INFLUENCE OF THE CLIMATIC SEASON AND DIET ON THE BIOCHEMICAL METHANE POTENTIAL FROM CATTLE MANURE

Marcus L. Carlin[1], Jéssica J. Silva[1] & Renata P. Rodriguez[1]*

[1 2] *Instituto de Ciência e Tecnologia, Universidade Federal de Alfenas, Poços de Caldas, Brasil.*
** Corresponding author's: renata.rodriguez@unifal-mg.edu.br*

ABSTRACT

Biogas production from cattle manure is a consolidated technique, contributing to the generation of. Due to Brazil's continental dimensions, cattle management practices vary throughout the year, especially due to climatic conditions. This work evaluated the Biochemical Methane Potential (PBM) of dairy cattle manure from cows in lactation (L) and non-lactation (NL) periods, during fall and winter. The manure was characterized in terms of total and volatile solids, and the PBM tests followed the VDI 4630 protocol. Tests carried out with substrate from the fall lasted 62 days, with an accumulated volume of biogas of 2,035 ml for the L manure and 1,530 ml for NL manure. The maximum specific methane production was 838 ml $NCH_4\ g^{-1}\ TVS$ and 640 $ml\ NCH_4\ g^{-1}\ TVS$ for L and NL tests, respectively. For the winter manure, lasting 63 days, the accumulated volume of biogas was 1,350 ml and 860 ml for L and NL tests, respectively. The maximum specific methane production was 594 $NCH_4\ g^{-1}\ TVS$ and $NCH_4\ g^{-1}\ TVS$ for L and NL, respectively. These findings highlighted the importance of considering seasonal and diet variations in the production of biogas from cattle manure, aiming to optimize biogas production systems in Brazil.

Keywords: Cattle manure biodigestion. Lactation cows. No lactation cows. Biogas. Diet variations.

1 INTRODUCTION

The intensification of management through confinement, increase the amount of waste produced in a concentrated area and requires urgent treatment solutions. However, cattle farming generates an effluent with great potential for generating bioenergy, making it possible to create a system that allows the concentration of waste generated by the animals. With advances in the design of biodigesters capable of treating effluent and also generating biogas, areas with an intense concentration of this activity can be integrated into thermoelectric plants, powered by biogas, feeding the natural gas supply network and the production of fuel for vehicles. The integration of a natural gas network system opens up new perspectives for the future.

However, dairy and beef farming differ in terms of animal management and food sources, and also in dairy farming there are differences, in terms of diet, for cows in either lactating periods or not (dry periods). Therefore, the energy potential of each sector must be assessed individually and responses for one sector may not necessarily be valid for the other sector. In the case of Brazil, it is also necessary to consider the climatic variations that occur throughout the year, together with periods of greater and lesser precipitation, which greatly influence the diet options to be given to the animals. All these factors, when combined, provide different potential for using biogas through anaerobic digestion (AD).

The objective of this work was to determine the biochemical potential of methane (PBM) from cattle manure from dairy farming as a function of variation in feeding diet, as well as climatic conditions.

2 MATERIAL & METHODS

The bovine manure samples were collected from lactating and dry period cows (non-lactation), referred to in this work as L and NL. Two samples were carried out in different climatic seasons, one in autumn (fall) and the other in winter. The samples were collected in Poços de Caldas - MG, Brazil. The substrates were of total solids, total volatile solids and total fixed solids content, according to APHA [1]. The methane production potential was investigated using the VDI 4630 methodology [2], which recommends biochemical methane potential (BMP) tests considering a volatile solids ratio of the inoculum and substrate of 2:1.

The tests were carried out in 250 ml borosilicate bottles, containing 125 ml of useful volume. The flasks were kept at 35º C under 20 rpm for approximately 65 days. The biogas produced was collected and determined using a 500ml Hamilton syringe. The biogas composition was determined by gas chromatography. The inoculum used in all tests was from a UASB reactor treating waste from a poultry slaughterhouse (Pereiras - SP, Brazil). Based on experimental data on the cumulative methane production of each experimental condition, the modified Gompertz equation (Eq. 1) was used to estimate the experimental parameters: methane production potential, maximum methane production rate and lag phase time.

$$P_{CH4}(t) = Pmax * exp\left\{-exp\left[\left(\frac{(Rmax*e)}{Pmax}\right) * (\lambda - t) + 1\right]\right\} \quad (1)$$

Where:

$P_{CH4}(t)$: specific cumulative methane production ($Nml\, CH_4\ g^{-1}TVS$)
P_{max}: specific methane maximum production ($Nml\, CH_4\ g^{-1}TVS$)
R_{max}: methane production maximum rate ($ml\ NCH_4\ g^{-1}TVS\ d^{-1}$)
λ: lag phase (d)

3 RESULTS & DISCUSSION

Specific methane production was lower from manure obtained from NL cows, whether in fall or winter (Fig. 1). The difference in potential for manure from L cows is due to the greater nutritional richness of the diets during the lactation period. The diet during the lactation period is composed of a higher level of concentrates (corn grains and soybean bran), containing higher levels of quickly degradable carbohydrates, in addition to proteins and lipids and, consequently, higher energy value, resulting in a greater efficiency in converting food into milk. The greater nutritional variety results in manure with a higher percentage of organic matter that is easily converted into biogas and methane. Another characteristic of the L diet is that it has a lower content of fibrous components (cellulose, hemicellulose and lignin) compared to the NL diet in which cows feed directly on brachiaria, with minimal or no supplementation of concentrates. The influence of climate can also be seen, with lower biogas production during winter, whether for lactating cows or not. During the winter period, in the study region, the climate is very dry, with minimal precipitation. The impact of the winter climate was more pronounced on the substrate originating from the NL diet considering that it originated from animals that fed on brachiaria and that, under these conditions, have a lower content of new leaves and a higher content of fibrous compounds.

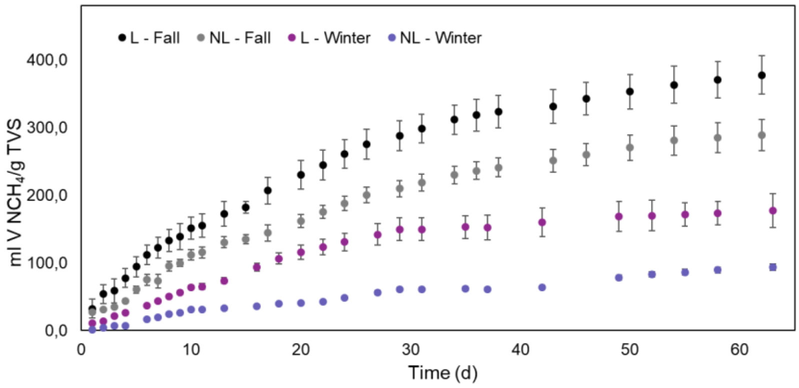

Figure 1 Specifc methane production for fall and winter manure for lactating and non-lactating cows.

Moraes [3] highlights the existence of relevant qualitative and quantitative variations in the waste produced from cattle, and that the climatic condition associated with the type of installation influences the amount of water ingested and the volume of urine produced. The fibrous components are structural components of grasses and constitute evolutionary adaptations that give them tolerance to climatic adversities, such as lack of rainfall or excess, high and low temperatures. These fibrous components are part of the cell wall of these plants. Optimized forage consumption occurs when animals are in dense pastures with leaves accessible to the animal, common in summer with high temperatures and high humidity [4].

Kinetic modeling indicated that in none of the evaluated conditions (L and NL) had a lag phase (Table 1). Considering the high biodegradability of the substrate, this result was expected. As previously discussed, the winter samples resulted in a lower volume of biogas produced, especially for NL manure, but also a lower methane maximum production rate, 29% lower for L manure and 49% for NL manure. This difference is quite significant when estimating the operation of continuous systems and indicates that the methane production process is directly dependent on the climatic season and, therefore, on the cattle feeding regime.

Table 1 Kinetics parameters using Gompertz modified model for methane production.

	Fall		Winter	
	L	NL	L	NL
Methane maximum volume production (ml)	2035.0	1530.0	1220.0	790.0
Methane production maximum rate ($ml\ NCH_4\ g^{-1}TVS\ d^{-1}$)	838.3	640.5	594.0	326.8
Lag phase (λ) (d)	0	0	0	0
R^2				

4 CONCLUSION

Diet and climatic conditions influenced the production of biogas and methane from cattle manure. Manure from lactating cows resulted in greater specific methane production and greater methane production rate, due to the nutritional richness that these animals receive during lactation. During the winter, a drop in methane production potential was observed, resulting both from the increase in fibrous content in the diet of NL cows and also from the drop in the animals' general metabolism, with lower residual energy content in the manure.

REFERENCES

1. APHA. AMERICAN PUBLIC HEALTH ASSOCIATION. 2012. Standard Methods for the Examination of Water and Wastewater. Washington.
2. VDI4630, 2006. in: Fermentation of Organic Materials. Characterization of the Substrate, Sampling, Collection of Material Data, Fermentation Tests.
3. MORAES, B.S., ZAIAT, M., BONOMI, A. 2015. Renewable and Sustainable energy reviews. 44. 888-903.
4. ORRICO JUNIOR, M.A.P., ORRICOLL, A.C.A., LUCAS JUNIOR, J., SAMPARIO, A.A.M., FERNANDES, A.R.M., OLIVEIRA, E.A. . 2021. Revista Brasileira de Zootecnia, 41, 1533-1538.

ACKNOWLEDGEMENTS

We thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for providing research funding (Process: 404494/2021-8, 310412/2022-6, and 405692/2022-6) and Fundação de Amparo à Pesquisa do Estado de Minas Gerais for scholarship.