was connected by a small hose to the digester to act as a gas transfer bridge, allowing the water in the jar to be compressed by the gas and enter the reservoir jar (Figure 1). The biogas volumes observed were daily and cumulative biogas volumes.

2.3.6 Flame test

The flame test is performed by releasing gas through a valve located above the gas tank and lighting it with a match. The flame test is performed after gas begins to be produced. This test aims to determine whether the biogas produced contains methane, allowing it to be used as a substitute for kerosene or LPG.

2.3.7 C and N Content Measurement

C and N content measurements were conducted in the Soil Laboratory, Faculty of Agriculture, Bogor Agricultural University, using the Walkley and Black method for organic carbon and the Kjeldhal method for total nitrogen. Once the carbon and nitrogen contents were determined, the ratio of each treatment was calculated using the C/N ratio formula.

2.4 Data Analysis

The research design used was a Completely Randomized Design (CRD) with three treatments of a mixture of cow dung and odot grass, namely a control of 100% cow dung without odot grass ($M_{100}G_0$), a mixture of 70% cow dung and 30% odot grass ($M_{70}G_{30}$) and a mixture of 50% cow dung and 50% odot grass ($M_{50}G_{50}$). Each treatment was repeated three times. The data obtained were analyzed using variance (ANOVA) at a confidence level of 95%, to determine the effect of the treatment and if the treatment had a real or very significant effect, the Tukey test was carried out also using descriptive analysis [4].

3. Result and Discussion

3.1 Material Characteristics

The C/N ratio is the comparison between carbon and nitrogen in an organic material [5]. The two main elements that make up the organic material substrate are carbon and nitrogen. The C/N ratio of odot grass is 20.18, while cow dung is 27.52. The calculated C/N ratio of the material is shown in Table 2.

Table 2. C/N ratio of material

Treatment	Cow Mature	Odor Grass	Rat C/N
$M_{100}G_0$	100	0	27,52
$M_{70}G_{30}$	70	30	25,32
$M_{50}G_{50}$	50	50	23,85

Methanogens require a number of macro and micronutrients to grow. The most important macronutrients are nitrogen (N), phosphorus (P), and potassium (K). Nitrogen is used by bacteria to produce protein. Typically, the C/N ratio should be less than 30, as nitrogen is a limiting factor for bacterial growth. Nitrogen levels should not be too high, as this can also inhibit the process [6]. Anaerobic microorganisms require carbon (C) as the primary source of energy and carbon formation for cells, to produce volatile fatty acids, methane (CH_4), and

CO₂. Anaerobic microorganisms also require nitrogen (N) for life and cell division [7]. A C/N ratio that is too high will inhibit microbial performance, resulting in low methane gas production. An N value that is too high will increase ammonia, which becomes toxic and causes microbial death. The optimum C/N ratio, according to Dioha, is 20-30. Based on their data, the C/N ratio for each treatment was 27.52; 25.32; and 23.85 values for each treatment meet the optimum ratio according to Dioha [8].

3.2 Temperature Conditions During the Biogas Formation Process

Temperature affects the activity of microorganisms that decompose organic matter in the digester. Increasing the temperature can accelerate the rate of decomposition, resulting in more optimal gas production and a more efficient decomposition process. The methane formation process operates in the range of 25-40°C [9]. Temperature measurements were taken three times a day: morning, noon, and evening. The following temperature measurement results (morning, noon, and evening) for each treatment can be seen in Figures 1.

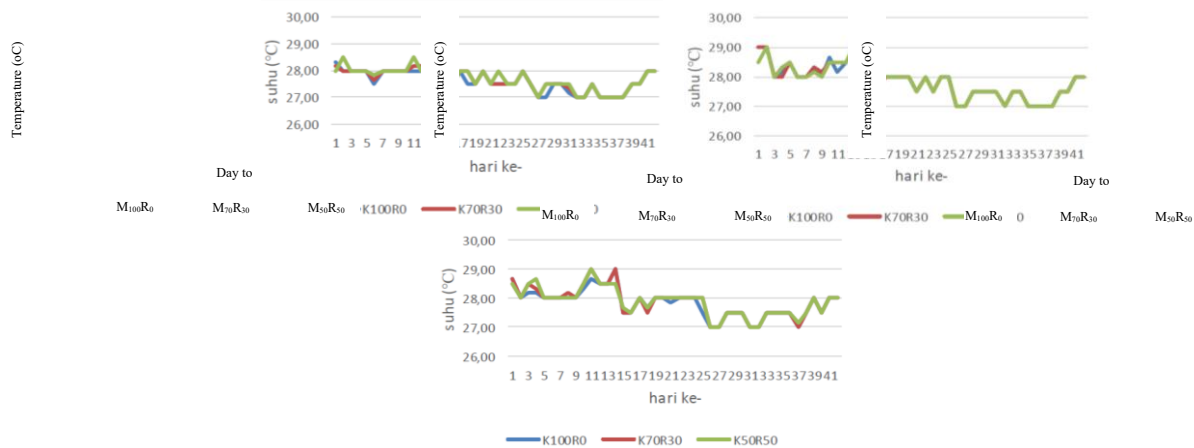


Figure 1. Temperature measurement result

Observations show that the temperature in the digester in the morning for each treatment tends to be stable, as seen from the overlapping graphs. The same thing also occurs in observations of the afternoon and evening temperatures, where the temperature in the digester for each treatment tends to be the same. According to Junaidi, the average digester temperature does not differ much because the digester is placed indoors and is not exposed to direct sunlight [10]. Temperature affects the formation of methane gas; the amount of gas contained in the material is formed quickly when the temperature is high, and conversely, if the temperature in the digester is low, the gas formation process will be slow [11].

Anaerobic bacteria can survive from low temperatures up to 70°C, but work optimally at mesophilic temperatures (25-40°C, with an optimum temperature of 35°C) or thermophilic temperatures (50-65°C, with an optimum temperature <55°C). The best temperature for producing biogas is thermophilic, where the higher the temperature in the digester, the easier it is for bacteria to break down the existing organic material. A good temperature for the biogas formation process is in the range of 20-40°C and the optimum temperature is in the range of 28-30°C [12].

3.3 pH Conditions During the Biogas Formation Process

Besides temperature, one factor that influences biogas production is pH. If it is too low or too high, the growth of microorganisms that decompose organic matter will be disrupted and may even die, preventing the breakdown of organic matter and preventing biogas from being formed. The results of the acidity measurement are shown in Figure 2.

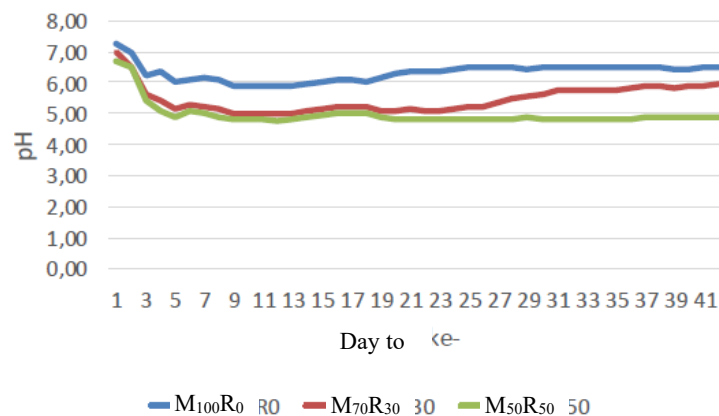


Figure 2. Daily pH value for each treatment

Based on the results of the pH graph, the pH experienced a decreasing process starting from the first day of around 7 in each treatment, then decreased on the following day until on the 20th day it began to increase again and biogas began to be produced on the 17th day. However, the K₅₀R₅₀ treatment pH tended to be low when the pH of other treatments increased for this treatment there was no increase, remaining at pH 4.8-4.9. The low pH in K₅₀R₅₀ resulted in no biogas production. The pH condition affects the growth of anaerobic microbes in producing biogas, especially methane [7]. Biogas began to appear at pH 6 and its production continued to increase at pH approaching 7 from the results of measuring the pH of the substrate liquid in the digester, the pH value was between 6-7, meaning that the acidity value of the substrate formed was suitable for producing biogas. Methane gas will form when the pH is between 6.5-7.5 and after 2-3 weeks, the pH will rise again, indicating the development of methanogenic bacteria [11]. The optimum pH required by acidogenic bacteria is 5 to 6.5, while the optimum pH for methanogenic bacteria is above 6.5 [13]. The optimum pH for biogas production is in the pH range of 6-8, with the highest production at pH 7 [14]. The decrease in pH in each treatment indicates that the microorganisms working in the initial stage are microorganisms in the acidogenesis process that have very fast growth, thus increasing the acidity level [15].

The biogas formation process is influenced by several factors, including pH and temperature. The pH value is crucial and needs to be considered in biogas formation because it can determine the condition of the microbes present in the biogas. The pH level influences enzyme activity within microorganisms, and each enzyme is only active at a specific pH and has maximum activity at an optimal pH. Each microorganism has a different optimal pH range. If the digester contains high levels of volatile acids, the methane gas formation process will be hampered or even stopped, as a pH below 5 will be toxic to methanogenic bacteria [16].

3.4 The Effect of Total Solids and Volatile Solids on Biogas Formation

Material characteristics influence the production and productivity of the biogas produced [17]. Too low a total solid concentration will result in a reduced nutrient source for microorganisms, resulting in a suboptimal decomposition process, resulting in less biogas production. Total volatile solids indicate the amount of organic material that serves as a nutrient source for anaerobic bacteria. Total volatile solids are used by bacteria to produce biogas by anaerobic bacteria. Total volatile solids represent the organic portion of the total solids [18]. The total solid and volatile solid values for each treatment can be seen in Table 3.

Table 3. Total solid and volatile solid values

Treatment	Start		End	
	TS (%)	VS (%)	TS (%)	VS (%)
M ₁₀₀ G ₀	11,014±0,003 ^b	8,838±0,0080 ^c	6,960±0,0230 ^a	5,734±0.0190 ^b
M ₇₀ G ₃₀	11,007±0,003 ^b	8,965±0,0382 ^b	6,794±0,0360 ^b	5,728±0,0170 ^b
M ₅₀ G ₅₀	11,195±0,011 ^a	9,309±0,0070 ^a	6,714±0,0110 ^c	5,831±0,0230 ^a

Superscripts with different letters indicate significant differences (P<0.05)

Table 3 shows a decrease in the initial total solids content, ranging from 11% to 6.7-6.9% after the study was completed. The volatile solids (VS) value for each treatment also decreased, ranging from 8.8-9.3 to 5.7-5.8 after the study was completed. ANOVA results showed significant differences between each treatment (P<0.05). This indicates that organic matter is being broken down, resulting in biogas production. Volatile solids are a substrate for non-methanogenic microorganisms that work in the initial stages of biogas production. The decrease in volatile solids indicates that organic compounds are being degraded by non-methanogenic microorganisms in the biodigester. Total solids and volatile solids in the form of slurry output from the biodigester decreased due to the degradation of organic compounds into biogas [15].

The optimum total solids required by microbes for fermentation is 5% to produce optimal methane content [19]. The higher the total solids content, the higher the biogas yield [18]. Optimal biogas yield is 8-10% total solids [20]. The VS removal indicates the degradation of organic compounds within the digester. The more organic matter digested by microorganisms, the more biogas is produced [21].

3.5 Biogas Production

Biogas production results from the breakdown of organic matter by microorganisms from livestock manure, producing a gas dominated by methane and carbon dioxide. The relationship between biogas production from a mixture of odot grass and cow manure is presented in Table 4.

Table 4. Average biogas production from a mixture of cow dung and odot grass

Treatment	Volume (ml)
M ₁₀₀ G ₀	191,3500 ± 206,24022 ^a
M ₇₀ G ₃₀	99,0067 ± 76,80041 ^b
M ₅₀ G ₅₀	0,0000 ± 0,00000

Superscripts with different letters indicate significant differences (P<0.05)

Based on Table 4, biogas production from the control (M₁₀₀G₀) is greater than the biogas production of the M₇₀G₃₀ and M₅₀G₅₀ treatments. The M₅₀G₅₀ treatment does not produce biogas because the amount of solids present affects the duration of decomposition and it is estimated that volatile acids are formed in the hydrolysis-acidogenesis process which causes the presence of methanogenic bacteria to be disturbed so that biogas is not formed. The main factor that influences the difference in the volume of biogas produced is the physical properties of the filling material caused by the water content and pH levels in each composition of the ratio of dirt and water resulting in the mixed conditions in each composition having different properties [22]. Figure 3 is a graph of biogas production from each treatment during 42 days of observation.

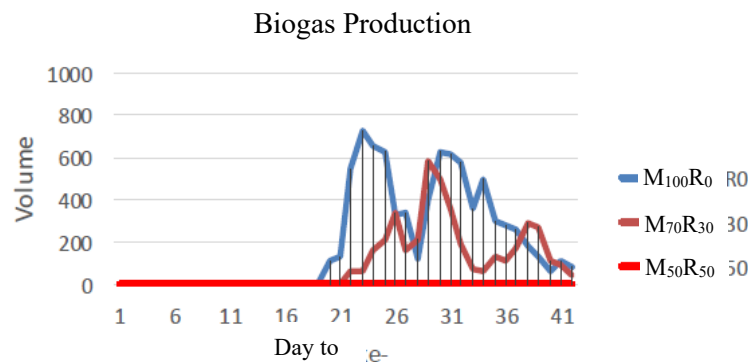


Figure 3. Daily biogas production for each treatment

Based on Figure 3, it is known that biogas began to be produced on the 17th day and the highest production occurred on the 23rd day then gradually decreased on the 28th day and increased again, while the production of the control (M₁₀₀G₀) was higher compared to the M₇₀G₃₀ and M₅₀G₅₀ treatments. In general, the fermentation time to produce biogas is around 15 to 30 days [23]. The M₅₀G₅₀ treatment did not produce biogas because it had a low pH as according to Ozmen and Aslanzadeh a pH below 5 will have a toxic effect on methanogenic bacteria so that methane gas is not formed [16]. According to Budiyo a pH value below 6 will begin to disrupt the activity of methanogenic bacteria and if it reaches 5.5 bacterial activity will stop completely [24]. The pH concentration in this reactor is greatly influenced by the amount of volatile fatty acids (VFA), ammonia, and CO₂ produced. The pH value decreases due to the production of volatile acids in the hydrolysis-acidogenesis process [15], the amount of K₅₀R₅₀ treatment solids also affects the duration of decomposition and it is estimated that volatile acids are formed in the hydrolysis-acidogenesis process which causes the existence of methanogenic bacteria to be disrupted so that biogas is not formed.

3.6 Biogas Flame

The flame test is an indicator to determine whether the gas contains methane. High methane (CH₄) content is one indicator of the success of the fermentation process in biogas. During the observation process of biogas production, it was found that in the M₁₀₀G₀ and M₇₀G₃₀ treatments, the flame was blue. This is in accordance with the research of Fairuz which stated that a blue flame indicates a very high methane content compared to other gas contents besides methane [17]. Good quality biogas consists of around 55-70% methane followed by around 30-45% carbon dioxide [21]. Biogas with a high methane (CH₄) content will produce a large blue flame [21]. According to Uwar the CO₂ level affects the combustion of methane (CH₄) [25]. Burning materials without CO₂ will produce a blue flame, while a yellow flame indicates that the CO₂ content in the biogas is quite high.

4. Conclusion

A mixture of odot grass and cow dung as a substrate did not produce high levels of biogas, compared to the non-odot grass mixture, which produced higher biogas production. Adding 50% odot grass produced no biogas.

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