

Methane – Is It All Hot Air?

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Greenhouse gases (GHG) and methane

Cattle lose about 10% of their metabolisable energy intake (MEI) as methane (CH₄) gas. The gas is produced during digestion in the main stomach (rumen) and is belched out through the mouth – it does not get farted out! In peak lactation a cow produces about 350 g methane per day (500 litres) and this energy is equivalent to about 0.5 litres of petrol. This is a large waste of energy and contributes to GHG emissions.

GHG are present in the atmosphere and trap energy from the sun, thus increasing the earth's temperature. There is gathering evidence that global warming is occurring. In addition to warm temperatures in recent years, retreating glaciers and widespread extremes of weather, the atmospheric concentration of GHG is increasing. Over the past 200 years the concentration of carbon dioxide (CO₂) has increased 30%, nitrous oxide (N₂O from dung, urine and wet soils) by 16%, and methane by 150%. These gases, and chloro-fluro-carbons (CFCs), trap heat in the atmosphere.

New Zealand is unique amongst developed countries because its GHG include a high proportion of methane (38%) and only 44% carbon dioxide. The remaining 18% is mainly nitrous oxide. The high proportion of methane is due to a large ruminant (sheep, cattle and deer) population in comparison to a small human population and limited industry. If total methane production per annum is divided over our human population, annual emission is about 400 kg CH₄ per human. The average for the rest of the world is 47 kg CH₄ per person per year. Methane is a potent GHG, 23 times as effective as carbon dioxide for global warming.

Most of our electricity comes from hydro-electric generation rather than burning coal or natural gas, but carbon dioxide emissions from transport are increasing rapidly. If all the gases are added up over a year and their warming potential is expressed in terms of carbon dioxide, then each human is responsible for 18 tonnes of carbon dioxide equivalents per year.

The Kyoto Protocol and what it means for New Zealand

An agreement was reached in December 1997 in Kyoto, Japan, as a result of a meeting of about 160 countries. The Kyoto Protocol requires developed countries, including New Zealand, to reduce GHG emissions. Each country that has signed the Protocol has its own targets and for New Zealand this means that between years 2008 and 2012, GHG emissions should not be, on average, greater than they were in 1990. The agreement will only come into force if a minimum of 55 countries ratify the Protocol, and if these countries are responsible for a minimum of 55% of the world's GHG emissions. Developing countries, such as China, India

and Mexico, are exempt and other countries, such as Australia and the United States, the world's biggest GHG emitter, are refusing to ratify.

Where does methane come from?

About 90% of New Zealand's methane is derived from agriculture and nearly all from belching ruminants. Dairy cattle account for 34% of animal emissions, with average annual production of 70 – 90 kg per cow depending on her size and how much she eats.

Methane is a by-product of microbial breakdown in the rumen. The fibre in grass cannot be digested by simple stomached animals (humans, dogs, pigs), but cows have a large fermentation vessel (the rumen) holding 80–110 kg of pasture, and each kilogram contains a lot of bacteria (10,000,000,000,000) as well as protozoa and fungi. The bacteria live on forage, especially fibre, degrading it to volatile fatty acids (acetate (vinegar), propionate and butyrate) which are absorbed and used by the cow. They also produce carbon dioxide and hydrogen. Another group of microbes, the methanogens, use the hydrogen for their own energy and make methane.

The more feed a cow eats, the more methane she is likely to produce, and poor quality feed results in more methane than good quality feed since it is in the rumen longer and has more fibre. Of course a well-fed cow needs a lot of forage, and she will produce a lot of methane, but her maintenance energy requirements will become a smaller proportion of feed energy needs, so methane production per unit of milksolids will be less in a high producing cow than in a low producer.

Feeding different diets to reduce methane emissions

Research at Dexcel has measured the total methane production by cows fed contrasting diets at different times throughout lactation. Diets have included pasture, birdsfoot trefoil (*lotus corniculatus*), sulla (*hedysarum coronarium*), and white clover or maize silage fed with grass. Legumes result in less methane than grasses because they contribute less fibre, and both birdsfoot trefoil and sulla also contain condensed tannins (CT) which are also able to lower methane production.

A trial conducted at Dexcel measured methane production by 32 Friesian dairy cows grazing either good quality perennial ryegrass pasture or birdsfoot trefoil (lotus) that contained 2.6% CT in the dry matter. Half the cows fed each diet were drenched with an inert polymer, polyethylene glycol (PEG), to inactivate the CT and allow the effect of CT on methane production to be determined. Total methane production was similar for the cows fed lotus and ryegrass, however, methane production per unit dry matter intake (DMI) was lower from cows fed lotus (Table 1).

Table 1 Performance of 32 Friesian cows fed either perennial ryegrass pasture or birdsfoot trefoil (lotus) and drenched twice daily (3.6 l/d) with either 50% polyethylene glycol (PEG) to remove effects of condensed tannins from lotus, or water. The means and SEDs given are for the individual treatments

	Ryegrass	Ryegrass +PEG	Lotus	Lotus +PEG	SED
Liveweight (kg/cow)	538	540	536	537	4.5
Intake (kg DM/cow/day)	14.9	14.9	17.4	17.1	0.5
Milk yield (kg/cow/day)	18.5	19.0	24.4	22.1	0.7
Milksolids (kg/cow/day)	1.49	1.55	2.01	1.81	0.05
Total methane production (g CH ₄ /cow/day)	361	368	343	392	12
Methane per unit intake (g CH ₄ /kg DM)	24.2	24.7	19.9	22.9	0.8
Methane per unit production (g CH ₄ /kg MS)	250	244	171	216	11
Methane energy (% of MEI)	12.3	12.6	9.8	11.3	0.3

The CT in lotus reduced methane production per unit DMI by 13% relative to lotus when the CT had been inactivated by PEG, and was responsible for 66% of the difference between lotus and ryegrass. Cows fed lotus produced 32% less methane per kg milksolids compared to good quality ryegrass. When expressed in terms of MEI, cows grazing lotus lost 9.8% to methane compared with 12.3% of MEI lost from cows grazing ryegrass (Table 1). For cows eating 15 kg DM per day the difference in methane losses from lotus versus ryegrass was 63 g per day or 2% of MEI. If this energy was absorbed as volatile fatty acid (VFA) it could contribute about 0.6 kg milk or 48 g MS per day. The mechanism by which the CT in lotus reduced methane production is not fully understood but CT can reduce microbial degradation of forages in the rumen and can also have direct effects on some methanogenic microbes in the rumen.

Feeding cows low fibre or high starch supplements can reduce methane emissions per unit intake. This is because the microbes in the rumen use the hydrogen ions to make propionate which is used more efficiently than acetate for milk production. At Dexcel we have measured emissions from Friesian cows grazing pasture or fed a total mixed ration (TMR) high in concentrates. When pasture quality was high, methane emissions (as a percent of MEI) were similar to cows fed TMR, but during summer, when pasture quality decreased (more fibre),

cows grazing pasture were less efficient, produced less milk and lost more energy as methane. Cows fed TMR had high feed intakes, produced more total methane per day but less methane per unit of milksolids.

Reducing methane on your farm

It is important to think beyond methane emissions at the cow level and instead consider emissions per unit product (milksolids) and the whole farm system when choosing suitable methane mitigation options for your farm. Some options may decrease methane production but may also decrease the cow's milksolids yield. Generally, feeding cows using an alternative legume forage or even TMR-type diets may allow stocking rates to be reduced slightly which could decrease the farm's total methane emissions without compromising milksolids production. However, forages and feeding systems appropriate for dairy farming in New Zealand must be identified. Some TMR feeding systems are uneconomic under current New Zealand conditions due to high costs. Other factors, including the amount of nitrous oxide from dung, urine and fertiliser, and also energy (fuel) costs associated with cultivation and cropping should be considered. Methane is an important GHG and must be considered as part of an environmentally sustainable farming system.