Will feeding high sugar grass reduce methane emission by grazing dairy cows?

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Abstract

This study aimed at investigating the effect of feeding high sugar grasses to dairy cows on CH_4 emission using modeling approaches. The dynamic mechanistic rumen model of Dijkstra *et al*. (1992) coupled with the CH_4 module of Mills *et al.* (2001) was used. Data from 4 experiments in which high and low sugar grasses were fed to dairy cows was used as an input to the model. The differential magnitude in sugar content between high and low sugar grasses ranged from 24 to 66 g kg^{-1} DM. Predicted CH_4 production by dairy cows consuming high and low sugar grasses was not different. A hypothetical situation in which the difference in sugar content between the two grasses was inflated to 100 g kg^{-1} DM on the expense of both protein and fiber that were reduced by 50 g kg^{-1} DM each, while keeping other input parameters constant was simulated. In this situation CH_4 production was 20.4 MJ d^{-1} (1.2 MJ kg^{-1} DMI) for the high sugar scenario compared to 18.6 MJ d^{-1} (1.1 MJ kg^{-1} DMI) for the low sugar scenario. It was concluded that feeding high sugar grass to dairy cows may not reduce methane emission from dairy production systems.

Keywords: methane, green house gases, high sugar grass, modeling.

Introduction

Emission of methane (CH_4) from ruminants on grasslands makes a substantial contribution to total agricultural methane emission. The global estimate of 44 Tg of CH_4 yr^{-1} from ruminants on grasslands implies that approximately 20 % of all agricultural CH_4 emissions, and between 40 and 55 % of the total ruminant CH_4 emissions, arise from grasslands (Clark *et al.*, 2005). In ruminants, CH_4 is produced as an end product to enteric fermentation of feed in the rumen, and to a lesser extent the large intestine, by specific groups of microbes (methanogens) present in these segments of the digestive tract. Methane produced either in the rumen or the large intestine cannot be absorbed and utilized by the animal and hence is considered a loss of feed energy. In free ranging animals on temperate pastures, between 6.5 and 8 % of the gross energy (GE) consumed is lost as CH_4 (De Ramus *et al*., 2003). Therefore, reducing CH_4 production by ruminants constitutes not only a reduction in the contribution of ruminant production systems to green house gases emission and hence environmental pollution, but also an improvement in feed-energy utilization. At present practical mitigation options for CH_4 emission that relate to grazing ruminants and grazed pasture are limited, with the best option for significant reductions in CH_4 being the direct manipulation of the rumen ecosystem (Clark *et al.*, 2005). Many strategies to directly manipulate the rumen ecosystem in order to reduce CH_4 emission have been investigated, i.e. the use of halogenated compounds, ionophores, and fatty acids (C_{12} and C_{14}). However, there are many limitation and restriction for those compounds to be widely used and accepted, i.e. toxicity, legislation and palatability. Changes in feed composition, mainly sugar and starch, have shown to significantly influence the rumen microbial population and ecosystem. Therefore, changing the composition of grass pastures to contain higher concentrations of sugars and starch presents a possibility to manipulate the rumen ecosystem and may be beneficial in reducing CH_4 emission. Recently, grass breeders succeeded in producing grass varieties that have high sugar content. Studies with high sugar grass (Peyraud *et al.,* 1997) showed a shift in rumen fermentation toward higher proportions of propionate and butyrate in rumen fluid. However, these studies did not measure CH_4 production. Measuring CH_4 production is laborious, expensive and requires sophisticated equipment. Mechanistic models have shown to be valuable for predicting CH_4 emission from dairy cows (Benchaar *et al.,* 1998; Mills *et al.,* 2001).

Therefore, the aim of this paper was to investigate the effect of feeding high sugar grass on CH_4 emission from dairy cows using modelling approaches.

Methodology

The dynamic mechanistic rumen model of Dijkstra *et al*. (1992) coupled with the rumen CH_4 module of Mills *et al.* (2001), was used to simulate the effect of feeding high sugar grass on CH_4 emission by dairy cows. Benchaar *et al.* (1998) evaluated the ability of several dynamic and static models to predict CH_4 production over a large range of diets and concluded that the Dijkstra *et al.* (1992) model was the most reliable one. Mills *et al.* (2001) version of the model contains a post-ruminal digestive element that predicts CH_4 production in the large intestine. However, considering the objective of this paper and the fact that less than 10 % of CH_4 originates from fermentation in the large intestine (Mills *et al.*, 2001), we chose to neglect post-ruminal CH_4 emission. As an input, the model requires a full an accurate description of the ingested feed, amount of ingested feed, degradation and solubility characteristics of starch, protein and fibre, passage rate of the liquid and solid phases, and rumen volume. The data from four experiments in three publications that evaluated the effect of feeding high sugar grass on intake and milk production were used (Peyraud *et al.,* 1997; Miller *et al.,* 2001; Taweel *et al.,* 2005). Most of the input parameters needed for the model to run were reported in those studies (Table 1). When needed input data were not available, data from literature and feeding tables for perennial ryegrass were used. Passage rates for the liquid and solid phases were not reported in any of the studies; therefore the values of 0.15 and 0.03 h^{-1}, respectively, were used and kept constant for all diets in all simulations.

Results and Discussion

The differential magnitude in sugar content between the high and low sugar grasses ranged from 24 to 66 g kg^{-1} DM (Table 1).

Table 1. The effect of feeding high sugar (HS) versus low sugar (LS) grass on CH_4 production by dairy cows predicted using the dynamic model of Dijkstra *et al*. and the CH_4 module of Mills *et al.*

	Peyraud *et al.,* 1997		Miller *et al.*, 2001		Taweel *et al.* 2005 [1]		Taweel *et al.* 2005 [2]	
	HS	LS	HS	LS	HS	LS	HS	LS
WSC (g kg^{-1})	246	180	165	126	181	157	180	149
CP (g kg^{-1})	106	150	92	106	159	162	151	157
S-fraction	0.47	0.50	0.15	0.12	0.07	0.06	0.07	0.07
D-fraction	0.44	0.41	0.77	0.72	0.75	0.77	0.76	0.77
U-fraction	0.09	0.09	0.08	0.16	0.18	0.17	0.17	0.16
kd-Protein	0.15	0.19	0.12	0.06	0.07	0.07	0.07	0.07
NDF (g kg^{-1})	496	528	544	589	415	428	414	430
D-fraction	0.86	0.82	0.85	0.85	0.86	0.87	0.86	0.86
U-fraction	0.14	0.19	0.15	0.15	0.14	0.13	0.14	0.14
kd-NDF	0.04	0.05	0.04	0.04	0.025	0.025	0.025	0.026
DMI (kg d^{-1})	15.1	15.3	11.6	10.7	16.2	16.6	16.2	17.1
Sugar intake (g d^{-1})	3715	2754	1914	1348	2932	2606	2916	2547
CH_4 (MJ d^{-1})	20.9	20.2	13.24	13.18	18.4	18.7	18.1	18.6
CH_4 (MJ kg^{-1} DMI)	1.38	1.32	1.14	1.23	1.14	1.13	1.12	1.09

[1] the first Latin square experiment in Taweel *et al.* (2005).
[2] the second Latin square experiment in Taweel *et al.* (2005).

At the level of dry matter intake (DMI) reported in the studies (10.7 to 17.1 kg), a difference of 326 to 960 g in daily sugar intake between the cows on high and low sugar grass was achieved. The predicted rumen CH_4 production by dairy cows in those studies ranged from 13.2 to 20.9 MJ d^{-1} and from 1.09 to 1.38 MJ kg^{-1} DMI. The range in CH_4 production predicted by the model is within reported ranges in the literature (Benchaar *et al.*, 1998). The predicted CH_4 production by cows on high sugar grass was not different than that of cows on low sugar grass in all of the studies (Table 1). A hypothetical situation in which the difference in sugar content between the two grasses was inflated to 100 g kg^{-1} DM at the expense of both protein and fiber that were reduced by 50 g kg^{-1} DM each, while keeping the other input parameters constant was simulated. In this situation CH_4 production was 20.4 MJ d^{-1} (1.2 MJ kg^{-1} DMI) for the high sugar scenario compared to 18.6 MJ d^{-1} (1.1 MJ kg^{-1} DMI) for the low sugar scenario. From this hypothetical scenario, it appears that dairy cows on high sugar grass pasture may produce slightly higher amounts of CH_4. In light of those findings, and the reported negligible effect on DMI and milk production (Peyraud *et al.*, 1997; Taweel *et al.,* 2005), it can be expected that higher amounts of CH_4 will be produced per unit of product when cows are offered high sugar grass pastures.

Conclusion

From the simulated results of CH_4 production, it can be concluded that offering dairy cows a high sugar grass pasture will not reduce CH_4 production and hence green house gases emission from dairy production systems.

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