Effect of crude protein intake by dairy cattle on NH_3 concentrations from a dairy stall

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Introduction

Atmospheric NH_3 can cause serious environmental problems related to soil acidification and eutrophication. Emissions of NH_3 from agriculture are the largest source, at 79% of the global total, with about 50% from animals (van Aardenne et al., 2001). Milking cows have the largest per animal emissions of NH_3 due to the energy and protein required per milk production. Emission of NH_3 from the dairy barn depends on the cow's diet (Smits et al., 1995), the design of the barn (Braam et al., 1997), the outdoor and indoor climate, and the management of the farm, e.g., grazing regime (Monteny, 1998). Improving N utilization on dairy farms is important to minimize negative environmental impacts.

New techniques to apply manure and to cover storage facilities have reduced NH_3 emission from dairy cattle production. Nevertheless, NH_3 emission from dairy barns must be reduced to achieve a further reduction. Paul and Beauchamp (1995) calculated a 29% loss of N following excretion prior to field application of dairy cattle manure. Altering the cows´ diet is a relatively easy measure to reduce NH_3 emission in the short term (James et al., 1999; de Boer et al., 2002). The aim of this study was to relate the protein nutrition of milking cows and its influence on NH_3 concentration in dairy stall barn.

Materials and methods

Three Holstein cows in their first lactation, with 257±12 milking days; 644±8 kg BW and 27±3 kg of milk, were offered three TMR rations differing in their CP content (LP 14.1%, MP 15.9% and HP 16.9%) in a 3 x 3 Latin square design. Ration forage:concentrate ratio was 50:50 being forage presence constant in the ration (28% maize silage and 22% alfalfa hay). Animals had free access to water and stones for mineral supply during the assay. Collection of most urine and faeces from each cow started on the first day of the balance week. Faeces and urine were collected from each of the cows while in the stalls (excluding periods when the cows were being milked) and were immediately stored in containers and kept refrigerated until required for the field trials. Subsamples of urine were collected in vessels and preacidified with 10% H_2SO_4 to adjust the pH of the sample to below 3 to minimize ammonia losses. Cows were housed in individual tie stalls and faecal, urinary and milk samples were collected for 4 days every sampling period. Faecal, urinary and milk samples were measured for its N content by N-Kjeldalh method. The diacetyl monoxime method (Marsh et al., 1957) was used to determine both urinary urea nitrogen (UUN) and milk urea nitrogen (MUN). The dairy house was based on slatted floor with a natural ventilation system. NH_3 concentration in the air was measured by photoacoustic infrared gas analyzer (Brüel & Kjaer) for 45 minutes at midday 4 hours after depositions removal. Atmospheric temperature was determined everyday by Microcomputer Thermometer HI 9350.

Experimental procedure

The experiment was conducted as a 3 by 3 Latin Square design: 3 cows x 3 protein concentrations during 3 feeding trials of 15 days (allowing an adjustment period of 11 days). Feed was offered to produce 10% orts and supplied as a mixed diet at two

times of the day (9.0 a.m. and 17 p.m.). Milk production was recorded and samples were collected twice a day (8 a.m and 6.30 p.m). Faeces were weighed following a.m. milking, and a 300 g sample was taken for analysis. Samples were stored at -20ºC until measurement. During the two consecutive days at the end of each experimental period, feed composition was analysed. Details of the diets are given in Table 1.

Table 1. Chemical composition of formulated rations

Chemical composition	LP	MP	HP
DM, %	66.8 (2.07)	66.6 (0.56)	67.0 (0.52)
OM, %	90.1 (0.14)	90.6 (0.07)	92.0 (0.06)
Ash, g/kg DM	9.9 (0.14)	9.4 (0.07)	8.0 (0.06)
CP, g/kg DM	14.1 (0.11)	15.9 (0.10)	16.9 (0.11)
NDF, g/kg DM	37.7 (0.18)	37.4 (0.09)	36.8 (0.08)
ADF, g/kg DM	20.6 (0.26)	20.8 (0.13)	21.1 (0.07)

DM: dry matter; OM: organic matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber

Analytical measurements for feed, milk and feces

Dry matter was calculated after drying simples in oven at 80 ºC for 24 hours. Ashs were determined by calcination at 550ºC. Total N as N-Kjeldahl using Kjeltec™ 2300. Crude protein in milk samples (N x 6,38) was measured by Milko-Scan 4000 in the Laboratorio Interprofesional Lechero in Santander.

Ammonia concentrations, faecal and urine N, milk yield and composition were analyzed by ANOVA using the General Linear Models statement of SAS. Differences were considered significant at the 5% level (P≤0.05).

Results and Discussion

Animal N balance, UUN and MUN values, milk yield and mean NH_3 concentrations in the stall are shown in Table 2.

Table 2. Animal N balance, urinary and milk urea nitrogen, milk yield and mean NH_3 concentrations at stall

Parameters	LP	MP	HP
N intake, g/d	438.6^{a}	490.8^{ab}	522.8^{b}
N fecal, g/kg DM	27.6^{a}	29.9^{ab}	31.0^{b}
N urinary, g/kg	8.11^{a}	8.92^{a}	9.09^{a}
N slurry, g/kg	17.8^{a}	19.4^{ab}	20.0^{b}
Milk yield, kg/d	23.4^{a}	24.1^{ab}	24.9^{b}
MUN, mg/dl	15.4^{a}	18.7^{b}	17.8^{ab}
UUN, g/l	5.59^{a}	6.22^{a}	7.42^{a}
NH_3, ppm	7.03^{a}	10.5^{b}	10.8^{b}

^{a,b} Different superscripts within the same row indicate significant differences ($P < 0.05$)

LP treatment showed the lowest NH_3 concentration (7.03 ppm) due to a lower slurry N content (faecal N plus urinary N) (P < 0.05). Smits et al (1995) reported a 39% decrease in NH_3 emissions from animal barns when lactating dairy cows were fed a diet containing 15% crude protein, compared to the standard 20% crude protein diet. In our experiment,

the concentration of NH_3 in the stall decreased by 35% when the crude protein decreased from 18.9 to 15.7%. Frank and Swensson (2002) also found that low protein diets gave significantly lower ammonia release from manure compared with the high protein diets. The ammonia concentration in the stall measured from the low crude protein diet was lower as the amount of N excreted was lower. This observation is in accordance with results reported by other authors (Smits et al., 1995 and Paul et al., 1998). In our study, urine urea nitrogen content was 25% lower in LP than in HP treatment, although the difference was not statistically significant. Elzing and Monteny (1997) found ammonia emission to be linearly dependent on the UUN concentration in a scale model. James et al (1999) also found that the relationship between N intake and NH_3 volatilization was linear and most of the UUN in the manure would be lost as NH_3 within the first 24h. On the contrary, Misselbrook et al (2005) reported that reducing the dietary crude protein reduced total N excretions and UUN, but did not reduce NH_3 emissions. In this study, parameters joined to NH_3 emission as UUN and MUN were also about 10% lower for LP treatment with respect to HP treatment, being the difference statistically significant for MUN ($P < 0.05$). NH_3 concentration per milk produced was also lower for LP (0.30 ppm/milk kg) than for MP and HP (0.43 ppm/milk kg) ($P < 0.05$). Atmospheric temperature ranged from 12.6 ºC to 18.0 ºC during the trial and did not show significant relationship regarding to NH_3 concentration ($P > 0.05$; $R^2 = 0.16$; positive slope). A slight increase of NH_3 concentration was observed for larger N intakes (MP and HP) when temperature was higher. We concluded that N intake below 490 g N/d would lead to NH_3 concentration reduction at dairy barns although this fact would also involve milk yield reduction.

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