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THE IMPACT OF BIOSTARTER EM-4 AND COW FECES ON THE QUALITY OF BIOGAS FROM SUGARCANE BAGASSE FIBRE

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ABSTRACT

Energy demand is increasing every year. The unlimited use of energy causes energy supplies to run out if used excessively, causing an energy crisis. This is a serious problem that must be addressed by finding renewable energy. Renewable energy can be created from biomass. Biomass from agricultural waste in the form of bagasse (BF) and livestock waste in the form of cow feces (CF) can be used as biogas filling material. The purpose of this study was to determine the impact of the composition of bagasse fibre (BF) and cow feces (CF) using EM-4 biostarter to produce biogas. Variations in the composition of bagasse fibre (BF) and cow feces (CF) in this study were 50% BF : 50% CF, 40% BF: 60% CF and 30% BF: 70% CF without using EM-4 biostarter and using EM-4 biostarter. The method used was experimental method. The results showed that EM-4 biostarter and cow feces affect the quality of biogas when viewed from indicators such as pH, gas pressure and gas temperature. The use of EM-4 biostarter and cow feces is very important in the fermentation process and biogas formation. The pH value in samples using EM-4 biostarter is more acidic than the pH value without using EM-4 biostarter. The use of EM-4 biostarter can accelerate the fermentation process and biogas production so that more gas was produced. The impact of cow feces in producing gas is that the greater the amount of cow feces mixed with bagasse, the higher gas pressure produced.

Keywords : Sugarcane Bagasse, Cow Feces, Biostarter EM-4, Biogas Quality, Biomass

I. INTRODUCTION

Energy is a force used for activities. Energy can be divided into two types, namely renewable energy and non-renewable energy. Renewable energy is energy from sustainable natural processes such as solar, wind and geothermal power. While non-renewable energy is energy that if used continuously until it runs out, it takes a very long time to replace it, one example is fossil fuels. The abundant and unlimited use of energy causes the supply of energy availability to be depleted [1].

The highest energy use in Indonesia comes from fossil fuels, reaching 95% [2]. The higher the use of fossil fuels, the higher the impact of air pollution such as depletion of the ozone layer due to global warming, health problems and environmental damage [3]. In addition, global warming can increase greenhouse gas emissions [4] so it is necessary to increase the utilisation of renewable energy so that fossil fuel supplies do not run out quickly. Long-term sustainability and energy security can be met by optimising the use of renewable energy such as biomass [5].

Biomass is a material derived from plants, animals and microbes. Materials for making biomass are divided into two types, the first comes from animals in the form of microorganisms or macroorganisms and the second comes from crops left over from processing or direct harvesting. Generally, fuel in the form of biogas comes from animal biomass while fuel from vegetable biomass is briquettes and bioethanol [6]. Humans have been using

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biomass as an energy source since ancient times, but biomass energy sources have been sidelined since they recognised fossil fuels. The fuel used in ancient times came from waste [7].

Agricultural and livestock waste is an energy source that is expected to replace gas fuel sources. One of the agricultural wastes that can be used as gas fuel is bagasse. Stockpiling bagasse in a certain time will cause problems, because this material is flammable, pollutes the surrounding environment and takes up a large area of land for storage [8]. Sugarcane that is milled will produce 35-40% bagasse. If used as fuel, the quality of bagasse is influenced by the level of softness and soil content contained in the bagasse [9]. Bagasse has a yellowish colour, fibrous and soft [10].

Livestock waste such as cow feces, if left alone, will produce methane gas. Burning methane gas can produce carbon dioxide gas, causing the amount of carbon dioxide in the air to increase and causing the greenhouse effect [11]. A cow with a mass of 454 kg can produce 30 kg of feces every day. With a cow feces weight of 10 kg/head/day can produce 0.36 m3 of biogas [12]. Cow feces contain hemicellulose 18.6%; sellulose 25.2%; lignin 20.2%; nitrogen 1.67%; phosphate 1.11% [13].

Sugarcane bagasse fibre and cow feces can be used as fuel, namely biogas. Biogas is an anaerobic fermentation of organic matter assisted by mycoorganisms and produces gas that can be burned. The main components of biogas are methane gas (CH_4), carbon dioxide (CO_2), hydrogen sulphide (H_2S), ammonia (NH_3), hydrogen (H_2) and nitrogen (N) [14]. The content of biogas can vary depending on the type of material used and the environmental conditions involved during the fermentation process [15]. Biogas has characteristics such as blue-coloured fire, clean and the temperature of the fire produced is higher than other fuels. The gas produced is usually methane gas and carbon dioxide gas [16]. To accelerate fermentation in the process of making biogas with anaerobic conditions, a biostarter is needed. Biostarter commonly used in anaerobic fermentation is Effective Microorganism (EM-4) [17]. In addition, to facilitate the process of decomposing the biogas filling material, an anaerobic digester is used [18]. In anaerobic digesters, complex organic matter is converted into biogas with the help of microorganisms [19].

The purpose of this study was to determine the impact of the composition of bagasse fibre (BF) and cow feces (CF) using EM-4 biostarter to produce biogas. In this study, the composition of BF and CF used was 50% BF : 50% CF, 40% BF : 60% CF and 30% BF : 70% CF without using EM-4 biostarter and using EM-4 biostarter. Biostarter EM-4 is expected to accelerate the fermentation process in biogas so that gas is formed quickly. The use of cow feces is expected to increase the pressure value of the gas produced. The use of biomass waste can reduce the impact of global warming and can be used as renewable energy to reduce the use of fossil fuels. This research was conducted at the Physics Laboratory, Faculty of Mathematics and Natural Sciences, Padang State University. The title of this research is **"THE IMPACT OF BIOSTARTER EM-4 AND COW FECES ON THE QUALITY OF BIOGAS FROM SUGARCANE BAGASSE FIBRE".**

II. METHOD

This type of research was experimental research. The measuring instrument to measure temperature and pressure on the gas using the Tire Pressure Monitoring System. The measuring instrument to measure pH uses a digital pH meter. This research was conducted with several stages including the stage of making a biogas digester, the sample preparation stage, the sample making stage, the stage of filling the mixed material into the digester and the data collection stage which was carried out for 28 days. There are three composition variations used in the manufacture of Bf and CF samples, namely 50% BF : 50% CF, 40% BF : 60% CF and 30% BF : 70% CF without EM-4 biostarter and the use of EM-4 biostarter.

The purpose of this study was about the impact of EM-4 biostarter and cow feces from bagasse fibre with indicators of pH, biogas pressure and gas temperature. In this study, several tools were used to make the digester, namely: 30 litre drum, gas tap stop, silicone glue, gas hose clamp, electric drill, double tape, scissors, gas hose, tyre valve, drill bit, knife, Daimaru paper glue and gloves. The measuring instruments used in this research are analytical scales, Tire Pressure Monitoring System (TPMS), digital pH meter, beakers and measuring cups. The materials used were cow feces, bagasse fibre, EM-4 and water. The digester is where the anaerobic fermentation process occurs. The digester used has corrosive properties and can store heat so that it uses a plastic drum, the lid of the digester is flat and there is a gripper. The digester used can be seen in Figure 1 below.

Fig 1. Digester Reactors

Based on Figure 1 for the shape of the digester reactor, the type of digester used is batch feeding with digester filling material can be replaced with new filling material if the old filling material cannot produce gas [20]. It is necessary to pay attention to the amount of material that is put into the digester reactor. The total mass of biogas filling material is 5 kg with a volume of water of 5 litres. The ratio between the volume of water and EM-4 biostarter is used 1 ml of water for every 1 litre of water. The dry ingredients consisted of bagasse fibre and cow dung. Sugarcane bagasse fibre ready for use can be seen in Figure 2.

Fig 2. Bagasse Fibre

Based on Figure 2, it can be seen that bagasse fibre must first be chopped at the Padang City Agriculture Office. The smaller the particle size, the faster the decomposition process [21]. Meanwhile, cow feces was taken from a farm on Jalan Gurun Laweh, Koto Panjang Ikua Koto, Padang City. The cow feces used is fresh cow feces so that it is easily mixed with bagasse during the stirring process. In the data collection stage using primary data. Primary data is data collected directly from the main source. Primary data used are initial ph measurements taken when the filling material is put into the digester and the final ph is taken after the biogas fermentation for 28 days, gas temperature measurements and gas pressure measurements.

III. RESULTS AND DISCUSSION

The samples have been successfully made in the form of sludge and have been homogeneously mixed with various variations in the composition of bagasse fibre (AT) and cow feces (FS), namely 50% BF : 50% CF, 40% BF : 60% CF and 30% BF : 70% CF by using EM-4 biostarter and without using EM-4 biostarter.
Based on the measurement results, the following results were obtained:

1) pH Value of Digester Fill Material

The pH of the digester filling material was taken twice, namely the initial pH and the final pH. Before the sample is put into each digester, the pH of the sample is measured first and this is referred to as the initial pH. Meanwhile, the final pH is taken after the fermentation process ends. The degree of acidity (pH) affects the growth of anaerobic microbes in producing gas, especially methane gas. The pH measurement is to see the acidic or alkaline nature of a digester filling material. The following can be seen the initial pH and final pH values in the variation of AT and FS composition, namely 50% BF : 50% CF, 40% BF : 60% CF and 30% BF : 70% CF without using EM-4 biostarter and using EM-4 biostarter in Table 1.

Table 1. Initial pH and Final pH values of AT and FS without using and using EM-4 biostarter.

Composition Variation		Initial pH	Final PH	Standart conditions PH 5-8
50% BF : 50% CF	Without EM-4	7,17	6,28	Complete
	With EM-4	6,91	6,19	Complete
40% BF : 60% CF	Without EM-4	7,20	6,34	Complete
	With EM-4	6,86	6,19	Complete
30% BF : 70% CF	Without EM-4	6,58	6,29	Complete

Composition Variation	Initial pH	Final PH	Standart conditions PH 5-8
With EM-4	6,51	6,04	Complete

Based on Table 1, the initial pH and final pH values with the composition of 50% BF : 50% CF without using EM-4 biostarter is 7.17 and 6.28. The initial pH and final pH values with the composition of 50% BF : 50% CF using EM-4 biostarter are 6.91 and 6.19. The initial pH and final pH values with the composition of 40% BF : 60% CF without using EM-4 biostarter are 7.20 and 6.34. The initial pH and final pH values with the composition of 40% BF : 60% CF using EM-4 biostarter are 6.86 and 6.19. The initial pH and final pH values with the composition of 30% BF : 70% CF without using EM-4 biostarter are 6.58 and 6.29. The initial pH and final pH values with the composition of 30% BF : 70% CF using EM-4 biostarter are 6.51 and 6.04.

The pH value in the sample without the use of EM-4 biostarter is higher than the provision of EM-4 biostarter. This is due to the EM-4 biostarter is already acidic with a pH of 3.25 so that it affects the pH of the biogas filling material. Biostarter is useful for accelerating the biogas fermentation process. The initial pH value of the digester filling material for all variations of biogas composition has a value with a range of 6.5-7.2. The ideal pH for biogas formation is 5-8 [22]. From the initial pH measurement results, it shows that the pH conditions are feasible and meet the standards for fermentation so that the fermentation process can run well and optimally. The pH value of the biogas filling material can decrease or increase during the fermentation process [23]. In this study, the final pH value was in the range of 6-6.34 so that at the end of biogas fermentation caused the biogas production process to decrease. This shows that the activity of methanogenic microorganisms decreases while the activity of acetogenic bacteria increases so that more acetic acid is contained [24]. The pH value affects the quantity of biogas [25]. The initial pH value tends to be close to the neutral pH value, this has been discussed in research [26] made from cow faeces and corn cobs that it is because the constituent materials of biogas are fresh materials. As long as the pH value is still in acidic conditions, methane gas production will continue [25].

2) Pressure Value of Biogas

Gas pressure values were taken in Week 1, 2, 3 and 4. Gas pressure data was taken using TPMS. The following can be seen the gas pressure values of AT and FS with a composition of 50% BF : 50% CF, 40% BF : 60% CF and 30% BF : 70% CF without using EM-4 biostarter and using EM-4 biostarter for 28 days in Table 2.

Table 2. Pressure values of AT and FS without using EM-4 and using EM-4 biostarter.

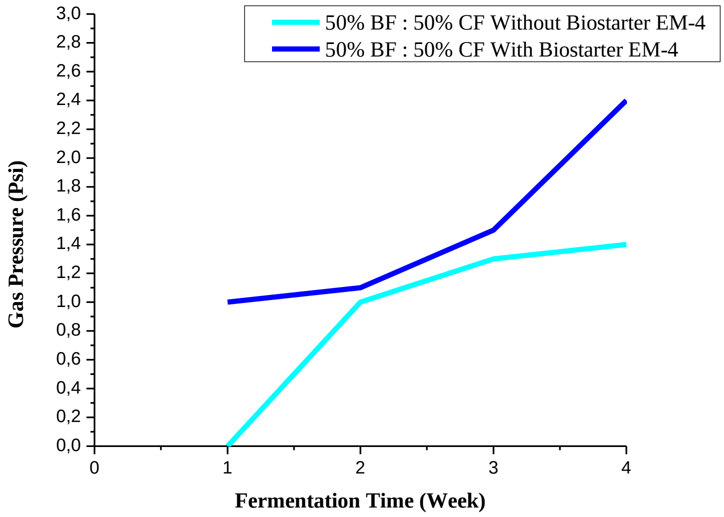
Composition Variation		Gas Pressure (Psi)			
		Week 1	Week 2	Week 3	Week 4
50% BF : 50% CF	Without EM-4	0 Psi	1 Psi	1,3 Psi	1,4 Psi
	With EM-4	1 Psi	1,1 Psi	1,5 Psi	2,4 Psi
40% BF : 60% CF	Without EM-4	0 Psi	1,1 Psi	1,4 Psi	1,5 Psi
	With EM-4	1 Psi	1,1 Psi	1,5 Psi	2,5 Psi
30% BF : 70% CF	Without EM-4	0 Psi	1,1 Psi	1,5 Psi	2,3 Psi
	With EM-4	1 Psi	1,4 Psi	1,5 Psi	2,7 Psi

Based on Table 2, the gas pressure increased every week. The composition variation without using EM-4 biostarter has not produced gas in week 1. It can be seen in the table that the pressure value is 0 Psi. In week 1, the composition variation using EM-4 biostarter has produced gas with each composition having a gas pressure value of 1 Psi.

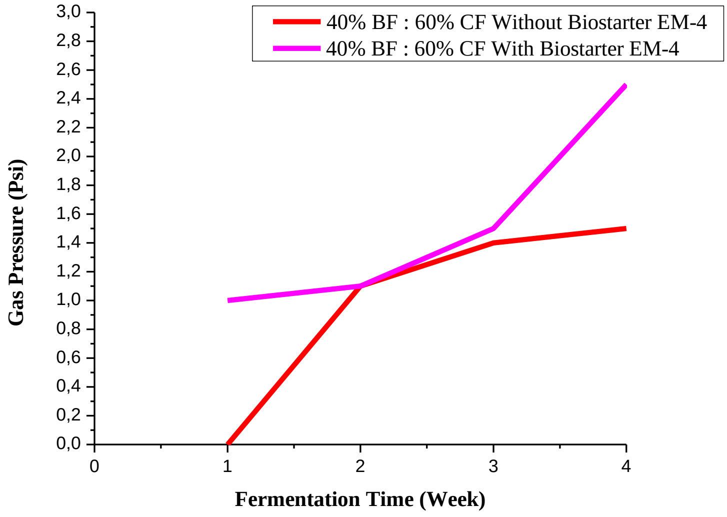
In week 2, it can be seen that all composition variations have produced gas. The composition of 50% BF : 50% CF without using EM-4 biostarter produces gas at 1 Psi. While in the composition of 50% BF : 50% CF using EM-4 biostarter produces gas at 1.1 Psi. Composition of 40% BF : 60% CF without and using EM-4 biostarter produces gas of 1.1 Psi. Composition of 30% BF : 70% CF without using EM-4 biostarter produces gas of 1.1 Psi. While in the composition of 30% BF : 70% CF using EM-4 biostarter produces gas of 1.4 Psi.

In week 3 the composition of 50% BF : 50% CF without using EM-4 biostarter produced gas of 1.3 Psi. While in the composition of 50% BF : 50% CF using EM-4 biostarter produces gas at 1.5 Psi. Composition of 40% BF : 60% CF without using EM-4 biostarter produces gas at 1.4 Psi. Composition of 40% BF : 60% CF using EM-4 biostarter produces gas at 1.5 Psi. Composition of 30% BF : 70% CF without using EM-4 biostarter produces gas at 1.5 Psi. While in the composition of 30% BF: 70% CF using EM-4 biostarter produces gas at 1.5 Psi.

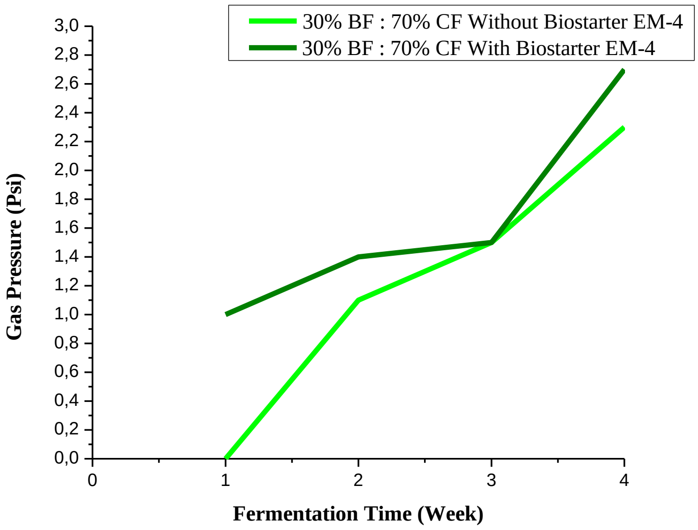
In the 4th week the composition of 50% BF : 50% CF without using EM-4 biostarter produces gas at 1.4 Psi. While in the composition of 50% BF : 50% CF using EM-4 biostarter produces gas at 2.4 Psi. Composition of 40% BF : 60% CF without using EM-4 biostarter produces gas at 1.5 Psi. Composition of 40% BF : 60% CF using EM-4 biostarter produces gas of 2.5 Psi. Composition of 30% BF: 70% CF without using EM-4 biostarter produces gas at 2.3 Psi. While in the composition of 30% BF : 70% CF using EM-4 biostarter produces gas of 2.7 Psi.



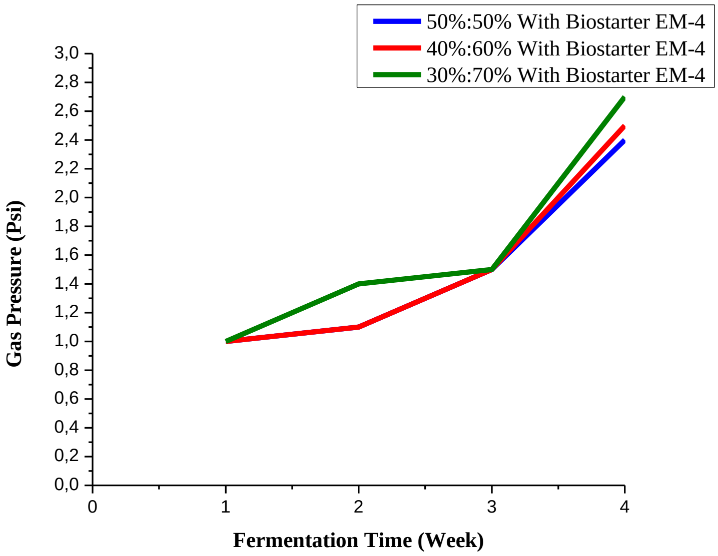
(a)



(b)



(c)



(d)

Fig 3. Gas pressure values at each week without and with EM-4 biostarter (a) 50%BF:50%CF

(b) 40%BF:60%CF (c) 30%BF:70%CF (d) Gas pressure values at each week for all compositions.

Based on Figures 3(a), (b) and (c), the best gas pressure was produced by samples with EM-4 biostarter. As the fermentation time increases, the sample with EM-4 biostarter has a higher gas pressure value and is faster in the gas formation process. This proves that the provision of EM-4 biostarter in biogas filling material can accelerate the fermentation process in biogas. In the composition with the provision of EM-4 biostarter produces higher gas than the sample without the provision of EM-4 biostarter. A fast fermentation process can produce higher gas. In this study it was proven that the provision of EM-4 biostarter can improve the quality of biogas produced. This is in accordance with research [27] using cow dung waste. Gas is difficult to form when it has passed 28 days because the anaerobic degradation process in biogas is decreasing. This is caused by bacteria that are no longer able to reduce compounds.

Based on Figure 3(d), the 30%AT:70%FS composition is the best composition because it has the highest gas pressure. The 50%BF:50%CF composition has the lowest pressure value. The provision of EM-4 biostarter and the difference in the amount of cow feces mass affect the value of gas pressure produced. The more cow feces used as biogas filling material, the more gas can be produced, indicated by the higher gas pressure value. This is in accordance with research [28] that the more cow feces, the more gas is produced because cow dung can be easily degraded.

Research [29] using vegetable waste and cow faeces with EM-4 biostarter showed that the more carbon-containing elements in the biogas filling material, the less gas produced. This is in accordance with this study that the more the mass of bagasse is used as digester filling material, the less gas is produced. In addition to being difficult to degrade, the carbon element in plants is consumed thirty times faster by bacteria than the nitrogen element. The carbon element is used as energy in the biogas fermentation process while the nitrogen element is used as an element of the formation of bacterial cell structures.

3) Temperature Value of Biogas

Gas temperature values were measured using a TPMS device on days 7, 14, 21 and 28. Temperature during the biogas fermentation process is very important because it is related to the livability of biogas processing microorganisms. Temperature values were taken during the day. The temperature value will be lower at night. The temperature value is also influenced by the temperature of the environment. The following can be seen the value of gas temperature in the sample of bagasse fibre and cow feces with a composition of 50% BF : 50% CF, 40% BF: 60% CF and 30% BF: 70% CF without using EM-4 biostarter and using EM-4 biostarter for 28 days in Table 3.

Table 3. Temperature values of AT and FS without using EM-4 biostarter and using EM-4 biostarter on Days 7, 14, 21 and 28.

Composition Variation		**Temperatur (ºC)**				**Biogas Optimum Temperature Standard (20-40ºC)**
		Days 7	**Days 14**	**Days 21**	**Days 28**	
50% BF : 50%CF	Without EM-4	24ºC	26ºC	28ºC	28ºC	Complete
	With EM-4	25ºC	27ºC	28ºC	29ºC	Complete
40% BF : 60%CF	Without EM-4	25ºC	26ºC	28ºC	28ºC	Complete
	With EM-4	26ºC	27ºC	28ºC	29ºC	Complete
30% BF : 70%CF	Without EM-4	25ºC	26ºC	27ºC	28ºC	Complete
	With EM-4	26ºC	27ºC	29ºC	30ºC	Complete

Based on Table 3, the gas temperature value produced in each sample is different. The gas temperature value meets the biogas standard. The composition variation without the use of EM-4 biostarter has a temperature of 24-28ºC. The composition variation with the use of EM-4 biostarter has a temperature of 25-30ºC. In Week 1, the gas temperature in the composition variation without using biostarter is 24-25ºC. While the gas temperature in the composition variation using biostarter is 25-26ºC. In week 2, the gas temperature in the composition variation without using biostarter is 26ºC. While the gas temperature in the composition variation using biostarter is 27ºC. In week 3, the gas temperature in the composition variation without using biostarter is 28ºC. While the gas temperature in the composition variation using biostarter is 28-29ºC. In week 4, the gas temperature in the composition variation without using biostarter is 28ºC. While the gas temperature in the composition variation using biostarter is 29-30ºC.

The temperature in this study is a good temperature for the process of biogas formation. The increase in temperature in the fermentation process is not followed by an increase in gas pressure. A good temperature for the process of biogas formation is between 20-40 ° C [14] the temperature in this study is in accordance with research [14]. Temperature in biogas is not influenced by the provision of biostarter and the type of biogas filling material. the higher the gas produced, the temperature will also increase [30].

The provision of EM-4 biostarter does not affect the temperature of the biogas during the fermentation process. Research that has been done [14] from cow faeces and sugarcane tops waste get the same temperature value as this study. This shows that the appropriate temperature will cause the growth of methane bacteria to get better too. The temperature value is influenced by the reactor, the reactor placed indoors will produce more stable gas compared to the reactor placed outside because the digester temperature is influenced by the environmental temperature. If the temperature of the environment affects the temperature of the digester, it will have an impact on the temperature of the gas produced.

4) Flame Test

The purpose of the flame test is to see the colour of the fire on the biogas. Biogas is ignited by opening the gas tap and bringing a lit match to the gas outlet [31]. Blue flame colour has good quality compared to yellow or red [32]. The following is the flame colour in the AT and FS flame test with a composition of 50% BF : 50% CF, 40% BF: 60% CF and 30% BF: 70% CF without using EM-4 biostarter and using EM-4 biostarter in Table 3.

Table 4. Flame Test of AT and FS without using EM-4 biostarter and using EM-4 biostarter.

Composition Variation		Color of Fire
50% AT : 50% FS	Without EM-4	Reddish Blue
	With EM-4	Blue
40% AT : 60% FS	Without EM-4	Reddish Blue
	With EM-4	Blue
30% AT : 70% FS	Without EM-4	Blue
	With EM-4	Blue

Based on Table 4, samples without EM-4 biostarter with a composition of 50% BF: 50%CF and 40% BF : 60% CF have a bluish red fire colour. Samples using EM-4 biostarter in each composition variation have a blue flame colour. The blue flame colour indicates the presence of large energy and high frequency so that the wavelength is getting shorter, while the bluish red flame colour indicates the presence of small energy and low frequency so that the wavelength is getting longer. The longest wavelength is owned by red light in the colour spectrum.

The more cow feces used, the more methane gas is produced so that the bluer the colour of the fire that appears during the flame test. This is in accordance with research [14] if methane gas is less than 55% then the fire cannot ignite. Blue flame is better than red flame because the redder the colour of the fire the more CO2 content produced by the biogas [31].

IV. CONCLUSION

The use of EM-4 biostarter and cow feces is very important in the fermentation process and biogas formation. The pH value in samples with the use of EM-4 biostarter is more acidic than the pH value without the use of EM-4 biostarter. The use of EM-4 biostarter can help accelerate the fermentation process and biogas production so that more gas is produced. The impact of cow feces in producing gas is that the greater the amount of cow faeces mixed with bagasse, the higher the gas pressure produced. The use of EM-4 biostarter and cow feces can produce large energy in biogas. This is evidenced by the blue colour of the flame.

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