Replacing Grass Silage with Maize Silage Affects Rumen Fermentation Characteristics and Enteric Methane Production in Dairy Cattle.

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Introduction

Methane (**CH_4**) is produced during microbial fermentation of feed in the gastrointestinal tract of ruminants, and released to the environment through breath and eructation. CH_4 is an important greenhouse gas in dairy cattle systems, and represents an energy loss ranging between 2 and 12% of gross energy intake, depending on the type of diet fed (Johnson and Johnson, 1995). It is beneficial to mitigate CH_4 production from dairy cattle, since it will reduce the ecological footprint of milk production, and may improve feed efficiency and reduce production costs.

Dietary manipulation seems to be the most effective approach for CH_4 mitigation. Several dietary strategies have been proposed to reduce the production of CH_4 from dairy cattle, one of which is the replacement of fibre-rich grass silage (**GS**) with starch-rich maize silage (M**S**).

In general, in comparison with fibre, fermentation of starch lowers ruminal pH and favours the production of propionate at the expense of acetate in the rumen, which decreases CH_4 production, given the general inverse relationship between propionate formation and ruminal methanogenesis (Ellis et al., 2008). Therefore, replacing GS with MS has potential in mitigating CH_4 emissions. However, the scientific evidence for this particular dietary replacement strategy is scarce. The purpose of this study was to determine the effects of replacing GS with MS in dairy cow diets on enteric CH_4 emission and to examine the accompanied changes in ruminal fermentation characteristics.

Material and Methods

A completely randomized block design experiment was conducted, with 32 multiparous lactating Holstein-Friesian dairy cows, of which 12 were rumen fistulated. Each block contained 4 cows, which were randomly assigned to the dietary treatments. All dietary treatments had a forage to concentrate ratio of 80:20 based on dry matter (**DM**) content. The composition of the concentrate was the same for all four treatments, while the forage was GS, MS or a mixture of both: 100% GS (**GS100**), 67% GS and 33% MS (**GS67**), 33% GS and 67% MS (**GS33**), and 100% MS (**GS0**; GS as fraction of the total amount of forage in the diet). The NDF content of GS was 510 g/kg DM; NDF and starch content of MS was 377 and 211 g/kg DM, respectively. Each period lasted 17 days, of which 12 days adaptation to the diet. The last 5 days, the cows were housed in climate respiration chambers to measure CH_4 production. Cows were fed ad libitum during the first 7 days of the adaptation period. From day 8 till day 17 feed intake was restricted to 95% of the ad libitum DMI. Samples of rumen fluid were taken from fistulated cows on day 10 and 11 to measure pH and VFA. Rumen fluid samples were collected 1h before morning feeding, and 1, 2, 4, 6, and 8h after morning feeding on both days.

Methane production data were analysed using the MIXED procedure in SAS (SAS Institute Inc), including dietary treatment as fixed factor, and cow and period as random factors. Post-hoc analyses were carries out using Tukey-Kramer test to test pairwise comparisons. The rumen variables were subjected to repeated measures ANOVA to take repeated samples within the same animal into account, with cow and period as random factors, and diet, time of sampling and the interaction of diet and time as fixed factors.

Results and Discussion

Mean DMI and FPCM production were 16.8 and 25.1 kg/d, respectively. Feeding the diet in which GS was completely replaced with MS caused significant changes in the ruminal environment and reduction in CH_4 production (g/d, g/kg DMI, g/kg FPCM, and % of GEI), whereas a lower replacement of GS with MS (i.e. 33% and 67%) did not (Table 1 and 2).

Table 1. CH_4 production of dairy cows receiving different dietary treatments

	Diet					
Item	GS100	GS67	GS33	GS0	SE	P-value
CH_4 (g/d)	399[ab]	414[a]	411[a]	387[b]	12.8	<0.001
CH_4 (g/kg DMI)	24.6[a]	25.0[a]	24.5[a]	22.0[b]	0.38	<0.001
CH_4 (g/kg FPCM)	16.6[a]	17.0[a]	16.2[ab]	15.3[b]	0.50	0.033
CH_4 (% of GEI)	6.96[a]	7.17[a]	7.11[a]	6.45[b]	0.105	<0.001

[a,b] Means within a row with different superscripts differ (P < 0.05).

Table 2. Rumen pH, total VFA concentration, and VFA molar proportions in fistulated cows receiving different dietary treatments

	Diet					P-value[1]		
Item	GS100	GS67	GS33	GS0	SE	D	T	D*T
pH	6.77	6.74	6.73	6.72	0.10	0.563	<0.001	<0.001
Total VFA (mM)	103	100	98	98	6.6	0.233	<0.001	<0.001
Acetate (%)	65.6[a]	66.0[a]	65.8[a]	63.6[b]	1.23	<0.001	<0.001	<0.001
Propionate (%)	18.9[a]	17.8[b]	17.7[b]	17.1[b]	1.10	<0.001	<0.001	<0.001
Butyrate (%)	11.7[d]	12.5[bc]	13.0[b]	15.2[a]	0.41	<0.001	<0.001	<0.001
Isobutyrate (%)	1.06[a]	1.05[a]	0.96[b]	1.05[a]	0.033	0.001	<0.001	<0.001
Valerate (%)	1.54[a]	1.33[b]	1.28[b]	1.37[b]	0.138	<0.001	<0.001	<0.001
Isovalerate (%)	1.20[b]	1.32[b]	1.30[b]	1.73[a]	0.069	<0.001	0.002	<0.001
Acetate: propionate	3.55[b]	3.83[ab]	3.97[a]	3.78[ab]	0.318	0.039	<0.001	<0.001

[a-d] Means within a row with different superscripts differ (P < 0.05).

[1] D = effect of diet; T = effect of time of sampling compared to morning feeding (-1, 1, 2, 4, 6, and 8h); D*T = interaction between diet and time of rumen sampling.

Such a response suggests that a critical dietary concentration of starch is required to make the ruminal environment less favourable for methanogenesis and thereby reduce CH_4 production. A similar response in daily CH_4 output (g/d) was observed by Hassanat et al. (2013) when replacing alfalfa silage with maize silage.

Conclusion

The results of the present study show that in common forage based diets for dairy cattle, replacing GC with MS can potentially contribute to CH_4 mitigation. Furthermore, the results suggest that the decrease in rumen acetate is a key component in this reduction of CH_4 production.

References

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