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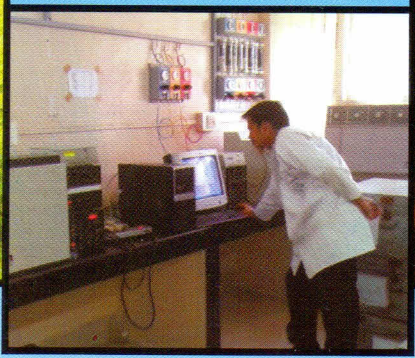
Evaluating the Impact of Ration Balancing on Methane Emission in Dairy Animals

National Dairy Plan I
(National Dairy Support Project)

FINAL REPORT



Co-ordination & Monitoring Cell
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(S.S. Kundu)
Project Leader

EXECUTIVE SUMMARY

It is projected that milk demand of the country could reach between 200 and 210 million tonnes by the year 2021-22. To meet the projected demand, the incremental annual milk production of about 6 million tonnes per annum is needed over the next 15 years, which is almost double the current rate of increase (3 million tonnes/year) and that too when there is huge deficit of feed and fodders. At the same time, the enteric methane emissions especially from bovines is becoming a global environmental issue. The National Dairy Plan Phase I (NDP I) is designed to address these twin challenges among others for increase in productivity with lesser methane emissions in ensuing years.

In India, bovines are mainly fed straw based diets supplemented with locally available concentrate feed ingredients comprising cereals, brans, cakes, chunnies etc. Such type of feeding practices are likely to provide imbalanced rations in terms of protein, energy and minerals. Studies conducted on lactating cows and buffaloes under different agro climatic regions have revealed that the ration balancing also helps in reducing enteric methane emissions per unit of milk production. Present levels of productivity of dairy animals suggest that the milk production of animals is far below their genetic potential, largely due to underfeeding of nutrients. Under the Ration Balancing Programme (RBP), milk producers are advised to balance the ration of their animals as per their nutrient requirements with locally available feed resources, with the expectation to increase daily milk production with decreased methane emissions.

The present experiment was planned to evaluate the impact of ration balancing on methane emissions in dairy animals and two villages viz., Hambran and Bassian Bet in Ludhiana district of Punjab state were selected for the study. Thirty six early lactating animals (cows and buffaloes) were shortlisted. A structured schedule/Questionnaire was prepared and the data on feeding practices followed by the dairy farmers in two selected villages were recorded through personal interview. Sulfur hexafluoride (SF_6) tracer technique was used for measurement of methane emissions from milch animals under field conditions. Permeation tubes were filled with SF_6 gas and its release rate was recorded. Permeation tubes with known release rate of SF_6gas were inserted in the rumen of experimental animals.

Dummy canisters and halters were fitted to individual animal for adaptation for 3 days. After adaptation period, breath samples (24 hours basis) were collected from individual animal for four consecutive days in evacuated canisters. The canisters were filled with nitrogen gas for maintaining neutral pressure and were brought to the laboratory at National Dairy Research Institute (NDRI) for further analysis of the gases. Thesecanisters were analyzed by gas chromatography (Nucon 5700, Nucon Engineers, New Delhi) in the laboratory at Dairy Cattle Nutrition (DCN) Division, NDRI, Karnal for methane and SF_6 concentration in the breath samples.

After completing the baseline methane emission measurement (before ration balancing), the ration of individual animal were balanced for energy, protein, calcium and phosphorus using software developed by NDDB Anand. The farmers were advised to feed balanced ration to their milch animals for a period of 30 days. After feeding balanced rations for a period of 30 days, again the breath samples (24 hours basis) were collected from individual animal for four consecutive days in evacuated canisters and analyzed for methane and SF_6 as described above. Daily milk production as well as milk fat content were recorded for individual animal during the gas collection period for thirty animals before and after balancing the ration.

The calculation of methane emission was done as per the product of the permeation tube release rate and the ratio of CH_4 to SF_6 concentration in the breath samples. All samples were analyzed in duplicates. Methane emission (g/kg milk yield) was calculated before and after feeding a balanced ration.

Statistical analysis of data was done using SAS software version 9.3, one way ANOVA and Tukey's test was used for test of significance for observing the statistical difference between the baseline methane emission and emission after balanced feeding of dairy animals. The respective readings of cows and buffaloes were analyzed separately.

In present study, average daily milk yield before ration balancing was 8.20 and 7.08 kg in cows and buffaloes, respectively. On feeding a balanced ration, milk yield (kg/d) increased significantly from 8.20 to 9.05 ($P<0.01$) and from 7.08 to 7.79 ($P<0.05$) in cows and buffaloes, respectively. However, there was no statistical difference in fat content of milk before and after feeding a balanced ration in both the species. Average baseline methane emission was 22.40 g/kg milk yield which was significantly reduced by 13.6% ($P<0.01$) after feeding a balanced ration (19.36 g/kg milk yield) in lactating cows. Similarly, in buffaloes, feeding a balanced ration significantly ($P<0.05$) reduced enteric methane emissions by 11.2% (31.40 vs. 27.87 g/kg milk yield). In present experiment, balanced feeding reduced average methane emission (g/kg milk yield) by about 12.4% in lactating cows and buffaloes. Based on the findings, it can be inferred that the ration balancing improved milk production while reducing enteric methane emission in lactating cows and buffaloes.

INTRODUCTION

The National Dairy Plan Phase I (NDP I) is a central sector scheme of Government of India assisted by the World Bank and implemented by NDDB, Anand, Gujarat. NDP I is a scientifically planned multi-state initiative to increase milk production by increasing milch animal productivity in existing herds through a focused approach for breeding and feeding.

In India, bovines are mainly fed straw based diets supplemented with locally available concentrate feed ingredients comprising cereals, brans, cakes, chunnies etc. This often causes an imbalance in protein, energy and minerals in the ration of animals leading to several metabolic diseases. Imbalanced diets and such metabolic conditions generally cause suboptimal milk production as compared to their genetic potential. In view of this, the National Dairy Development Board (NDDB) has developed software for Ration Balancing Programme (RBP) for working out least cost balanced ration for dairy animals using locally available feed resources. Under the programme, milk producers are advised to balance the ration of their animals with locally available feed resources more specifically on re-appropriation of existing ingredients to make a balanced ration. The objective of the software/programme is to increase the net daily income by way of increasing daily milk yield and milk fat per cent with reduction in cost of feeding.

Studies conducted on lactating cows and buffaloes under different agro climatic regions have revealed that the ration balancing also helps in reducing enteric methane emissions per kg of milk production. Enteric methane emissions from ruminants is a challenge currently being faced by the dairy industry as it causes not only dietary energy loss but also contributes to greenhouse gas levels.

Two villages namely Hambran and Bassian Bet located in Ludhiana district of Punjab were selected for the study as Ludhiana district in Punjab is very important from agriculture and dairying point of view. Accordingly, thirty six animals were identified based on their level of milk yield and stage of lactation and tagged. Enteric methane emission was measured on traditional feeding systems in the selected 30 animals and thereafter they were fed balanced rations prepared using ration balancing software developed by NDDB. After feeding a balanced ration for 30 days, methane emissions was measured on balanced feeding systems. During four days of methane measurement of treatment period, feed intake and milk yield of individual animals were also recorded.

BACKGROUND OF THE STUDY

Milk demand in the country is growing rapidly and likely to reach about 150 million tonnes by 2016-17. It is further projected that milk demand could reach between 200 and 210 million tonnes by 2021-22. To meet the projected demand, incremental annual milk production of about 6 million tonnes per annum is needed over the next 15 years which is almost double the current rate of increase (3 million tonnes /year). On the other hand, the enteric methane emissions especially on an imbalanced ration is becoming a global environmental issue at the expense of feed energy. The National Dairy Plan Phase I (NDP I) is designed to address these challenges. The first phase of the National Dairy Plan referred to as the National Dairy Support Project (NDSP) by the World Bank has been rolled out. The NDSP will cover about 14 of the country's 28 states. These states are referred to as the major dairying states and together they account for more than 90 percent of the nation's milk production. Present levels of productivity of dairy animals suggest that the milk production of animals is far below their genetic potential, largely because of imbalanced feeding. Under the Ration Balancing Programme, milk producers were advised to balance the ration of their animals as per their nutrient requirements with locally available feed resources with an expectation to increase daily milk production while decreasing the methane emission for these animals. Keeping this in view, increasing the net daily income and reduction in methane emission per kg of milk are considered as indicators in present study.

METHODOLOGY

In the present study for evaluation of impact of ration balancing on methane emission and milk production, sulfur hexafluoride (SF_6) tracer technique was used for measurement of methane emissions from milch animals under field conditions. Thirty six early lactating (up to 100 days post calving) cows and/or buffaloes were shortlisted based on milk production and sound health. These animals were divided into three groups of 12 animals each for efficient handling during the sample collection. A structured questionnaire was prepared and the data on feeding practices of the animals by the dairy farmers in these two selected villages was recorded through personal interview. During BRB period, animals were fed the rations as per animal owners schedule with available ingredients. Milk production and composition was recorded during this period. After one

Photo 1: Collection of breath sample from a buffalo, for estimation of methane emission

month of observation, the measurement of methane emission was done in all the animals. After collecting the breath samples for methane emission measurements, the rations were balanced for individual animals as per NDDB software and farmers were advised to feed the balanced ration. Regular monitoring and execution was followed during ARB period. After one month of feeding the balanced rations, the milk yield, milk fat content and breath samples were collected as during BRB period. The respective samples and readings of all the control animals were also recorded and analyzed during both i.e. baseline (before) and after feeding balanced ration periods.

Permeation tubes were filled with SF_6 gas and its release rate was recorded. Depending on the higher release rate of SF_6, 36 permeation tubes were selected for 36 experimental animals. The range of release rate of the selected tubes was 0.00125 to 0.00275 g/d. The insurance of 36 experimental animals in the study was done before inserting permeation tubes. Scientists and other research workers from NDRI, Karnal regularly visited and stayed in the project adopted villages for proper implementation and monitoring of the activities involved.

A. Estimation of baseline methane emission

Permeation tubes with known release rate of SF_6 were inserted in the rumen of each of the experimental animal. Dummy canisters and halters were tied to individual animals for 3 days for adaptation. After this period, breath samples (24 hours basis) were collected from individual animal for four consecutive days in evacuated canisters by fitting canister and halter with necessary accessories. The canisters were filled with nitrogen gas for maintaining neutral pressure and were brought to the laboratory at NDRI for further analysis of the gases. Breath samples collected in these canisters were analyzed in the laboratory for methane and SF_6 concentration. The feed intake was recorded for seven days including the days of gas collection. During baseline methane emission measurement period, feeding of milch animals were in accordance with the prevailing feeding practices followed by the farmers.

Photo 2: Weighing of feed ingredients for animal feeding

B. Estimation of methane emission after feeding a balanced ration

After completing the baseline methane measurement phase (before feeding balanced ration), the ration of individual animal were balanced for energy, protein, calcium and phosphorus as per NDDB ration balancing software. The farmers were advised to feed the balanced rations to their milch animals for a period of 30 days.

After feeding a balanced ration for a period of 30 days, the breath samples (24 hours basis) were again collected from individual animal in evacuated canisters for four consecutive days and analyzed for methane and SF_6 gases. After collection of samples, the canisters were immediately pressurized with nitrogen gas and the concentration of SF_6 in the canisters was analyzed by gas chromatography (Nucon 5700, Nucon Engineers, New Delhi) fitted with an electron capture detector (250°C) to determine SF_6 and 3.3 m molecular sieve column with an i.d. of 0.32 mm in the laboratory of Dairy Cattle Nutrition Division. Another gas chromatograph was fitted with a flame-ionization

Photo 3: Analysis of methane emission by Gas Chromatograph

detector (100°C) and stainless steel column packed with Porapak-Q (length 1.5 m; o.d. 3.2 mm; i.d. 2 mm; mesh range 80-100) to determine CH_4 concentration. The column and injector temperatures were 50° and 40°C, respectively in both gas chromatographs.

All samples were analyzed in duplicate except standards which were run in triplicate. Nitrogen was used as the carrier gas at a pressure of 1 kg/cm^3. The standards were run at the beginning and end of each day with the medium standard run every 10 samples throughout the day. Gas concentrations (SF_6 and CH_4) were determined from peak areas and identified from their different retention times relative to the known standards.

C. Data analysis

The calculation of methane emission was done from the product of the permeation tube release rate and the ratio of CH_4 to SF_6 concentration in the breath samples. All samples were analyzed in duplicates. The calculation of methane emission rate was done as under: $QCH_4 = QSF_6 \times (CH_4)/ (SF_6)$

Where,

QCH_4 = Methane emission rate (g/min)

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

CH_4 = Concentration of CH_4 in collected sample (µg/m^3)

SF_6 = Concentration of SF_6 in collected sample (µg/m^3)

Methane emission (g/kg milk yield) of individual animals was calculated before and after feeding a balanced ration.

D. Milk yield and milk fat

Daily milk production as well as milk fat content were recorded during the methane collection period before and after balancing the individual ration in 30 animals. The morning and evening milk samples were collected and analyzed for fat content.

E. Statistical analysis

Data was analyzed using SAS version 9.3. For statistical analysis of results, one way ANOVA was used and the Tukey's test was used for test of significance for testing the statistical difference between the baseline methane emission and emission after balanced feeding of dairy animals.

RESULTS AND DISCUSSION

The data on milk yield, milk fat and enteric methane emission of cattle, before and after feeding a balanced ration in villages Hambran and Bassian Bet are presented in Table 1. In cattle, average milk yield was 8.20 kg/day before feeding a balanced ration which increased to 9.05 kg/d ($P<0.01$) after feeding a balanced ration. Average milk yield before and after feeding a balanced ration was 7.08 and 7.79 kg/d ($P<0.05$), respectively in buffaloes (Table 2). However, milk fat was not affected to a significant level in both cattle and buffalo before and after ration balancing in the present experiment. Present findings indicated that ration balancing increased milk yield significantly in both cattle and buffalo suggesting the positive impact of ration balancing under field conditions.

The information on enteric methane emissions from dairy cattle is presented in Table 1. Average baseline methane emissions was 22.40 g/kg milk yield which was significantly reduced by 13.6% ($P<0.01$) after feeding a balanced ration to 19.36 g/kg milk yield in lactating cows (Table 1). Similarly in

Photo 4: Advice to farmers about balanced ration for individual animal

Table 1: Effect of ration balancing on methane emission in cattle (n=12)

Parameter	Before Ration Balancing	After Ration Balancing	P Value
Milk yield (kg/d)	8.20 ± 0.72	9.05 ± 0.75	0.009**
Fat (%)	3.89 ± 0.27	3.81 ± 0.27	0.548
Methane emission (g/kg milk yield)	22.40 ± 2.02	19.36 ± 1.63	0.005**

** (P<0.01)

buffaloes, ration balancing significantly (P<0.05) reduced enteric methane emissions (Table 2) by 11.2% (31.40 vs. 27.87 g/kg milk yield). Therefore, balanced feeding significantly reduced enteric methane emission (g/kg milk yield) by about 12.4% in lactating cows and buffaloes.

These results reaffirm the earlier reports that due to re-appropriation and balancing the ration for all essential nutrients in lactating ruminants, organic matter is fermented to produce more microbial biomass and propionic acid and hence the energy is diverted away from the methane production in the rumen.

Table 2: Effect of ration balancing on methane emission in buffaloes (n=18)

Parameter	Before Ration Balancing	After Ration Balancing	P Value
Milk yield (kg/d)	7.08 ± 0.36	7.79 ± 0.43	0.025*
Fat (%)	6.63 ± 0.23	6.76 ± 0.29	0.493
Methane emission (g/kg milk yield)	31.40 ± 2.31	27.87 ± 2.09	0.019*

* (P<0.05)

Feeding as per the nutrient requirement of animals is an imperative for improving genetic potential of low producing dairy animals in developing countries like India. Improving productivity and efficiency of nutrient use through balanced nutrition approach appears to be one of the most promising ways to reduce enteric methane emissions in dairy animals. Balanced feeding has an indirect effect on enteric methane emissions by maintaining an appropriate rumen environment suitable for microbial proliferation, which is required for improving feed efficiency and decreasing methane emission per unit of milk. It is reported that animals on imbalanced ration produce more methane as most of the dietary fibrous matter is fermented to produce acetate and butyrate resulting into more methane production.

In the present study, balancing of nutrients might have shifted the rumen fermentation pattern towards higher propionic acid and microbial cell production resulting in lower acetate and butyrate production. Higher propionic acid synthesis uses more hydrogen leading to reduced methane emission. Present findings also confirm that the ration balancing helps in increasing net daily income of milk producers by way of increasing milk yield and/milk fat content.

LIMITATIONS OF THE STUDY

In the stated methodology for estimation of SF_6 tracer dilution technique, a very small error may result in major variation in calculation of methane release from the animals.

CONCLUSION

The present study demonstrated that the ration balancing resulted in improved milk production while simultaneously reducing the enteric methane emissions in lactating cows and buffaloes which is significant from economic and environment point of view.

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