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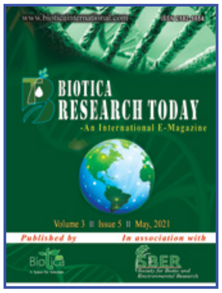

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Methane and Its Reduction in Ruminants

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Abstract

Methane is a potent greenhouse gases responsible for global warming. Efforts have been made through research in last decade by the animal nutritionist for finding methods to reduce methane emissions. Since global warming potential of methane is 23 times higher than carbon dioxide, so reduction in methane emission can impact the global warming at early. The strategies should be lower methane production by our livestock. Various strategies like genetic selection for production traits, feeding of highly digestible forages, use of feed additives, rumen manipulation and ration balancing will reduce enteric CH_4 emissions and cause an increase in animal performance by conserving energy and reducing feed costs associated with animal maintenance.

Introduction

Greenhouse gases like carbon dioxide (CO_2), methane (CH_4) and nitrous oxides are produced as a result of agricultural and livestock activities. The gross energy loss in form of methane in cattle is around 2-15% of their ingested energy. Enteric CH_4 is the most significant single source of greenhouse gas emissions of the world. Over the past three centuries, the amount of atmospheric methane has grown up by 2.5 folds. As per the Intergovernmental Panel on Climate Change (IPCC), out of the total 87.9 Mt carbon dioxide emissions from the agricultural sector, 50% were from enteric fermentation in cattle, 16% from sheep and 0.3% from other animals. On average, mature beef cows emit 350 g CH_4/day in the tropics and 240 g/day in temperate zones. It has been reported that CH_4 promotes stratospheric ozone depletion. The water vapour that is added to the stratosphere when CH_4 is oxidized may provide surfaces for heterogeneous reactions that destroy ozone. At this rate, methane is expected to cause 15-17% of the global warming over the next 50 years. Reducing CH_4 emissions can increase animal performance by conserving energy that could be redirected to milk production or weight gain.

Methane Production

Radiocarbon (C_{14}) isotope measurements on atmospheric methane indicate that approximately 20 to 30% is originated from fossil, gas drilling, venting, mining and wet land emissions. The remaining 70 to 80% of atmospheric carbon is derived from sources like enteric fermentation, natural wetlands, biomass burning, rice production and waste treatment. Microorganisms in the rumen referred to as methanogens, convert H_2 and CO_2 into CH_4 and water. This process lowers the amount of H_2 in the rumen. Methane production is the main way that H_2 is used in the rumen. The type of carbohydrate fermented influences methane production most likely through impacts on ruminal pH and the microbial population. Fermentation of cell wall fiber yields higher acetic: propionic acid and higher methane losses. Studies conducted with forage-fed sheep found that 87% of enteric CH_4 originates from the reticulo-rumen, the remainder being generated from the hindgut. Out of the total CH_4 produced in the hindgut, majority (89%) are absorbed and expired through the lungs. The remainder was excreted via the anus.

Measurement of Methane Production

There are many methods available which would be suitable for measuring CH_4 produced from the various stages of animal production. However, several factors need to be considered in order to select the most appropriate technique like the cost, level of accuracy required and design of the experiments to be undertaken.

Gas Chromatography

The principle of gas chromatography is individual partitioning of different gases in the sample between a mobile phase and a stationery solid phase. After separating the components in the gaseous mixture, each component was identified by its retention time on the column and quantified by a subsequent detector (Steele *et al.,* 1987). Quantification of methane is accomplished by comparing the peak height and retention time of the sample to standards of known concentration. Gas chromatography is highly accurate and precise.

Fourier Transform Infrared (FTIR) Spectroscopy

A number of gases of interest in climate change research could be uniquely and simultaneously determined by FTIR technique. In FTIR spectroscopy the unique infrared absorption of different molecules are used to quantify their concentration.

Tuneable Doide Laser (TDL) Absorption Spectroscopy

This is based on the absorption of an infrared laser beam as it travels along a path through the gas sample. The sensitivity of the TDL based instruments depends on the path and strength of the absorption line.

Semiconductor Chip Sensor

This sensor can detect hydrogen, CH_4 and CO gas within 5 min and with a sensitivity of 0.1 ppm for each gas. The correlation between CH_4 concentrations detected by semiconductor chip sensor and gas chromatography was 0.86 (Takenaka *et al.,* 2004).

Respiration Calorimetry

It consists of animal chambers, head boxes, ventilated hoods and face masks to collect emitted gases from cattle. The principle behind open-circuit indirect-respiration techniques is that outside air is circulated around the animal's head, mouth, and nose and expired air collected. Methane emissions are determined by measuring the total air flow through the system and the difference in concentration between inspired and expired air.

Tracer Gas Technique

Methane emission from ruminants can also be estimated by using the Calibrated Tracer technique. The tracer can either be isotopic or non-isotopic. Isotopic methods involve the use of ^3H or ^{14}C in fistulated animals. Non-isotopic tracer techniques are also available for measurement of CH_4 emissions by using sulphur hexafluoride (SF_6), an inert gas tracer. Using the continuous infusion technique, sampling of gas takes place in the dorsal rumen and specific activity of the radio-labeled methane gas can be calculated.

Ruminant Enteric Methane Mitigation

Enteric methane mitigation is not so much successful, but with appropriate policies, technologies and management practices, it may be possible to achieve reductions in methane inhibition of up to 75%. However, most technologies to control methane production from ruminants have not proved cost-effective and some may result in the under-utilisation of low-cost fibrous feed resources. Some commonly used procedures for methane mitigation are as follows.

Level of Intake

As the daily feed eaten by any given animal increases, the percentage of dietary GE lost as methane decreases by an average of 1.6% per level of intake.

Diet Type

Feeding more amounts of grains in the diet reduces the methane production. Diets containing more corn grain produce 30% less methane as compared the diets having more barley grains. Supplementing diets containing fats & oils reduces methane emission. Use of corn silage and small grain silages, rather than grass silage, and hay, can also lower CH_4 production.

Type of Carbohydrate

Fermentation of cell wall fibre yields higher acetic: propionic acid and higher methane losses. Fermentation of soluble carbohydrate in ruminants is less methanogenic than cell wall carbohydrates.

Addition of Lipid

Addition of long-chain polyunsaturated fatty acids decreased methanogenesis by providing an alternative metabolic hydrogen acceptor for reduction of CO_2.

Addition of Ionophore

Ionophore additions to beef cattle diets, particularly monensin, decreases acetic: propionic acid ratio and methane losses. The decrease in methane production is approximately 25%.

Propionate Enhancers

Dicarboxylic organic acids such as malate and fumarate when added in the diet, propionate production increased with a stoichiometric decrease in methane production.

Rumen Manipulation

Microbial population of rumen can be changed to decrease methane production. Various methods are used for rumen manipulation:

• **Defaunation**: Defaunation of the rumen of cattle fed a barley diet decreases methane production by approximately one half (Whitelaw *et al.,* 1984). However, defaunation of animals receiving high-forage diets (did not reduce methane losses).

• **Probiotics**: *Aspergillus oryzae* has been seen to reduce methane by 50% which was directly related to a reduction in the protozoal population. On the other hand, addition of *Saccharomyces cerevisiae* to an in vitro system reduced the methane production by 10%.

• **Antibiotics**: Monensin is a naturally occurring polyether antibiotic that reduces methane production mainly by selective reduction of acetate formation and associated H_2 production.

• **Halogenated compounds**: Halogenated compounds such as chloroform and BES (2-bromoethanesulfonic acid) have direct inhibitory effects on methanogenic bacteria and reduce methane production both in vitro and in vivo.

• **Addition of natural compounds**: Natural compounds such as Paranthocyanidins (condensed Tannins), mystiric acid and various oils reduce methane production.

Animal Management

Animal selection for increased production may reduce CH_4 emissions.

Vaccination or Immunisation

May be possible to immunise ruminants against their own methanogens with associated decreases in methane output.

Conclusion

Reduction in methane production from ruminants reduces global green house gas and enhances the feed conversion efficiency. Various scientific strategies reduce enteric methane production with out any hazard to the animal and environment. Large inhibition in methane production requires the application of an integrated suite of option.

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