Research Article

Effect of Ration Balancing on Methane Emission Reduction in Lactating Animals Under Field Conditions

A. Kannan and M. R. Garg*

Balancing of ration improved milk yield and milk fat per cent in cows and buffaloes under field conditions in Gujarat state. Twenty-two lactating Jaffarabadi buffaloes (8 to 12 kg milk/d with 6.0 to 7.5 per cent milk fat) and five Gir cows (9.5 to 12.5 kg milk with 4.0 to 4.5 per cent milk fat) selected for the trial. Initially, baseline methane emissions of all the animals were estimated using sulphur hexa fluoride technique, thereafter their ration was balanced as per their nutrient requirement. After 30 days of feeding of balanced ration, methane emission by the animals was estimated again. Average methane emission reduction, in terms of g/day and g/kg DMI was 14.14 % and 11.56 % in lactating buffaloes, was lower (P<0.01) than baseline emission. Corresponding values for cows were 13.29% and 10.87% and methane emission was also lower (P<0.01 and P<0.05, respectively) than the baseline emission, resulting a reduction (P<0.01) in loss of gross dietary energy as methane, in both lactating buffaloes (14.14%) and cows (13.29%). The results suggest that ration balancing has the potential to reduce methane emission from lactating buffaloes and cows, under field conditions.

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

INTRODUCTION

Methane is one of the important greenhouse gases responsible for global warming. In view of large animal population of cattle and buffaloes, which are mainly fed on crop residues based rations, causing the imbalanced nutrient availability, India's contribution in green house gas is sizable. Beside this, methane production during enteric fermentation is a nutritionally wasteful process, which represents 2 to 15 % gross energy loss to the host animal (Moss,1993). Animals fed balanced ration produce more methane per unit of dry matter intake due to lower microbial protein production and higher acetate production (Leng, 1991; Blummel *et al.* 2001). 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 in lactating animals under field conditions.

MATERIALS AND METHODS

On Farm Experiment

Twenty two lactating Jaffarabadi buffaloes and five Gir cows belonging to ten farmers were chosen for the study in three villages, Kadodara, Moradya and Simasi, of Junagadh district in Gujarat state. The selected buffaloes were in their third to fifth lactation, with a production of 8.0 to 12.0 kg milk per day with 6.0 to 7.5% milk fat. The cows were in their fourth to sixth lactation with a production of 9.5 to 12.5 kg milk per day with 4.0 to 4.5% fat. Initially, the feed offered by the farmers was fed to animals, equally in morning and evening. The feed intake of each animal was measured and representative sample taken for dry matter analysis and 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. The body weights of

* Productivity Enhancement (Animal Nutrition), National Dairy Development Board, Anand - 388 001, Gujarat, India. Phone : +91-2692-226248, Fax : +91-2692-260158, E-mail: mrgarg@nddb.coop

2009-053 Date received:March 2009; Accepted:May 2009

the animals were calculated using Shaeffers's formula (Sastry *et al.* 1982).

Body weight (in lbs) = [(heart girth in inches)^2 x length of the body in inches] /300

Sample Collection and Analysis

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 ube 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. Due to the negative pressure, sample of air around the mouth and nose of the animal, containing mixture of gases including methane and SF_6, sucked in the canister put around the neck of animals through a capillary tube. One week before start of sample collection, permeation tubes with known SF_6 release rate was 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 'ie study. After one month of experimental feeding, methane emission was measured similarly. Methane and SF_6 concentrations are 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. A gas chromatograph fitted with an electron capture detector was used to determine SF_6 and a flame ionization detector was used to determine methane concentration in collected samples. Samples were analyzed in duplicate. The gas chromatograph was fitted with a molecular sieve 5A column for SF_6 and a Poropack 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 (5.6 ppm 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)

Chemical and Statistical Analysis

Proximate composition of feeds and fodders were analyzed as per the methods of AOAC (1995). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) of feeds and fodders were determined as per the methods of Van Soest et al. (1991). The milk samples were drawn daily during sampling days and 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 generated during the study were statistically analyzed using paired student's t-test (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

Farmers were feeding wheat bran, cottonseed cake, jowar fodder, wheat straw and groundnut straw to the animals. Cotton seed cake is a good source of protein, wheat bran is medium in energy and protein, groundnut straw is a good source of protein and calcium. 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 dietary intake of TDN was higher in buffaloes (12.8%) and cows (10.2%) while CP intake was lower in buffaloes (10%) and cows (8%) than their requirements. The calcium and phosphorus were also deficient by, 25.8 and 36.0% in buffaloes and 23.2 and 31.5 % in cows, respectively.

After the collection of samples for baseline

Table 1: Body Weight, Plane of Nutrition and Milk Yield of the Experimental Animals

Parameters	Buffaloes (n=22)		Cows (n=5)	
	Baseline	After ration balancing	Baseline	After ration balancing
Body weight (kg)	428 ± 22.81	441± 21.45	414 ± 16.02	422 ± 19.81
DM intake (kg/day)	12.68 ± 0.31	12.31 ± 0.36	12.50± 0.21	12.16 ± 0.19
Concentrate : Roughage ratio	42:58	42:58	40:60	41:59
DMI (g /100 kg B. Wt)	2963 ± 11.91	2790 ± 12.14	3042 ± 9.91	2881 ± 9.02
DMI (g/kg $W^{0.75}$)	134.75 ± 0.78	127.88 ± 0.68	136.99 ± 0.61	130.58 ± 0.59
CP intake (g/day)*	1450.39^{A} ± 9.71	1611.54^{B} ± 10.64	1200.82^{A} ± 9.17	1305.24^{B} ± 10.14
TDN intake (g/day)*	7954.09^{A} ± 36.54	7051.50^{B} ± 33.65	7475.79^{A} ± 29.49	6783.84^{B} ± 30.56
N intake g/kg digestible organic matter intake	29	33	24	27
Milk yield (kg/day) *	8.52^{A} ± 0.49	8.92^{B} ± 0.40	10.47^{A} ± 0.35	10.97^{B} ± 0.31
Milk fat (%)*	6.50^{A} ± 0.08	6.83^{B} ± 0.09	4.30^{A} ± 0.09	4.58^{B} ± 0.10

^{A,B} Values with different superscript for a species differ significantly (p<0.05).

Table 2: Effect of Ration Balancing on Methane Emission in Lactating Animals

Parameters	Buffaloes (n=22)		Cows (n=5)	
	Baseline	After RBP	Baseline	After RBP
Methane emission (g/animal/day) **	232.48^{a} ± 5.93	199.60^{b} ± 4.98	237.74^{a} ± 4.37	206.13^{b} ± 1.50
Dry matter intake (kg/day)	12.68 ± 1.25	12.31 ± 1.09	12.50 ± 0.35	12.16 ± 0.44
Methane emission (g/kg DMI) **	18.33^{a} ± 2.23	16.21^{b} ± 1.96	19.02^{A} ± 0.47	16.95^{B} ± 0.55
Organic matter intake (kg/day)	11.61 ± 1.21	11.30 ± 1.11	11.44 ± 0.36	11.15 ± 0.45
Methane emission (g/kg OMI) **	20.02^{a} ± 2.23	17.67^{b} ± 1.96	20.77^{A} ± 0.47	18.48^{B} ± 0.55
Gross energy intake (kcal/day)	55032.04 ± 9.88	54304.34 ± 8.19	54166.80 ± 8.01	53473.76 ± 7.23
Energy loss as methane (kcal/day)**	3101.22^{a} ± 7.23	2662.64^{b} ± 6.43	3171.42^{a} ± 5.41	2749.81^{b} ± 5.12
Energy loss as methane (% of gross energy) *	5.64^{A} ± 0.14	4.90^{B} ± 0.09	5.85^{A} ± 0.10	5.14^{B} ± 0.08

^{a,b} Values with different superscript for a species differ significantly (p<0.01).
^{A,B} Values with different superscript for a species differ significantly (p<0.05).

methane emission, the ration was balanced as per the requirement of individual animal for TDN, crude protein, calcium and phosphorus. Protein sources like cottonseed cake and groundnut straw were increased and wheat straw and wheat bran decreased in the diet to increase protein availability in the diet. Ration balancing did not affect body weight of animals and dry matter intake (Table 1), in buffaloes and cows. 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

Balancing of ration significantly (P<0.05) improved the milk yield and milk fat (%) in cows and buffaloes (Table 1). The improvement 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 were 232.48 and 237.74 g per day, respectively (Table 2). These values are similar to those reported earlier (Holter and Young, 1992; Woodward *et al.* 2002; Singhal and Madhumohini, 2003). Holter and Young (1992) found methane emission from 358 lactating Holstein cows varied from 175 to 299 g/day/cow. Woodward *et al.* (2002) reported 253 and 260g methane emissions from cattle producing 10.6 and 13.7 litres milk/day. Similarly, Primavesi *et al.* (2003) reported 331 g methane emission/day from cows producing average 13.3 liter of milk. Singhal and Madhumohini (2003) reported 162.67 to 259.74 g methane emission from buffaloes fed on balanced diet.

Average reduction of 14.14 % and 11.56 % methane emission in terms of g/day and g/kg DMI were observed in lactating buffaloes which was significantly lower from the baseline emissions ($P<0.01$). Average reduction of 13.29 % and 10.87 % methane emission, in terms of g/day and g/kg DMI, were observed in lactating cows, which was also significantly ($P<0.01$ and $P<0.05$, respectively) lower from the baseline emissions. There was a significant reduction ($P<0.01$) in loss of methane energy, in both lactating buffaloes (14.14%) and cows (13.29%).

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. Feed intake data revealed that the animals were deficient in crude protein in the diet. 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 methane emission observed in the study is consistent with the earlier reports (Leng, 1991; Blummel *et al.* 2001). Leng (1991) reported that deficiency of any nutrient, required in the growth of microorganisms will result in low microbial cell yield relative to volatile fatty acid and this will increase methane generation per unit of feed consumed. On most diets based on crop residues and low digestible forages, as practiced in India, the limitation for the growth of microorganisms is probably the inadequate concentration of ruminal ammonia and deficiency of trace and macro minerals besides the 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 balancing the ration as per the nutrient requirement of animals provides an effective measure for reducing methane emission as recorded in Canada (GHGMP, 2005) in beef cattle due to improved feed utilization and enhanced overall production efficiency of the herd.

CONCLUSIONS

The present study indicates that ration balancing programme has the potential to reduce methane production by 13 to 14 per cent. Similar experiments on these lines are required to be conducted under different condition 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.

ACKNOWLEDGEMENTS

Financial assistance and facilities provided by the management of National Dairy Development Board, Anand, for undertaking this study, are gratefully acknowledged.

REFERENCES

AOAC, 1995. Official Methods of Analysis. 15th ed. Association of Official Analytical Chemists, Washington, D.C.

Blummel, M.; Krishna, N. and Orskov, E. R.. 2001. Supplementation strategies for optimizing ruminal carbon and nitrogen and nitrogen utilization: concepts and approaches. Proc. x Anim. Nutr. Conf. Karnal , India. pp10-22.

Brouwer, E. 1965. Report of subcommittee on constants and factors. Proc. III EAAP Symp. In: Energy Metabolism, EAAP Publ.No.11, Academic Press, London. pp.441-443.

Czerkawski, J. W. 1986. An Introduction to Ruminant Studies. Pregmon Press. Oxford. England.

GHGMP. 2005. Greenhouse Gas Mitigation Program for Canadian Agriculture. Report to the Cattle Industry.

Canadian Cattlemen's Association, NE Calgary, Canada.

Guenther, K. D. 1979. Nettoenergie Lactation (NEL) die neue energetsche Futterbewertung fur milchkihe. *Kraftfutter*, **62**: 310-311.

Holter, J. B. and Young, A. J. 1992. Methane Production in Dry and Lactating Holstein Cows. *J. Dairy Sci.* **75**:2165–2172.

IS: 1224, 1977. Indian Standards Methods of Test for Dairy Industry Part-I, Chemical Analysis of Milk, Indian Standards Institute, New Delhi, India.

Johnson, K. A.; Huyler, M. T.; Westberg, H. H.; Lamb, B. K. and Zimmerman, P. 1994. Measurement of Methane Emissions from Ruminants Livestock Using a SF_6 Tracer Technique. *Environ. Sci. & Technol.* **28**:359.

Kearl, L. C. 1982. Nutrient Requirements of Ruminants in Developing Countries. International Feedstuffs Institute, Utah Agricultural Experiment Station, Utah State University, Logan, Utah, USA.

Leng, R. A. 1991. Improving Ruminant Production and Reducing Methane Emissions from Ruminants by Strategic Supplementation. US EPA. Washington D.C.

Moss, A. R. 1993. Methane-Global Warming and Production by Animals, Chalcambe Publications, Canterbury, UK.105pp.

NRC. 1989. Nutrient Requirement of Dairy Cattle. 6th edn. National Research Council, National Academy Press, Washington, D.C., U.S.A.

Primavesi, O.; Frighetto, R. T. S., Pedrieira, M. S., Lima M. A. and Berchielli, T. T. 2003. Methane Emission from Grazing Dairy Cattle in Tropical Brazil: Mitigation by Improving Production. Proc.3rd International Methane and Nitrous Oxide Mitigation Conference. Beijing, China. pp 349-355.

Sastry, N. S. R.; Thomas, C. K. and Singh, R. A. 1982. Farm Animal Management and Poultry Production, 2nd edn. Vikas Publishing House Pvt. Ltd., New Delhi.

Singhal, K. K. and Madhumohini. 2003. Uncertainity Reduction in Methane and Nitrous Oxide Gases Emission from Livestock in India. Annual Report of the National Dairy Research Institute, Karnal, India.

Snedecor, G. W. and Cochran, W. G. 1989. Statistical Methods, 9th edn. The Iowa State University Press. Ames, IA.

Van Soest, P. J.; Robertson J. B. and Lewis, B. A. 1991. Methods for Dietary Fiber, Neutral Detergent Fiber, and Nonstarch Polysaccharides in Relation to Animal Nutrition. *J. Dairy Sci.* **74**:3583-3597.

Woodward, S. L.; Waghorn, G. C., Lassey, K. R. and Laboyrie, P. G. 2002. Does Feeding Sulla (*Hydesarum coronarium*) Reduce Methane Emission from Cows? *Proc. N. Z. Soc. Anim. Prod.* **62**:227-230.