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Amylase addition increases starch ruminal digestion in first-lactation cows fed high and low starch diets

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ABSTRACT

The objective of this study was to evaluate the effect of an exogenous amylase preparation on digestion of low- and high-starch diets in dairy cattle. Rumen and total-tract nutrient digestibility were measured in a 4 × 4 Latin square design with 28-d periods using 4 first-lactation cows cannulated at the rumen and duodenum. Corn silage-based diets had 20 or 30% starch, attained by changing the composition of concentrate, with or without addition of an exogenous amylase preparation. Effects of the enzyme additive were observed on ruminal digestibility but not at the total-tract level. Ruminal digestibility of starch increased from 75% in control to 81% with amylase supplementation. This difference in ruminal starch digestion was compensated postruminally, so that the total-tract digestibility of starch was almost complete and did not differ between treatments. The amylase supplement also increased the true ruminal digestibility of organic matter but did not affect microbial N flow to the duodenum. Amylase supplement reduced the proportion of acetate and butyrate and increased that of propionate, particularly in the high-starch diet, where it tended to increase the concentration of total volatile fatty acids in the rumen. Other effects were a higher amylase activity in the solid-associated microbial community and a tendency for lower numbers of protozoa. In contrast, we observed no changes in intake, production, dry matter and fiber (neutral detergent fiber and acid detergent fiber) digestibility, or ruminal digestion, and no or small changes on selected fibrolytic and amylolytic bacteria and on the microbial community in general. We conclude that the exogenous amylase improved starch digestion in the rumen in first-lactation cows with moderate intake and production levels.

Key words: amylase, ruminal digestion, starch, dairy cow

INTRODUCTION

Dairy cows of high genetic merit require an energy-dense diet to fulfill their production potential. This is why starchy cereals are so prevalent in the diets of high-producing dairy cows. However, cereals are also a human staple food, and compared with other feed components, they are expensive and their prices are expected to rise due to increasing costs of production and higher demand. Increases in cereal price also directly affect the profitability of dairy farms. For these reasons, the pressure is growing to reduce starch in dairy cow rations, making optimization of starch digestibility an important area of research if performance of milk production is to be maintained at a high level. In this context, the use of exogenous amylase as a feed additive for high-producing ruminants is of interest (McCarthy et al., 2013). Several studies have demonstrated that exogenous amylase preparations resistant to ruminal degradation are able to improve OM digestibility in dairy cows (Hristov et al., 2008; Klingerman et al., 2009; Gencoglu et al., 2010) or beef steers (DiLorenzo et al., 2011). This increased OM digestibility was associated, in some cases, with improved NDF digestibility, whereas no effect on starch digestibility (Gado et al., 2009; Klingerman et al., 2009; Gencoglu et al., 2010) or on true digestibility of OM in the rumen (Hristov et al., 2008) was found. Although there is abundant information on the use and mode of action of exogenous fibrolytic enzymes in ruminants (Beauchemin et al., 2003, 2004), the number of studies on exogenous amylase is still small and the exact mechanisms by which amylases might improve digestibility have not been fully explored. The objective of the present work was to evaluate the effect of an exogenous amylase preparation on ruminal and total-tract digestion of low- and high-starch diets in dairy cows.

MATERIALS AND METHODS

The experiment was conducted in respect of the national legislation on animal care (Certificate of Authori-

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sation to Experiment on Living Animals, no. 004495, Ministry of Agriculture, France). The experiment was approved by the Auvergne regional ethic committee for animal experimentation (approval number CE30-10).

Animals, Feeding, and Experimental Design

Four Holstein first-lactation cows in mid lactation, weighing 545 ± 25 kg (means ± SD) and at 82 ± 3 DIM at the beginning of the trial were used in a 4 × 4 Latin square design. Six weeks before the start of the experiment, cows were fitted with ruminal cannulas (external and internal diameter = 123 and 106 mm) made of polyamide-polyvinyl chloride, and T-shaped cannulas (external and internal diameter = 30 and 19 mm) made of plastisol with a gutter-type flange placed at the proximal duodenum, before the bile duct entrance. Cannulas were manufactured in the INRA workshop (St-Genès Champanelle, France). Surgery was performed under general anesthesia. Four dietary treatments were applied to the cows during 4 successive 4-wk periods. Treatments consisted of 30% (high starch) or 20% (low starch) starch in the ration with or without addition of amylase.

The proportion of corn silage was the same for all diets (Table 1). Diets were isoenergetic on a net energy basis and isonitrogenous on CP and digestible protein basis, and not deficient in rumen-fermentable N (INRA, 2007). Differences in starch content were achieved by changes in formulation of the concentrate, with corn grain in the high-starch diet being replaced by soybean hulls and citrus pulp in the low-starch diet. Cows were housed in individual stalls and fed ad libitum during adaptation wk 1 and 2, and were fed at 95% of ad libitum intake during adaptation wk 3 and during wk 4 when measurements were done. Rations were distributed as TMR twice a day. For practical reasons, cows were fed at 0900 h (60% of the daily ration) and 1700 h (40% of the daily ration) during wk 1 and 2, and at 0945 and 2145 h (2 equal meals) during wk 3 and 4. Fifteen minutes before each meal, each cow received 300 g of ground concentrate alone or supplemented with amylase [Ronozyme RumiStar 600 (CT), DSM Nutritional Products, Basel, Switzerland]. The enzyme dose (10 g/d) was calculated to be equivalent to a dosage of 300 kilo novo units (**KNU**)/kg of DM total ration, assuming an average daily feed intake of 20 kg of DM. Corn silage, hay, and additional concentrate without any enzyme supplementation were distributed after the ground concentrate had been entirely consumed. Water and mineral salt were freely available. Cows also received 200 g/d of a mineral and vitamin complement (Galaphos midi duo, CCPA, Janzé, France; 4.5% P, 20% Ca, Mg 4.5%, 5% Na). Milking times were 0630 and 1530 h.

Measurements and Sampling

Intake and Weight. Cows were weighed at the start of each experimental period. Water consumption

Table 1. Ingredients and chemical composition of the diets

	High starch (30%)		Low starch (20%)	
Item	Control	Amylase	Control	Amylase
Ingredient composition, % of DM				
Corn silage	59.0	59.0	58.5	58.9
Hay	7.9	8.0	8.1	7.9
Pelleted high starch concentrate[1]	33.1	33.0	—	—
Pelleted low starch concentrate[2]	—	—	33.4	33.2
Amylase activity,[3] KNU/kg of DM		354		350
Chemical composition, g/kg of DM				
CP	159	158	161	160
NDF	313	314	349	349
ADF	156	156	185	184
Starch	299	299	197	199
Feed value, /kg of DM				
NE_L, MJ	6.97	6.97	6.76	6.76
Digestible protein, g of PDI[4]	105	105	104	104

[1]High starch concentrate: 44.4% corn grain, 6.3% citrus pulp, 16.9% tanned soybean meal, 30% soybean meal 48, 2.5% urea, on a DM basis.

[2]Low starch concentrate: 1.3% corn grain, 15.6% soybean hulls, 33.8% citrus pulp, 16.9% tanned soybean meal, 30% soybean meal 48, 2.5% urea, on a DM basis.

[3]Amylase activity calculated from the actual analyzed enzyme activity of the test product Ronozyme RumiStar 600 [CT; DSM Nutritional Products, Basel, Switzerland; declared amylase activity: 600 kilo novo units (KNU)/g; analyzed amylase activity: 669 KNU/g], intake of the enzyme (10 g/cow per day), and actual DMI.

[4]PDI = protein digestible in the intestine (INRA, 2007).

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