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Improved milk production efficiency in early lactation dairy cattle with dietary addition of a developmental fibrolytic enzyme additive

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ABSTRACT

A 3-part study was conducted to evaluate the effect of a developmental fibrolytic enzyme additive on the digestibility of selected forages and the production performance of early-lactation dairy cows. In part 1, 4 replicate 24-h batch culture in vitro incubations were conducted with alfalfa hay, alfalfa silage, and barley silage as substrates and ruminal fluid as the inoculum. A developmental fibrolytic enzyme additive (AB Vista, Marlborough, UK) was added at 5 doses: 0, 0.5, 1.0, 1.5, and 2.0 μL/g of forage dry matter (DM). After the 24-h incubation, DM, neutral detergent fiber (NDF), and acid detergent fiber (ADF) disappearance were determined. For alfalfa hay, DM, NDF, and ADF disappearance was greater at the highest dosage compared with no enzyme addition. Barley silage NDF and ADF and alfalfa silage NDF disappearance tended to be greater for the highest enzyme dosage compared with no enzyme addition. In part 2, 6 ruminally cannulated, lactating Holstein dairy cows were used to determine in situ degradation of alfalfa and barley silage, with (1.0 mL/kg of silage DM) and without added enzyme. Three cows received a control diet (no enzyme added) and the other 3 received an enzyme-supplemented (1.0 mL/kg of diet DM) diet. Enzyme addition after the 24 h in situ incubation did not affect the disappearance of barley silage or alfalfa silage. In part 3, 60 early-lactation Holstein dairy cows were fed 1 of 3 diets for a 10-wk period: (1) control (CTL; no enzyme), (2) low enzyme (CTL treated with 0.5 mL of enzyme/kg of diet DM), and (3) high enzyme (CTL treated with 1.0 mL of enzyme/kg of diet DM). Adding enzyme to the diet had no effect on milk yield, but dry matter intake was lower for the high enzyme treatment and tended to be lower for the low enzyme treatment compared with CTL. Consequently, milk production efficiency (kg of 3.5% fat-corrected milk/kg of DM intake) linearly increased with increasing enzyme addition. Cows fed the low and high enzyme diets were 5.3 (not statistically significant) and 11.3% more efficient, respectively, compared with CTL cows. This developmental fibrolytic enzyme additive has the potential to increase fiber digestibility of forages, which could lead to greater milk production efficiency for dairy cows in early lactation.
Key words: fibrolytic enzyme, dairy cow, milk production efficiency

INTRODUCTION

Beauchemin et al. (2003b) reported overall increases of 1.0 ± 1.3 kg/d in DMI and 1.1 ± 1.5 kg/d in milk yield with the addition of fibrolytic exogenous enzymes to dairy cow diets when combining data from 20 studies and 41 treatments. It is clear from the standard deviations that responses to adding fibrolytic enzymes to ruminant diets have been variable. It is therefore not surprising that the use of fibrolytic enzyme products in commercial dairy operations has not yet been widely adopted. However, continuing increases in feed costs and consumer concerns about the use of growth promoters and antibiotics in livestock production provide ample incentive to revisit and refine the use of enzyme feed additives in ruminant diets as a means of improving feed conversion efficiency and lowering the cost of milk production.

Exogenous feed enzymes that contain fibrolytic activities may help enhance fiber digestion in the rumen (Feng et al., 1996; Yang et al., 1999; Kung et al., 2000), which could lead to improved feed conversion efficiency. Improvements in ruminal fiber digestibility of feed would also allow dairy producers to feed higher forage diets or high-fiber byproduct feeds without compromising energy intake or animal productivity.

Fibrolytic enzyme additives of interest for ruminants are concentrated fermentation products containing a broad spectrum of carbohydrases, including cellulases and hemicellulases. However, most commercial enzyme products containing cellulases and xylanases have been designed for use in the food, textile, or chemical industries (Bhat and Hazlewood, 2001). Enzyme activities provided by the manufacturers for these products have

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been determined under conditions most favorable for the specific enzymatic activity (pH 4.5 to 5.5, 45 to 60°C) and can vary substantially under different conditions (Kung et al., 2002). Colombatto and Beauchemin (2003) therefore recommended that the enzymic activities of enzyme products intended for ruminant use be determined at pH 6.0 to 6.5 and 39°C. Beauchemin et al. (2003a) also proposed using in vitro techniques to screen potential products for improvements in NDF degradability before embarking on the necessary, but more costly, in vivo validation.

This logical stepwise approach has not been used to evaluate potential exogenous fibrolytic enzyme products for use in ruminant diets. We obtained a developmental exogenous fibrolytic enzyme product and set out to determine its potential for use in ruminant diets following the steps proposed by Colombatto and Beauchemin (2003) and Beauchemin et al. (2003a). We hypothesized that the developmental enzyme product would increase fiber digestibility of alfalfa hay, alfalfa silage, and barley silage in vitro or in situ, and that feed efficiency or milk production of dairy cows in early lactation would be improved when the cows were fed a diet containing these 3 forages supplemented with the enzyme additive.

MATERIALS AND METHODS

A 3-part study, including an in vitro fermentation, an in situ incubation, and a lactation study, was conducted to evaluate the effect of a developmental fibrolytic enzyme additive on the digestibility of selected forages and the production performance of early-lactation dairy cows. All cows were cared for in accordance with the guidelines of the Canadian Council on Animal Care (1993).

In Vitro Fermentation

This study was conducted at the Agriculture and Agri-Food Canada's Research Centre in Lethbridge, Alberta, Canada. Four replicate, 24-h batch culture in vitro incubations (i.e., 1 run each on 4 separate days with different inocula) were conducted in a completely randomized design with alfalfa hay, alfalfa silage, and barley silage as substrates and ruminal fluid as the inoculum. A representative sample of each substrate was dried at 60°C for 48 h and ground through a 1-mm-screen Wiley mill (standard model 4, Arthur H. Thomas, Philadelphia, PA). Approximately 0.9 ± 0.01 g DM of substrate was weighed into 5 replicate filter bags (F57, Ankom Technology, Macedon, NY) for each forage × enzyme × dose combination.

The developmental (i.e., not commercially available) enzyme product (Econase RDE, AB Vista, Marlborough, UK) was added as a liquid (100 μL) directly onto the substrate in the filter bags at 4 doses: 0.5, 1.0, 1.5, and 2.0 μL/g of substrate DM. Endoglucanase (EC 3.2.1.4) and xylanase (EC 3.2.1.8) activities for the batch of Econase RDE used in the study were 722 and 2,604 nmol/μL of enzyme product, respectively. Enzymatic activity was determined at 39°C and pH 6.0 using low-viscosity carboxymethyl cellulose (Sigma Chemical Co., St Louis, MO; catalog no. C-5678) and birchwood xylan (Sigma Chemical Co., catalog no. X-0502) as substrates (10 mg/mL in 0.1 *M* citrate phosphate buffer, pH 6.0), following the procedures outlined by Wood and Bhat (1998) and Bailey et al. (1992) for endoglucanase and xylanase activities, respectively. An equal amount of distilled water was added to a set of filter bags to serve as the control (**CTL**; no enzyme added).

The filter bags were then heat-sealed and placed individually into 250-mL glass vials. Two hours later, 60 mL of buffered medium (Goering and Van Soest, 1970) was added to each glass vial and the vial closed with a rubber stopper. The vials were kept at room temperature for 20 h and then transferred to an incubator at 39°C to prewarm before adding 15 mL of inoculum to each vial approximately 60 min later. For the inoculum, ruminal contents were obtained approximately 3 h after the morning feeding from 2 cannulated cows receiving a barley silage-based TMR with a 50:50 forage to concentrate ratio (DM basis). The ruminal fluid was strained through a polyester screen (PECAP, pore size 355 μm; B & S H Thompson, Ville Mont-Royal, Quebec, Canada) into an insulated thermos, pooled across the 2 cows, and immediately transported to the laboratory. After adding the inoculum to the prewarmed, buffered medium, the vials were again sealed with rubber stoppers, crimp-sealed to avoid gas leakage, and placed on a rotary shaker platform at 120 rpm in the 39°C incubator. After the 24-h incubation, fermentation was terminated by exposing the samples to oxygen. The filter bags were removed from the vials, rinsed under a gentle stream of cold water until the water ran clear, and placed in a 60°C oven for 48 h to determine DM disappearance. Sequential NDF and ADF analyses were performed to determine NDF and ADF disappearance (Ankom^{200} Fiber Analyzer, Ankom Technology, Macedon, NY).

In Situ Incubation

The study was conducted at the University of Alberta Dairy Research and Technology Center (**DRTC**), Edmonton, Alberta, Canada. Six ruminally cannulated,