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Effect of Ration Balancing on Methane Emission and Milk Production in Lactating Animals under Field Conditions in Raebareli District of Uttar Pradesh

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ABSTRACT

A field trial was conducted to study the effect of balancing the ration on methane emission and milk production in lactating buffaloes and crossbred cows under field conditions in Raebareli district of Uttar Pradesh. Thirteen lactating animals each of buffaloes and crossbred cattle belonging to twenty farmers of five villages of Raebareli district in Uttar Pradesh state were selected for the study. The selected buffaloes were in their second to fourth lactation, with a production of 4.0 to 6.5 kg milk per day with 5.0 to 6.5 % milk fat. The cows were in their third to fourth lactation with a production of 4.0 to 6.5 kg milk per day with 3.5 to 5.0 % fat. Initially, baseline methane emissions of all the animals were estimated using sulphur hexafluoride technique, thereafter, their ration was balanced as per their nutrient requirement. After 30 days of feeding balanced ration, methane emission by the animals was estimated again. Analysis of the feeding practices revealed that though the dietary intake of TDN was adequate, CP intake was lower in both buffaloes (8.63 %) and cows (18.55%) than their requirements. The calcium and phosphorus were also deficient by 43.50 and 46.43% in buffaloes and 54.06 and 51.83% in cows, respectively. Balancing of ration significantly ($P<0.05$) improved the milk yield and milk fat in both the species. Baseline methane production from buffaloes and cows were 214.68 and 195.79 g per day, respectively. Average methane emission, in terms of g/day and g/kg DMI was significantly ($P<0.05$) reduced by feeding balanced ration in both the species. The average reduction was 10.48% and 10.84% in lactating buffaloes and 11.36 % and 14.32% in cows, in terms of g/day and g/kg DMI, respectively. Gross energy lost as methane also reduced significantly ($P<0.05$). Therefore, ration balancing has the potential to improve production and reduce methane emission from lactating buffaloes and cows.

Key words : Ration Balancing, Methane Emission, Lactating Cows, Lactating Buffaloes, Field Trial.

INTRODUCTION

Climate change due to increased emission of green house gases in the atmosphere has drawn worldwide attention. As per the Intergovernmental Panel on Climate Change (IPCC) report, the share of different green house gases is CO_2 -76.7%, CH_4 -14.3%, N_2O -

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7.9% and other gases 1.1% (IPCC, 2007). Methane is the second most important greenhouse gas and enteric fermentation from ruminants is the predominant source. Indian bovines (57% of world's buffalo and 14% of the cattle population) are considered as one of the important source of global methane emission.

Animals fed imbalanced ration produce more methane per unit of dry matter intake due to lower microbial protein production and higher acetate production (Leng,1991). Despite the concerted efforts put forth by various agencies to popularize scientific feeding, most of the farmers still follow the traditional methods of feeding, based on locally available feed resources. Various studies conducted at field level have shown that either there is deficiency of energy (Mudgal et al. 2003) or it is in excess (Singh et al. 2002). Similarly, either protein is deficient (Mudgal et al. 2003, Singh et al. 2002) or in excess (Gupta et al. 2006). Very few farmers supplement mineral mixture in the ration, thereby, leading to widespread mineral deficiency which results in poor productive and reproductive performance of the animals (Garg et al. 2000). Traditional feeding usually results in over or underfeeding, thereby it paves way for the importance of balanced ration for improving milk production of animals. Beside this, methane production during enteric fermentation is a nutritionally wasteful process which represents 2 to 15% of gross energy loss (Moss,1993). Thus, ration balancing could be one of the important strategies for improving microbial protein synthesis and shifting volatile fatty acid production in favour of propionic acid, thus lowering methane emission, besides improving the animal productivity. Keeping this in view, the present study was carried out to know the effect of ration balancing on methane emission and milk production in lactating animals under field conditions.

MATERIALS AND METHODS

Thirteen lactating animals each of buffaloes and cattle belonging to twenty farmers were chosen for the study from five villages (Gohanna, Palia, Chaklorahar, Udaipur and Dilawalpur) of Raebareli district in Uttar Pradesh state. The selected buffaloes were in their second to fourth lactation, with a production of 4.0 to 6.5 kg milk per day with 5.0 to 6.5% milk fat. The cows were in their third to fourth lactation with a production of 4.0 to 6.5 kg milk per day with 3.5 to 5.0% fat. The feed was offered by the farmers to animals twice a day i.e. morning & evening. The feed intake of each animal was measured and representative sample was taken for proximate and detergent fiber analysis. Thereafter, the ration of all the animals was balanced for total digestible nutrients (TDN), crude protein (CP), calcium and phosphorus using the ration balancing software developed by National Dairy Development Board (NDDB), which is based on Kearl (1982) standards for buffaloes and NRC (1989) for cows. The balanced diet was fed to all the animals for 30 days. Blood samples were collected before and after balancing the ration. The body weights of the animals were calculated using Shaeffers's formula (Sastry et al. 1982). Body weight (in kg) = ([(heart girth in inches) 2 × length of the body in inches] /300) × 0.4536.

Dry matter intake, milk yield and milk fat were recorded daily during methane gas sampling period. Methane measurement was done by sulfur hexafluoride tracer technique (Johnson et al. 1994). All the selected animals for the study were covered under the insurance for a period of one year, in view of farmer's reluctance to allow insertion of permeation tube in the lactating animals. A small permeation tube containing sulfur hexafluoride (SF_6) was inserted in the rumen of each of the experimental animal. The release rate of SF_6 from the permeation tube was determined prior to inserting in the rumen. A halter fitted with a capillary tube was placed on the animal's head and connected to an evacuated sampling canister. One week before start of sample collection, permeation tubes with known SF_6 release rate were inserted in the rumen of all the animals selected for the experiment and all the animals were acclimatized to wearing the halter and canister. The breath samples of all the experimental animals were collected daily for four consecutive days in canisters and brought to the laboratory for methane and SF_6 analysis at the start of the study. After one month of experimental feeding, methane emission was measured similarly. Methane and SF_6 concentrations were then determined by gas chromatography. Methane emission rate was calculated as the product of the permeation tube emission rate and the ratio of CH_4 to SF_6 concentration in the sample. Samples were analyzed in duplicate. The gas chromatograph was fitted with a molecular sieve 5A column for SF_6 and a Porapack N for methane. The column temperature was maintained at 50° C and nitrogen was used as a carrier gas, with a flow rate of 30ml min-1. Prepared standards were used to standardize the gas chromatograph for SF_6 (39ppt and 79ppt, Scott-Marrin Inc., Riverside, CA,USA) and methane (5.2ppm and 10ppm, Scott-Marrin Inc., Riverside, CA, USA).

Methane emission rate was calculated as under :

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

Where

QCH_4 - Methane emission rate (g/min)

QSF_6 - Known release rate of SF_6 from permeation tube (g/min)

CH_4 - Methane concentration of collected sample in canister (ug/m^3)

SF_6 - SF_6 concentration of collected sample in canister (ug/m^3)

Proximate composition (AOAC, 1995) and acid detergent fiber (ADF) and neutral detergent fiber (NDF) of feeds and fodders were determined (Van Soest et al. 1991). The milk samples were analysed for milk fat (IS: 1224, 1977). Gross energy of feed and fodder samples were calculated from the prediction equation of Guenther et al. (1979). Energy content of methane was taken as 13.34 kcal per g (Brouwer, 1965). The data were statistically analyzed using paired student's t-test (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

Farmers used wheat grain, wheat bran and wheat straw as feeds for the animals. Body weight and feed intake of the experimental animals before and after ration balancing is presented in Table 1. Analysis of the feeding practices revealed that though the dietary intake of TDN was adequate, CP intake was lower in both buffaloes (8.63%) and cows (18.55%) than their requirements. The calcium and phosphorus were also deficient by, 43.50 and 46.43% in buffaloes and 54.06 and 51.83% in cows, respectively.

After the collection of samples for baseline methane emission, the ration was balanced as per the requirement of individual animal for TDN, crude protein, calcium and phosphorus. Protein sources like mustard cake were included and wheat grain and wheat bran decreased to increase protein availability in the diet. Ration balancing did not affect body weight and DMI (Table-1) in buffaloes and cows. Though TDN intake

Table 1. Body weight, plane of nutrition and milk yield of the experimental animals

Parameter	Buffaloes (n=13)		Cows (n=13)	
	Baseline	After ration balancing	Baseline	After ration balancing
Body weight (kg)	417±4.53	420± 3.86	382±4.89	386±5.03
DM intake (kg/day)	10.24±0.15	10.29±0.13	9.37±0.08	9.69±0.17
Concentrate : Roughage ratio	48:52	48:52	44:56	45:55
DMI (kg /100 kg B. Wt)	2.46±0.03	2.45±0.03	2.45±0.02	2.51±0.04
DMI (g/kg W 0.75)	111.04±1.38	110.91±1.27	108.40±0.86	111.19±1.72
CP intake (g/day)*	853.85^a±11.42	973.51^b±13.53	621.91^a±10.01	789.18^b±11.51
TDN intake (g/day)	5037.84±87.17	5060.40 ±70.14	4851.25±51.49	4901.42±53.27
Blood urea nitrogen (%)	8.19^a±0.38	10.30^b±0.59	7.35±0.22	8.46±0.65
N intake (g/kg digestible organic matter intake)	24.40^a±0.43	27.64^b±0.51	19.72^a±0.26	24.11^b±0.45
Milk yield (kg/day) *	5.25^a±0. 14	5.93^b±0. 13	4.95^a±0.13	5.50^b±0.11
Milk fat (%)	5.98^a±0.09	6.32^b± 0.08	4.20^a±0.09	4.39^b±0.06

a,b Values with different superscript within a species differ significantly ($P<0.05$)

was similar, the CP intake was significantly ($P<0.05$) higher in both buffaloes and cows after feeding balanced ration. Concentrate and roughage intake was also similar in both species before and after balancing the ration as evident from similar concentrate: roughage ratio.

Effect of Ration Balancing on Milk Yield and Milk Fat

Initially, average daily milk production was 5.25 and 4.95 (kg/d) and milk fat 5.98 and 4.20%, in buffaloes and cows, respectively. Due to implementation of ration balancing programme, there was an average increase of 0.68 kg milk/animal/day and 0.34% milk fat, in buffaloes, which was significantly ($P<0.05$) higher than before implementation of the programme (Table1). In cows also there was an increase of 0.55 kg milk/animal/day and 0.19% milk fat, which was also significantly ($P<0.05$) higher than baseline. The improvement in milk yield and milk fat may be due to balancing of nutrients, which might have improved microbial protein synthesis and also due to supply of good quality mineral mixture which might have alleviated the deficiency of calcium and phosphorus.

Methane Emission

Baseline methane production from buffaloes and cows was 214.68 and 195.79 g per day, respectively (Table 2). These values are similar to those reported earlier (Holter and Young 1992; Singhal and Madhu Mohini, 2003). Holter and Young (1992) found methane emission from 358 lactating Holstein cows varying from 175 to 299 g/day/cow. Singhal and Madhu Mohini (2003) reported 162.67 to 259.74 g methane emission from buffaloes fed on balanced diet.

Average reduction of 10.48% and 10.78% methane emission in terms of g/day and g/kg DMI was observed in lactating buffaloes which were significantly lower than the baseline emissions ($P<0.05$). Average reduction of 11.37% and 14.04% methane emission, in terms of g/day and g/kg DMI, were observed in lactating cows, which was also significantly ($P<0.05$) lower than the baseline emissions. The gross energy lost as methane has reduced significantly ($P<0.05$) from 6.48 to 5.78 % in buffaloes and from 6.46 to 5.55 % in cows respectively. The reduction in the methane emission observed in the present study is attributed to the balancing of nutrients, which might have changed rumen fermentation towards more microbial cell production and lower volatile fatty acids (acetate and butyrate) production. More acetate and butyrate production leads to production of more hydrogen and carbon dioxide, the main substrates for methane production. There was deficiency of crude protein in the diet. This was further confirmed by very low blood urea nitrogen level observed in both buffaloes and cows (Table 1). The increased nitrogen supply after ration balancing might have provided the required fermentable nitrogen for efficient microbial protein synthesis (Table 1). The minerals supplied in the diet also could have enhanced the microbial cell growth since ash content of microbial matter is 13% (Czerkawski, 1986). The reduction in

Table 2. Effect of ration balancing on methane emission in lactating animals

Parameter	Buffaloes (n=13)		Cows (n=13)	
	Baseline	After RBP	Baseline	After RBP
Methane emission (g/animal/day)*	$214.68^{b}\pm7.10$	$192.19^{a}\pm5.93$	$195.79^{b}\pm5.74$	$173.54^{a}\pm4.75$
Dry matter intake (kg/day)	10.24 ± 0.15	10.29 ± 0.13	9.37 ± 0.08	9.69 ± 0.17
Methane emission (g/kg DMI)*	$20.97^{b}\pm0.65$	$18.71^{a}\pm0.61$	$20.91^{b}\pm0.60$	$17.98^{a}\pm0.56$
Organic matter intake (kg/day)	9.34 ± 0.15	9.39 ± 0.13	8.47 ± 0.08	8.79 ± 0.17
Methane emission (g/kg OMI)*	$23.00^{b}\pm0.78$	$20.51^{a}\pm0.74$	$23.14^{b}\pm0.73$	$19.83^{a}\pm0.71$
Gross energy intake (Mcal/day)	40.64 ± 0.66	43.40 ± 0.57	39.17 ± 0.33	37.98 ± 0.74
Energy loss as methane (Mcal/day)*	$2.86^{a}\pm0.09$	$2.56^{b}\pm0.08$	$2.61^{a}\pm0.08$	$2.32^{b}\pm0.06$
Energy loss as methane (% of gross energy)*	$6.48^{a}\pm0.20$	$5.78^{b}\pm0.19$	$6.46^{a}\pm0.19$	$5.55^{b}\pm0.17$

a,b Values with different superscript within a species differ significantly ($P<0.05$)

methane emission observed in the study is consistent with the earlier reports (Leng, 1991).

The limitation for growth of microorganisms on diets based on crop residues and low digestible forages, as practiced in India, is probably due to inadequate concentration of ruminal ammonia and deficiency of trace and macro minerals besides low feed intake. Depending on the efficiency of utilization of ATP for microbial cell synthesis, the amount of carbohydrate converted to microbial cells can be highly variable, which controls the production of methane and volatile fatty acids (Leng, 1991). Therefore, feeding as per the nutrient requirement of animals provides an effective measure for reducing methane emission as recorded in dairy cattle in USA (Capper et al. 2009) and in beef cattle in Canada (GHGMP, 2005) due to improved feed utilization and enhanced overall production efficiency of the herd.

Thus, ration balancing programme has the potential to reduce methane production by 10 to 11%. Similar experiments on these lines are required to be conducted under different conditions of feeding and management to generate more information and also to popularize the concept of ration balancing programme, for improved productivity and reduced methane emissions, leading to efficient utilization of available feed resources.

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