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Rumen pH and NH_3-N concentration of sheep fed temperate pastures supplemented with sorghum grain

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Abstract

The aim of this study was to evaluate the effect of sorghum grain supplementation on ruminal pH and NH_3-N concentration of wethers consuming a fresh temperate pasture (*Lotus corniculatus)* in metabolism cages. Sixteen Corriedale x Milchschaf wethers were fed temperate pastures *ad libitum* and were non-supplemented or supplemented with ground sorghum grain at 5, 10 or 15 g/kg of their body weight (BW). Rumen fluid samples were collected at 0, 1, 2, 3, 4, 5 and 6 h after supplementation through permanent tubes inserted in the rumen. Ruminal pH was measured immediately and NH_3-N concentration was determined by direct distillation. Mean daily pH values for non-supplemented wethers and supplemented with 5, 10 and 15 g/kg of their BW were 6.45, 6.14, 6.09 and 5.43, respectively. Significant differences in pH were found between the 15 g/kg supplemented group and non-supplemented, 5 and 10 g/kg supplemented groups, while a trend was found between non-supplemented and 10 g/kg supplemented group. After 0 h, all mean pH values for the non-supplemented group were above 6.15, while values for the 10 and 15 g/kg supplemented groups were below 6.2 and 6.0, respectively. No differences in NH_3-N concentration among groups (mean = 37.15 mg/100 mL), between time or interaction between time and treatment were found. There was a correlation between pH and NH_3-N when all measurements were considered. Ground sorghum grain supplementation significantly reduced rumen pH when 15 g/kg of BW was provided to wethers fed temperate pastures, but it did not affect NH_3-N concentration.

Keywords: Temperate pasture, wether, grain supplementation, rumen environment
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Introduction

Temperate pastures are widely used in semi-intensive sheep production systems in Uruguay. Nitrogen fractions of these pastures are rapidly and extensively degraded in the rumen (Repetto *et al*., 2005) to produce NH_3-N. Grains containing rapidly fermentable carbohydrates are suggested to improve the microbial incorporation of the NH_3-N produced from the pasture (Owens, 1997; Trevaskis *et al.*, 2001; Bargo *et al.*, 2003). However, grain supplementation may alter rumen environment and affect ruminal pH of sheep (Moss *et al.*, 1995; Du Toit *et al*., 2006), ruminal digestion and cause the metabolic disorder, acidosis (Allen, 1997). Brossard *et al.* (2004) found that the ruminal pH of wethers was significantly decreased when grain was incorporated up to 600 g/kg of a hay-based diet.

Sorghum grain is commonly used in Uruguay. Its agronomic characteristics make it more resistant to adverse climate conditions compared to other crops, and have a relative low cost. However, there is little information about the inclusion of sorghum grain in the diet of ruminants grazing on temperate pastures. Horadagoda *et al*. (2008) found low rumen pH, NH_3-N concentrations and high microbial protein synthesis when using sorghum as a supplement of a rye grass hay. The aim of this study was to evaluate the effect of sorghum grain (*Sorghum bicolor*) supplementation on ruminal pH and NH_3-N concentration of wethers consuming a fresh temperate pasture (*Lotus corniculatus*).

Materials and Methods

The experiment was conducted on the Experimental farm of the Veterinary Faculty of Uruguay, located in San José Department, Uruguay (34º South and 55º West). Sixteen Corriedale x Milchschaf wethers (45.6 ± 6.2 kg body weight, (BW)) were blocked in four groups according to their BW, and within each

Table 1 Chemical composition (g/kg of dry matter) of feeds used in the experiment

	Lotus corniculatus	Sorghum grain
Dry matter	317	913
Organic matter	930	988
Crude protein	126	62.7
Neutral detergent fibre	416	142

group were randomly assigned to one of four treatments: no supplement (0 g/kg) or supplemented with sorghum grain at 5, 10 or 15 g/kg of their BW. Pasture and sorghum grain chemical composition are presented in Table 1.

Animals were housed in metabolism cages and fed fresh temperate pasture (*Lotus corniculatus) ad libitum*, allowing 200 g/kg of orts, while ground sorghum grain was provided individually in two equal meals (08:00 and 20:00). After 21 days of adaptation, rumen fluid samples were collected through permanent tubes inserted in the rumen, at 0, 1, 2, 3, 4, 5 and 6 h after morning supplementation, and pH was measured immediately after sampling using a handheld pH meter. A sample of 10 mL was conserved with 10 mL of 200 g/L NaCl and frozen for NH_3-N determination. After thawing, NH_3-N concentration was determined by direct distillation in Kjeldahl equipment according to Cajarville *et al.* (2006), and the results were expressed as mg/100 mL of ruminal fluid.

The pH values and NH_3-N concentrations were analyzed by the PROC MIXED procedure (SAS, 2000). The model included as fixed effects: treatment, time and their interaction, and block as random effect. The covariance structure was autoregressive order 1. Least square means were separated with PDIFF statement. Pearson´s correlation coefficient was calculated to study the relationship between ruminal pH and NH_3-N. Significance was always declared at P <0.05.

Results and Discussion

For non-supplemented wethers and those supplemented with 5, 10 and 15 g/kg BW, the concentrate represented 0, 137, 318 and 495 g/kg of diet dry matter (DM), respectively. Mean daily pH values for non-supplemented wethers and those supplemented with 5, 10 and 15 g/kg of the BW were 6.45, 6.14, 6.09 and 5.43, respectively (s.e. = 0.15). The pH values were lower with the highest level of grain supplementation than in the other treatments (P <0.01), while pH values tended to be higher in the 0 g/kg treatment group than in the 10 g/kg (P = 0.07). These results are in agreement with other authors who reported differences in mean pH values when DM forage to concentrate ratio was reduced (Moss *et al.*, 1995; Rymer & Givens, 2002; Brossard *et al.*, 2004). Increasing grain level in a diet often results in higher rumen fermentation (Rymer & Givens, 2002), which in turn reduces ruminating time (Desnoyers *et al.*, 2008), and decreases saliva flows (Cirio *et al.*, 2000), resulting in a reduced amount of buffer in the rumen.

Rumen pH dynamics during six hours after morning supplementation are presented in Figure 1 (A). Differences between time were found (P <0.01), but there was no interaction between time and treatment. Minimum mean pH values for the 0, 5, 10 and 15 g/kg groups were 6.17, 5.91, 5.96 and 5.31, respectively. Brossard *et al.* (2004) included wheat grain up to 600 g/kg in a wethers' diet and reported higher mean pH values compared to the 495 g/kg of sorghum supplementation in the 15 g/kg group, but minimum pH values were similar to those reported in this experiment. In contrast, Rymer & Givens (2002) reported higher medium and minimum pH values when maize was included at 500 g/kg in a diet. After 0 h, all mean pH values for the non-supplemented group were above 6.15, while values for the 10 and 15 g/kg supplemented groups were under 6.2 and 6.0, respectively. Negative effects of pH values below 6.2 on rumen microbial fermentation are well documented, as neutral detergent fibre (NDF) and acid-detergent fibre (ADF) digestibility decrease with increasing time under suboptimal pH (Van Soest, 1994; de Veth & Kolver, 2001; Cerrato-Sánchez *et al.*, 2007). Therefore, low pH values in 10 and 15 g/kg supplemented groups probably affected cellulolytic activity and rumen fibre degradability. In contrast, the pH values in the non-supplemented and supplemented at 5 g/kg were near the optimal to maximize pasture DM digestibility and microbial protein synthesis (de Veth & Kolver, 2001)

Rumen NH_3-N dynamics during six hours after morning supplementation are presented in Figure 1 (B). NH_3-N concentration was similarly high between groups; 36.4, 35.3, 39.4 and 37.6 mg/100 mL (s.e. = 3.6, P >0.05) for the non-supplemented and those supplemented with 5, 10 and 15 g/kg of the BW, respectively. No differences between time or interaction between time and treatment were found. There was a correlation between pH and NH_3-N when all measurements were considered (r = -0.46, P <0.001), which is in agreement with Cajarville *et al.* (2006) who reported a low, but significant negative correlation between rumen pH and NH_3-N concentration of cows grazing temperate pastures and supplemented with different sources of grain. Kaur *et al.* (2008) included different concentrate levels from 0 g/kg up to 450 g/kg on forage-based diets, and found no differences on mean daily ruminal NH_3-N concentration, but a marked decline in NH_3-N concentration after feeding concentrates. Moss *et al.* (1995) reported no differences in rumen NH_3-N concentrations when a concentrate was included in the diet of wethers up to 250 g/kg.

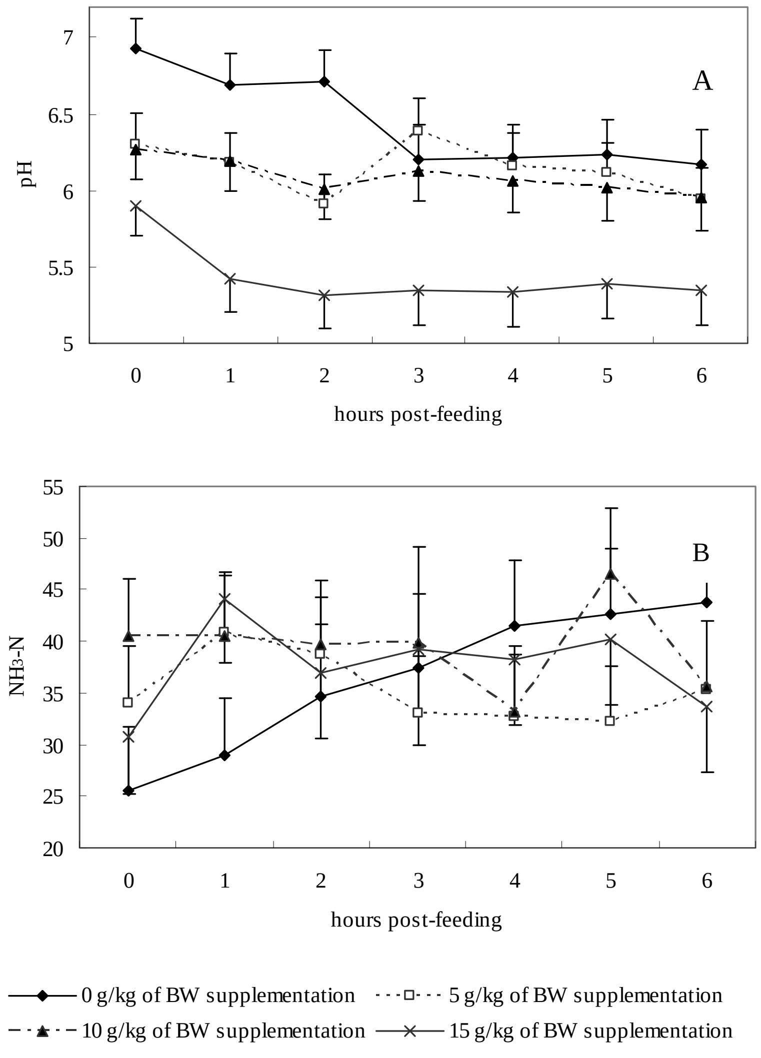

Figure 1 Rumen pH (A) and NH_3-N (B) dynamics of wethers supplemented with ground sorghum grain at 0, 5, 10 or 15 g/kg of BW in two equal meals (means ± s.e.m.; n = 4). Hour 0 represents morning supplementation.

Cajarville *et al.* (2006) showed a marked peak in rumen NH_3-N concentrations of supplemented cows five to six hours after they started feeding on fresh temperate pastures. Similarly, Trevaskis *et al*. (2001) reported maximum rumen NH_3-N concentrations of sheep three to four hours after feeding ryegrass. In this study NH_3-N concentrations were measured during the 6 h after supplementation. During this period all animals had high pasture intake rates, which could explain the high levels of rumen NH_3-N concentration observed. However, no peak was detected.

Conclusion

Low levels of grain supplementation did not affect rumen pH and were close to the optimal values for maximal pasture DM digestibility. However, supplementation with greater amounts of sorghum grain reduced ruminal pH to levels that probably affected cellulolytic activity and fibre rumen degradability. Ammonia concentration was similarly high between groups. The inclusion of additives should be considered when supplementation of wethers fed temperate pastures with sorghum grain is above 10 g/kg of BW.

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References

Allen, M.S., 1997. Relationship between fermentation acid production in the rumen and the requirement for physically effective fiber. J. Dairy Sci. 80, 1447-1462.

Bargo, F., Muller, L.D., Kolver, E.S. & Delahoy, J.E., 2003. Invited Review: Production and digestion of supplemented dairy cows on pasture. J. Dairy Sci. 86, 1-42.

Brossard, L., Martin, C., Chaucheyras-Durand, F. & Michalet-Doreau, B., 2004. Protozoa involved in butyric rather than lactic fermentative pattern during latent acidosis in sheep. Reprod. Nutr. Dev. 44, 195-206.

Cajarville, C., Aguerre, M. & Repetto, J.L., 2006. Rumen pH, NH_3-N concentration and forage degradation kinetics of cows grazing temperate pastures and supplemented with different sources of grain. Anim. Res. 55, 511-520.

Cerrato-Sánchez, M., Calsamiglia, S. & Ferret, A., 2007. Effect of time at suboptimal pH on Rumen fermentation in a dual-flow continuous culture system. J. Dairy Sci. 90, 1486-1492.

Cirio, A., Méot, F., Delignette-Muller, M.L. & Boivin, R., 2000. Determination of parotid urea secretion in sheep by means of ultrasonic flow probes and a multifactorial regression analysis. J. Anim. Sci. 78, 471-476.

Desnoyers, M., Duvaux-Ponter, C., Rigalma, K., Roussel, S., Martin, O. & Giger-Reverdin, S., 2008. Effect of concentrate percentage on ruminal pH and time-budget in dairy goats. Animal 12, 1802-1808.

de Veth, M.J. & Kolver, E.S., 2001. Digestion of ryegrass pasture in response to change in pH in Continuous Culture. J. Dairy Sci. 84, 1449-1457.

Du Toit, C.J.L., Van Niekerk, W.A., Hassen, A., Rethman, N.F.G. & Coertze, R.J., 2006. Fermentation in the rumen of sheep fed *Atriplex nummularia* cv. De Kock supplemented with incremental levels of barley and maize grain. S. Afr. J. Anim. Sci. 36 (Suppl. 1), 74-77.

Horadagoda, A., Fulkerson, W.J., Barchia, I., Dobos, R.C. & Nandra, K.S., 2008. The effect of grain species, processing and time of feeding on the efficiency of feed utilization and microbial protein synthesis in sheep. Livest. Sci. 114, 117-126.

Kaur, R., Nandra, N.S., García, S.C., Fulkerson, W.J. & Horadagoda, A., 2008. Efficiency of utilisation of different diets with contrasting forages and concentrate when fed to sheep in a discontinuous feeding pattern. Livest. Sci. 119, 77-86.

Moss, A.R., Givens, D.I. & Garnsworthy, C., 1995. The effect of supplementing grass silage with barley on digestibility, in sacco degradability, rumen fermentation and methane production in sheep at two levels of intake. Anim. Feed Sci. Technol. 55, 9-33.

Owens, F.N., Secrist, D.S., Hill, H.J. & Grill, D.R., 1997. The effect of grain source and grain processing on performance of feedlot cattle: a review. J. Anim. Sci. 75, 868-879.

Repetto, J.L., Cajarville, C., D' Alessandro, J., Curbelo, A., Soto, C. & Garin, D., 2005. Effect of wilting and ensiling on ruminal degradability of temperate grass and legume mixtures. Anim. Res. 54, 73-78.

Rymer, C. & Givens, D.I., 2002. Relationships between patterns of rumen fermentation measured in sheep and in situ degradability and the in vitro gas production profile of the diet. Anim. Feed Sci. Technol. 101, 31-44.

SAS, 2000. Statistical Analysis System, SAS Institute, Cary N.C., USA.

Trevaskis, L.M., Fulkerson, W.J. & Gooden, J.M., 2001. Provision of certain carbohydrate-based supplements to pasture-fed sheep, as well as time of harvesting of the pasture, influences pH, ammonia concentration and microbial protein synthesis in the rumen. Aust. J. Exp. Agric. 41 (1), 21-27.

Van Soest, P.J, 1994. Microbes in the gut. In: Nutritional Ecology of the Ruminant. (2nd ed.) New York: Cornell University Press, USA. pp. 253-280.