Rumen pH and NH$_3$-N concentration of sheep fed temperate pastures supplemented with sorghum grain

M. Aguerre$^{1*}$, J.L. Repetto$^1$, A. Pérez-Ruchel$^2$, A. Mendoza$^1$, G. Pinacchio$^2$ and C. Cajarville$^2$

$^1$Departamento de Bovinos, $^2$Departamento de Nutrición, Facultad de Veterinaria, Universidad de la República, Lasplaces 1550, Montevideo, Uruguay

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

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

<table>
<thead>
<tr>
<th></th>
<th>Lotus corniculatus</th>
<th>Sorghum grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>317</td>
<td>913</td>
</tr>
<tr>
<td>Organic matter</td>
<td>930</td>
<td>988</td>
</tr>
<tr>
<td>Crude protein</td>
<td>126</td>
<td>62.7</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
<td>416</td>
<td>142</td>
</tr>
</tbody>
</table>

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 NH₃-N determination. After thawing, NH₃-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 NH₃-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 NH₃-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](image-url)  

**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 context...
study NH₃-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 NH₃-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 cellulytic 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.

**Acknowledgements**

Authors want to thank Britos, A. Gonzalez, A. Cabrera, C. Fiol, C. Acosta, G. Persak, I. Cuitiño, L. Assandri, R. Vera, R. Carbone and V. Machado for assistance with animal management and sampling contribution. PDT-DINAcyT (Programa Jóvenes Investigadores en el Sector Productivo), S/PSP/02/52 and CALCAR for the scholarship. Project PDT 78/12 supported this work.

**References**


*The South African Journal of Animal Science is available online at http://www.sasas.co.za/sajas.asp*

