EFFECT OF BEEF CATTLE AND HORSE FECES MIXTURE ON THE QUALITY OF BIOGAS AND SLUDGE

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Abstract

The objective of the study was to find out the effect of beef cattle and horse feces mixtures on biogas energy content and sludge quality. This experimental study was based on Completely Randomized Design with three C/N ratio treatments, i.e. P1 = 25, P2 = 30 and P3 = 35. The treatments represent the mixtures of beef cattle and horse feces. The effect of the treatments was analyzed by ANOVA, and Duncan's Multiple Range Test analyzed the different effects among treatments. The results show that the beef cattle and horse feces mixtures significantly ($P<0.05$) increase biogas energy content. The C/N ratio of 35 provides the highest biogas energy content (147.6667 KJ). Furthermore, significantly ($P<0.05$) produces the highest sludge product (10.1533 kg) as well as the highest content of N (0.48%), P (0.44%) and K (0.32%).

Key words: feces, energy, biogas, sludge

INTRODUCTION

Organic substances of beef cattle and horse carry high amount of potential energy that can be converted into kinetic energy by microorganism's activities. Therefore, feces can be used as energy sources. The possible way to get the energy is convert the organic substances of feces into biogas.

Generally, biogas contains 65-75% CH_4, 25-30% CO_2, 1% N, 1% H_2, 1% H_2S, and 1% O_2. Methane (CH_4) contains more energy than other gasses. Therefore, the energy content of biogas is depending on the concentration of CH_4 [9]. The more methane generated the higher energy content of biogas.

Methane production was mainly influenced by microorganism's activities. Therefore, the success of methane production depends on factors that promote the activities of microorganisms such as C/N ratio, water content, temperature, pH, and anaerobicity. Among those influencing factors, C/N ratio is the most important one due to its function as an indicator of nutrient availability. An appropriate C/N ratio may support the activities of microorganisms, which give the best biogas and sludge production. The C/N ratios of biogas production vary between 30 and 50 [7].

However, there are some parts of organic compounds remain unconverted and settle at the bottom of digester. This substance, which is known as sludge, contains some elements that high potential value as fertilizer. This organic fertilizer must has minimum content of nitrogen (N) 0.40%, phosphorus (P_2O_5) 0.1%, and potassium (K_2O) 0.20% [8].

Beef cattle feces have a lower C/N ratio than horse feces. Therefore, mixing of those two feces, will resulting in C/N ratio that meet the requirement for methane generation. However, since there is no information available about the proper mixture of both feces, study about the effect of beef cattle and horse feces mixture on biogas and sludge production is important in developing biogas production from animal feces.

MATERIAL AND METHODS

The study was carried out at the Laboratory of Microbiology and Waste Management, Faculty of Animal Husbandry University Padjadjaran, Bandung, Indonesia. The experiment based on Completely Randomized Design with three treatments. Three different mixtures of beef cattle feces and horse feces represent the treatments.

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Table 1 Mixtures of beef cattle and horse feces and its C/N ratios

Treatment	Cattle feces (Kg)	Horse feces (kg)	C/N ratio
P1	7	18	25
P2	4	20.5	30
P3	2.3	22	35

Those treatments were performing in six replicates. After the mixtures placed in the digesters, mixed with water, viz. 33 kg, 33.5 kg and 33.7 kg respectively, until the substrates water content became 90% (or 10% of dry matter content). Each substrate was incubated for 30 days. Variables observed in this study were energy content of biogas and quality of sludge. Energy content (calorific value) of biogas was calculated by mean of the following formula [14].

$$Q = mc \times \Delta t.$$

With Q = heat energy (KJ), m = mass (gram), c = calorie (Joule/gram.^{0}C), and Δt = temperature different (^{0}C).

The quality of sludge is represented by the content of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O). The obtained data were analyzed using Analysis of Variance to determine the effect of the treatment, and then continued with Duncan's Multiple Range Test to observe the different effect among treatments.

RESULTS AND DISCUSSIONS

1. Effect of the treatments on Biogas Production

The energy contents of produced biogas are presented on Table 2. Data on the table confirm that P1 resulting in the lowest energy content of the produced biogas (90.667 KJ), followed by P2 (126.167 KJ), and P3 (147.667 KJ). The result of Analysis of Variance informed that the energy content of biogas significantly ($P<0.05$) increases along with the increase of C/N ratio. The result of Duncan's Test shows that P3 (C/N ratio of 35) significantly generates the highest energy content of biogas ($P<0.05$).

Table 2 Energy contents of biogas resulted from beef cattle and horse feces mixtures

Treatment	Energy (KJ)	Significance (0.05)
P1	90.667	a
P2	126.167	b
P3	147.667	c

In this study, microorganisms that involve in biogas production were indigenous microorganisms of beef cattle feces, and the availability of nutrients required by the microorganisms in treatment P3 (C/N ratio of 35) were higher than the other treatments. Hence, the treatment provides an optimal condition for better methane process productions, and resulting in high energy content of the produced biogas. The optimal C/N ratio gives maximum methane production [1][11]. Furthermore, the more methane produced, the higher the biogas energy content is [9].

2. Effect of the Treatments on Sludge Production

The sludge quantities resulted from the treatments are presented on Table 3.

Table 3 The average sludge quantities resulted from beef cattle and horse feces mixtures

Treatment	Sludge Production (Kg)	Significance (0,05)
P1	8.197	a
P2	8.687	b
P3	10.153	c

Table 3 shows that treatment P1 produces the lowest sludge quantity (8.197 Kg), followed by P2 (8.687 Kg), and P3 (10.153 kg). The result of Analysis of Variance shows that C/N ratios are significantly increases sludge productions ($P<0.05$). Further analysis using Duncan's Test revealed that treatment P3 significantly produces more sludge quantities than other treatments ($P<0.05$). This finding may related to the concentration of horse feces in the substrate, which is higher than other treatments. The horse feces contain about 15% of total solid [5] that affects sludge

production. Sludge contains most of the main nutrient and organic materials. The types of nutrients contained in the sludge depend on raw materials used [4].

2.1. Effect of treatment of the nutrient content of nitrogen (N).

The nitrogen (N) contents of produced sludge are presented in Table 4.

Table 4 The average nitrogen (N) content of produced sludge

Treatment	Nitrogen content (%)	Significance (0.05)
P1	0. 42	a
P2	0.44	a
P3	0.48	b

Table 4 shows that treatment P1 produces the lowest nitrogen content (0.42 %), followed by P2 (0.44 %) and by P3 (0.48 %). The Analysis of Variance's result indicates that the C/N ratio significantly increase the nitrogen content of the sludge ($P<0.05$). Moreover, the result of Duncan's test shows that treatment P3 (C/N ratio 35) significantly result the highest nitrogen content ($P<0.05$). Having C/N ratio of 35, P3 contain more carbon and less nitrogen compared to P1 and P2, less than 50 the maximum C/N ratio for biogas production [6], while the optimum C/N ratio varies between 25 and 35 [6]. Therefore, this C/N ratio provides an optimal condition for microbial growth and activities. All organic nitrogen left in the sludge. In this study, indigenous microorganisms of beef cattle feces store nitrogen in their cells, so that contribute to the nitrogen content of the sludge. Sludge quality reflected by the content of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O). The content of N in compost derived from organic materials degraded by microorganisms, so that the process of degradation greatly affects the content of N in the sludge. All treatments produce nutrient content of N between 0.42% and 0.48%, which still in accordance with its standards of 0.40% [8].

2.2. Effect of treatment of the nutrient content of phosphorus (P_2O_5).

The phosphorus (P_2O_5) contents of the sludge are presented on Table 5.

Table 5 The average phosphorus (P_2O_5) content of produced sludge

Treatment	Phosphorus content (%)	Significance (0.05)
P1	0,35	a
P2	0,42	b
P3	0,44	b

Based on Table 5, it is known that there were differences in the average content of P_2O_5. The treatment P1 produced the lowest phosphorus content (0.35%), followed by P2 (0.42%) and P3 (0.44%). As indicated by the result of Analysis of Variance, the treatments significantly influence the phosphorus content of the sludge ($P<0.05$). Furthermore, the result of Duncan's test shows that P2 and P3 treatment significantly produce P_2O_5 content higher than others ($P<0.05$). Generally, phosphorus content is in line with the content of N in the sludge [10][12]. The higher the nitrogen contained in the biomagnifications of microorganisms, the more phosphorus broken down, so that the content of phosphorus in sludge is also increased. Most microorganisms use phosphorus in biogas substrates to build their cell. The occurring of all organic matter and phosphorus assimilation processes are because of microorganisms produce phosphatise enzyme. Based on its phosphorus content, the produced sludge can be used as fertilizer.

2.3. Effect of treatment on nutrient element content of potassium (K_2O).

The potassium (K_2O) contents of sludge are presented in Table 6. It is shown that there are differences in the average content of K_2O. Treatment P1 produces the lowest potassium content (0.28%), followed by P2 (0.29%) and P3 (0.32%). According to the result of variance, those treatments significantly provide different potassium content of the sludge ($P<0.05$). Moreover, the result of Duncan's test shows that P3 significantly produces the highest K_2O content ($P<0.05$). Potassium (K_2O) content of sludge was derived from the raw materials or biogas substrates used.

Table 6 The average potassium (K_2O) content of produced sludge

Treatment	Potassium content (%)	Significance (0.05)
P1	0,28	a
P2	0,29	ab
P3	0,32	b

The biogas substrate, namely beef cattle and horse feces, contain a lot of forage materials which contain potassium. When biogas formation process takes place, microorganisms use potassium in its activity. Potassium has many functions within the cell, and can represent up to 2% of the dry cell weight of yeast cells, very high for a mineral (most are under 0.1%) [13]. Sludge K_2O contents were in accordance with the organic compost standards that the compost contains at least 0.20% of K_2O [8].

CONCLUSIONS

Beef cattle and horse feces mixtures with varying C/N ratios (25 – 35) significantly influence the biogas and sludge productions. The mixture of beef cattle and horse feces with C/N ratio of 35 provides the highest biogas and sludge productions, that are 147.667 KJ and 10.153 kg. Mixture of beef cattle and horse feces with the C / N ratio of 35 also produces the highest content of nitrogen (N) 0.48%, phosphorus (P2O5), 0.44% and potassium (K2O) 0.32% of sludge which can be use as organic solid fertilizer.

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REFERENCES

[1] Basuki P. *Problems in the Application of Livestock Wastes Bioconversion on Biogas Production and Its Solution Alternatives.* Aarp Project. R & D. Ministry of Agriculture. The Republic of Indonesia, Jakarta. 1992

[2] Chan, K.Y., C. Dorahy, T. Wells, D. Fahey, N Dowoan, F Saleh, and I Barchia.. Use of Garden Organic Compost in vegetable Production Under Contrasting Soil P Status. *Australian Journal of Agricultural Research*, 59, 374 – 382. 2008

[3] Eulis Tanti Marina. *Bioconversion of Livestock Industries Wastes*. UNPAD PRESS.Bandung. 2009

[4] Institute of Soil and Fertilizer-AASR. Research Work on the Utilization of Digester Sludge and Effluent As Fertilizer. *In: Biogas Fertilizer System. Technical Report on Training Seminar in China.* UNEP Report and Proceeding Series.2.UNEP. Nairobi 1981:49-56

[5] Lawrence, L. J. R. Bicudo, E. Wheeler. Horse manure characteristics literature and database review. *Proceedings of the Ninth International Symposium Animal, Agricultural and Food Processing Wastes IX*. Raleigh, NC. ASAE, St.Joseph, MI. 2003. pp. 277-284

[6] Lin, Chitsan. A negative-pressure aeration system for composting food wastes. Bioresource Technology (2008) Volume: 99, Issue: 16, 2008 Pages: 7651-7656

[7] Merkel, J.A. Managing Livestock Wastes. AVI Publishing Company, INC, Westport, 1981

[8] NSI. SNI-19-7030-2004. Specification of Domestic organic garbage compost. ICS 13.030.10. National Standardization Agency of Indonesia. Jakarta. 2004

[9] Price, E.C, and P. N. Cheremisinof. *Biogas Production and Utilization*. Ann Arbor Science Publishers Inc. The Butterworth Group. Michigan. 1981

[10] Stofella, P.J. dan Brian A. Kahn, *Compost Utilization in Holticultural Cropping Systems*. Lewis Publishers.USA. 2001

[11] Yuli Astuti Hidayati. 1996. *Effect of Initial pH of Livestock Wastes on the Quality of Biogas and Sludge.* Thesis. Universitas Padjadjaran, Bandung. 1996

[12] Yuli Astuti Hidayati., Ellin Harlia, dan Eulis Tanti Marina. The Effect of Beef Cattle and Organic Waste Ratio in Composting Process on the Quality of Compost. *Reserach Journal Universitas Jambi.* Science Series. Vol 12. No 3. August. 2008

[13] White,C. Yeast Nutrients Make Fermentations Better. Whitelab. Pure Brewer Yeast. Accessed 10 February 2012.

[14] Zemansky, M.W. *Modern Physics. Mechanics and Thermodynamics*. Addison-Wesley Publishing Company. Inc. Londong.1963.