Use of Sulfur Hexafluoride Tracer Technique for Measurement of Methane Emission from Ruminants

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Effect of feeding two different feed supplements on methane emission was measured in adult ruminants fed straw based basal diet, using sulfur hexafluoride tracer technique. Two young crossbred bulls of approx. 12 months of age, weighing between 120-140 kg, were fed a basal diet comprising ad lib. *paddy straw and 2 kg hybrid napier green fodder. Experimental animal was also fed 2 kg compound cattle feed. Methane emission (g/kg OMI) reduced significantly ($P<0.05$) by 9.18 ± 1.07 per cent on supplementing 2 kg cattle feed. Average methane loss as per cent digestible energy intake (DEI) in control and experimental animal was 12.85 ± 0.45 and 9.98 ± 0.24 respectively. Average methane loss as per cent gross energy intake (GEI) in control and experimental animal was 6.29 ± 0.22 and 5.85 ± 0.14 respectively. In another experiment, two bull calves were fed a basal diet comprising* ad lib *paddy straw and 2 kg cattle feed. Experimental animal had free access to urea molasses mineral block (UMMB) lick. Methane emission (g/kg OMI) was significantly ($P<0.05$) reduced by 12.97 ± 7.49 per cent on supplementing UMMB lick. Average methane loss as per cent of DEI in control and experimental animals was 10.02 ± 0.41 and 8.62 ± 0.27 respectively. Average methane loss as per cent of GEI in control and experimental animals was 5.93 ± 0.25 and 5.14 ± 0.16 respectively. These studies indicate that methane emission from ruminants could be significantly reduced, if their diet is supplemented with deficient nutrients in various forms.*

Keywords: Sulphure hexafluoride, tracer technique, methane emission, straw based diets, Crossbred cattle

INTRODUCTION

Methane is an important green house gas, second only to carbon dioxide in its contribution to anthropogenic greenhouse gas emissions. Importance of methane has increased due to its 21 times more potential than CO_2 for global warming and ozone layer depletion. Methane's atmospheric abundance currently ~4850Tg has increased 2.5 times in the past two centuries and continues to increase at the rate of 35-40 Tg per year (IPCC, 1995a). Major sources of methane emissions are coal mining, natural gases and petroleum industry, ruminants, livestock manure, landfills, waste water, biomass burning and rice cultivation.

In ruminant animals (cattle, buffalo, sheep, goat and camels) methane is produced as part of normal ruminal fermentation process. The methane, which is eructated by the animal, represents about 8 to 12 per cent of gross energy intake and is a hydrogen sink by-product, for removing free hydrogen ions from the system, which could otherwise interfere in the fermentation process. Since methane emission is considered to be an energy loss to the animal, its production need to be minimized by carefully manipulating the diet of ruminant animals. Emission is estimated to be 65 to 100 Tg per year, with cattle accounting for 75 per cent of the global annual methane emission from domestic livestock (USEPA, 1993). The estimated values of methane emission from digestive process of ruminants in India accounts for 6.47 Tg per year, while that from animal wastes accounts for 1.60 Tg per year (Bandopadhyay *et al.* 1996).

In India, very little work has been done on methane emissions under natural conditions, using various feed supplements. With this objective, present study was undertaken so that more information could be generated on these aspects.

MATERIALS AND METHODS

SF_6 Technique for Methane Emission Measurements

For measurement of methane emission, technique developed by Johnson *et al.* (1994) at Washington State University was standardized. In this

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technique, a small permeation tube containing sulfur hexafluoride (SF_6) is inserted in the rumen. The release rate of SF_6 from the permeation tube is determined prior to inserting in the rumen of an animal. A halter, fitted with a capillary tube is placed on the animal's head and connected to an evacuated sampling canister. The vacuum in the canister slowly dissipates and a sample of air around the mouth and nose of the animal containing mixture of gases including methane and SF_6 is taken. Sample collected in the canister is analysed for concentration of methane and SF_6.

Permeation tubes made of brass were fabricated and teflon membrane and porous – stainless steel object called 'frit' were placed on the permeation tube and fitted with a nut to control the release rate of SF_6. Filling of SF_6 in Permeation tube was done at liquid nitrogen temperature and then weighted for at least one and half months to establish a constant permeation rate at rumen temperature (39°C). Permeation of SF_6 was in the range of 2.04-2.08 mg SF_6/day.

Canisters were fabricated in the lab using PVC pipe, elbows and end caps for collection of samples. After fabrication, canisters were checked properly for leakage. Then they were evacuated upto zero atmospheric pressure approximately and air samples around the nose and mouth of the animals were collected. Gas samples entering the evacuated canister were controlled though a modified halter fitted with capillary tubing. Animals were acclimatized to wearing the halter and canister a week prior to sampling.

After removal of the canisters from the host animal, methane and SF_6 concentration was analysed using Flame Ionisation Detector (FID) and Electron Capture Detector (ECD). Methane emission rate was calculated as under:

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

Where

QCH_4 – Methane emission rate (gm/min.)

QSF_6 – Known release rate of SF_6 from permeation tube (gm/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)

Two experiments were conducted to estimate effect of feeding on methane production.

Experiment A

This experiment was conducted to study the effect of supplementing cattle feed on methane emissions on two crossbred young bulls aged approx. 1 year. Initial body weight of animals was 120 and 136 kg. Animal under control was offered *ad lib.* paddy straw and 2 kg green fodder, whereas experimental animal was offered 2 kg cattle feed in addition to *ad lib* paddy straw and 2 kg green fodder, to meet NRC requirement for maintenance and growth. Cattle feed comprised grain 10%, protein meals 55%, rice polish 20% and molasses 10%, with 22% CP and 67% TDN.

Experiment B

This experiment was conducted to study the effect of supplementing urea molasses mineral block (Garg *et al.* 1998) on methane emissions. In this experiment, two pure bred Sahiwal male young bulls aged approx. one and half years were selected. Initial body weight of animals was 146 and 148 kg. Animal under control was offered *ad lib.* paddy straw and 2 kg cattle feed to meet NRC requirement for maintenance and growth, whereas experimental animal was offered UMMB *ad lib* in addition to paddy straw and 2 kg cattle feed.

Animals in both the experiments were given 50 g of mineral mixture every day and Vimeral (vitamin-concentrate) 15 ml. once in a week to meet mineral and vitamin requirements. Water was offered twice a day to the animals. Every day feed offered was measured and left over was collected and weighed. Average dry matter and organic matter intake are shown in Table 1.

Animals under both the experiments were stall fed and were left in fenced area for two hours in a day. Grass in this area was removed so that the animals could not eat anything other than the feed and fodder offered to them.

After pre-trial period of 40 days, breath samples from both the animals under Experiment A and Experiment B were collected in canisters for four and three days respectively, as devised in SF_6 tracer technique. Concentration of SF_6 and methane was analysed in these gas samples and methane emission was calculated as per the above mentioned formula.

RESULTS AND DISCUSSION

Methane emission in animals is largely

Table 1 : Dry Matter Intake (DMI) and Organic Matter Intake (OMI) kg/day

Feed	Experiment A				Experiment B			
	DMI kg/day		OMI kg/day		DMI kg/day		OMI kg/day	
	Control	Experi-mental	Control	Experi-mental	Control	Experi-mental	Control	Experi-mental
Paddy straw (Av. ± SE)	2.66 ± 0.016	2.46 ± 0.030	2.1± 0.013	1.95± 0.024	2.35± 0.018	2.44± 0.005	1.72± 0.014	1.79± 0.005
Green fodder (Av. ± SE)	0.37 ± 0	0.37 ± 0	0.06 ± 0	0.06 ± 0	1.81 ± 0.006	1.81 ± 0	1.39 ± 0.004	1.40 ± 0
Cattle feed (Av. ± SE)	Nil	1.86 ± 0	Nil	1.51 ± 0	-	-	-	-
UMMB (Av. ± SE)	-	-	-	-	Nil	0.15 ± 0.001	Nil	0.09 ± 0.001
Total (Av. ± SE)	3.03 ± 0.016	4.69 ± 0.030	2.16 ± 0.012	3.52 ± 0.024	4.16 ± 0.020	4.40 ± 0.005	3.12 ± 0.016	3.28 ± 0.003

dependent on organic matter intake (OMI). Methane emission (g/kg OMI) in animal offered cattle feed reduced in the range of 6.91 to 12.06 % (Average 9.18% ± 1.07) as compared to control (Table 2), which was significantly different ($P<0.05$). Methane loss as % digestible energy (DE) in control and experimental animals was in the range of 12.04 to 14.07 (Average 12.85 ± 0.45) and 9.59 to 10.63 (Average 9.98 ± 0.24), respectively. Average methane loss as % gross energy (GE) in control and experimental was in the range of 5.89 to 6.88 (Average 6.29 ± 0.22) and 5.62 to 6.23 (Average 5.85 ± 0.14), respectively (Table 3). Methane emission in control and experimental was in the range of 55.69 to 65.09 (Average 59.46 ± 2.06) and 82.95 to 91.57 (Average 86.34 ± 2.03) g per day, respectively.

Methane emission (g/kg OMI) in animal offered UMMB reduced in the range of 6.23 to 16.63% (Average 12.97 % ± 7.49) as compared to control (Table 2), which was significantly lower ($P<0.05$). Methane loss as % DE in control and experimental animals was in the range of 9.43 to 10.82 (Average 10.02 ± 0.41) and 8.10 to 9.00 (Average 8.62 ± 0.27), respectively. Average methane loss as % GE in control and experimental was in the range of 5.58 to 6.40 (Average 5.93 ± 0.25) and 4.83 to 5.37 (Average 5.14 ± 0.16), respectively. Methane emission in control and experimental was in the range of 72.69 to 83.47 (Average 77.27 ± 3.21) and 66.29 to 73.68 (Average 70.54 ± 2.21) g per day respectively.

Khan *et al.* (1988) reported methane energy loss in the range of 5.93 and 6.63% of GE in adult Murrah buffaloes when fed on straw based diet. McDonald (1983) reported that methane production is closely related to food intake and at the maintenance level of nutrition about 8 per cent of gross energy of the food (12% of digestible energy) is lost as methane. Preston and Leng (1989) reported that supplementation of urea and minerals to straw based diet reduced the energy loss through methane from 8 to 15 per cent of DE. Poots (1991) reported that when basal silage diet was given as such or supplemented with either soyameal or soyameal + fish meal, there was progressive reduction in methane emission with the use of supplements. Thus, the present studies, in line with the reported literature, indicate that the feed supplements to straw based diet help reducing methane

Table 2 : Methane Emission g/kg OMI*

No. of sampling	Experiment A			Experiment B		
	Control	Experi-mental	% reduction	Control	Experi-mental	% reduction
1st day sampling	25.32	23.57	6.91	23.29	21.84	6.23
2nd day sampling	29.59	26.02	12.06	24.24	20.21	16.63
3rd day sampling	27.19	24.79	8.83	26.75	22.46	16.04
4th day sampling	26.01	23.69	8.92	-	-	-
Average ± S.E.	27.03 ± 0.94	24.52 ± 0.57	9.18 ± 1.07	24.76 ± 1.03	21.5 ± 0.67	12.97 ± 7.49

* ($P<0.05$)

Table 3 : Methane Emitted Per Cent Gross Energy (GE) & Digestible Energy (DE) Intake Per Day

	Experiment A									
	1st Day Sampling		2nd Day Sampling		3rd Day Sampling		4th Day Sampling		Average	
Parameters	Control	Experi-mental	Control	Experi-mental	Control	Experi-mental	Control	Experi-mental	Control	Experi-mental
Total intake										
DM intake kg/d	3.03	4.69	3.03	4.69	3.03	4.69	3.03	4.69	3.03	4.69
GE intake Kcal/d	12616.99	19690.81	12616.99	19690.81	12616.99	19690.81	12616.99	19690.81	12616.99	19690.81
DE intake Kcal/d	6170.30	11538.30	6170.30	11538.30	6170.30	11538.30	6170.30	11538.30	6170.30	11538.30
Methane emission										
Methane emission g/d	55.69	82.95	65.09	91.95	59.82	87.26	57.22	83.2	59.46	86.34
Energy in methane (Kcal)	742.69	1106.55	868.3	1226.61	798	1164.05	763.31	1109.89	793.13	1151.78
Methane loss % GE	5.89	5.62	6.88	6.23	6.32	5.91	6.05	5.64	6.29±0.22	5.85±0.14
Methane loss % DE**	12.04	9.59	14.07	10.63	12.93	10.09	12.37	9.62	12.85±0.45	9.98±0.24

*** (P<0.01)* *(Values for GE & DE taken from Sen, K. C. 1976 & Kurar, C. K. 1998).*

Table 4 : Methane Emitted Per Cent Gross Energy (GE) & Digestible Energy (DE) Intake Per Day

	Experiment B							
	1st day sampling		2nd day sampling		3rd day sampling		Average	
Parameters	Control	Experi-mental	Control	Experi-mental	Control	Experi-mental	Control	Experi-mental
Total intake								
DM intake kg/d	4.16	4.40	4.16	4.40	4.16	4.40	4.16	4.40
GE intake Kcal/d	17387.87	18314.39	17387.87	18314.39	17387.87	18314.39	17387.87	18314.39
DE intake Kcal/d	10287.50	10916.60	10287.50	10916.60	10287.50	10916.60	10287.50	10916.60
Methane emission								
Methane emission g/d	72.69	71.64	75.66	66.29	83.47	73.68	77.27	70.54
Energy in methane (Kcal)	969.68	955.68	1009.3	884.31	1113.49	982.89	1030.82	941.01
Methane loss % GE	5.58	5.22	5.8	4.83	6.40	5.37	5.93±0.25	5.14±0.16
Methane loss % DE*	9.43	8.75	9.81	8.10	10.82	9.00	10.02±0.41	8.62±0.27

** (P<0.05)* *(Values for GE & DE taken from Sen, K. C. 1976 & Kurar, C. K. 1998).*

emission in ruminants. More experiments on these lines are required to be conducted to generate more information.

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