Determination of methane emissions per unit of intake in young dairy heifers compared to mature cows

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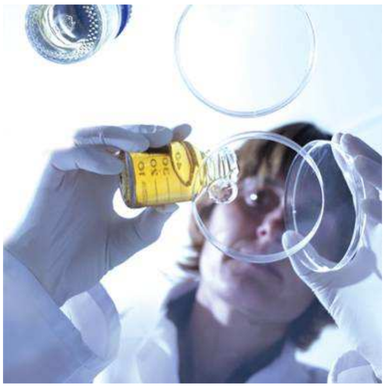

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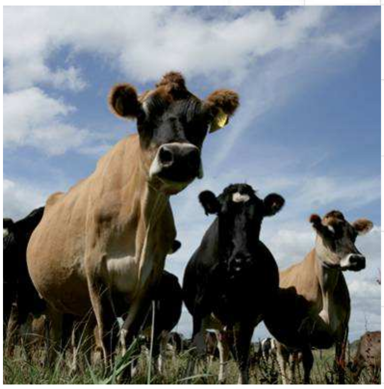

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1. Summary

Ten 12-week old dairy heifer calves (Friesian x Jersey) and 11 mature dairy cows, including 9 cows that had rumen fistula, were fed Ryegrass chaffage (Fiber-Way) at the rate of 1.3 X maintenance for 18 days. Half the diet was fed in the morning (09.00 hr) and the other half in the afternoon (16.00 hr). Refusals were collected and weighed each morning before the morning feed. On Day 7 the calves and cows were weighed and sulphur hexafluoride (SF_6) permeation tubes were administered into the rumen of each animal. Methane (CH_4) emissions were measured over the last 5 days of the 18 day trial. Data from the 2 non-fistulated cows had to be excluded because the SF_6 permeation tubes from a previous trial were not releasing enough SF_6. As expected the CH_4 emissions per day were higher for the mature cows than the calves (39.5 vs 123.9 (2.07 sed) g /day), but unexpectedly the CH_4 emissions per kg DMI were higher for the calves than for the cows (24.08 vs 22.13 (0.707) g CH_4 /kg DMI). There was no apparent reason for this difference.

2. Introduction

Enteric methane (CH_4) emissions make up about a third of all New Zealand's Green House Gas emissions. Estimates of these CH_4 emissions involves estimating the dry matter intake (DMI) of the class of ruminant (i.e. sheep beef cow or lactating dairy cow) and multiplying it by the CH_4 emissions per kg DMI for that class of ruminant. These latter values are obtained from experiments on the specific class of ruminant. Currently the national inventory uses a single value for cattle regardless of the age of the cattle. Experiments with sheep indicate the CH_4 emissions per kg DMI were lower for young sheep than for mature sheep (Knight et al. 2008). A similar age related reduction in methane emissions per kg DMI for cattle could reduce New Zealand's CO_2 equivalent emissions by approximately 250,000 tonnes per annum.

The aim of this trial is to determine if CH_4 emissions per kg of DMI are the same for young dairy heifers and mature dairy cows.

3. Materials and methods

3.1 Animals

Ten 12-week old dairy heifer calves (Friesian x Jersey) were selected on 9 June (Day = 0) from a herd of 15 calves that had been hand reared under contract to Agresearch Grasslands. The calves were weighed and then placed in a pen in the animal house at Grasslands and introduced to the Ryegrass chaffage (Fiber-Way) over 3 days. The calves were then placed in individual pens and fed Ryegrass chaffage at the rate of 1.3 X maintenance for the average liveweight of the 10 calves. Half the diet was fed in the morning (09.00 hr) and the other half in the afternoon (16.00 hr). Refusals were collected and weighed each morning before the morning feed.

Eleven mature dairy cows, including 9 cows that had rumen fistula, also arrived on 9 June. They were weighed off the truck and fed Ryegrass chaffage as a group in covered pens for 3 days and then individually fed Ryegrass chaffage at the rate of 1.3 X maintenance on the same schedule as the calves. On Day 7, the calves and cows were weighed again and on Day 8 the calves were fitted with harnesses and halters for 2 days to get them used to wearing the equipment needed to collect the breath for measuring CH_4 and sulphur hexafluoride (SF_6). The cows had already been trained to wear the equipment from their involvement in previous trials.

The cows and calves continued to be fed for a total of 18 days with CH_4 emissions being measured over the last 5 days. Samples of Ryegrass chaffage were collected on Day 0 and samples from three separate bag of Ryegrass chaffage were collected on Day 11. The samples were analysed for nutrient composition by Infrared Reflectance Spectrophotometry (NIRS; Corson et al. 1999) plus a sub-sample was dried at 105 C° for 16 hr to determine true dry matter (DM) content. The maintenance requirement of the calves and cow was calculated using the equations from Nicol and Brooks (2007). The initial liveweights on 9 June and a metabolisable energy (ME) content of the feed of 10.5 MJ ME /kg DM was used to calculate daily DM requirements of the cows and calves.

3.2 Measurement of methane emissions

Methane was measured using the SF_6 tracer technique (Johnson & Johnson, 1995). Brass permeation tubes (12.5 mm in diameter x 40 mm long) with known SF_6 release rates (range 1.6 to 4.8 mg SF_6 per day) were given to each animal on Day 7. All permeation tubes were stored at 39°C for a period of 8 weeks prior to insertion into the rumen, and the release rates of SF_6 for each tube were determined by weighing them weekly over this period. A sample of the gases exhaled by each cow was collected in a pre-evacuated PVC yoke with an average volume of 1.8 l while for the calves the exhaled gases was collected in smaller yokes with a capacity of 1.5 l. The gas was collected through a nylon tube of 3.2 mm internal diameter placed adjacent to the nose and held in place by a halter. The flow of gas to the collection yoke was regulated by a capillary attached to the halter so that the gas sample collected filled approximately 65% of the yoke volume over a 24-hour period. Yokes were fitted on Day 14 and were changed every 24 hours between 9.00 and 10.00 hr for five consecutive days. On the morning of Day 19, the yokes and halters were removed and the calves and cow weighed before being released to pasture. Background air samples were collected each day so that gas concentrations in the samples from the collection yokes could be adjusted for ambient concentrations. The concentrations of CH_4 and SF_6 collected in the evacuated yokes over 24 hours were measured in duplicate by gas chromatography as described by Boadi & Wittenberg (2002) and daily CH_4 emissions were calculated according to Johnson & Johnson (1995).

3.3 Statistical analyses

All the data was analysed by analyses of variance (GenStat 2005) with the only factor being the age of the animals (cows vs calves).

4. Results

4.1 Feed Quality

The Ryegrass chaffage had a true DM content of 36.6 ± 1.32 (s.d) % and contained, on a DM basis, 7.2 ± 0.40% ash, 12.4 ± 0.92% crude protein, 62.6 ± 2.5% neutral detergent fibre (NDF), 41.4 ± 0.74% acid detergent fibre (ADF), 2.7 ± 0.09% lipid and 5.57 ± 0.56% soluble sugars and starch. The feed had a NIRS estimated *in vitro* digestibility of 61.5 ± 3% and a metabolisable energy (ME) content of 9.8 ± 0.48 MJ /kg DM.

4.2 Liveweights

The cows arrived at Grasslands weighing 515 ± 23 (SD) kg and at the end of the 19 days on the trial they weighed 505 ± 24 kg. The calves were significantly lighter ($P < 0.001$), weighing 90.5 ± 3.4 kg at the start of the trial and 91.6 ± 2.6 kg at the end of the trial.

4.3 Feed intake

The cows were offered the ryegrass chaffage at 5.6 kg DM / day and they ate all the feed on offer leaving no refusals. In contrast, the calves were offered 1.68 kg DM / day of ryegrass chaffage and over the five days when the CH_4 emissions were being measured the refusals averaged 40 ± 98 g DM / day. Most of the refusals were due to one calf (tag 251) which had refusals averaging 317 ± 233 g DM/day over the five days the CH_4 emissions were being measured. The DMI of ryegrass chaffage of the calves for this period averaged 1.64 ± 0.098 kg DM /day.

4.4 Methane emissions

The two non-fistulated cows had SF_6 permeation tubes in them from a previous experiment and this interfered with the measurement of the CH_4 emissions from these cows and their data was removed from the analyses.

The calves produced significantly ($P < 0.001$) lower CH_4 emissions per day than the cows (39.5 vs 123.9 ± 2.07 (SED) g /day), but the emissions per kg DMI were higher ($P = 0.014$) for the calves than for the cows (24.08 vs 22.13 ± 0.707 g CH_4 /kg DMI).

5. Discussion

The higher CH_4 emissions per kg DMI for 12-16 week old calves than for mature cows was unexpected, especially since earlier trials with sheep had shown that lambs up to 53 weeks of age had lower CH_4 emissions per kg DMI than mature ewes (Knight et al. 2008). Even in the New Zealand Green House Gas Inventory, lambs younger than 12 months of age are considered to have a lower loss of dietary gross energy as CH_4 than for sheep older than 12 months of age (National Inventory 2007). Lower CH_4 emissions per kg DMI have also been reported for young red deer compared with values reported for mature deer (Swainson et al. 2007). The Ryegrass chaffage fed to the animals in this trial was of low quality with only 12.4 % crude protein and an apparent digestibility of 61.5%. This was not a typical diet for such young calves and this may have contributed to the higher CH_4 emissions per kg DMI. Another possible explanation for the difference in CH_4 emissions per kg DMI for the calves and cows could be due to sheep yokes and halters being used on the calves because they were too small for the cattle yokes used on the cows. There is no evidence for a difference in the measurement of CH_4 emissions from the different sized yokes and no theoretical reason for a difference to occur (B. Vlaming *pers com*).

These results need to be confirmed using better quality feed and using the more accurate calorimetry method to measure CH_4 emissions.

6. References

Boadi, D.A.; Wittenberg, K.M. (2002) Methane production from dairy and beef heifers fed forages differing in nutrient density using the sulphur hexafluoride (SF_6) tracer gas technique. *Canadian Journal of Animal Science* ***82**:* 201-206.

Corson DC, Waghorn GC, Ulyatt MJ, Lee J (1999) NIRS: Forage analysis and livestock feeding. *Proceedings of the New Zealand Grassland Association* **62**: 127-132.

GenStat (2005) GenStat for Windows. Release 8.1. Eighth Edition. VSN International Ltd., Oxford.

Johnson, K.A.; Johnson, D.E. (1995) Methane emissions from cattle. *Journal of animal science* **73***:* 2483-2492.

Knight, T. W., Molano G., Clark H., and Cavanagh A. (2008) Methane emissions from weaned lambs measured at 13, 17, 25 and 35 weeks of age compared with mature ewes consuming a fresh forage diet. *Australian Journal of Experimental Agriculture* **48***:* 240-243.

Nicol, A. M., and Brookes, L.M. (2007). The metabolisable energy requirements of grazing livestock. In Pasture and supplements for grazing animals. Ed. Rattray P. V., Brookes, I. M. and Nicol, A. M. Occasional publication 14 of the New Zealand Society of Animal Production. pp. 151-172.

Swainson, N. M.; Hoskin, S. O.; Clark, H. and Lopez-Villalobos N. (2007) The effect of age on methane emissions from young, weaned red deer *(Cervus elaphus)* stags grazing perennial-ryegrass (*Lolium perenne*) –based pasture. New Zealand Journal of Agricultural Research **50**: 407-416.