Methane Emission From Sheep

A PRODUCTION REPORT SUBMITTED BY

Niaj Ahmed Shimul
Intern ID. 08
Roll No:16/08
Reg No: 1613
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Faculty of Veterinary Medicine

CHATTOGRAM VETERINARY AND ANIMAL SCIENCES UNIVERSITY

Zakir Hossain Road, Khulshi, Chattogram-4225

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Signature of Supervisor

Professor Ashraf Ali Biswas

Director of Research and Extension

Department of Animal Science And Nutrition.

Faculty of Veterinary Medicine

Faculty of Veterinary Medicine

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Abstract

Ruminant livestock can produce 250 to 500 L of methane per day. Many factors influence methane emissions from ruminant and include the following: level of feed intake, type of carbohydrate in the diet, feed processing, addition of lipids or ionophores to the diet, and alterations in the ruminal micro flora. On a global scale agriculture and in particular enteric fermentation in ruminants is reported to produce about one fourth (21 to 25%) of the total anthropogenic emissions of methane (CH_4). Methane is produced during the anaerobic fermentation of hydrolyzed dietary carbohydrates in the rumen and represents an energy loss to the host besides contributing to emissions of greenhouse gases into the environment. However, there appears to be uncertainty in the CH_4 estimation from livestock due to the limited availability of data to document the variability at the farm level and also due to the significant impact of diet on the enteric CH_4 production. The methane mitigation strategies require robust prediction of emissions from rumen. 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 the scale and design of the experiments to be undertaken. We collected methane gas in polythene bag with bottle and estimated amount of gas by Gas Chromatography. Result shows highest emission 984.84 PPM at 1 pm after feeding and lowest emission 17.29 PPM at 9:30 am before feeding.

Keywords: Ruminant, Methane, Emission, Gas chromatography.

Chapter 1: Introduction

Methane (CH_4) is a colorless, odorless gas produced as a byproduct of ruminant animals' gastrointestinal tract microbial fermentation of feed. The term "methanogen" refers to bacteria that produce methane. Methanogens create methane from hydrogen and carbon dioxide. As a result of microbial fermentation, hydrogen and carbondyoxide are generated. Enteric fermentation in ruminant animals produces methane, a powerful gas.

Methane (CH_4) has been linked to ozone depletion in the stratosphere (Blake and Rowland, 1988). When CH_4 is oxidized, water vapour is released into the stratosphere, which could provide surfaces for heterogeneous processes that degrade ozone. Global initiatives like the Kyoto Protocol demand that these emissions be minimized or at the very least avoided from increasing further (Howden and Reyenga, 1999). With a 100-year global warming potential (GWP) 23 times that of CO_2, methane is the second most significant contributor to global warming (IPCC, 2001). Despite being present in the atmosphere at much lower concentrations than CO_2, CH_4 is said to be responsible for roughly 20% of the greenhouse gas effect (IPCC, 1990; 1992).

CH_4 is produced largely by ruminant eructation from microbial fermentation of hydrolyzed dietary carbohydrates such as cellulose, hemicellulose, pectin, and starch in the rumen. Hydrogen and CO_2 are the key substrates for ruminal methanogenesis. The majority of hydrogen created during the fermentation of hydrolyzed dietary carbohydrates, particularly during the conversion of hexose to acetate or butyrate, ends up in CH_4. Microbial fermentation of amino acids, which produces ammonia, volatile fatty acids, CO_2, and CH_4, can also produce significant amounts of CH_4. Methane causes a large energy loss in ruminant animals, accounting for around 8% of gross energy at maintenance intake levels and declining to about 6% as intake levels rise. Increased knowledge and quantification of CH_4 generation in the rumen has implications for both global environmental protection and effective animal production.

It is critical to have faith in the accuracy of the CH_4 measurement equipment in order to create an accurate inventory or apply mitigation techniques. Methane emissions from livestock have been evaluated as part of research into ruminal fermentation, energy balance, feed additive evaluation, and most recently, to describe and minimize ruminant contribution to the global CH_4 load. Respiration calorimetry equipment such as complete body chambers, head boxes, ventilated hoods, and face masks have been used to monitor livestock CH_4 emissions (Johnson and Johnson, 1995). The data gathered through these methods served as the basis for the prediction equations that were utilized to create mathematical models and national and global inventories (Benchaar *et al*., 1998; Mills *et al*., 2001). The precise estimation of CH_4 emissions from ruminants under a variety of conditions is critical for developing measures to reduce CH_4 emissions. There are a variety of methods that may be used to measure CH_4 generated at various phases of animal production. They are ECD-Electron capture detector; FID-Flame ionization detector; FTIR-Fourier transform infrared (spectroscopy); GC-Gas chromatography/Gas chromatograph; TCD-Thermal conductivity detector; TDL-Tuneable diode laser; TGA-Trace gas analyzer; SF6- Sulfur hexafluoride. However, various criteria must be considered in order to choose the best technique, including the cost, the level of precision necessary, and the scale and design of the experiments to be conducted (Johnson *et al*., 2000).

Objectives:

1. To Know about gas produced by sheep.
2. To Determine suitable methane detection method from sheep.

Review of the literature

Sheep are grazing animals, and the forages they graze have an effect on intestinal CH_4 output. Because it is difficult to identify the exact feed intake, CH_4 emissions from sheep on grazing pasture are difficult to forecast; the nutritional value of the pasture may fluctuate both between and within seasons. In general, the nutritious content of forages is determined by their maturation level. The nutritious content of forages diminishes as pasture matures, while the concentration of structural carbohydrates rises, decreasing pasture's nutritional value. As a result, when sheep feed on low-quality pastures, acetic fermentation will prevail in the rumen, increasing CH_4 output. The amount of CH_4 produced by comparatively nutrient-rich pasture will be lower than that produced by poor-quality pasture (Clark *et al*., 2011).

Sheep are grazing animals in general, but due to the intensification of the production system, they are now reared in many regions of the world under semi-intensive and intensive feeding systems. The amount of enteric CH_4 produced in the rumen of sheep is determined by the feed consumed, the substrate degraded, and the type of end products created. Because the synthesis of propionate requires H_2, whereas the formation of acetate and butyrate releases H_2, rumen fermentation that produces more propionate lowers enteric CH_4. As a result, any feeding regimen that encourages rumen fermentation to shift from acetate to propionate would reduce H_2 release and CH_4 output (Basarab *et al*., 2013), and these associations have been demonstrated in many of the studies in sheep.

The chamber method has good accuracy and precision for assessing the daily production of CH_4 from housed animals but limited capacity with regards to the number of animals (Storm *et al*., 2012).

Though the adoption of a methodology for the estimation of CH_4 depends on many factors, in vivo techniques such as GreenFeed, sulfur hexafluoride tracer technique and respiration chambers are instrumental in order to estimate the precise emission and could be useful in determining the national CH_4 emission when a large number of experiments are conducted involving large animals and locally available seasonal feedstuffs with repeated measurements.

Polythene tunnels are just like respiration chambers, but these are easy to transport and operate and can be placed on pasture where animals are grazing. These tunnels overcome the limitation of respiration chambers where measurement of enteric CH_4 emission in pasture-grazing sheep is difficult. Polytunnels are used for measuring the emission in grazing animals without much disturbance to their natural behavior (Malik *et al*., 2017).

Methane emissions increased ($P \leq 0.05$) with increasing live weight, feeding level measured as multiples of maintenance and digestibility of dry matter and decreased for rations with wider ratios of crude fibre intake and intake of N-free extracts. Crude fibre content in the ration and energy density of the ration showed no clearly identifiable effect on methane emissions (pelchen and peters 1998).

CH_4 production from the open-circuit chambers was greater than from the tunnel system (Murray *et al*., 1999).

Enteric CH_4 contributes 17% and 3.3% of the global CH_4 and greenhouse gases (GHGs) emissions, respectively (Knapp *et al*., 2014).

Regional estimates by various agencies suggested a huge disparity in enteric CH_4 emission across the globe, and countries like Latin America, Africa, China and India hold first, second, third and fourth position in enteric CH_4 emission, respectively (Malik *et al*., 2016).

Facemask also uses the same principle as in chamber and hood for quantifying the CH_4 emission from livestock (Liang *et al*., 1989).

Laser methane detector (LMD) could be a quick and reliable method for measuring CH_4 emission from sheep in a stress-free natural environment (Chagunda *et al*., 2009).

Infrared Thermography technique relies on the principle that the animal's body surface temperature is related to the feed efficiency which in turn affects the degree of CH_4 emission from the animal. Montanholi et al. (2008)

The intraruminal gas measurement device was developed by the Commonwealth Scientific and Research Organization in Australia to estimate enteric CH_4 emission from ruminants. The device can be used as an alternative to SF6 tracer technique and respiration chambers. The device is impermeable to liquid and is placed into the stomach of the animal. The animals swallow the device as a bolus with tubular body.

The bolus is permeable to gases and has gas sensors that can detect CH_4 in rumen. A controller is attached to the gas sensor so that it can periodically process and give out data regarding the amount of CH_4 in the rumen (Wright *et al*., 2013).

In vitro gas production test is employed in laboratory where conditions akin to the rumen are simulated in an artificial environment and gas production is recorded, which is subsequently analyzed on gas chromatograph for CH_4. This technique is a powerful tool for generating real-time data in short duration for a large number of samples for their CH_4 reduction abilities (Lee *et al*., 2003).

Portable accumulation chambers (PAC) may be used for screening a large number of animals in order to select low-CH_4-emitting sheep. PAC allows you to test a huge number of animals in a short amount of time. Pastoral Greenhouse Gas Consortium (PGgRC) in New Zealand is developing one such PAC, in which sheep walking into the chamber will be held within for roughly 25–30 minutes while the CH_4 content is measured. A translucent polycarbonate box makes up the PAC. When the sheep is in the polycarbonate box, the concentration of CH_4 in the box rises, giving an estimate of CH_4 emission. A gas detector is used to track the change in CH_4 content in the chamber's environment over time. The results of this technique were comparable to those of respiratory chamber measurements (Goopy *et al*., 2009, 2011, 2016).

All the ruminant species emit CH_4 by virtue of their digestive system which is adapted for anaerobic fermentation, especially the rumen, the largest of the four chambers. Most ruminant species in underdeveloped nations rely on low-quality roughages to meet their nutritional needs, and as a result, they contribute significantly to global CH_4 emissions.

Table 1. Enteric methane emission from different livestock species in the world

Livestock species	[a]Enteric CH_4 emission (kg $\times 10^9$)
Cattle	69.9
Buffalo	10.7
Sheep	6.04
Goat	4.61
Swine	1.08
Camel	1.11
Horse	1.05
Ass	0.42
Mule	0.11
Alpaca	0.063
Total CH_4 production	94.9

[a]Estimated methane emitted by different livestock species in 2010. Adopted from Patra (2014a)

Cattle and buffaloes, for example, produce more CH_4 than smaller ruminants (Table 1). According to one estimate, total global enteric CH_4 emission (kg$\times 10^9$) from various animal classes will reach 105 by 2025, with cattle, buffalo, sheep, goat, swine, camel, horse, ass, mule, and alpaca contributing 77.3, 12.1, 6.18, and 5.19, 1.29, 1.17, 1.03, 0.45, 0.09, and 0.13, respectively (Patra, 2014a). Sheep and goats, which are smaller ruminants, produce somewhat more CH_4 than horses and swine, which are non-ruminants. The amount of CH_4 emitted by different ruminants is determined by a variety of parameters such as the animal's species, population, dry matter intake, degree of production, pasture quality, roughage quality, rumen volume, and other factors (Broucek, 2014).Sheep and goats, on the other hand, can create 10–16 kg CH_4 per year, whereas cattle can produce 60–160 kg per year, depending on the animal's size and dry matter consumption. Non-ruminant herbivore animals such as donkeys, horses, mules, and others produce CH_4 as a result of anaerobic fermentation in their hindgut.

Chapter 2: Materials and Method

Materials required

Rubber band, water bottle, polythene bag, three way cannula, syringe, vacutainer tube, Gas chromatography machine.

Gas Chromatography: The principle is based on the individual partitioning characteristics of various gases in the sample between a mobile phase (such as Helium) and a stationary solid phase packed in a column. Each component was identified by its retention time on the column and quantified by a subsequent detector after the components in the gaseous mixture were separated. The detector is the most important component of the GC system. For measuring greenhouse gases, three types of detectors are typically used: thermal conductivity detectors (TCD) for CO_2, flame ionization detectors (FID) for CH_4, and electron capture detectors (ECD) for N_2O.The detectors can be connected to GC systems singly or in groups, allowing for the simultaneous investigation of multiple gases (Sitaula *et al*., 1992). CH_4 has detection limits of less than 200 ppb, according to Crill *et al*., (1995).

Procedure

Bottom part of a water bottle was cutted circularly. A round rubber band was attached with the cutted part of the bottle. The open part (the bottom) was inserted into the mouth of the sheep. As it takes air, one valve (upper position) becomes open, but when it releases air, this valve is closed and that gas will go through the mouth of the bottle to the collection bag (polythene). Collection of methane was done from sheep for 4 days at different times of the day: 9:30 am, 1 pm, 5:30 pm, and 6:10 pm.

Gas was then collected in a vacutainer tube with the help of a syringe and a 3-way cannula. Here we needed restraining of the animal properly. As the animal's mouth was inserted through the facemask, it was hard to make the animal calm and quiet. Gas was collected for 5 minutes, 10 minutes, and 15 minutes. Expelled gas from the mouth was collected. After collecting the gas, it was transferred into a vacutainer tube. Here, caution was taken so that the gas would not be contaminated.

We tried to separate methane from CO_2. Sample was inserted in container carrying NaOH. Indicator was added with NaOH. CO_2 will react with NaOH to form Na_2CO_3. With this conversion the color of the solution will be changed. But in our case no color change occurred. So separation of CO_2 was not possible here from the sample.

Chapter 3: Results and Discussion

The experiment shows that methane released by sheep was higher after feeding the animal concentrate and roughage at 1 pm. Methane concentration can vary with animal size, feed intake, genetic variation etc.

Table 2. Amount of methane detected at different time from sheep

Time	9:30 am	1 pm	5:30 pm	6:10 pm
Methane concentration (PPM)	32.6465	959.027	376.808	69.558
	47.996	984.847	374.619	100.037
	17.297	782.368	310.414	39.079
Average Methane concentration (PPM)	32.6465	908.7473	353.947	69.558

Concentrate feed was given to the sheep at 12 pm. Sheep get roughage from pasture land. Each sheep get 250 gm of gram as concentrate. As the table 2 is showing that average methane concentration is highest at 1 pm (908.743 ppm). At 5:30 pm the average concentration of the methane decreased to 353.947 ppm. And lastly At 6:10 pm methane emission was declining more. But in the morning methane concentration was lowest because they were in empty stomach at that time.

Limitations

As methane collection device was not fully accurate, there was a chance of contamination with other atmospheric gas. And we were able to detect limited amount of methane from sheep.

Conclusion

The amount of methane detected was very less amount. But the experiment shows the relationship between the feed intake and methane production. Methane production was high after feeding and less before feeding.

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Biography

I am Niaj Ahmed Shimul, son of Atiqul Islam Babul and Shamima Yasmin. I Passed my Secondary School Certificate examination from Gafargaon Islamia Govt. High School, Gafargaon in 2013 and Higher Secodery Certificate examination from Shahid Syed Najrul Islam College, Mymensingh in 2015. I enrolled for Doctor of Veterinary Medicine (DVM) degree in Chattogram Veterinary and Animal Sciences University (CVASU), Bangladesh. In future, I want to be a veterinary practitioner and want to contribute to the development of the nation.