RESEARCH ARTICLE

Study of Methane Emission and Energy Efficiency in Adult Cross-bred Cattle and Buffaloes on Maintenance Ration

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Abstract

This study was planned to determine methane production and energy efficiency in cross bred cattle and buffaloes at maintenance on a wheat straw-based total mixed ration. The experiment was conducted in two groups consisting of seven crossbred cattle (T1) and seven buffaloes (T2) with an average body weight of 395.04 ± 44.18 and 401.43 ± 13.26 Kg, respectively. Intake of gross energy, digestible energy, and metabolizable energy (Mcal/day)of cattle (T_1) was lower ($p > 0.05$) than buffaloes T_2). Methane energy loss, when expressed daily and about percent of gross energy, digestible energy and metabolizable energy did not differ significantly. In conclusion, methane emission was non significantly ($P > 0.05$) lower and hence energy efficiency was higher in crossbred cattle than buffaloes on wheat straw-based total mixed maintenance ration.

Keywords: Buffaloes, Cattle, Energy efficiency, Methane emission.

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Introduction

Nowadays, global warming is a big environmental concern. In recent decades, an increase in greenhouse gases from anthropogenic activity has heightened this issue. Livestock production systems have roughly 12.0-14.5 % share of world anthropogenic greenhouse gas-(GHG) emmissions expressed in carbon dioxide equivalent terms (Gerber *et al.*, 2013; Havlik *et al.*, 2014). According to a report by the Indian Network on Climate Change Assessment (INCCA, 2010), ruminants produce up to 50% of total methane emissions, with a total of 2.0 million tonnes annually. Among the ruminants large ruminants (cattle and buffalo) account for more than 90% of total enteric methane emissions in India (Swamy and Bhattacharya, 2006). Apart from being associated with environmental issues, methane emission from enteric fermentation is also a loss of energy from the animals (Cottle *et al.*, 2011). Methane emission (g/kg OM) data from cattle calves (Srivastava and Garg, 2002) and buffalo calves (Mohini and Singh, 2001) indicated that the species differed in methane emission. The present study was carried out with this background to determine the methane emission and energy losses through the methane emission of cattle and buffalo on a wheat straw-based total mixed ration.

Materials and Methods

The experiment protocol was sanctioned by Institutional Animal Ethical Committee-IAEC of the College, vide sanction order no. 335/ANRS/2021. Seven crossbreed Cattle (T_1) and Buffaloes (T_2) were grouped at Animal Nutrition Research Station and Reproductive Biology Research Unit, based on body weight (395.04 ± 44.18 and 401.43 ± 13.26 kg) to study the methane emission and energy efficiency for the period of 75 days including 15 days of adaptation feeding. Cross-breed Cattles and buffaloes were maintained in separate units to avoid influence on rumen fermentation and behavioral conflict. All the animals were housed in well-ventilated concrete-floored sheds with individual feeding and watering facilities. All the animals were fed two times daily at 9:00 O'Clock and 16:00 O'Clock. Clean and wholesome water was provided to all animals *ad libitum*. The animals were let loose for exercise for two hours in the morning and one hour in the afternoon under controlled conditions. They were dewormed and vaccinated before starting the experiment. TMR was prepared using wheat straw, ground maize, soybean meal, de-oiled rice bran, molasses and mineral mixture mixed @70, 05, 10, 04, 10 and 01 kg/100kg, respectively, with a roughage concentrate ratio of 70:30. The calculated crude protein and total digestible nutrient of TMR were 8 and 50%, respectively.

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All cattle and buffaloes were fed TMR (8.21 ± 0.10 vs. 8.74 ± 0.08 kg DM/day) to meet the nutrient requirements for maintenance (ICAR (2013). Proximate composition and fibre fractions of TMR were analyzed as per AOAC (1995) and Van Soest *et al*. (1991), respectively.

The methane emission of cattle and buffaloes was measured by SF_6 tracer technique as per Johnson *et al*. (2007) with slight modification of canister shape on both sides from middle to end to suit the horned cattle and buffalo. The breath samples of all experimental animals were collected daily for three consecutive days in canisters. Methane-CH_4 and SF_6 concentrations were determined by Gas Chromatography (Johnson *et al.,* 1994). All samples were analyzed in triplicate and the CH_4 emission rate was calculated as the product of the permeation tube SF_6 emission rate and the ratio of CH_4 to SF_6 concentration in breath sample.

Methane emission rate was calculated as under:

$$Q\ CH_4 = Q\ SF_6 \times (CH_4)/(SF_6)$$

Where,

$Q\ CH_4$= Methane emission rate (g/min),

$Q\ SF_6$ = Known release rate of SF_6 from permeation tube (g/min),

CH_4= Methane concentration of collected sample in canister (µg/m^3),

SF_6= SF_6 concentration of collected sample in canister (µg/m^3).

Energy content of CH_4 was considered as 13.34 Kcal/g (Donev *et al*., 2021). Loss of energy in the form of CH_4 as % of gross energy intake, digestible energy intake, and metabolizable energy intake was calculated as per NRC (1989).

Table 1: Chemical composition of TMR on dry matter basis (%)

Parameters	*TMR (%)*
Crude protein	7.55
Ether extract	1.85
Crude fibre	33.03
Nitrogen-free extract	44.04
Total ash	13.53
Organic matter	86.47
Neutral detergent fibre	58.84
Acid detergent fibre	38.72
Cellulose	29.07
Hemicellulose	20.12

The data thus obtained were analysed statistically as per the procedure of Snedecor and Cochran (1994). Significant differences between means of different treatments were assessed by Duncan's test and the differences were declared significant at $p < 0.05$.

Results and Discussion

TMR Composition

The proximate composition and fibre fraction values for NDF, ADF, ADL, cellulose and hemicellulose of the TMR are presented in Table 1. TMR contained 7.55 % crude protein, which was slightly lower than the calculated value (8.00%), and was adequate to satisfy the nutrient requirements for maintenance of adult cattle and as per ICAR (2013). This was indicated by gain in weight (19.12 kg-T1 vs. 11.8 kg-T2) of animals in both groups on feeding dry matter (8.21 ± 0.10-T1 vs. 8.74 ± 0.08-T2 kg/day).

Enteric Methane Emission

The average daily enteric methane (CH_4) emission from experimental animals in terms of g/day, g/kg DMI, g/kg DDMI, g/kg OMI, g/100 kg BW and g/kg $W^{0.75}$ is presented in Table 2.

The results indicated that daily CH_4 emission (g) and in terms of g/kg DMI in cattle (T_1) was non significantly Lower ($p > 0.05$).by 8.66 and 4.06 %, whereas, in terms of g/kg DDMI and g/kg OMI was lower by 5.20 and 4.07% and in terms of g/100 kg BW and g/kg $W^{0.75}$it was reduced by 6.93 and 7.81% in cattle (T_1) as compared to buffalo (T_2).

Malik *et al*. (2021) reported non-significantly ($p > 0.05$) higher methane emission in buffalo than cattle fed TMR with 30:70 concentrate:roughage ratio and consisted of green Napier grass (*Pennisetum purpureum*) as roughage. Singh *et al*. (2014) compared the methane emission between male crossbred cattle and male buffalo fed total mixed ration having different concentrate to roughage ratio (20:80T_1, 50:50T_2, 80:20T_3) using Latin square design. They observed significantly higher methane emissions by male buffalo daily, metabolic body weight, unit dry matter intake, unit digestible dry matter intake, unit organic matter intake, and unit digestible organic matter basis compared to male crossbred cattle which was similar to the trend observed. The higher number of Genus Methanobrevibacter - *M. boviskoreani* and *M. ruminantium, Methanomassiliicoccales*

Table 2: Enteric methane emission of experimental animals

Attributes	*T_1 (Cattle)*	*T_2 (Buffalo)*	*% change over T_2*
CH_4 emission (g/d)	160.81 ± 14.96	176.05 ± 13.90	-8.66
CH_4 emission (g/kg DMI)	22.24 ± 2.14	23.18 ± 1.75	-4.06
CH_4 emission (g/kg DDMI)	42.83 ± 4.20	45.18 ± 4.79	-5.20
CH_4 emission (g/kg OMI)	25.66 ± 2.47	26.75 ± 2.02	-4.07
CH_4 emission (g/100 kg BW)	39.64 ± 4.47	42.59 ± 3.89	-6.93
CH_4 emission (g/kg $W^{0.75}$)	1.77 ± 0.18	1.92 ± 0.17	-7.81

Table 3: Energy intake and loss of energy as methane

Attributes	T_1	T_2	*%change over* T_2
GE intake (Mcal/day)	20.02 ± 1.54	21.05 ± 0.60	-4.89
Energy loss as CH_4 (Mcal/day)	2.15 ± 0.20	2.35 ± 0.19	-8.51
Energy loss as CH_4 (% of GEI)	10.91 ± 1.05	11.18 ± 0.85	-2.42
DE intake (Mcal/day)	16.76 ± 1.28	17.61 ± 0.50	-4.83
Energy loss as CH_4 (% of DEI)	13.04 ± 1.26	13.36 ± 1.01	-2.40
ME intake (Mcal/day)	13.61 ± 1.04	14.37 ± 0.41	-5.29
Energy loss as CH_4 (% of MEI)	16.05 ± 1.55	16.38 ± 1.24	-2.01

and *Methanobacterium alcaliphilum* in water buffalo compared to Jersey cows under similar feeding conditions (Iqbal *et al*, 2018) might be responsible for higher methane production in buffaloes though statistical analysis revealed non-significant ($p > 0.05$) difference. Studies by several researchers (Wanapat *et al*., 2000; Chanthakhoun *et al.,*2012) indicated larger populations of ruminal cellulolytic bacteria and fungi in the buffalo compared to cow under identical dietary conditions. A larger number of cellulolytic bacteria in the buffalo rumen makes it more efficient in utilization of fibrous feed, which produces more acetic acid and a higher generation of H_2 and large volume of CH_4 production than cattle. An incubation of feeds with swamp buffalo rumen liquor produced more gas than cattle rumen liquor (Chanthakhoun and Wanapat, 2012) with higher methane production, which indicated that the buffalo had higher fibre digestibility (Wanapat *et al.*,2000; Kumar *et al*., 2013).The higher methane emission in the present study than Malik *et al*. (2021) might be due to wheat straw being used as sole roughage source.

Energy Efficiency

The average values of daily gross energy intake (GEI), digestible energy intake (DEI), metabolizable energy intake (MEI), energy loss as CH_4, energy loss in the form of CH_4 as % of GEI, % of DEI and % of MEI are presented in Table 3. The gross energy intake of crossbred cattle was 4.89% lower ($p > 0.05$) compared to buffalo. The daily energy (Mcal) loss as CH_4 was non-significantly ($p > 0.05$) lower by 8.51% in cattle as compared to buffalo. As a result, the energy loss in the form of CH_4 as % of GEI in cattle was non-significantly lower by 2.42% as compared to buffalo.

The digestible energy intake was non-significantly lowered by 4.83 % in cattle compared to buffalo. The energy loss through CH_4 emission as % of DEI in cattle was numerically lower (2.40%) compared to buffalo. The metabolizable energy intake was non-significantly lower by 5.29 % in cattle compared to buffalo. The energy loss in the form of CH_4 as % of MEI in cattle was lower numerically by 2.01% compared to buffalo. Similarly, Sinha *et al*. (2016) revealed non-significantly higher gross energy intake as well as metabolizable energy intake and significantly ($p < 0.01$) higher methane energy loss in buffalo (*Bubalus bubalis*) compared to crossbred cattle on feeding three total mixed rations having concentrate to roughage ratio of 60:40, 40:60 and 20:80. Similar trends and statistically higher ($p < 0.05$) gross and metabolic body weight basis energy intake, fecal energy loss, methane energy loss, net energy intake and numerically higher ($p > 0.05$) urinary energy loss along with significantly ($p > 0.05$) lower metabolizable energy intake, lower ($p > 0.05$) heat production were observed in buffaloes than the crossbred cattle, with similar digestible energy intake (Singh *et al*., 2014). The variation in values compared to the present study might be due to the use of TMR with three different concentrations to roughage ratios. In contrast to the present finding, lower energy loss on account of methane production per unit gross energy intake in buffalo (3.7%) was observed than in cattle (4.4%) (Kawashima *et al.,* 2006) on feeding *Brachiaria ruziziensis* grass hay. This difference may be due to breed variations on account of metabolic activity and adaptation of rumen microbes to feed composition.

Conclusion

Based on the results of this study, it is concluded that crossbred cattle had lower methane emission and hence higher energy efficiency than buffaloes at maintenance on feeding total mixed rations with wheat straw as the sole roughage at 70:30 roughage to concentrate ratio.

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