IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 7, Issue 3 Ver. I (Apr. 2014), PP 25-28
www.iosrjournals.org

Enhancing biogas production rate of cattle manure using rumen fluid of ruminants

Rabiu, A.[1], Yaakub, H.[1], Liang, J. B.[2], and Samsudin, A. A.[1,2*]
[1]*Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia*.
[2]*Institute of Tropical Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.*

Abstract: *The effects of rumen fluid from cattle and goats used as inoculums to increase biogas production using cattle manure as a substrate were investigated. Approximately 100 grams of fresh cattle manure (M) was assigned to each biodigester and mixed with rumen fluid (R) and a distilled water (W) according to five different treatment ratios, T1 (1:1:0); T2 (1:0.75:0.25); T3 (1:0.5:0.5); T4 (1:0.25:0.75); and T5 (1:0:1) (correspond to 0; 12.5; 25, 37.5; 50 % rumen fluid, respectively). All treatments were prepared in triplicates and runs at mesophilic condition. No significant different (P>0.05) was observed when comparing the biogas produced between the two type of rumen fluid used in this study. However, significant difference was noted when comparing between hours interval in the cattle manure inoculated with rumen fluid of the cattle and also goats. Data recorded that cattle rumen fluids produced more biogas than the goats. It was established that the increase in the biogas production at certain level was in respond to the amount of rumen fluids added into the mixture. The best performance of biogas production in this study was observed if the rumen fluid used between the ranges of 0.75 to 1 that correspond to 37.5 – 50 % of rumen fluid respectively.*
Keywords: *biogas, cattle manure, rumen fluid*

I. Introduction

Biogas is a term used to represent a mixture of different gases produced as a result of the action of anaerobic microorganisms on domestic and agricultural waste [1]. It usually contains 50% and above methane (CH_4) and other gases in relatively low proportions namely, CO_2, H_2, N_2 and O_2 [2]. The mixture of the gases is combustible if the methane content is more than 50 % [3]. Anaerobic digestion may be seen as a technology world widely used in the treatment of organic waste for biogas production. Anaerobic digestion that utilizes manure for biogas production is one of the most promising uses of biomass wastes as it provides a source of energy and at the same time resolving ecological and agrochemical issues [4]. The anaerobic fermentation of manure for biogas production does not reduce its value as a source of fertilizers supplement, as available nitrogen and other substances remain in the treated sludge [5]. Numerous studies have been conducted from researches all over the world in order to increase biogas yield in the anaerobic digestion. An attempt to improve biomass conversion efficiency and biogas yield are numerous: which include using two continuously stirred tank reactors [6]; selectively retaining the solids within the reactor by holding mixing prior to effluent removal [7]; pretreatment of manure by separating solids from digested materials in order to improve bio-degradability and accessibility [8]; improving bacterial nutritional requirements [9]; improving contact between bacteria and substrate using stirring [10]; immobilizing microbes using fixed film reactor [11]; and improving substrate composition by co-digesting with other substrate [12];[13]. In developed countries, the biogas technology is used on a large scale for power and heat production. It is also one of the technologies supported by governments and the international organizations such as UN and EU [14], because it reduces greenhouse gas emissions from manure and produces renewable energy [15];[16]. Enhancement of the biogas production for the rural households will helps in reducing the indiscriminate felling of trees used for firewood, thereby reducing the ill-effect of soil erosion, greenhouse gas emission and many more. Biogas produced from animal waste is widely used as a renewable bio-fuel source. This source of energy is regarded as cheap and clean and is also known to produce a residue with a high fertilizer value for crop production [17];[16]. The production of the biogas is manifested by the anaerobic bacteria that are abundantly present in the rumen of the ruminant that are considers as a waste disposal from abattoir. Taking of these advantages, the continuously supply of the rumen content from abattoir if properly managed and manipulated could generate heat through biogas production thus reducing the cost of electricity bills. To our best knowledge, the information of biogas production between different levels of cattle or goats rumen fluid on the cattle manure is rather limited. Therefore the aim of the current work was to determine the level of biogas produced from different levels of cattle and goats rumen fluid that were used as an inoculum in anaerobic digestion of cattle manure.

II. Materials and Methods

2.1 Sample preparation

Both cattle manure and the rumen fluids derived from cattle and goats used in this study were obtained from slaughterhouse located at Department of Animal Science, Faculty of Agriculture, Universiti Putra Malaysia. The animals were fed with basal diet containing 60% of roughages and 40% of concentrates and given based on 3% DM/bwt daily intake. Rumen fluid was prepared in the following ways: approximately 2 kg of rumen content was mixed thoroughly with 15 liters of distilled water in a container. The solid content is then separated from the slurry by a filter sieve. The manure and rumen fluids sample collected are manually homogenized using hands to ensure proper mixture of all the contents. The pH of the mixture was recorded.

2.2 Experimental apparatus set up

A laboratory test of 1000 ml biodigester was operated in batch operating system. The experimental apparatus consists of biodigester and biogas measurement that was made from conical flask tightly plugged with rubber stopper and equipped with valve for biogas measurement. The inner temperature of biodigester was maintained between 34^0C to 38^0C and thermostatically controlled by heated water bath. Biogas formed was measured by the use of liquid displacement method as described previously by [4].

2.3 Experimental design and procedure

Approximately 100 gram of cattle manure (M) was used as substrate. The manure was fed into each biodigester and mixed with rumen fluid (R) and distilled water (W) in several ratio resulting into five different treatment groups (M: W: R); T1 (1:1:0); T2 (1:0.75:0.25); T3 (1:0.5:0.5); T4 (1:0.25:0.75); and T5 (1:0:1) that are correspond to 0; 12.5; 25, 37.5; 50 % of rumen fluid, respectively. The composition of the substrates and inoculums used in this study is presented in Table 1. Prior to experiment, the biodigester was flushed with CO_2 to provide an anaerobic condition. Biogas formed was measured at every 12 hours with three days intervals for 23 days. All of the samples in this experiment were run in triplicates. Significance differences between treatments were determined statistically using SAS by Duncan Multiple Range Test (DMRT).

Table 1: Composition of five cattle manure samples with different water and rumen fluid content

	M:W:R ratio	MANURE (g)	WATER (ml)	RUMEN (ml)	RUMEN %
T1	1:1:0	100	100	0	0
T2	1:0.75:0.25	100	75	25	12.5
T3	1:0.5:0.5	100	50	50	25
T4	1:0.25:0.75	100	25	75	37.5
T5	1:0:1	100	0	100	50

Keys: M=manure; W=water; R=rumen fluid.

III. Result and Discussion

The pH values of the cattle manure and rumen fluids of cattle and goats taken before and after the experiment recorded a reading of 6.93 before and 6.57 after for cattle manure, while for the rumen fluid of the cattle recorded 7.63 (before) and 7.74 (after), and the goats rumen fluids were 7.02 (before) and 7.22 (after) respectively. Significantly difference ($P<0.01$) was observed in all of the treatment groups that used cattle rumen fluid as a substrate throughout the experimental period (Fig. 1). The biogas production increased as days of fermentation increased. The highest biogas produced was in the T5 throughout the experimental periods except on the last day of sampling where T4 produced the highest biogas production (Fig. 1). The biogas production on day 2 increased by three-fold in T5 compared to T1 when the amount of rumen fluid used in the treatment is 1:1 with the amount of cattle manure mixed in the biodigester. Among the treatment groups, T4 produced the highest biogas production at the end of the experimental periods.

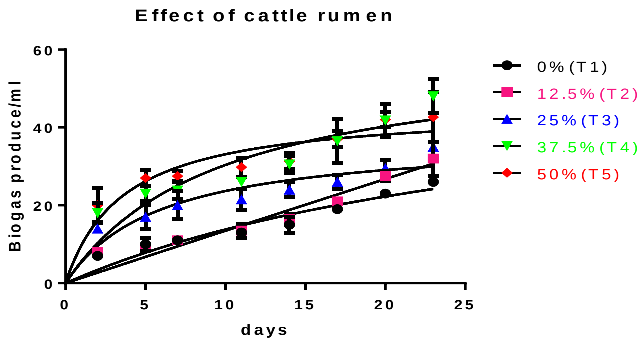

Figure 1: Biogas production from cattle manure inoculated with cattle rumen fluid

In the present study, the biogas production using rumen fluid of goats as a substrate had demonstrated a significant difference between the treatment groups from day 2 until day 11 of observation (Fig. 2). On day 2 of fermentation, the biogas produced in T5 has increased by three-fold when comparing with T1 and this is similar to what has been produced in the cattle manure mixed with rumen fluid of cattle. However, the amount of gas produced in rumen fluid of goats is not as much as recorded in the rumen fluid of cattle. Among the treatment groups, T5 recorded with the highest biogas production at the end of the experiments (Fig. 2). The production of biogas was recorded lower at the beginning of the experiment due to the low number of methanogenic archea that are directly correspond with the rate of biogas been produced in the biodigester [18]. Our data is in agreement with a study done by [19], in which the amount of biogas has not increased much during the first week of fermentation. The authors elucidated that this condition was due to adjustment process of the rumen microorganisms towards the available substrates. In the present study, the best performance biogas production was observed if the rumen fluid used between the ranges of 0.75 to 1 that correspond to 37.5 – 50% of rumen fluid. This result is in agreement with the findings of [4] that demonstrated the optimum amount of rumen fluid that produced high level of biogas is in the range of 25-50%. Similarly, [20] reported the best performance of biodegradation for food waste and methane generation is when 20 - 30% of inoculums was used in the biodigester. Moreover, no substantial difference was observed when 5% and 10% of the inoculum were used in preparation of the substrate, however the highest biogas production was recorded when rumen content was used at the amount of 15% [21].

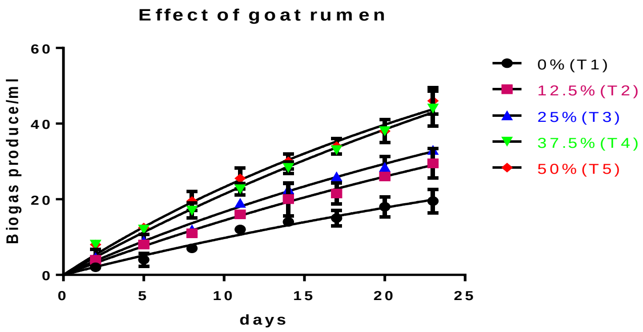

Figure 2: Biogas production from cattle manure inoculated with goat rumen fluid

The substrates consist of manure and rumen exhibit higher biogas production than substrates contain manure and water. In other words, specific biogas production rate per gram of treatment group consists of rumen fluid are higher than the control group. This result demonstrated that the addition of rumen fluid in the cattle manure had caused biogas production produced more than twice-fold as in comparison to cattle manure without the rumen fluid. This may suggest that abundance concentration of anaerobic bacteria content in liquid rumen works effectively to degrade organic substrate from manure. According to [22], rumen of the ruminant contains highly anaerobic bacteria dominated by cellulolytic bacteria that are able to degrade cellulose material from manure. The used of rumen fluid as inoculums are substantially relevant in process kinetics of biogas production. Our data is in congruent with data reported by other studies that demonstrated the amount of biogas produced was seemed proportional to the initial inoculums [23] and the bovine rumen fluid inoculums had a strong effect on anaerobic bio-stabilization of fermentable organic fraction of municipal solid waste [21]; as well as the higher percentage of inoculums gave the higher production of biogas [20]. In the present study, cattle manure inoculated with cattle rumen fluid produced higher biogas than cattle manure inoculated with goat rumen fluid. These may be attributed to the antagonism in the activities of the microorganism present in the goat rumen in association with those present in the cattle manure.

IV. Conclusion

Based on the present study, it can be concluded that the rumen fluids of cattle and goats could serve as a suitable substrate for biogas production. The best performance biogas production was observed if the rumen fluid used between the ranges of 37.5 – 50% of rumen fluid. Although no significant different ($P<0.05$) was demonstrated when comparing between the two rumen fluids used, the biogas production rate in cattle rumen fluid is much higher than goat rumen fluid. The utilization of these substrates for biogas production could eliminate its disposal problems and create another abundant source of sustainable energy. The data generated from this study also provide a basis for future work in determining the best retention time for both substrates in biogas production.

References

[1] Ezeonu S. O. Dioha IJ, Eboatu AN, Daily Report production from different wastes and identification of methanogenic bacteria involved, *Nigerian Journal of Solar Energy, 15, 2006, 80-85.*

[2] Kalia VC, Sonakya V, Raizada N., Anaerobic digestion of banana stems waste, *Bioresource Technology, 73, 2000, 191-193*

[3] Elijah, T. I., I. A. Mangibo, and Y. S. Mohammad, The study of cow dung as co-substrate with rice husk in biogas production, *Scientific Research and Essay, 4(9), 2009, 861-866.*

[4] Budiyono, Wadiasa, I. N., Johari, S., Sunarso, Increasing biogas production rate from cattle manure using rumen fluid as inoculums, *International Journal of Basic & Applied Sciences, 10(1), 2010, 68-75.*

[5] Alnaney, R and G. Liden, The effect of temperature variation on bio methanation at high altitude, *Bioresource Technology 99:2008, 7278-7284.*

[6] Boe. K, and Angelidaki, I., Serial CSTR digester configuration for improving biogas production from manure, *Water Research, 43(1),2009,166-172*

[7] Kaparajo, P. and Angelidaki, I., Effect of Temperature and Microbial activity on passive separation of digested cattle manure, *Bioresource Technology, 99, 2008, 1345-1352.*

[8] Moller, H. B., A. M. Nielsen, R. Nakakubu and H. J Olsen., Process performance of Biogas digesters incorporating pre separated manure, *Livestock science, 112, 2008, 217-223.*

[9] Dermici. G. G. and G. N Demirer., Effect of initial COD concentration, nutrient addition, temperature and microbial acclimation on anaerobic treatability of broiler and cattle manure, *Bioresource Technology, 93, 2004, 109-117.*

[10] Kamir, KR. Hoffmann, K. T. Klassonb, M. H. Al-Dahlan., Anaerobic digestion of animal waste: effect of mode of mixing, *Water Research, 39, 2005, 3597-3606.*

[11] Lo. K. V. , A. J. Whitehead, P. H. Liao, N. R. Bulley., Methane production from screened dairy manure using a fixed film reactor, *Agricultural wastes, 9(3), 1984, 175-188*

[12] Gelegenis, J., D. Georgakakis, I. Angelidaki, V. Mauris., Optimization of biogas production by co-digesting whey with diluted poultry manure, *Renewable Energy, 23(13), 2007, 2147-2160.*

[13] Lehtomaki A., S. Huttunen, J. A Rintala., Laboratory investigations on co-digestion of energy crops and crop residues with cattle manure for methane production, Effect of crop to manure ratio, *Resources, conservation and recycling, 51, 2007, 591-609.*

[14] Eriksson and Olsson, *Bioenergy: power and heat generation,* EU SETIS-Strategic energy technologies information system, 2007.

[15] Mueller, R.L., J.R. Macey, M. Jaekel, D.B. Wake, and J.L. Boore, Morphological homoplasy, life history evolution, and historical biogeography of plethodontid salamanders inferred from complete mitochondrial genomes. *Proceedings of the National Academy of Sciences 101, 2004, 13820-13825.*

[16] Sommer, R. J., Hume, A. J., Ciak, J. M., VanNostrand, J. J., Friggens, M. and Walker, M. K. (2004), Early developmental 2,3,7,8-Tetrachlorodibenzo-p-dioxin Decreases Chick Embryo Heart Chronotropic Response to Isoproterenol but not to Agents Effecting Downstream Signals of the Beta-Adrenergic Receptor, *Toxicology Science, 83(2), 2005, 363-371.*

[17] Albihn, A. and Vinneas, B., Biosecurity and arable use of manure and bio waste – treatment alternatives, *Livestock Science, 112, 2007, 232–239.*

[18] Nopharatana, A., P. C. Pullammanappallil, W. P. Clarke, Kinetics and dynamic modeling of batch anaerobic digestion of municipal solid waste in a stirred reactor, *Waste Management, 27, 2007, 595–603.*

[19] Rabah, A. B., Baki, A. S., Hassan, L. G., Musa, M. & Ibrahim, A. D., Production of biogas using abattoir waste at different retention time, *Science World Journal 5 (4), 2010, 23-26.*

[20] Forster-Carneiro, T., M. Pérez and L. I. Romero, Influence of total solid and inoculum contents on performance of anaerobic reactors treating food waste, *Bioresource Technology, 99(15), 2008, 6994-7002.*

[21] Lopes, W.S., V.D. Leite and S. Prasad, Influence of inoculum on performance of anaerobic reactors for treating municipal solid waste. *Bioresource Technology, 94, 2004, 261-266.*

[22] Aurora, S.P., *Microbial Digestion in Ruminants*, Indian Council of Agricultural Research, New Delhi, 1983.

[23] Castillo, R.T., P.L. Luengo, and J.M. Alvarez, Temperature effect on anaerobic of bedding manure in a one phase system at different inoculums concentration, *Agriculture, Ecosystems and Environment, 5, 1995, 55-66.*