Effects of type and level of starch in concentrate on methane emission in lactating dairy cows

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Introduction

Starch is a major source of glucogenic energy for high-yielding dairy cows as well as an accessible source of fermentable energy for rumen microorganisms (Koenig *et al*., 2003). Compared with dietary fibre, starch may result in reduced methane (CH_4) production because fermentation of starch promotes production of propionate, which acts as a hydrogen sink (Bannink *et al*., 2006) and, unlike fibre, the rumen bypass fraction of starch is well digested in the small intestine, without the production of VFA. However, measurements with regard to its effect on CH_4 emission in dairy cattle are scarce. The objective of this study was to determine the effects of type and level of dietary inclusion of maize starch on CH_4 emission in lactating cows.

Materials and methods

Forty Holstein-Friesian dairy cows were selected and allocated to 10 blocks based on parity (mean ± SD: 2.9 ± 1.1 parity), days in milk (215 ± 89 DIM), and fat- and protein-corrected milk production (35.9 kg/d ± 9.5 FPCM). Cows within a block were assigned to one of four diets in a 2 × 2 factorial arrangement of treatments (2 types and 2 levels of starch) in a randomized complete block design. Treatment diets were composed of concentrate which contained either 27% (27) or 53% (53) starch on dry matter (DM) basis. The starch source was ground native maize starch (slow degradable, S) or ground gelatinized maize starch (fast degradable, F). Maize starch was exchanged with beet pulp and palm kernel expeller. Cows were fed a total mixed diet consisting of grass silage and concentrate at 60:40 ratio on DM basis. The experiment was conducted in 10 successive periods. Each experimental period consisted of 12 days of adaptation to the diets in tie-stalls, and 5 days in respiration chambers to evaluate methane production and animal performance. Two cows were housed per chamber, and the experimental unit for CH_4 and energy balance traits in the chambers thus consisted of a pair of cows. On day 10 and 11, rumen fluid was collected from fistulated cows (n =16) to determine VFA concentration and rumen pH at 0, 1, 2, 3, 4, 6 and 8 h after morning feeding. All other measurements and data collection were done during the days in the respiration chambers. Data were analysed by PROC MIXED model of SAS. The model included type, level, type × level interaction and respiration chamber as fixed effects, and period as random effect on CH_4 and energy balance traits; the model included block, respiration chamber, type, level, and type × level interaction as fixed effects on dry matter intake, milk yield and composition. Data for rumen pH and VFA were analysed as repeated measurements. Block, type, level, time, type × level and type × level × time interactions were included in the model as fixed effects, cow as random effect, and time as repeated measure.

Results

Preliminary results are presented in table 1. Dry matter intake (DMI) was higher for low starch compared with high starch, but type of starch did not affect DMI. Differences among treatments in milk yield or CH_4 production per g/kg of FPCM or per kg of DMI remained insignificant. Also milk fat and protein content were not affected by treatment (data not shown). Both total VFA concentration and molar proportion of propionate increased with fast degradable starch. Molar proportion of acetate tended to be affected by type of starch, but unaffected by level of starch. No significant differences were observed for butyrate molar proportion and rumen pH among treatments.

Table 1 Effect of type and level of starch in concentrate on DMI, milk yield, fermentation characteristics and methane emissions in lactating cows

Item	Treatment				SED	P-value		
	S27	S53	F27	F53		Type (T)	Level (L)	T × L
DMI (kg/d)	18.7	17.6	18.7	17.6	0.56	0.98	0.01	0.94
FPCM (kg/d)	28.0	25.2	27.0	26.9	1.21	0.64	0.11	0.15
CH_4 (g/kg of FPCM)	15.6	16.0	16.0	15.0	0.59	0.51	0.42	0.13
CH_4 (g/kg of DMI)	23.3	22.7	23.2	22.7	0.76	0.92	0.369	0.93
Total VFA (mM)	100.5	95.1	108.8	103.1	3.40	0.003	0.03	0.95
Acetate (%)	68.4	69.2	68.4	67.6	0.53	0.07	1.00	0.45
Propionate (%)	16.2	15.4	16.2	16.9	0.50	0.04	0.96	0.04
Butyrate (%)	11.6	11.2	11.1	12.0	0.30	0.55	0.36	0.09
Rumen pH	6.53	6.50	6.51	6.53	0.08	0.85	0.87	0.68

Conclusions

Type and level of maize starch in the concentrate has no effect on CH_4 production per kg FPCM or per kg DMI and on FPCM production.

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References

Bannink A., Kogut J., Dijkstra J., France J., Kebreab E., Van Vuuren A.M. and Tamminga S. 2006. Journal of Theoretical Biology 238, 36-51.

Koenig K.M., Beauchemin K.A. and Rode L.M. 2003. Journal of Animal Science 81, 1057-1067.