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Effect of fibrolytic enzymes on lactational performance, feeding behavior, and digestibility in high-producing dairy cows fed a barley silage–based diet

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ABSTRACT

The objectives of this study were to evaluate the effects of pretreating dairy cow rations with a fibrolytic enzyme derived from *Trichoderma reesei* (FETR; mixture of xylanase and cellulase; AB Vista, Wiltshire, UK) on lactation performance, digestibility, and feeding behavior in response to feeding a barley silage–based diet. Before starting the dairy trial, in vitro incubations were conducted to determine whether the addition of FETR would have an effect on these animal performance characteristics when applied to a barley silage–based diet for dairy cows. The dairy trial was performed using 8 Holstein dairy cows. The cows were blocked by parity and assigned randomly to 1 of 4 treatments: 0, 0.5, 0.75, and 1 mL of FETR/kg of dry matter (DM) diet in a replicated Latin square design. The pretreatment was applied to the complete diet during the mixing process. The experimental period continued for 22 d, with each experimental period consisting of a 16-d adaptation period and a 6-d sampling period. The daily feed intake of each individual cow was monitored using Insentec feed bins (RIC system, Insentec, Marknesse, the Netherlands). Feeding behavior characteristics were measured during the entire sampling period using the feed bin attendance data. Milk samples were collected in the last 3 d of each experimental period. The addition of FETR linearly increased the in vitro DM digestibility and tended to improve the in vitro digestibility of barley silage. There was a cubic effect of the enzyme levels on the total-tract DM and neutral detergent fiber digestibility. Maximal digestibility was reached at 0.75 mL of FETR/kg of TMR. The milk fat yield, fat-corrected milk, and energy-corrected milk quadratically responded to the incremental levels of FETR. The milk protein percentage linearly improved in response to FETR. Increasing FETR levels resulted in a quadratic effect on feed efficiency. There was no effect of FETR level on feeding behavior. In conclusion, pretreating dairy cow barley silage–based diet with 0.75 mL of FETR/kg of TMR increased the milk production efficiency of dairy cows fed diet containing 34% barley silage (DM basis). The positive effect of adding FETR could benefit the dairy industry in western Canada, where barley silage–based diets are common.
Key words: barley silage, dairy cow, feed efficiency, feeding behavior, fibrolytic enzyme

INTRODUCTION

Dairy cows are able to utilize the digestible nutrients from forages and convert them into milk and meat products for humans. The rate and extent of forage digestion in dairy cows are lower than those of concentrates, which limits feed intake and performance of dairy cows (Reynolds, 2000). Thus, it is important to improve forage digestibility to increase milk production level. Fibrolytic enzymes are used as feed additives in ruminant diets to enhance forage fiber digestibility and lactational performance of dairy cows. Addition of enzymes directly to the feed enhances the digestibility of DM and NDF (McAllister et al., 1999; Kung et al., 2000; Yang et al., 2000). However, there are inconsistent results regarding the effect of providing fibrolytic enzymes to ruminant diets on dairy cow performance (Bernard et al., 2010; Chung et al., 2012; Dean et al., 2013). Thus, the use of fibrolytic enzymes as feed additives has not yet been extensively adopted in commercial dairy farms. Nevertheless, due to a continuous increase in feed costs, it is essential to reconsider and refine the use of enzymes as feed additives in ruminant

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diets as a strategy to improve feed efficiency and decrease the cost of milk production (Titi, 2003).

Whole-crop barley (*Hordeum vulgare* L.) silage is a main forage component of dairy and beef rations in western Canada because the crop is well adapted for production in this region (Wallsten and Hatfield, 2016). In a previous study, 3 barley forage varieties were selected based on their varying rate of in vitro NDF digestibility to study the effects of barley silage on growing performance of beef cattle (Nair et al., 2017). From the results of this study, it was found that all barley varieties, despite differences in NDF digestibility, have a similar effect on feed efficiency. However, other factors did substantially affect forage quality and digestibility, such as the environmental temperature and the stage of maturity at harvest. The large differences in nutritional quality among forage barley varieties suggest that it is necessary to apply other approaches to improve forage digestibility, such as using fibrolytic enzyme products with high activity (xylanase and cellulase) for improving the digestibility of barley silage. To our knowledge, there is little documentation of the lactation performance response by cows to fibrolytic enzymes applied to barley silage. This study aimed to evaluate the effects of supplementing a fibrolytic enzyme product applied directly to a barley silage–based diet fed to dairy cows during mid lactation on milk yield, milk composition, nutrient intake and digestibility, and feeding behavior.

MATERIALS AND METHODS

In Vitro Study

An in vitro study was conducted to determine whether the addition of fibrolytic enzymes derived from *Trichoderma reesei* (**FETR**; mixture of xylanase and cellulase; AB Vista, Wiltshire, UK) would have an effect on animal performance when applied to a barley silage–based diet for dairy cows. This product was selected based on its high fibrolytic enzymatic activities (xylanase and cellulase). The product is a mixture of xylanase (EC 3.2.1.8; xylanase activity = 350,000 BXU/g, where 1 BXU is the amount of enzyme that is able to release 0.06 μmol of xylose equivalent from birchwood xylan per minute) and cellulase (EC 3.2.1.8; endoglucanase activity = 10,000 ECU/g, where 1 ECU is the amount of enzyme that is able to release 0.06 μmol of glucose from medium-viscosity carboxymethyl cellulose per minute). The enzyme was tested on barley silage harvested at mid-dough stage with 41% DM content. The samples of barley silage were oven dried at 55°C for 48 h. The dried samples were ground through a 1-mm screen for the chemical analysis and the in vitro study (Christy and Norris mill 8-in. lab mill, Christy Turner Ltd., Chelmsford, UK). The detailed chemical composition of barley silage is shown in Table 1. The cumulative gas production of silage treated with different doses of enzyme was measured using the batch culture technique as described by Eun et al. (2007). Enzyme doses (0.00, 0.25, 0.50, 0.75, 1.00, and 1.25 mL of FETR/kg DM of silage) were added directly onto the substrate immediately before addition of rumen fluid and buffer medium. The enzyme added to an approximately 0.5-g sample (1 mm grind size) of dried silage was weighed in triplicate into acetone-washed filter bags (F57, Ankom Technology, Macedon, NY). The bags were sealed and placed into 100-mL serum bottles. All dosages of enzymes were diluted with distilled water (0.1% FETR). The volume of diluted enzyme solution was equal for all doses. In addition, an equal volume of distilled water was added to serum bottles to serve as the control. Two experimental runs were performed on different days. Ruminal fluid was collected 2 h after feeding from 2 rumen-cannulated Holstein cows. The cows were fed diets formulated with 34.1% barley silage, 16.1% chopped alfalfa hay, 30.1% lactation concentrate pellet, and 19.7% barley grain to meet the requirements for lactating dairy cows producing 40 kg of milk (National Research Council, 2001). Each serum bottle received 15 mL of strained ruminal fluid and 45 mL of McDougall's buffer, during which oxygen-free CO_2 was flushed. Three blanks that contained 60 mL of medium without feed samples were used for each incubation time. Sealed bottles were incubated in an oscillating shaker at 39°C with an oscillation speed of 125 rpm for 48 h. Headspace gas production was measured at 3, 6, 9, 12, 24, and 48 h by inserting a 23-gauge (0.6 mm) needle attached to a pressure transducer (model PX4200-015GI; Omega Engineering Inc., Laval, QC, Canada) connected to a visual display device (Data Track, Christchurch, UK). Pressure values, corrected for the gas released from the blanks, were used to generate volume estimates using the equation described by Mauricio et al. (1999).

Experimental Cows and Diets

A lactational performance study was conducted using 8 mid-lactating Holstein dairy cows (average parity = 2.8 ± 1.2) consisting of 4 primiparous cows (average BW = 618 ± 61 kg; DIM = 118 ± 17) and 4 multiparous cows (average BW = 738 ± 13 kg; DIM = 137 ± 5.4). All experimental procedures used in this experiment were approved by the University of Saskatchewan Animal Care Committee. All cows were housed at the Rayner Dairy Research and Teaching Facility farm, University of Saskatchewan (Saskatoon, SK, Canada).