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ANAEROBIC CO-DIGESTION OF DIFFERENT TYPES OF COW DUNG WITH FOOD WASTE

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Abstract

The value of manure as a source of clean energy can be increased through the conversion of animal waste into energy, which can also reduce the negative effects that animal waste disposal has on the environment. Anaerobic digestion (AD) is a potential bioprocess for the utilisation of waste biomass and the conservation of energy. It is also an alternative method of energy recovery and waste treatment that produces biogas, which can be used to generate either electricity or heat and is a byproduct of the digestion process. In this study, different types of cow dung in terms of nutritional processes (grass: bran); 100 % grass, 95 % grass: 5 % bran, and 80 % grass: 20 % bran were taken for anaerobic co-digestion with food waste. The purpose of this study is to investigate the production of biogas as well as the properties of anaerobic co-digestion using different types of cow dung under mesophilic temperature (37°C). Biogas production was measured by the water displacement method. The pH value, Organic Matter (OM) content, C/N ratio, and Volatile Acid (VA) were recorded throughout the experiment. Samples of 100 % grass accumulated the highest biogas production (1250 ml) followed by samples of 80 % grass: 20 % bran (1080 ml) and samples of 95 % grass: 5% bran (780 ml) between the 20th and 23rd days. This shows the sample of 100 % grass-feeding has a better performance on biogas production among the samples.

Keywords: *Anaerobic digestion; Biogas; Livestock; Food waste;*

Introduction

Over the course of the past two decades, researchers have been looking into alternative energy sources in response to the growing demand for energy as well as concerns regarding traditional forms of energy that are not renewable. This is due to the fact that traditional forms of energy pose concerns regarding environmental sustainability. This is the result of an increase in the total amount of demand for energy that has taken place recently. People from all over the world are beginning to focus their attention on renewable sources of energy because of the fact that these sources of energy are sustainable and have the potential to improve the overall quality of the environment [1].

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The process of converting animal waste into energy has the potential to increase the value of manure as a source of clean energy. This process also has the potential to reduce the adverse effects that the disposal of animal waste has on the environment. The production of biogas from animal waste, such as manure from livestock and poultry, is a method that has received a lot of attention recently. Animal manure is a complex substrate rich in organic material that anaerobic microbial consortiums may easily convert into biogas. Compared to direct combustion, livestock manure conversion not only produces more energy but also has lower loss energy requirement [2]. Furthermore, reusing manure for biogas production offers many benefits, including the creation of fossil-free energy, nutrient recycling, and a reduction in agricultural greenhouse gas emissions. When waste from livestock is released into the environment, it pollutes the soil, the water, and causes anthropogenic gases to be released into the atmosphere. This creates an unpleasant environment [3]. Therefore, anaerobic digestion (AD), which is a technique for producing clean biomass energy, is an effective way to realise the resource utilization of waste from animal husbandry and agricultural practices [4]. AD also has been widely adopted to treat high-strenght organic wastewaster, waste activated sludge, agricultural waste and food waste due to its high energy conservation potential [5].

There is not a single feedstock that must be used in order to produce biogas from materials that can be broken down biologically. This is because biogas can be produced from any material that can be broken down biologically. The process of anaerobic digestion that makes use of multiple feedstocks at the same time is referred to as co-digestion. This is the term that is used to describe the process. The co-digestion of cow dung and food waste which is can be included in a small fraction of inoculum under optimum circumstances that can improved the quantity and quality of anaerobic digestion products. It is highly likely that a single substrate will perform poorly in terms of buffering and nutrient content, which will result in an inadequate environment for anaerobic digestion [6].

Through anaerobic co-digestion with food waste, this study explored the biogas production from different types of cow dung in terms of nutritional processes. The purpose of this study is to determine the potential of biogas production from various cow dung and the characteristics of cow dung and food waste samples co-digested anaerobically under mesophilic conditions.

Experimental part

Materials

The samples of fresh cow dung used were collected from different cow barns according to nutritional processes namely; 100 % eat grass, 95 % eat grass + 5 % bran and 80 % eat grass + 20 % bran. Specifically, the cow barn located at Padang Besar, Perlis. Approximately 1kg of each type of cow dung sample was collected. The ratio of cow dung diluted with tap water was 1:1; which was 400mL of cow dung for 400mL tap water before being placed in the anaerobic reactor.

The food waste was collected from the campus food stall area, which is located on Campus Jejawi, Perlis. Approximately 500 grams of food waste was collected every week. Separation of food waste is important to obtain a predetermined ratio for the nutritional content of food waste in terms of vegetables, protein, and carbohydrates. The collection of food waste consisted of vegetables, eggshells, and rice. The food wastes were crushed using an electrical kitchen blender, and the slurry of food was that was produced was sieved to remove any large pieces. The ratio of food waste mixture feed in the reactor is 1:3:5 which contains vegetables: protein: and carbohydrates. 50mL of food waste was fed in the reactor every 3 days. Table 1 represents the ratio of food waste. The ratio of food waste in Table 1 used because carbohydrate such as rice were degraded more efficiently than proteins and were degraded before proteins during anaerobic digestion of sludge [7].

Table 1. The ratio of food waste used.

Nutrient	Vegetable	Protein	Carbohydrates
Ratio	1	3	5
Type of food waste	vegetables	eggshell	rice

Methods

The sample comprises three different types of cow dung. Thus, three 1.5-liter plastic bottles were used as an anaerobic digestion reactor which was equipped with a plastic bottle cap designed with two holes as a gas inlet and outlet and connected with a 6 mm diameter silicone tube as shown in figure 1. The reactor filled with fresh cow dung samples was purged with Nitrogen gas for 5 minutes and placed in the water bath at a temperature of 37°C to maintain a mesophilic condition. The gas outlet tube was connected with a water displacement setup that used a 1-liter measuring cylinder to accumulate the volume of gas produced. A syringe is used to collect the gas accumulated in the measuring cylinder and transferred into a gas bag. Figure 1 illustrated the laboratory setup of the experimentation. The volume of water that it displaced was recorded every three days.

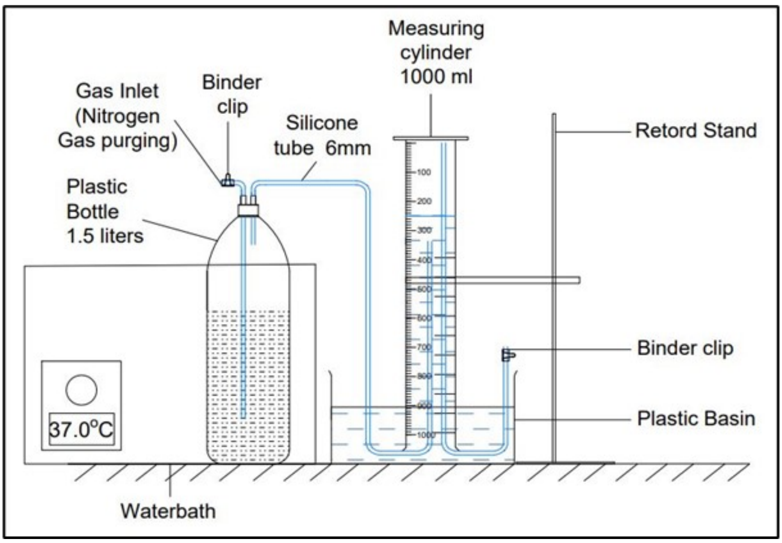

Fig. 1. Schematic diagram of laboratory experimental setup

The samples were left in the reactor for 14 days for the acclimatization process. Acclimatization is important in the process of becoming accustomed to the sample in a new climate or to new conditions. Initial characteristics of samples were observed and presented in Table 2. After the acclimatization period, the food waste was fed in the reactor every 3 days, and the samples in the reactor were collected and analyzed for their physical and chemical properties by using the standard method.

Table 2. Initial Characteristics of samples

Samples types \ Parameters	pH	OM (%)	Carbon (%)	Nitrogen (mg/L)	VA (mg/L)
100% grass-feeding CD	7.7	72.9	39.6	3.3	9795.9
95% grass-feeding,5% bran CD	7.5	43.2	23.5	2.0	10530.6
80% grass-feeding, 20% bran CD	7.3	44.4	24.1	1.7	9813.3
Food waste	5.65	-	-	-	-

Results and discussion

Characterizing the feedstocks is essential to the anaerobic digestion process. During anaerobic digestion, the quality of biogas produced depends on the characteristics of the feedstocks [8]. The initial characteristics of the samples utilized during the co-digestion of cow dung and food waste are lisred in Table 2. This study focused on biogas production and the cow dung characteristics that influence biogas production during anaerobic co-digestion with food waste.

Biogas production

The accumulated gas volume every three days after 14 days acclimatization period during 29 days study period is shown in figure 2. It was observed that the volume of biogas accumulates a high amount of biogas in the first 14th days and started to decrease after the co-digestion of food waste feed in the reactor.

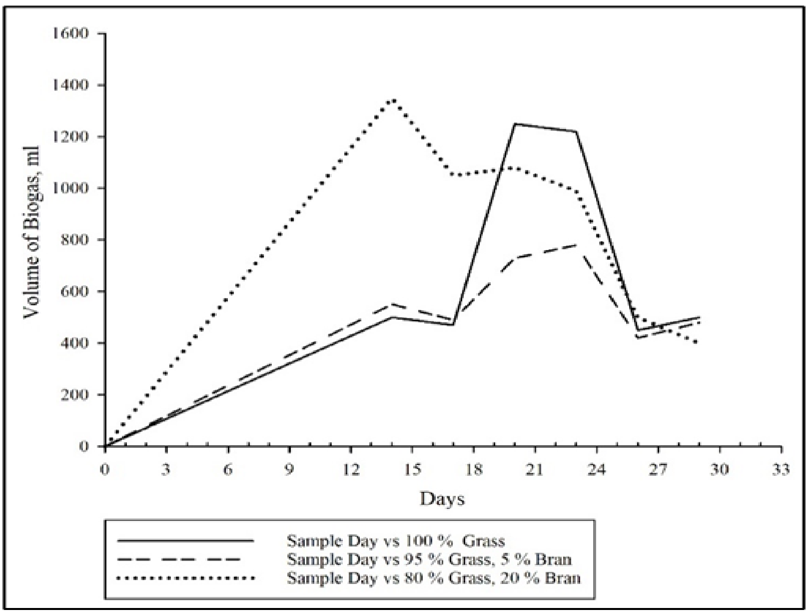

Fig. 2. Result of biogas production of 100% grass-feeding, 95% grass-feeding and 80% grass-feeding

. The graph shows the pattern of biogas production is similar which indicated that the biogas produced in three types of cow dung increase between the 20th and 23rd days however the pattern shows decreases until the end of the experiment. In this study, the sample of 100 %

grass-feeding accumulated the highest biogas production (1250mL) followed by the sample of 80 % grass-feeding (1080mL) and the sample of 95 % grass-feeding (780mL) between the 20th and 23rd days. After 14 days acclimatization period, the sample was fed with food waste, and biogas production was observed to decline significantly. This is predicted due to the uncontrolled pH of food waste used, which simultaneously leads to an increased concentration of nitrogen ammonia which may be assumed to inhibit the process [9].

The presence of a high concentration of ammonia–nitrogen during the digestion process can be toxic to anaerobic bacteria, which in turn reduces the efficiency of digestion and disrupts the anaerobic process [10]. Co-digesting cow dung with food waste has been shown in earlier studies to result in an increase in the amount of biogas produced [11]. This was reported as the finding of experiments that were conducted. There was no question that cow dung is an excellent raw material for the anaerobic digestion process and has the potential to raise the amount of biogas that is produced. Even though the pH was not being controlled, the number of anaerobic bacteria that were present in the cow dung demonstrated a significant ability to degrade the organic components of the cow dung.

Effect on pH

The pH values of cow dung samples represented in figure 3 shows decreasing on the 17th day in the range of pH 5 to pH 6.

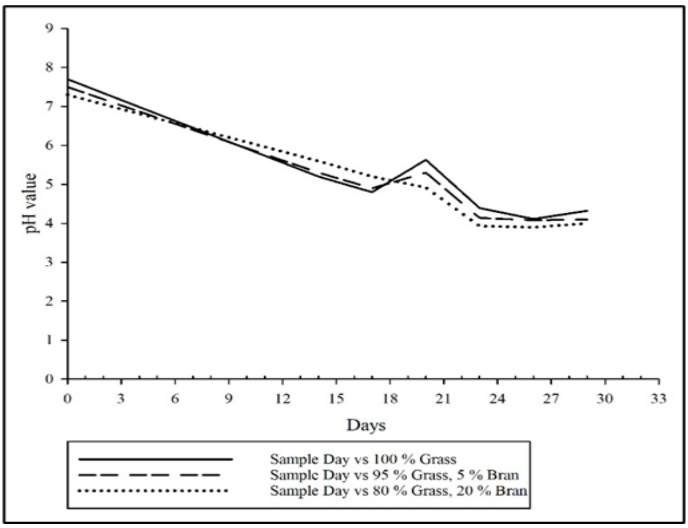

Fig. 3. Result of pH value of 100% grass-feeding, 95% grass-feeding and 80% grass-feeding

The result shows the pH value was fluctuating which indicates an increase on the 20th day and continues to decrease on the 23rd. However, the pH started to stable in each sample between 23rd and 29th at pH 4. This happened due to the different pH of food waste fed to the samples every three days. The pH of digestion has a substantial impact on biogas production because it affects the activity of bacteria that breakdown organic matter into biogas. Because the digester has a low pH, it is hard for microorganisms, especially methanogenic bacteria, to help break down the food [12]. During digestion, a high volatile acids formation, which made the pH drop. The best pH range for making biogas in the AD process is between 6.5 pH and 7.5 pH. But the pH value changes depending on what is being digested and how it is being digested. The value of pH needs to be controlled for the digestion process to improve the rate of biogas or methane gas production [13].

Effect on Organic Matter Content

The organic matter content shown in figure 4 is slightly increased over the period of the experiment. The graph shows an unstable OM percentage in the sample which indicated that fluctuated between the 14th and 29th days. The fluctuation of OM in the anaerobic digester is caused by microbial activity. According to *K. Dhamodharan et al*. [14], the decrease in OM is due to the loss of inoculum mass from the AD system and may have an effect on the performance of biogas production. The reduction of OM is primarily determined by the activity of the inoculum and the adaptability of the sample within the digester. The OM reduction indicates the amount of organic matter that methanogens can convert into biogas. Thus, the greater OM reduction led to a greater biogas conversion [15].

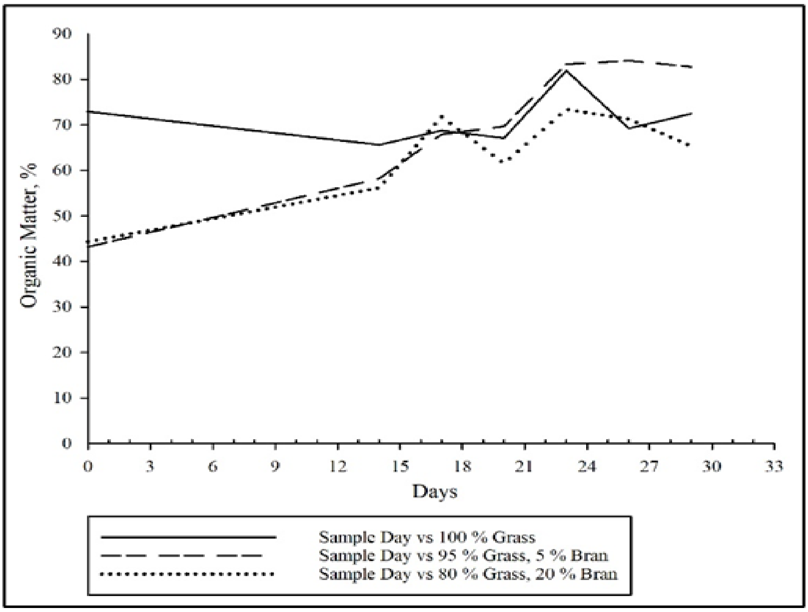

Fig. 4. Result of organic matter content of 100% grass-feeding, 95% grass-feeding and 80% grass-feeding

Effect on C/N Ratio

The result of the carbon to nitrogen ratio is represented in figure 5. The result shows the increase in the C/N ratio over the period of the experiment. The initial reading of the C/N ratio was in the range of 15 to 18 was increased gradually increases by day until reached 33 to 40 on the 29th day. The highest C/N ratio was recorded on the 29th day for the sample of 95% grass-feeding, and 5 % bran is 40. According to *I.J. Dioha et al*. [16], the ratio of carbon to nitrogen in the feedstocks has a significant impact on the production of biogas, and variations in the value of carbon to nitrogen can also have an effect on the pH of the sample. An increase in the carbon content of a slurry will lead to an increase in the production of carbon dioxide and decrease in the pH of the slurry.

On the other hand, an increase in the nitrogen content of a slurry will stimulate variation in the ratio of carbon to nitrogen, which can have effect on the pH of the slurry. Additionally, the C/N ratio has an effect on methane production during anaerobic digestion and is crucial factor for maintaining a stable environment. Biogas production is not optimal condition when C/N ratio is too high because acidogenic bacteria consume more nitrogen than methanogenic bacteria. When

C/N ratio is insufficient, bacteria absorb nitrogen to grow. Nitrogen accumulates in the form of ammonium in the absence of carbon, which raises the pH and inhibits the biogas production [17]. Thus, the value of C/N ratio in 30 was determined to be optimal for the cow dung biogas production [18].

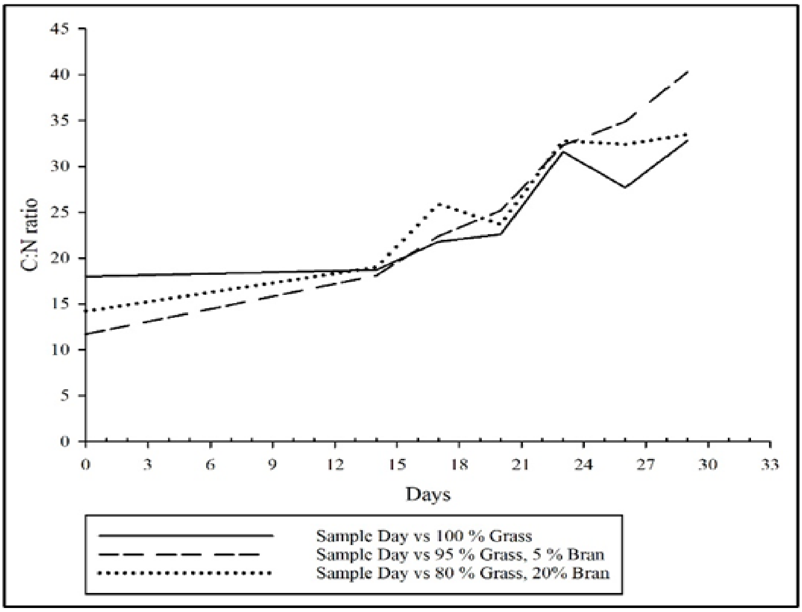

Fig. 5. Result of C/N ratio of 100% grass-feeding, 95% grass-feeding and 80% grass-feeding

Effect on Volatile Acid

The volatile acid shown in figure 6 indicates an increase over 14 days of the acclimatization period and remains stable in the range of 10 000mg·L^{-1} to 11 000mg·L^{-1}. However, the graph shows the volatile acid was reduced between the 20th and 23rd days. During acidogenesis, the second phase of the anaerobic process, volatile acid was produced during anaerobic digestion. The concentration of volatile acid in the samples affects the methanogenesis stage of the anaerobic process, which reduces methane and biogas production [19]. Reducing the sample's volatile acid content results in an increase in pH value. Co-digestion of food waste in the sample is a method for regulating the pH level of the sample. This is because food waste has a high nitrogen content due to ammonia's protein-forming properties. During degradation, the high nitrogen content of food waste is combined with the reactor solution to produces ammonium bicarbonate, which helps to buffers the pH of the digester [20].

It is necessary to regulate the pH level of the food waste that fed into the reactor in order to bring the amount of volatile acid present in the samples down to a more manageable level. According to the findings, a drop in the pH value of the samples is brought on by an increase in the proportion of volatile acids present in the samples. In the previous studies, anaerobic digestion produced the greatest amount of butyric acid under conditions of uncontrolled pH and pH 5 levels. At a pH of 7, it produced primarily acetic acid as well as propionic acid and only a small amount of butyric acid, whereas at a pH of 11, it produced almost no acetic acid at all. After a number of hours of fermentation, acidification was prevented in reactors with pH values of 5.0 and 11.0, while it steadily increased in reactors with pH values of 7.0 and uncontrolled pH. This result can be explained by the microorganisms in the inoculum adapting to neutral conditions and a sudden change in pH, which slightly inhibits the activity of the microorganism. Both of these factors occurred simultaneously [21].

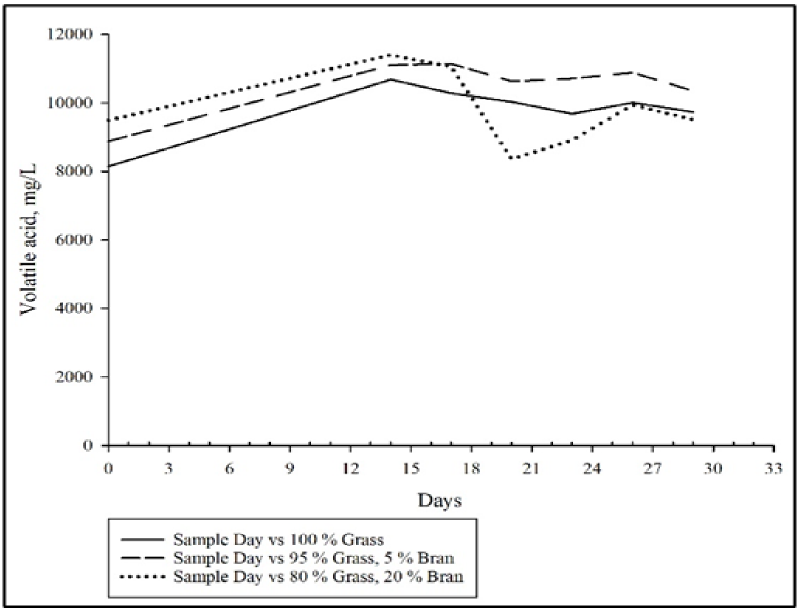

Fig. 6. Result of volatile acid of 100% grass-feeding, 95% grass-feeding and 80% grass-feeding

Conclusions

In this study, the potential for biogas production was investigated using three distinct types of cow dung in terms of nutritional processes. Additionally, the effects of anaerobic co-digestion with food waste presented over the course of 29 days while the environment was mesothermal. In comparison to the samples consisting of 95% grass-feeding and 5% bran and 80% grass-feeding and 20% bran, the sample consisting of 100% grass-feeding produced the greatest amount of biogas (1,250mL) between the 20th and 23rd day. In addition, the production of biogas is affected by some factors as the pH level and the amount of volatile acid contained in cow dung and food waste. In spite of this, there are no discernible differences between the properties of the various types of cow dung, as the graphs all display the same pattern. In addition, the acidic properties of the food waste contributed to the low pH of the sample. According to the findings of this study, the digestate from food waste should have its pH adjusted before it is put to use because the application of the digestate is profoundly impacted by the acidity of the digestate.

The municipal operations produce a lot of organic waste, which harms the environment and human health. Anaerobic digestion systems may help reduce this waste. Because anaerobic digestion breaks down waste without oxygen, it seems to be better for the environment and human health. Animal excrement energy can help mitigate local ecosystem damage. Implementing this method may also improve waste management and also can increase the renewable energy sources.

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