Effect of N underfeeding and energy source on ruminal digestion and protein metabolism in dairy cows

Audrey Fanchone, Pierre Noziere, Josiane Portelli, Béatrice Chauveau-Duriot, Vincent Largeau, Michel M. Doreau

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A Fanchone, P Nozière, J Portelli, B Chauveau-Duriot, V Largeau and M Doreau
INRA, St Genès Champanelle, France *Email: michel.doreau@clermont.inra.fr*

Introduction Optimising the efficiency of N utilisation in the rumen of dairy cows is a way to improve the use of dietary N by animals, and thus to limit N output in manure (urine and faeces). In the rumen, efficiency of N utilisation is affected by modification of some key factors including protein degradation, N uptake and efficiency of microbial synthesis (MS) but there is little information with very low N diets. At the same time, the MS efficiency may depend on energy source. This study aimed to determine the effect of a strong decrease in dietary N on protein ruminal digestion and metabolism in cows, when concentrates were based on starch or fibre.

Material and methods Four Holstein cows in mid-lactation fitted with rumen, proximal duodenum and terminal ileum cannulae were used in a 4x4 Latin square design. Treatments were two levels of N (low and high level) and two energy sources (starch and fibre). On a DM basis, the four diets had the same forage content based on maize silage, hay, and dehydrated lucerne. The high N level (H) was sufficient in rumen degradable N, the low N level (L) was deficient in rumen degradable N. Energy sources differed by their nature, starch (S) from barley, maize and wheat, or fibre (F) from soybean hulls and dehydrated beet pulp. The CP content of the diets was 142, 144, 109, and 111 g/kg DM for treatments HS, HF, LS and LF, respectively. Differences in degradable N supply were obtained mainly by soybean meal and urea. Diet was distributed twice daily at 0900 and 1700 h. Each experimental period lasted 28 d. Total tract digestibility was determined by total faeces collection. Duodenal digesta flow was determined using $YbCl_3$ as marker. Microbial N duodenal flow was determined using purine and pyrimidic bases as marker, from a mixed bacteria sample. The efficiency of microbial N synthesis was calculated as the ratio between microbial N duodenal flow and OM fermented in the rumen. In ruminal liquid, kinetics of ammonia and volatile fatty acids in the rumen were determined before feeding and 1, 2.5, 5 and 8 h after feeding, and protozoa were counted before and 2.5 h after feeding. Statistical analysis was performed using GLM procedure of SAS.

Results Organic matter (OM) total tract digestibility, non ammoniacal N (NAN) duodenal flow, N intestinal digestibility, rumen ammonia, rumen ammonia mean and post-prandial peak were higher with H diets than with L diets (Table 1). Rumen ammonia post-prandial peak was higher with fibre diets, especially at low N level (significant interaction). Despite important numerical differences, no significant difference was observed among diets for OM apparent ruminal digestibility, microbial duodenal flow and efficiency of microbial synthesis. Total volatile fatty acids and rumen protozoa concentrations did not vary among diets.

Table 1 Ruminal digestion and protein metabolism in dairy cows receiving concentrates rich in starch or fibre at low or high N level

	L		H		SEM	Statistical analysis		
	S	F	S	F				
OM intake (kg/d)	18.8	19.0	18.7	19.0	0.37	ns		
OM total tract digestibility (g/kg)	664	658	705	677	8.4	N**		
OM apparent ruminal digestibility (g/kg)	432	507	432	467	38.9	ns		
NAN duodenal flow (g/d)	390	347	499	437	23.6	N**	E*	
NAN duodenal flow (% N intake)	111	96	110	93	5.4	E*		
Microbial N duodenal flow (g/d)	317	277	374	306	32.2	ns		
Microbial synthesis efficiency (g N/kg OM fermented)	26.0	20.6	28.1	23.9	2.68	ns		
N intestinal digestibility (% duodenal N)	62.2	55.7	69.8	62.0	2.64	N*	E*	
Rumen ammonia, post-prandial peak (mg/l)	71.0	245.4	224.5	288.4	24.15	N**	E**	N×E*
Ammonia, average (mg/l)	23.8	123.1	126.8	150.6	13.49	N**	E**	
Total volatile fatty acids, average (mM)	95.6	101.8	101.2	104.8	2.71	ns		
Acetate / propionate (mol/mol)	4.02	3.77	3.79	3.90	0.142	ns		
Total protozoa ($\times 10^3$/ml) prefeeding	163.3	247.4	283.2	244.4	88.67	ns		
Total protozoa ($\times 10^3$/ml) 2.5 h postfeeding	56.8	96.5	81.8	87.5	24.15	ns		

N: effect of N level; E: effect of energy source; ns: non significant; *: $P < 0.05$ - **: $P < 0.01$

Conclusions A substantial shortage in fermentable N in the rumen resulted in a decrease in OM digestibility, and in a very low ammonia concentration, as previously shown in low N diet (Doreau *et al.*, 1990), especially when concentrate was rich in starch. Low N diets decreased NAN duodenal flow but microbial N duodenal was not significantly decreased, and microbial synthesis efficiency was not modified. Low dietary N does not impair N ruminal metabolism, with diets differing in fibre/starch ratio.

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Reference

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