078

Effects of dietary protein concentration on the efficiency of nitrogen utilisation in lactating dairy cows

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Introduction The European Union Nitrates Directives set a limit on the amount (170 kg/ha) of manure nitrogen (N, = faecal N + urine N) that may be applied to land each year. This limit has very significant implications for stocking rates on intensive livestock farms. Consequently, there is increasing interest in developing mitigation strategies to reduce N output in faeces and urine in animal production systems. The objectives of the present study were to evaluate the effects of dietary crude protein (CP) concentration on the efficiency of N utilisation in lactating dairy cows.

Materials and methods A large continuous design study (47 first and 40 multi-lactation Holstein dairy cows) was undertaken to examine effects of 3 dietary CP concentrations (180, 150 and 120 g/kg DM) on animal performance and nutrient utilisation from week 1 to 44 of lactation. The 3 mixed diets each contained 450 g/kg DM of forage (60% grass silage and 40% maize silage (DM basis)) and 550 g/kg DM of concentrates. Concentrate supplements (n = 3) consisted of different proportions of the same ingredients (barley, wheat, sugar beet pulp, citrus pulp, soya bean meal, rapeseed meal and molasses). Full details of experimental design, animal, diets and managements are reported by Law *et al* (2008). During early (70 to 90 days), mid (150 to 170 days) and late (230 to 250 days) lactation, the same 4 cows and 4 heifers from each treatment were transferred to metabolism units for 8 days, with measurements of feed intake and faeces and urine outputs during the final 6 days. Live weight was recorded at the beginning and end of digestibility measurements and milk yield and fat, protein and lactose concentration in milk were measured daily during the digestibility trials. The data were analysed as a one way ANOVA, with experimental period as block.

Results Dietary CP concentration had no significant effect on live weight or fat, protein or lactose concentration in milk, but increasing dietary CP concentration significantly increased DM intake (16.5, 18.4, 19.5 kg/d, s.e. 0.43, $P < 0.001$) and milk yield (20.6, 26.1 and 28.3 kg/d, s.e. 0.94, $P < 0.001$). Consequently, increasing dietary CP concentration significantly increased N intake, N outputs in faeces, urine and milk and N retention ($P < 0.001$, Table 1). Increasing dietary CP concentration significantly reduced N output in faeces and milk as a proportion of N intake ($P < 0.001$), while significantly increased urine N output ($P < 0.001$) and N retention ($P < 0.01$) as a proportion of N intake. There was no significant difference in milk N output as a proportion of N intake between low and medium CP diets. Manure N output as a proportion of N intake was significantly higher with low than medium and high CP diets ($P < 0.001$). However, manure N output as a proportion of DM intake or milk yield significantly increased with increasing dietary CP concentration ($P < 0.001$). There was no significant difference in manure N output as a proportion of milk yield between low and medium CP diets.

Table 1. Effects of dietary CP concentration on nitrogen utilisation

	Dietary CP concentration (g/kg DM)				
	120	150	180	s.e.	P value
Nitrogen intake (g/d)	321.5	444.6	561.8	10.53	< 0.001
Faecal N output (g/d)	134.9	161.9	172.9	5.14	< 0.001
Urine N output (g/d)	92.0	137.6	206.8	5.43	< 0.001
Milk N output (g/d)	99.5	132.3	143.9	4.35	< 0.001
Retained N (g/d)	-4.9	12.8	38.2	1.84	< 0.001
Faecal N/N intake (g/g)	0.425	0.363	0.308	0.0097	< 0.001
Urine N/N intake (g/g)	0.282	0.311	0.368	0.0082	< 0.001
Milk N/N intake (g/g)	0.310	0.297	0.256	0.0068	< 0.001
Retained N/N intake (g/g)	-0.017	0.030	0.068	0.0043	< 0.01
Manure N/N intake (g/g)	0.707	0.673	0.676	0.0065	< 0.001
Manure N/DM intake (g/kg)	13.8	16.3	19.5	0.19	< 0.001
Manure N/milk yield (g/kg)	11.4	12.0	14.1	0.53	< 0.001

Conclusions The results demonstrate that manure N output associated with one kg milk production increased with increasing dietary CP concentration, but the increase was not significant with diets containing CP levels above 150 g/kg DM. This indicates that overall dietary CP concentration of 150 g/kg DM may be appropriate in order to reduce manure N output, whilst reducing the decrease in milk yield normally observed with very low protein diets.

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Reference Law, R. A., Young, F. J., Patterson1, D. C., Kilpatrick, D. J. Wylie, A. R. G. and Mayne, C. S. 2008. Effect of dietary protein content on animal production and blood metabolites of dairy cows during lactation. J. Dairy Sci. (In press).