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Effects of exogenous amylases from *Bacillus licheniformis* and *Aspergillus niger* on ruminal starch digestion and lamb performance

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Abstract

Two industrial exogenous enzymes, alpha-amylase from *Bacillus licheniformis* and glucoamylase from *Aspergillus niger*, were evaluated in vivo and in lambs fed 700 g/kg (dry matter (DM)) sorghum grain diets. Six Suffolk lambs (30 ± 2.5 kg body weight (BW)) fitted with ruminal and duodenal cannulas were randomly allotted to two 3×3 Latin square experiments, to evaluate effects of alpha-amylase and glucoamylase on intake, digestibility and ruminal fermentation. The same level of protein from the two enzyme sources (0.0, 1.45 or 2.90 g enzyme/kg DM sorghum) was applied to sorghum. The enzymes were sprinkled on the sorghum 24 h before mixing the diet. The highest level of each enzyme was also fed (45 days) to 15 individually housed lambs (Suffolk crossbred, 22.5 ± 1.4 kg BW) in a completely randomized design (i.e., control, alpha-amylase or glucoamylase) to evaluate lamb performance. The highest activity units/mg protein ($P < 0.01$) was for the alpha-amylase (4.190) followed by glucoamylase (1.952) and ruminal fluid (0.062). Dry matter, organic matter (OM) and starch intake decreased as level of dietary alpha-amylase increased (linear: $P < 0.05$), but ruminal starch digestion and total tract digestibility of DM, OM and starch

Abbreviations: ADG, average daily gain; AOAC, Association of Official Analytical Chemists; BW, body weight; DM, dry matter; GLM, general lineal model; OM, organic matter; PFEU, partial feed efficiency utilization; SAS, statistical analyses system; SEM, standard error of the mean; VFA, volatile fatty acids

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increased quadratically ($P < 0.05$). Total volatile fatty acids VFA and protozoa numbers decreased linearly ($P < 0.01$), whereas lactate was quadratically ($P < 0.01$) increased with alpha-amylase. Ruminal pH, protozoa and lactate increased ($P < 0.01$) with glucoamylase. Propionate molar proportion responded quadratically ($P < 0.01$) with both enzymes. The intermediate level of glucoamylase increased intake of DM, OM and starch (quadratic: $P < 0.09$), but total tract starch digestibility decreased (linear: $P = 0.08$) as level of glucoamylase increased. Feed intake, gain and feed conversion were not affected by enzymes, but alpha-amylase improved ($P < 0.05$) partial feed efficiency. Results indicate that amylase from *B. licheniformis* increases ruminal starch digestion and could be used to improve ruminal starch digestion in ruminants fed diets high in grains with low digestion rates.

Keywords: Digestion; Enzymes; Sheep; Starch; Sorghum grain

1. Introduction

Ruminal starch digestion is recognized as one of the most important factors determining performance of ruminants fed high grain diets (Britton and Stock, 1986; Huntington, 1997) and several grain processing techniques (e.g., dry-rolled, steam-rolled and reconstituted) have been developed to increase the rate of starch digestion and energetic value of grains (Owens et al., 1997). Use of amylolytic enzymes could increase the rate of starch digestion in some slowly digested grains, such as sorghum, to improve performance of ruminants.

Several cellulolytic enzymes have been used to increase ruminal fiber digestion and improve ruminant production (Beauchemin et al., 1995). However, amylases have received little attention as a grain treatment, even though ruminant performance can be improved with a mixture of external enzymes, including amylases and cellulases (Romero et al., 1992; Mora et al., 2002).

Amylases in the rumen are extracellular or cell-bound (Walker, 1965; Hobson and Summers, 1976; Thurn and Kotarski, 1987), but most amylolytic bacteria secrete extracellular amylases (Cotta, 1988). Although exogenous enzymes added to the diet are degraded by ruminal proteases, some polysaccharide-degrading enzymes have been shown to be resistant to degradation by ruminal proteases (Beauchemin et al., 1995).

Use of external enzymes may be more efficient in increasing starch digestion than manipulation of amylase activity of rumen microbes. Amylolytic activity of ruminal bacteria has been shown to increase as much as two-fold when grains are added to the diet (Palmquist and Baldwin, 1966; Mendoza et al., 1998), although a two-fold increase is relatively small compared with the activity of the exogenous amylases.

Our objective was to study amyloytic activity and ruminal fermentation characteristics in response to alpha-amylase from *Bacillus licheniformis*, glucoamylase from *Aspergillus niger* and endogenous ruminal amylases. Lambs fed sorghum-based diets were used to determine effects of these enzymes on ruminal starch digestion, ruminal fermentation and lamb performance.