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Effects of dietary and animal factors on methane production in dairy cows offered grass silage-based diets

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Abstract. An analysis of a large dataset, derived from lactating ($n=299$) and dry ($n=16$) Holstein–Friesian cows offered grass silage-based diets, was undertaken at the Agricultural Research Institute of Northern Ireland. Methane (CH_4) produced by cattle was measured in indirect calorimeter chambers. The level of CH_4 emission was positively related to live weight, DM intake (DMI), milk yield (MY) and feeding level, respectively ($P<0.001$), whereas the latter three variables each had a negative relationship with CH_4/DMI or CH_4/MY ($P<0.001$). The CH_4/DMI and CH_4/MY ratios increased with increasing dietary silage proportion and concentration of acid and neutral detergent fibre ($P<0.001$), but reduced with increasing dietary CP and energy concentration ($P<0.001$). The CH_4 production can be accurately predicted from DMI or MY together with other animal and dietary variables (R^2 up to 0.79). The results suggest that nutritional and management strategies can be used to reduce methane production from dairy cows, for example by increasing productivity or manipulating dietary composition. The reduction in CH_4 emission was quantified and discussed in the present paper. © 2006 Published by Elsevier B.V.

Keywords: Dairy cow; Grass silage; Methane production; Mitigation; Prediction

1. Introduction

Methane (CH_4) production from ruminant animals is a considerable source of global warming. Dairy cows are the major producer of CH_4 in Europe and North America because of their large numbers and high productivity. In the UK, dairy cows are estimated to contribute about 20% of total UK atmospheric CH_4 emissions [1]. This leads to an increasing interest across the world in approaches to mitigate CH_4 production of ruminant

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animals. At the Agricultural Research Institute of Northern Ireland, a number of studies with dairy cattle offered grass silage-based diets were recently undertaken to evaluate effects on energy metabolism including CH_4 energy output. The objectives of the present study were to use these data to examine relationships between CH_4 production and dietary and animal factors, and then develop equations to predict CH_4 production and develop nutritional and management strategies to reduce CH_4 production.

2. Materials and methods

Data used in the present study were obtained from lactating ($n=299$) and dry ($n=16$) Holstein–Friesian cows offered grass silage-based diets in a number of feeding studies ($n=16$) undertaken at this Institute since 1992. The animals were of various genetic merits (low to high), lactation number (1 to 9), stage of lactation (early to late) and live weight (LW, light to heavy). Milk yield (MY) for lactating cows ranged from 3.2 to 49.1 kg/day (mean 22.9 kg/day and S.D. 7.72). All cattle were given mixed diets of grass silage and concentrates, except for 43 animals in 3 studies for which the silages were given as the sole diets. A total of 42 perennial ryegrass silages were examined, which encompassed primary growth and first and second regrowth material. The grass was either unwilted or wilted prior to ensiling and ensiled with or without application of silage additives. The concentrates used included a vitamin and mineral supplement and some of the following ingredients: barley, wheat, maize, maize gluten meal, molassed sugar-beet pulp, citrus pulp, molasses, soyabean meal, rapeseed meal and fish meal. Cow LW, total DM and GE intake (DMI and GEI) and energy outputs in faeces and urine were determined in a 6-day digestibility trial following at least 3 weeks of feeding of experimental diets. Immediately after completion of the

Table 1
Dataset used in the present study and correlation coefficients (R) in linear relationships

	Dataset			Correlation coefficients		
	Mean	S.D.	Range	CH_4 (l/day)	CH_4/DMI (l/kg)	CH_4/MY (l/kg)
Cow data						
Live weight (kg)	568	63.4	385–747	0.35	NS	NS
DM intake (kg/day)	16.2	3.82	4.6–24.5	0.77	−0.57	−0.43
Milk yield (kg/day)	21.7	9.05	0.0–49.1	0.52	−0.55	−0.82
Methane production (l/day)	518	104.3	173–757	–	–	–
DM intake/live weight (g/kg)	29	6.4	7–54	0.61	−0.60	−0.51
Feeding level [2]	3.5	0.86	0.9–6.9	0.59	−0.65	−0.51
Dietary concentration (g/kg DM)						
Silage proportion	559	216.1	181–1000	−0.21	0.35	0.53
Gross energy (MJ/kg DM)	18.6	0.52	16.6–20.8	−0.29	−0.21	−0.21
Crude protein	180	23.9	116–250	0.25	−0.49	−0.55
Ash	82	9.8	57–111	0.23	−0.17	−0.25
Acid detergent fibre	246	51.9	157–386	−0.24	0.26	0.45
Neutral detergent fibre	418	80.5	265–604	−0.22	0.31	0.48

Correlation coefficients (R) were obtained without removing experimental effects; R=NS, not significant; $[R]=0.17$, $P<0.01$; $[R]\geq 0.21$, $P<0.001$. CH_4/MY is for lactating cow data only ($n=299$).