



Comparative evaluation of nutrient utilization, growth performance and methane emission in Murrah buffaloes, Vrindavani and Tharparkar cattle fed on a similar diet

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ABSTRACT

Present study was conducted to compare the indigenous, crossbred cattle and buffaloes for the utilization of nutrients, growth and methane emission when fed on a similar diet. A 120-days feeding trial was carried out with six animals each of Murrah buffalo, Vrindavani and Tharparkar cattle, each on a similar diet comprising of wheat straw 30% and concentrate 70%. The DM intake (kg/d) was significantly higher for Vrindavani cattle than Murrah buffaloes and Tharparkar cattle. Whereas, the apparent digestibility of nutrients was similar in all the groups. Average daily gain (g/d) was higher in Murrah buffaloes than Vrindavani and Tharparkar cattle. Higher feed conversion ratio was seen in Vrindavani than other two groups which indicate that the Murrah and Tharparkar have better feed efficiency than Vrindavani. The N balance was significantly higher in Murrah followed by Vrindavani and was lowest in Tharparkar. The methane emission (l/kg DMI, l/kg DDMI) was similar among the three groups. It was concluded that Vrindavani cattle showed higher feed conversion ratio than buffaloes and Tharparkar cattle, which signifies later two species are superior in nutrient utilization than former one. In terms of methane production and digestibility of nutrients, the animals of all three groups were similar.

Keywords: Methane, Murrah, Nutrient digestibility, Similar diet, Tharparkar, Vrindavani

In India, cattle and buffaloes are mainly maintained as dairy animals. As ruminants, both have the capacity to utilize high fibrous roughage diet and bio-convert it into usable nutrients. Despite similarities, there exist some differences with respect to overall metabolism and physiology. Many reports suggest that the dry matter (DM), organic matter (OM), protein, and total digestible energy (TDN) intake is higher in buffalo than in cattle when expressed in gram per kg metabolic body weight ($\text{g/kgW}^{0.75}$) (Singh *et al.* 2018, Das *et al.* 2022). Buffaloes also exhibit a higher concentration of ruminal ammonia ($\text{NH}_3\text{-N}$), blood urea with greater recycling of nitrogen (N), higher cellulolytic bacteria and higher rumen microbial enzyme activity in the rumen of buffaloes (Chanthakhoun *et al.* 2012, Wanapat *et al.* 2016, Rathode *et al.* 2022). In addition, digestibility of DM, organic matter, crude protein (CP), ether extract (EE), neutral detergent fibre (NDF) and acid detergent fibre (ADF) was found higher in buffaloes and it may possibly be due to the higher cellulolytic bacterial population or higher fibre degrading activity of rumen microbes in

the buffaloes (Pradhan *et al.* 1997, Agarwal *et al.* 2009, Singh *et al.* 2013, Dixit *et al.* 2023). Conversely, other reports suggest a significantly lower DM intake (DMI), digestibility of OM, NDF in buffaloes (Puppo *et al.* 2002) and similar cellulolytic bacterial density between cattle and buffalo (Asai *et al.* 2021).

There is a debate whether cattle or buffalo emit higher enteric methane (CH_4) on same management/feeding conditions since long. Methane production is majorly driven by diet, which has been observed by many researchers on cattle and buffaloes fed similar diet (Malik *et al.* 2021, Dixit *et al.* 2023, Kala *et al.* 2023). Multiple meta-genomic studies have revealed that both cattle and buffalo were containing similar methanogen abundance or population (Iqbal *et al.* 2018, Malik *et al.* 2023). Contrarily, Singh *et al.* (2014) reported higher enteric CH_4 emission from buffaloes over cattle. There are conflicting results regarding the digestive functions of the two species. With this background, the present study has been designed and carried out to compare Murrah buffaloes, Vrindavani (crossbred) and Tharparkar (indigenous) cattle fed on a similar diet in terms of nutrient digestibility, growth and enteric methane emission.

MATERIALS AND METHODS

Experimental animals and design: Three species

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(6 animals in each) of ruminants (approximately 9-10 months old), viz. male growing Murrah buffalo (BW 255.5±7.84 kg), Vrindavani (BW 273.5±5.51 kg) and Tharparkar (BW 205±9.93 kg) cattle were housed in the Animal Nutrition shed of ICAR-IVRI, Izatnagar. All the animals were fed 30% wheat straw and 70% concentrate mixture (consisting of crushed maize grains, 39%; deoiled soybean meal, 15%; wheat bran, 43%; mineral mixture, 2% and salt, 1% on air dried basis) to meet their nutrients requirement as per the feeding standards of ICAR (2013), targeting the growth rate of 500 g/d. The ratio of wheat straw (roughage) and concentrate (R:C) was maintained throughout the feeding trial. The animals were kept in well-ventilated experimental sheds having facility for individual feeding. Fresh and clean drinking water was made available *ad lib.* thrice in a day.

Determination of growth and nutrient digestibility: The body weight of the animals was measured fortnightly during the experimental period. A metabolism trial of 9 days duration including 3 days adaptation followed by 6 days collection period was conducted to evaluate the nutrient utilization efficiency and nitrogen balance. The animals were shifted in metabolic cages having facility for separate collection of faeces and urine. The body weight of the animals was recorded before and after the trial. Each animal's representative sample of feed offered, residues and faeces were collected individually in a tagged polythene bag after 24 h. A suitable aliquot (1/10 of fresh faeces) was taken for the sample and dried at 100°C in a hot air oven for DM measurement. Daily collected dry materials were pooled per animal, crushed to pass through a 1 mm sieve, and used for proximate analysis and fibre fractions. An appropriate portion (1/100 of fresh faeces) was combined with a reasonable amount of 20% sulphuric acid and stored in a previously weighed airtight bottle for nitrogen estimation. The proximate principles of feed ingredients, residue, faeces and urine were analysed as per the procedures of AOAC (1995) and fibre fractions by Van Soest *et al.* (1991).

Estimation of methane emission: The methane estimation study was carried out after 90 days of experimental using open circuit respiration chamber. Animals were weighed in the morning before being fed and watered, and then housed in a respiration chamber for 2-3 days to acclimatize chamber environment, and methane measurements were being done at hourly intervals for two days. The observations were noted for flow rate, temperature of dry, wet bulb and atmospheric pressure. Methane was measured in the air coming to the chamber and going out from the chamber by an Infrared Gas Analyzer (Analytical Development Co. Ltd. Hoddesdon, England, model 300).

Statistical analyses: The statistical analyses were performed using SPSS computer package (SPSS version 20.0, SPSS Inc., Chicago, USA). The data were statistically analyzed using one-way ANOVA for body weight gain, DM intake, methane emission and metabolic trial. The means were compared using Duncan's multiple range test

if the main effect was significant (i.e. $P < 0.05$).

RESULTS AND DISCUSSION

Nutrients intake and digestibility: The chemical composition of feeds offered to the experimental animals are presented in the Table 1. All the nutrients were supplied through the diet in adequate amounts to match the requirements of the experimental animals. The animals consumed as per the required energy and protein levels as possible for the proper maintenance and growth according to the requirements of ICAR (2013).

Table 1. Chemical composition (% DM basis) of concentrate and wheat straw

Nutrient	Concentrate mixture	Wheat straw
Dry matter	91.49	92.02
Organic matter	92.34	92.2
Crude protein	15.8	3.1
Ether extract	4.1	1.15
Neutral detergent fibre	40.1	75.04
Acid detergent fibre	9.64	56.14
Total ash	7.66	7.8

The intake of nutrients (DM, OM, CP, EE, NDF and ADF) was significantly ($P < 0.05$) higher for Vrindavani cattle than Murrah buffalo and Tharparkar cattle, however the apparent digestibility of above-mentioned nutrients did not differ significantly ($P > 0.05$) among the three species of ruminants. Similar to our finding, Malik *et al.* (2023) also reported that the cattle group (10.5 kg) had higher DMI as compared to buffalo (6.86 kg), however there was no difference in the digestibility coefficients of nutrients between the two groups fed napier grass and concentrate in a ratio of 70:30. There was no difference in digestibility of various nutrients between cattle and buffalo fed total mixed ration containing different levels of R:C levels (Sinha *et al.* 2017, Singh *et al.* 2018). In contrast, Das *et al.* (2022) reported that there was higher intake of DM, CP, digestible CP, TDN (%W^{0.75}) in buffalo than the cattle with no difference in apparent digestibility of the nutrients between the two groups fed maintenance ration. This result can possibly be attributed to physiology, metabolism and behavioural differences among the groups. Regulation of DM intake in ruminants is a complex mechanism involves various factors such as hormonal, environmental, physiological, feeding practices and others (NRC 2021).

Body weight (BW) gain and feed conversion ratio (FCR): There was a significant ($P < 0.01$) difference in the body weight gain as well as average daily gain (ADG), with Murrah buffalo gaining higher BW and ADG than the remaining two groups (Table 2).

FCR was significantly ($P < 0.01$) higher for Vrindavani cattle (10:1) compared to the Murrah buffalo (7.1:1) and Tharparkar cattle group (8.4:1). Similar to findings of this study, in a comparative study by Wang *et al.* (2020), buffalo calves demonstrated lower FCR than in Holstein

Table 2. Body weight changes, nutrient intake and digestibility in Murrah buffalo, Vrindavani and Tharparkar cattle

Attribute	Murrah	Vrindavani	Tharparkar	SEM	P-value
<i>Body weight</i>					
Initial (kg)	254.5 ^b	275.5 ^b	208.7 ^a	9.53	<0.001
Final (kg)	359.2 ^b	357.0 ^b	279.0 ^a	12.73	<0.001
Gain (kg)	104.8 ^b	81.5 ^a	70.3 ^a	5.09	<0.001
ADG (g)	873 ^b	680 ^a	585 ^a	42.49	<0.001
FCR	7.1 ^a	10.0 ^b	8.4 ^a	0.42	<0.001
<i>Nutrient intake (kg/d)</i>					
DM	6.46 ^b	7.52 ^c	4.55 ^a	0.38	<0.001
OM	5.84 ^b	7.13 ^c	4.22 ^a	0.33	<0.001
CP	0.79 ^b	0.86 ^c	0.56 ^a	0.04	<0.001
DCP	0.58 ^b	0.60 ^b	0.41 ^a	28.15	<0.001
EE	0.170 ^b	0.189 ^c	0.120 ^a	9	<0.001
NDF	3.61 ^b	4.49 ^c	2.61 ^a	0.24	<0.001
ADF	1.46 ^a	1.90 ^b	1.19 ^a	0.1	<0.001
TDN	4.31 ^b	4.88 ^c	3.04 ^a	0.24	<0.001
<i>Apparent nutrient digestibility (%)</i>					
DM	66.75	67.66	67.36	0.52	0.8
OM	67.07	67.94	68.27	0.38	0.44
CP	73.21	69.48	73.67	1.34	0.41
EE	75.43	75.31	68.9	1.98	0.33
NDF	39.54	38.44	40.33	0.59	0.46
ADF	43.65	45.62	44.53	0.88	0.7

^{abc}, Means bearing different superscripts in a row differ significantly; ADG, average daily gain; FCR, feed conversion ratio; DM, dry matter; OM, organic matter; CP, crude protein; DCP, digestible crude protein; EE, ether extract; NDF, neutral detergent fibre; ADF, acid detergent fibre; TDN, total digestible nutrients; SEM, standard error of the mean.

calves. Lapitan *et al.* (2008) reported that the weight gain and ADG was significantly higher in buffalo than in Brahman cattle fed on the high roughage diet. As reported by Kearn (1982), buffalo and cattle mature at a different age relative to body size depending on genetics, nutrition and the environment. The initial, final and average body weights were significantly ($P<0.01$) higher for Vrindavani cattle and Murrah buffalo than Tharparkar cattle. This may be due to the higher N retention in buffalo and also the higher initial BW and higher DMI in Vrindavani cattle and buffalo than Tharparkar. Rathode *et al.* (2022), reported higher ruminal $\text{NH}_3\text{-N}$ concentration and higher ruminal protease activity in Murrah buffaloes. In line with this, in the current study there was higher N retention in buffalo, which implies that there was efficient N recycling in rumen and overall N metabolism in the buffaloes. The higher

proteolytic activity in rumen of buffalo, results in higher $\text{NH}_3\text{-N}$ concentration than cattle (Paliwal and Sagar 1990, Dixit *et al.* 2023) which was also confirmed by (Bhatia *et al.* 1992).

Nitrogen balance: The N balance was highest ($P<0.01$) in Murrah buffalo followed by Vrindavani and lowest balance was seen in Tharparkar cattle group, respectively (Table 3). Similar to our finding, there are reports suggesting that buffalo presented with higher N balance than crossbred cattle on different roughage to concentrate ratios (Singh *et al.* 2018, Dixit *et al.* 2023). Therefore, the differences in balance are attributable to capability of retention. Buffalo excels over cattle in the ability to retain dietary N. Several experiments also reported that ruminal characteristics of buffalo are more favourable to ammonia nitrogen utilization. Nha (2008) also reported higher N

Table 3. Nitrogen metabolism during metabolic trial

Attribute	Murrah	Vrindavani	Tharparkar	SEM	P-value
Nitrogen intake (g/d)	126.7 ^b	139.0 ^c	93.4 ^a	5.95	<0.001
N intake (g/kg $\text{W}^{0.75}$)	1.59 ^b	1.74 ^c	1.43 ^a	0.04	<0.001
N loss in faeces (g/d)	37.15 ^b	45.68 ^c	23.79 ^a	2.74	<0.001
N loss in urine (g/d)	45.67 ^b	58.22 ^c	41.76 ^a	2.34	<0.001
Total N loss (g/d)	82.81 ^b	103.89 ^c	65.54 ^a	4.86	<0.001
Faecal N excretion (% intake)	45.02 ^b	43.98 ^b	36.26 ^a	1.31	<0.001
Urine N excretion (% intake)	54.99 ^a	56.02 ^a	63.74 ^b	1.31	<0.001
N balance (g/d)	43.85 ^c	35.12 ^b	27.81 ^a	2.04	<0.001

^{abc}, Means bearing different superscripts in a row differ significantly; N, nitrogen; SEM, standard error of the mean.

Table 4. Methane production in Murrah buffalo, Vrindavani and Tharparkar cattle

Attribute	Murrah	Vrindavani	Tharparkar	SEM	P-value
Body weight (kg)	292 ^b	316 ^c	246 ^a	6.57	<0.001
Metabolic BW	70.58 ^b	75.03 ^c	62.08 ^a	1.21	<0.001
Average DMI	6.19 ^b	7.15 ^c	4.85 ^a	0.23	<0.001
Methane (L/d)	150.7	148.6	119.8	7.15	0.140
Methane (g/d)	107.7	106.2	85.55	5.11	0.140
Methane (L/kg DMI)	24.61	20.51	24.52	0.93	0.120
Methane (L/kg DDMI)	37.39	30.27	35.96	1.37	0.070
Methane (L/kg OMI)	26.67	22.23	26.58	1.01	0.120

^{abc}, Means bearing different superscripts in a row differ significantly; DMI, dry matter intake; l/d, litre/day; DDMI, digested dry matter intake; OMI, organic matter intake; SEM, standard error of the mean.

balance in buffalo which reflected in higher weight gain. Similarly in the current study, there was higher ($P<0.001$) ADG in buffaloes than the cattle groups, which indicates better N balance in former group than the latter two groups.

Methane production: Total CH₄ production (L/d, g/d, L/kg DM intake, and L/kg Digested DM intake) was comparable ($P>0.05$) among the three groups (Table 4). This might be due to the similar diet and managerial conditions being provided to the all groups. In agreement with our finding, Kala *et al.* (2023) reported that there was no difference in methane production among buffalo, crossbred and indigenous cattle on similar diet and management. In an *in vitro* study conducted by Kamra (2015) using rumen liquor of Murrah buffalo and cattle, showed that the gas and CH₄ production and *in vitro* true digestibility were similar in both the species on R:C ratio of 25:75. Dixit *et al.* (2023) reported that crossbred cattle (Karan Fries) and Murrah buffalo emitted similar quantities of CH₄ (g/kg DMI) fed a diet of varied C:R ratio (30-60% concentrate). Malik *et al.* (2021) also demonstrated similar enteric methane production in buffaloes and cattle fed R:C in 70:30 ratio. There was no difference in CH₄ yield (g/d and L/kg digested DM intake) in cattle (45.4 g/kg DDMI) and buffalo (46.5 g/kg digested DM intake) fed finger millet straw and para grass in 70:30 ratio (Malik *et al.* 2023). Similarly, many reports suggest, there were similar quantities of methanogenic and protozoal population between the cattle and buffalo on similar plane of nutrition (Kala *et al.* 2023, Malik *et al.* 2023, Rathode *et al.* 2022). Conversely, Singh *et al.* (2014) reported buffaloes yielded higher CH₄ (54.8 L/kg DMI) as compared to crossbred cattle (49.8 L/kg DMI) on similar diet which might be due to the difference in the body weight of two species. CH₄ emission depends on the type of animal, type of diet and frequency of feeding to the animals. In majority of studies, it has been shown that by nutritional interventions, the total population density was not affected but there was always shift within different methanogen species (Parmar *et al.* 2017).

This study demonstrated the superiority of buffaloes over cattle in recycling and utilizing nutrients. Vrindavani cattle and Murrah buffalo showed higher nutrient intake, but the apparent digestibility of nutrients was similar across

all three groups. In terms of nitrogen balance and average daily gain, Murrah buffaloes outperformed both cattle groups. Murrah buffalo and Tharparkar exhibited lower feed conversion ratio, indicating superior feed utilization efficiency compared to Vrindavani. However, nutrient digestibility and methane production were similar among all three groups.

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