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Short communication

Chitosan affects total nutrient digestion and ruminal fermentation in Nellore steers

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ABSTRACT

This study aimed to investigate the effects of chitosan on dry matter intake (DMI), nutrient digestibility, ruminal fermentation, and blood metabolites in Nellore steers. Eight ruminally cannulated Nellore steers (540 ± 28.5 kg of BW) were used in a replicated 4 × 4 Latin square design, with 21-d of experimental periods. The animals were randomly assigned to the following treatments: control (without chitosan addition; Q0), Q50, Q100 and Q150, by dosing 50, 100 and 150 mg/kg BW chitosan, respectively, through the cannula. Although there was no difference on DMI, chitosan addition increased dry matter, neutral detergent fiber, and crude protein apparent total-tract digestibility ($P < 0.05$). Ruminal pH was not affected, whereas NH_3—N concentration was quadratically affected with chitosan addition ($P = 0.01$). There were no differences in total volatile fatty acids concentration among treatments. Chitosan had a quadratic effect on propionate and butyrate, whereas acetate molar proportions decreased linearly ($P < 0.05$). Acetate:propionate ratio decreased with chitosan addition ($P < 0.05$). Plasma glucose concentration was higher with chitosan addition ($P < 0.05$); however, total protein, urea, aspartate aminotransferase, and gamma-glutamyl transferase were not affected by chitosan. Addition of chitosan altered ruminal fermentation, improved nutrient digestibility, and did not appear to damage animal health.

1. Introduction

Chitosan is one of the most abundant natural polysaccharide biopolymers. It is obtained by deacetylation of chitin, which is found in the exoskeleton of insects and crustaceans; due to its characteristics, such as biodegradability and nontoxicity, chitosan has received much attention due to its potential antimicrobial properties against bacteria, fungi, and yeasts (Kong et al., 2010).

Abbreviations: ADF, acid detergent fiber; DM, dry matter; DMI, dry matter intake; OM, organic matter; CP, crude protein; EE, ether extract; aNDF, neutral detergent fiber with residual ash; NFC, non-fiber carbohydrate; VFA, volatile fatty acids.

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Table 1
Ingredient and nutrient composition of diet.

Item	Diet
Ingredient composition (g/kg DM)	
Corn silage[a]	600.0
Ground corn	287.0
Soybean meal	48.5
Whole raw soybean	39.9
Urea	4.8
Ammonium sulfate	2.0
Limestone	0.9
Mineral premix[b]	16.0
Salt	0.9
Chemical composition (g/kg DM)	
Dry matter (g/kg)	513.5
Organic matter	933.1
Crude protein	137.8
Neutral detergent fiber (aNDF)[c]	386.4
Non-fiber carbohydrate[d]	376.3
Ether extract	32.6
Net energy[e] (MJ/kg)	6.77

[a] Nutrient composition (g/kg DM): 261.9 DM; 91.8 CP; 577.2 aNDF and 246.7 NFC.
[b] Supplied per kilogram of product. Ca: 180 g; P: 90 g; Na: 120 g; Mg: 20 g; S: 15 g; Cu: 100 mg; Zn: 2500 mg; Mn: 1000 mg; I: 80 mg; Co: 100 mg; Se: 20 mg.
[c] aNDF, neutral detergent fiber with residual ash.
[d] Non-fiber carbohydrate (NCF) = 1000 − [(g/kg of CP − g/kg of CP of urea + g/kg of urea] + g/kg of NDF + g/kg of EE + g/kg of ash) Hall (2000).
[e] Calculated from NRC (2000) model.

Although chitosan has application in different areas (food, pharmaceutical, and cosmetics), its use as an additive in ruminant nutrition has not been extensively investigated, with a small number of studies reporting conflicting results. In *in vitro* assays, inclusion of chitosan changed ruminal fermentation parameters, reflected by elevated propionate concentration (Goiri et al., 2009a,b); but in these studies, chitosan decreased digestibility of dry matter (DM) and neutral detergent fiber (NDF). On the other hand, when added to the diet of sheep, chitosan increased propionate proportion without affecting OM digestibility (Goiri et al., 2010). Thus, chitosan might alter ruminal fermentation for more energetically efficient patterns and may provide an alternative to antimicrobial growth promoters (Goiri et al., 2009a,b, 2010); nevertheless, more *in vivo* studies are necessary to identify the effect of chitosan on ruminal fermentation. Therefore, this study was aimed to evaluate the effects of chitosan on dry matter intake (DMI), nutrient digestibility, ruminal fermentation and blood metabolites in Nellore steers.

2. Materials and methods

Experimental procedures were approved by the Animal Use Ethics Commission of the School of Veterinary Medicine and Animal Science (protocol number 2222/2011), University of São Paulo, Brazil.

2.1. Animals and experimental treatments

Eight ruminally cannulated Nellore steers (24 month old; 540 ± 28.5 kg of BW) were used in a replicated 4 × 4 Latin square design, with 21-d experimental periods, with 14 d of adaptation to treatments and 7 d of sampling. The animals were kept in confinement in covered, individual tie-stall barns. Chitosan used in this assay had the following technical specifications: apparent density 0.64 g/mL; total ash ≤ 2.0%; pH 7.0–9.0; viscosity <200 cPs; and degree of deacetylation > 92% (Polymar Indústria e Comércio Importação e Exportação LTDA, Fortaleza, Ceará, Brazil).

The Nellore steers were randomly assigned to the following experimental treatments: (Q0), without chitosan addition; or Q50, Q100 and Q150, with addition of 50, 100 and 150 mg/kg BW chitosan, respectively. The amount of chitosan provided to each animal was weighed daily into paper bags, divided equally into two portions and placed directly in the rumen through the cannula, twice daily, in the morning and in the afternoon before feeding. Steers were fed twice daily at 0700 and 1400 h, and the feed offered was adjusted daily to yield 5–10% orts. Experimental diet was formulated according to the NRC (2000) to allow approximately 1.20 kg/d body weight gain and was provided as total mixed ration (TMR; Table 1).

2.2. Data collection and analysis

Feed intakes were recorded daily as the difference between feed offered and refused. During sampling periods, individual feed and orts sample (about 0.5 kg) were taken daily, pooled by steers for each sampling period and stored at −20 °C. Samples of feed and orts were dried in a 55 °C forced-air oven for 72 h, ground to pass through a 1 mm screen (Wiley Mill, A.H. Thomas,