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Assessment of energy metabolism and methane emission in cattle and buffaloes fed TMR diets having different concentrate to roughage ratios

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ABSTRACT

India has the largest livestock population and ruminants are one of the main contributors of methane production i.e. about 20% of the total CH_4 emission. The present experiment was carried out to compare methane production and energy metabolism in crossbred cattle and buffaloes fed on 3 different total mixed ration (TMR) having various concentrate to roughage ratios. Crossbred cattle (6) and buffaloes (6), 2-year-old, were randomly divided into 3 homogenous groups following 3×3 switch over design. Experimental feeding consisted of 3 ratio of concentrate (C) and roughage (R) ((20C:80R (T_1); 50C:50R (T_2) and 80C:20R (T_3)) fed as TMR alternately to each group. After every 21 days of feeding trial, energy metabolism and methane production was determined using open circuit respiration chamber. Methane emission (L/day/kg $W^{0.75}$) was significantly higher in buffaloes (2.61±0.039) as compared to crossbred cattle (2.13±0.050). Methane emission (L/day) and methane energy (kcal/day) was significantly higher in buffaloes as compared to crossbred cattle. Methane emission (L/day and L/day/kg $W^{0.75}$) and methane energy (kcal/day) was significantly higher in T_1 than T_2 and T_3. This may lead to the conclusion that buffalo produces more methane than cattle. Under the high plane of nutrition there is significant reduction in methane production than that of lower plane of nutrition in both species of animals. However, efficiency of energy utilization is significantly higher in buffaloes as compared to crossbred cattle. Though, higher concentrate to roughage ratio in the diet of CB cattle and buffaloes significantly reduces enteric CH_4 emissions.

Key words: Buffaloes, Cattle, Energy metabolism, Methane production, Roughage: concentrate ratios

Greenhouse gas (GHG) emissions have become an increasingly important topic worldwide due to their effects on global warming and climate. Methane is the second largest anthropogenic GHG, which contributes 14.3% of total anthropogenic GHG emissions (IPCC 2007). Methane emissions from the agriculture sector represents 40 % of total anthropogenic production while enteric fermentation in ruminants makes the largest single (25 %) contribution (Key and Tallard 2012). The emission of methane from ruminants also varies based on the geographical location, feed composition and quality, feed intake, processing of feed and animal breed (FAO 2010). By understanding the reasons of variability in enteric CH_4 production in relation to diet, animal nutritionists are working for finding out various strategies to reduce the methane from ruminant. Alteration of concentrate ratio of feeds in the diet of ruminants is one of the most effective management practices recommended for mitigating greenhouse gas emissions from ruminants (Boadi *et al.* 2004 and Hristov *et al.* 2013). Literature has scanty data on comparison between cattle and buffaloes for methane production on TMR feeding. Keeping in view the above facts, the present study was specifically designed to study comparative methane production in crossbred cattle and buffaloes by feeding diets as TMR varying in roughage and concentrate ratios.

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MATERIALS AND METHODS

Feeds and feeding: Male crossbred cattle (6), about 2-year-old, and 6 male buffaloes, about 2-year-old, were taken for the experiment. They were divided according to 3×3 switch over design. Groups T_1, T_2, T_3 of animals, each consisting 2 crossbred calves, and 2 buffaloes were fed experimental diets CP and TDN as per Kearl (1982). Physical composition (%) of concentrate mixture was maize 37, wheat bran 40, deoiled soyabean 20, mineral mixture 2 and common salt 1. Composition of TMR is given Table 1. Group 1 (T_1): The crossbred cattle and buffaloes of this

Table 1. Chemical composition (% on DM basis) of various total mixed rations (TMR)

Attributes	TMR–1	TMR-2	TMR–3
DM	89.60	89.80	89.80
OM	91.27	91.67	92.07
CP	5.82	10.06	14.29
EE	1.64	2.74	3.83
GE (Mcal)/kg	4.21	4.33	4.45

group were fed wheat straw and concentrate in the ratio of 80:20 as TMR diet.

Group 2 (T_2): This was the control group, animals of this group were fed wheat straw and concentrate in the ratio of 50:50 as TMR diet.

Group 3 (T_3): The crossbred cattle and buffaloes of this group were fed wheat straw and concentrate in the ratio of 20:80 as TMR diet.

Six-day metabolic trials were conducted to determine the nutrient utilization in crossbred cattle and buffaloes after 21 days feeding trial.

Analysis of biological samples: The urinary nitrogen and feed and faeces samples were analyzed for the proximate principles (AOAC 1995). The open circuit respiration study involved the measurement of methane concentration in the air going in and coming out from the respiratory chamber. For the calculations flow rate, temperature of dry and wet bulb and atmospheric pressure were recorded. On line methane was measured by a gas analyzer, and flow rate and the total volume of air coming to the chamber were measured by using a flow meter attached with chamber. The dry and wet bulb temperatures of air coming out of chamber were recorded. Atmospheric pressure was recorded by an electronic device. The gas analyzer attached with respiration calorimetry was calibrated with standard gas as per standard protocol. Concentration of methane in incoming and outgoing respiration gas was measured online and recorded hourly interval. Total volume of air passed through the chamber was changed into total volume on standard temperature and pressure as per following formula.

Volume (at standard temperature and pressure):

$$V_{STP} = V(273)/\ (273+t) \times (P\text{-}PV)/760.$$

Methane and carbon dioxide produced and oxygen consumed was calculated by formula-

= VSTP × difference in the concentration of in-coming air and outgoing air from the chamber × 100.

Heat production: The heat production was calculated by using data of respiratory (gaseous) exchange and urinary nitrogen excreted (g/day) using Brouwer's equation,

$$\text{Heat production (kcal/day)} = 3.866 + 1.200\ CO_2 - 0.518\ CH_4 - 1.431\ N$$

Statistical analysis: All the data were statistically analyzed using SPSS 16.0th version computer package. For comparison of groups, Generalized Linear Model ANOVA procedure and Duncan's multiple range tests were used (Snedecor and Cochran 1994).

RESULTS AND DISCUSSION

Six male crossbred cattle (about 2-year-old) and 6 male buffaloes (about 2-year-old) were taken for the experiment. They were divided in groups following 3×3 switch over design. They were fed according to Kearl (1982).

Intake and digestibility of nutrients: The dry matter intake and digestibility of DM and OM in crossbred calves and buffaloes are given in Table 2. The DMI (% BW and DMI/kgW$^{0.75}$) were comparable among the different treatments (T_1, T_2, T_3). The total DMI (kg/day), % DMI and DMI/kgW$^{0.75}$ consumption was significantly higher ($P<0.05$) in buffaloes than cattle. Regulation of DMI is a very complex process and influenced by various factors like breed, age, sex, live weight, stage of growth, milk yield, stage of lactation, pregnancy, previous feeding, body condition and diseases etc. Feed factors (plant species, diet composition, chemical composition, digestibility, rate of degradation, rate of passage, physical form etc);

Table 2. Dry matter intake and digestibility of DM and OM in crossbred cattle and buffaloes fed various TMR

Species	20C:80R (T_1)	50C:50R(T_2)	80C:20R(T_3)	Mean	P Value		
					T	S	T× S
DMI (kg)							
Cattle*	4.01±0.16	4.02±0.16	4.02±0.17	4.02±0.09^q	0.268	0.020	0.072
Buffaloes*	5.74±0.21	5.81±0.17	5.82±0.17	5.79±0.10^p			
Mean	4.88±0.29	4.92±0.29	4.92±0.29				
DMI (kg/100 kg BW)							
Cattle*	1.86±0.03	1.92±0.04	1.89±0.03	1.89±0.02^p	0.432	0.039	0.682
Buffaloes*	1.83±0.05	1.87±0.02	1.86±0.02	1.86±0.02^q			
Mean	1.85±0.03	1.90±0.02	1.87±0.02				
DMI (g/kgW$^{.75}$)							
Cattle*	72.29±1.02	73.27±1.36	71.83±1.43	72.46±.71^q	0.510	0.027	0.865
Buffaloes*	77.00±1.45	78.62±1.12	77.83±0.63	77.816±.6^p			
Mean	74.64±1.10	75.94±1.16	74.83±1.17				
DM digestibility (%)							
Cattle	56.18±0.35	61.61±0.63	66.50±0.87	61.43±1.00	0.009	0.605	0.624
Buffaloes	57.60±0.70	61.93±1.27	66.14±0.49	61.72±0.97			
Mean**	56.89±0.38^c	61.02±0.69^b	66.32±0.48^a				
OM digestibility (%)							
Cattle	58.60±0.34	61.78±0.46	65.77±0.64	61.81±0.62	0.002	0.079	0.920
Buffaloes	59.42±0.84	62.46±1.20	65.26±0.72	62.00±0.74			
Mean**	58.35±0.73^c	61.79±0.56^b	65.10±0.65^a				

p, q shows significance across column and a, b, c shows significance across rows * ($P<0.05$) ** ($P<0.01$) .

management, housing and environmental factors also influences the intake. The results obtained in the present experiment were found to be similar with Kennedy (1990), who after a series of comparative studies between buffalo and cattle, concluded that buffalo exhibit a higher voluntary intake (DM and OM) than cattle on low-quality forage such as spear grass and rice straw. Similarly, Ferdous *et al.* (2010) observed higher average daily dry matter intake in buffalo calves fed UMB supplemented ration with wheat straw than cattle calves.

Digestibility of dry matter and organic matter was significantly ($P<0.01$) higher in T_3 than T_1 and T_2. Dry matter and organic matter digestibility was highest in diet of T_3 due to high proportion of concentrate mixture in it. Digestibility of DM and organic matter was comparable among cross bred cattle and buffalo. Similarly, Lapitan *et al.* (2008) reported that there was no species difference in the digestion coefficient and feed conversion rate between the crossbred cattle and water buffalo when fed with under high roughage-based fattening rations. However, Chanthakhoun *et al.* (2011) reported higher nutrient digestibility of buffalo than those in cattle particularly those of DM, OM when fed with rice straw *ad libitum* and concentrate mixture with12% CP and 76%TDN. The digestibility of DM depends on quality of roughage in feed, which in turn depends on the content of protein and energy together with minerals and vitamins.

Methane emission: In the current experiment the emission of methane in L/day; L/day/kg $W^{0.75}$; L/day/DMI (kg); L/day/DMD (%); L/day/OMI (kg) and L/day/OMD (%) were significantly higher ($P<0.01$) in buffaloes than crossbred cattle (Table 3). CH_4 is emitted as a by-product of the normal livestock digestive process, in which microbes resident in the animal's digestive system, which ferment the feed consumed by animals. The microbes present in the rumen of farm animals also play a vital role in emission of methane. Buffaloes are more efficient in utilization of fibrous feed than cattle because they have more population of celluloytic bacteria in their rumen. Since more acetic acid is produced in the rumen this leads to higher generation of H_2 and higher rate of CH_4 production in them. Similarly, Gandra *et al.* (2011) reported that the buffaloes group presented higher acetate: propionate ratio compared to cattle when fed with corn-silage based diets. The poor tolerance

Table 3. Methane production in crossbred cattle and buffalo fed different TMR diets

Species	20C:80R (T_1)	50C:50R(T_2)	80C:20R(T_3)	Mean	P Value		
					T	S	T× S
Methane production (L/day)							
Cattle**	133.97±3.32	120.35±2.22	110.11±2.57	121.49±2.79^q	0.006	0.008	0.990
Buffaloes**	207.15±6.28	192.54± 5.33	181.95±6.46	193.85±4.12^p			
Mean**	170.56±11.54^a	156.44±11.23^b	146.04±11.33^c				
Methane production (L/day)/kg$W^{0.75}$							
Cattle**	2.42±0.05	2.23±0.03	1.97±0.04	2.13±0.050^q	0.007	0.005	0.47
Buffaloes**	2.78±0.04	2.60±0.054	2.43±0.022	2.61±0.039^p			
Mean**	2.60±0.06^a	2.41±0.06^b	2.20±0.07^c				
Methane production (L/day)/ kg DMI							
Cattle**	33.49±0.62	30.10±0.70	27.54±0.70	30.37±0.70^q	0.007	0.006	0.600
Buffaloes**	36.14±0.49	33.11±0.12	31.25±0.23	33.58±0.517^p			
Mean**	34.82±0.56^a	31.61±0.56^b	29.40±0.66^c				
Methane production (L/day) / kg DMD							
Cattle**	58.59±1.27	49.70±1.40	41.11±1.65	49.81±1.902^q	0.003	0.008	0.87
Buffaloes**	63.96±1.55	54.01±0.98	46.75±0.60	54.89±1.81^p			
Mean**	61.24±1.254^a	51.8±1.048^b	43.951±1.18^c				
Methane production (L/day) / kg OMI							
Cattle**	36.78±0.74	33.17±0.76	30.46±0.76	33.44±0.75^q	0.003	0.004	0.580
Buffaloes**	39.68±0.53	36.50±0.13	34.58±0.26	36.92±0.54^p			
Mean**	38.23±0.61^a	34.89±0.62^b	32.52±0.73^c				
Methane production (L/day)/kg OMD							
Cattle**	63.88±1.92	55.02±2.25	48.249±2.32	55.72±1.95^q	0.009	0.010	0.900
Buffaloes**	69.85±3.27	59.13±1.91	52.62±1.28	60.53±2.13^p			
Mean**	66.86±2.02^a	57.07±1.54^b	50.43±1.42^c				
Methane energy production (kcal/day)							
Cattle**	1266.06±31.4	1137.33±20.99	1040.54±24.29	1147.97±26.45^q	0.007	0.006	0.990
Buffaloes**	1957.54±59.41	1819.55±50.41	1719.75±61.13	1832.28±38.99^p			
Mean**	1611.80±109.0^a	1478.43±106.09^b	1380.15±107.08^c				

p, q shows significance across column and a, b, c shows significance across rows ** (P<0.01).

Table 4. Energy metabolism in crossbred cattle and buffaloes fed different TMR diets

Species	20C:80R (T_1)	50C:50R(T_2)	80C:20R(T_3)	Mean	P Value		
					T	S	T× S
Gross energy intake (Mcal/kg/day)							
Cattle*	16.71±0.69	17.15±0.69	17.57±0.73	17.14±0.39[q]	0.07	0.03	0.89
Buffaloes*	23.89±0.87	24.82±0.71	25.44±0.74	24.72±0.45[p]			
Mean	20.30±1.21	20.98±1.25	21.51±1.29				
Gross energy intake (kcal/day)/kgW$^{0.75}$							
Cattle*	300.88±4.81	312.69±5.54	314.12±6.36	309.27±5.42[q]	0.04	0.05	0.74
Buffaloes*	320.53±2.67	335.53±2.58	340.25±2.53	332.15±1.5[p]			
Mean*	310.63±3.24[b]	324.13±2.63[a]	327.37±2.53[a]				
Faecal energy loss (kcal/day)/kgW$^{0.75}$							
Cattle**	97.0±0.19	96.1±0.17	94.66±0.17	94.6±0.10[q]	0.040	0.003	0.845
Buffaloes**	124.9±0.01	118.78±0.16	110.0..±0.29	116.24.±0.11[p]			
Mean*	113.9±0.36[a]	107.4±0.36[a]	102.183±0.36[b]				
Digestible energy (kcal/day)/kgW$^{0.75}$							
Cattle	203.4.±0.217	216.7±0.042	223.0±.044	214.0±0.15	0.046	1.000	0.452
Buffaloes	196.2..±0.03	216.0±0.02	228.30±.004	214.±0.04			
Mean*	200.8±0.05[b]	216.34±0.08[a]	220±.075[a]				
Methane energy loss (kcal/day)/kgW$^{0.75}$							
Cattle**	22.0±0.03	19.8±0.02	17.5±0.09	19.8±0.007[q]	0.004	0.002	0.642
Buffaloes**	26.0±0.002	24.6±0.03	23.2±0.04	24.6±0.02[p]			
Mean**	24.0±0.05[a]	22.2±0.02[b]	20.35±0.12[c]				
Urinary energy loss (kcal/day)/kgW$^{0.75}$							
Cattle	7.82±0.64	7.58±0.66	6.77±0.52	7.39±0.35	0.032	0.914	0.963
Buffaloes	7.95±0.42	7.49±0.27	6.87±0.24	7.44±0.20			
Mean*	7.89±0.37[a]	7.54±0.34[ab]	6.82±0.27[b]				
Metabolisable energy (kcal/day)/kgW$^{0.75}$							
Cattle	174.01±4.22	189.16±4.09	199.32±5.15	187.50±3.51	0.002	0.167	0.782
Buffaloes	165.23±5.96	184.68±4.45	196.94±2.39	182.28±4.00			
Mean**	169.62±3.72[c]	186.92±2.96[b]	198.13±2.73[a]				
Heat production (kcal/day)/kgW$^{0.75}$							
Cattle*	127.52±3.57	126.56±2.94	122.55±2.63	125.54±1.75[p]	0.020	0.060	0.854
Buffaloes	110.67±1.45	109.24±1.31	105.99±1.05	108.63±0.84[q]			
Mean	119.09±3.13	117.90±3.03	114.27±2.84				
Net energy (kcal/day)/kgW$^{0.75}$							
Cattle**	46.50±5.76	62.60±5.83	76.77±6.52	61.95±4.44q	0.010	0.007	0.756
Buffaloes**	54.56±5.78	75.45±3.33	90.95±2.50	73.65±4.25p			
Mean**	50.53±4.08c	69.02±3.74b	83.86±3.96a				

p, q show significance across column and a, b, c show significance across rows; * ($P<0.05$) ** ($P<0.01$).

to low pH by protozoa and cellulolytic bacteria decreases further hydrogen production. A positive correlation between cellulolytic and methanogens in the rumen of different animal species (cattle, sheep, deer) has been shown, except in the buffalo (Rowlinson *et al.* 2008). This exception may be explained by the fact that *F. succinogenes*, a non-hydrogen-producing cellulolytic species, is the major cellulolytic bacteria in buffaloes. Among various treatment methane production (L/day/kg, L/day/kg W $^{0.75}$; L/day/DMI (kg); L/day/ DMD (%), L/day/OMI (kg) and L/day/ OMD (%)) was significantly higher ($P<0.01$) in T_1 than T_2 and T_3. It was similar to Madhu and Singh (2010) who observed that changing plane of nutrition through concentrate mixture or urea molasses mineral block, improved digestibility of nutrients as well as decreased methane production in lactating cows. An increased proportion of starch in the diet changes ruminal volatile fatty acids (VFAs) concentrations in such a way that less acetate and more propionate is formed, and the supply of hydrogen for methanogenesis is limited. A similar result was reported by Lovett *et al.* (2006) when they increases dietary concentrate, they found a significant decrease in enteric methane production in an individual animal. A high proportion of concentrate in diet reduces rumen pH and consequently affects the protozoa population. Furthermore, it also reduces the acetate: propionate ratio and thus decreases the amount of methane produced per unit of feed intake (Kumar *et al.* 2013). On the contrary to other researchers, Sejian *et al.* (2011) reported that higher proportion of forage to concentrate resulted in decreasing ruminal methane production and attributed it to the effect of the high content of fat in the diet which could potentially reduce fiber degradation. He also reported that total mixed ration (TMR) feeding leads to decrease methane production vs. separate forage-concentrate feeding in dairy cows.

Energy utilization: Energy metabolism in different groups of crossbred cattle and buffaloes are presented in Tables 4 and 5.Gross energy intake (Mcal/d, Kcal/day/ kg $W^{0.75}$) was significantly higher (P<0.05) in buffaloes than the crossbred cattle. Among the various treatments gross energy intake (Kcal/day/kg$W^{0.75}$) was significantly lower (P<0.05) in T_1 than T_2 and T_3. Total faecal energy loss (kcal/ d/ kg $W^{0.75}$) was significantly higher (P<0.01) in buffaloes than the crossbred cattle. Total faecal energy loss was depended upon intake and digestibility of animal. It might be the reason for higher fecal loss in buffaloes than cattle. Among different treatments faecal energy loss (kcal/d/ kg $W^{0.75}$) was significantly higher (P<0.05) in T_1 and T_2 than T_3. Similarly, Blaxter and Wainman (1964) reported increase faecal energy loss with increasing proportion of flaked maize in the diet beyond 60–80%. The digestible energy was comparable among buffaloes and crossbred cattle. Among the treatments digestible energy kcal/d/kg $W^{0.75}$ was significantly lower (P<0.05) in T_1 than T_2 and T_3. Similarly, Kawashima *et al.* (2006) found that DE was the lowest in treatment with lower CP (7.45%) and was higher in treatment in which CP is high (13.47%).

Methane energy loss (kcal/day) as the % of GE intake (Table 5) and methane energy loss (kcal/day/ kg $W^{0.75}$) was also found to be significantly higher (p<0.01) in buffaloes than the crossbred cattle (kcal/day), since methane production was more in buffaloes than crossbred cattle so the methane energy loss was also greater. Among the various treatments methane energy loss as the % of GE intake and methane energy loss (kcal/day/ kg $W^{0.75}$) was significantly higher (P<0.01) in T_1 than T_2 and T_3. This occurs in accordance to the methane production since methane production related directly to the methane energy loss. Contrarily, Kawashima *et al.* (2006) reported that energy loss into methane production on the basis of GE intake tended to be lower in buffalo (3.7%) than in cattle (4.4%) when fed with grass hay (*Brachiaria ruziziensis)*. Total energy (kcal/d / kg $W^{0.75}$) excreted in urine was comparable among buffaloes and crossbred cattle. Among different treatments it was significantly higher (P<0.05) in T_1 than T_3. Metabolisable energy (kcal/day/kg$W^{0.75}$) was comparable among crossbred cattle and buffaloes. Among different treatments ME (kcal/day/kg$W^{0.75}$) was significantly higher (P<0.01) in T_3 than T_2 and Heat production (kcal/day/kg$W^{0.75}$) and heat production as % of GE intake was significantly higher (P<0.05) in crossbred cattle than buffaloes. As heat production depends mainly upon CO_2 and CH_4 produced O_2 consumed and urinary nitrogen excretion. The heat production (kcal/day/kg$W^{0.75}$) was comparable among the various treatments. Among the treatments heat production as % of GE intake was significantly higher (P<0.05) in T_1 than T_3. As heat production across diets, was affected by type of feed ingested, more fibrous feed intakes had higher heat production than concentrate rich diets. intake of energy.

Net energy (kcal/day)/kg$W^{0.75}$ in buffaloes was significantly higher (P<0.01) than crossbred cattle group (Table 5). Net energy as % of GE intake in crossbred cattle was comparable with buffaloes. It depends upon various

Table 5. Balance of energy as % of energy intake in crossbred cattle and buffaloes fed different TMR diets

Species	20C:80R (T_1)	50C:50R(T_2)	80C:20R(T_3)	Mean	P Value		
					T	S	T× S
Digestible energy as % of gross energy intake							
Cattle**	67.71±0.48	69.25±0.29	71.12±0.30	69.36±0.39[p]	0.000	0.000	0.611
Buffaloes**	62.19±0.82	64.57±0.58	66.61±0.58	64.46±0.57[q]			
Mean**	64.95±0.95[c]	66.91±0.77[b]	68.87±0.75[a]				
Methane energy lost as % of gross energy intake							
Cattle**	7.30±0.23	6.35±0.21	5.56±0.15	6.40±0.20[q]	0.00	0.00	0.615
Buffaloes**	8.20±0.10	7.33±0.03	6.75±0.05	7.43±0.15[p]			
Mean**	7.75±0.18[a]	6.84±0.18[b]	6.16±0.19[c]				
Metabolisable nergy as % gross energy intake							
Cattle**	57.80±0.60	60.48±0.48	63.40±0.44	60.56±0.62[p]	0.000	0.000	0.783
Buffaloes**	51.49±1.05	55.01±0.62	57.84±0.56	54.78±0.76[q]			
Mean	54.65±1.11[c]	57.74±0.91[b]	60.62±0.90[a]				
Heat production as % of gross energy intake							
Cattle**	42.43±1.31	40.53±1.25	39.10±1.30	40.65±0.77[p]	0.005	0.000	0.997
Buffaloes**	34.57±0.58	32.54±0.28	31.11±0.16	32.70±0.40[q]			
Mean**	38.55±1.36[a]	36.59±1.35[ab]	35.15±1.35[b]				
Net energy as % gross energy intake							
Cattle	15.38±1.73	19.93±1.63	24.30±1.64	19.87±1.26	0.000	0.069	0.929
Buffaloes	16.91±1.57	22.44±0.68	26.72±0.71	22.02±1.13			
Mean**	16.14±1.14[c]	21.19±0.92[b]	25.51±0.93[a]				

p, q shows significance across column and a, b, c shows significance across rows ** (P<0.01).

energy intake and energy losses. Among the various treatments NE (kcal/day/kg$W^{0.75}$) and NE as % intake of GE were significantly higher ($P<0.01$) in T_3 group than the T_2 and T_1. Due to physiological, behavioural differences and more relaxed behavior of buffaloes is thought to be the reason for lower energy requirement for maintenance and growth of buffaloes when compared to cattle fed similar diets under same conditions (Liang and Samiyah 1989). However, Kawashima *et al*. 2006 reported no significant difference in energy balances between Brahman cattle and swamp buffalo during feeding grass hay (*Brachiaria ruziziensis)*.

From the results, it is concluded that the crossbred cattle showed lower CH_4 emission than that of buffaloes. However, efficiency of energy utilization is significantly higher in buffaloes as compared to crossbred cattle. So, higher concentrate to roughage ratio in the diet of CB cattle and buffaloes significantly reduces enteric CH_4 emissions.

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