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Limestone with different particle size and sodium bicarbonate to feedlot lambs fed high grain diets with or without monensin

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ABSTRACT

The objectives of this study were to determine the effects of using different buffer sources and monensin on total tract apparent digestibility of nutrients and ruminal constituents of feedlot lambs fed high grain diets. Twenty-four lambs cannulated in the rumen were used in a randomized complete block design. Animals were fed diets containing 90% concentrate and 10% hay with addition of two limestone sources of different particle sizes and sodium bicarbonate, with or without monensin addition. Experimental treatments were arranged in a 2 × 3 factorial, with two monensin (0 or 30 mg/kg of diet) and three buffers: L = 1.3% limestone; FL = 1.3% filler limestone, and L + SB = 1.3% limestone + 1% sodium bicarbonate (DM basis). Dry matter, organic matter and crude protein digestibilities were higher ($P < 0.05$) for animals fed FL, when compared to other buffer treatments. Similarly, NDF digestibility was higher ($P < 0.01$) for treatments containing monensin compared to treatments without monensin. There were no differences in ruminal pH, water intake, ruminal acetate:propionate, and ruminal butyrate concentration. There was an interaction ($P < 0.05$) between FL and monensin addition for ruminal NH_3-N, VFA, acetate, and propionate concentrations. Concentrations of these two VFA were lower ($P < 0.05$) when the ionophore was added. There was an interaction between the L + SB and monensin for total VFA ($P < 0.01$), acetate ($P < 0.01$), and propionate ($P < 0.05$) concentrations, with lower ($P < 0.05$) concentrations in treatments without monensin. The use of FL improved digestibility of DM, and it may be used in feedlot systems in which high concentrate diets are fed to lambs; however, the cost of this product in relation to limestone should be considered. Monensin increased NDF digestibility, as well as showed a positive interaction with FL and sodium bicarbonate; therefore, the use of monensin is recommended in high concentrate diets for finishing lambs.

1. Introduction

High grain diets contain a large amount of highly fermentable carbohydrates which can cause nutritional disorders. These changes may be controlled with the addition of buffering substances which can reduce pH variations

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Table 1
Ingredients and chemical composition of experimental diets (%, DM basis).

Item	Diets					
	With monensin			Without monensin		
	L	FL	L + SB	L	FL	L + SB
Ingredient						
Ground corn	70.77	70.77	69.47	70.80	70.80	69.50
Soybean meal, 48% CP	15.90	15.90	16.20	15.90	15.90	16.20
Mineral premix[a]	1.52	1.52	1.52	1.52	1.52	1.52
Ammonium chloride	0.48	0.48	0.48	0.48	0.48	0.48
Limestone	1.30	–	1.30	1.30	–	1.30
Filler limestone	–	1.30	–	–	1.30	–
Sodium bicarbonate	–	–	1.00	–	–	1.00
Coastcross hay, chopped	10.00	10.00	10.00	10.00	10.00	10.00
Chemical analysis						
Dry matter, as-fed basis	89.50	89.70	89.60	89.80	89.90	89.70
Ash	4.74	5.65	5.62	5.34	5.52	5.48
Crude protein	18.70	17.30	18.70	18.90	18.30	18.40
Neutral detergent fiber	23.70	22.40	22.10	22.00	21.90	22.70
ME (Mcal/kg)[b]	2.94	2.94	2.91	2.94	2.94	2.91

L: 1.3% limestone; FL: 1.3% filler limestone; L + SB: 1.3% limestone + 1% sodium bicarbonate.

[a] Composition: 7.5% P; 19% Ca; 1% Mg; 7% S; 14.3% Na; 21.8% Cl; 500 ppm Fe; 300 ppm Cu; 4600 ppm Zn; 1100 ppm Mn; 80 ppm I; 405 ppm Co, and 30 ppm Se.

[b] Estimated using the Small Ruminant Nutrition System, V. 1.9.4468 (Cannas et al., 2004; Tedeschi et al., 2008).

in the digestive tract (Erdman, 1988), allowing the use of high concentrate proportions for feedlot animals.

Sodium bicarbonate is among the most widely used buffer as a feed additive; however, its course of action in the ruminal environment is not yet completely clarified. Addition of sodium bicarbonate may result in higher water intake, consequently increasing the dilution and passage rates of nutrients and VFA through the rumen, thus increasing ruminal pH (Russell and Chow, 1993). Other feed additives, such as feed-grade limestone and filler limestone, have been used by some researchers with contradictory results. According to Erdman (1988), feed-grade limestone has a high ability to decrease acids, but it is considered to be inefficient as a ruminal buffer due to its low solubility in the rumen. On the other hand, filler limestone, which undergoes a ball mill grinding process and presents a finer particle size when compared to normal limestone, could be more effective in the ruminal environment.

Another type of feed additive with effects on ruminal fermentation is monensin. Its effects are linked to changes in ruminal fermentation by modifying the proportion of VFA, decreasing the production of methane, and increasing the energy available from the feed (Russell and Strobell, 1988). According to DiCostanzo et al. (1996), ionophores improve feed conversion by 6% in commercial beef feedlots as a result of reducing the DM intake without changing the average daily gain.

Our hypotheses were that ruminal pH would be higher in lambs fed high grain diets containing monensin and that filler limestone would be more effective for improving nutrient digestibility and ruminal pH than feed-grade limestone because filler limestone has a smaller particle size and higher water solubility. We also hypothesized that feeding sodium bicarbonate would increase ruminal pH by increasing dilution rates of VFA.

The objectives of this trial were to evaluate the effects of adding limestone with different particle sizes and sodium bicarbonate on the total tract apparent digestibility of nutrients and ruminal fermentation in feedlot lambs fed high grain diets with or without monensin.

2. Materials and methods

The experiment was performed at sheep facilities of the Department of Animal Science, College of Agriculture "Luiz de Queiroz", University of São Paulo, Piracicaba (22°42′30″ S and 47°38′01″ W), São Paulo State, Brazil. The research protocol and all animal care followed the guidelines recommended in the Guide for the Care and Use of Agricultural Research and Teaching (FASS, 1998). All procedures were approved by "Luiz de Queiroz" College of Agriculture Animal Ethics Committee.

2.1. Animals and experimental design

Twenty-four ruminally cannulated Santa Inês ram lambs (44 ± 5 kg of BW and 6 months old) were used in a randomized complete block design according to BW and age, with 6 treatments and 4 replications. Animals were placed in suspended metabolism crates (1.3 m × 0.55 m) designed to allow the separation and collection of feces and urine. In order to reduce contamination by hair and urine, harnesses for feces collection were used. Crates equipped with feeders and water troughs were kept in a shaded barn.

2.2. Experimental diets

The experimental diets (Table 1) were formulated to meet the nutritional requirements of growing lambs according to the NRC (2007) and contained 10% chopped coastcross hay and 90% concentrate in the DM. Experimental treatments were arranged in a 2 × 3 factorial, with two concentrations of monensin (0 or 30 mg/kg of diet) and three buffer treatments: L = 1.3% limestone (particle size 0.30 to 1.5 mm according to supplier specifications); FL = 1.3% filler limestone (particle size < than 0.30 mm according to supplier specifications), and L + SB = 1.3% limestone + 1% sodium bicarbonate ($NaHCO_3$) (DM basis). Limestone sources were included to meet calcium requirements of growing lambs according to the NRC (2007), whereas the amount of monensin and sodium bicarbonate used were recommended by the suppliers and the proportions found in the literature, respectively. Sodium bicarbonate was added only in the diet with limestone because this is the standard diet used for Brazilian feedlot lambs and our intention was to compare the use of SB plus limestone with the standard diet of limestone only as a buffer. Diets were