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Effect of exogenous amylase on lactation performance of dairy cows fed a high-starch diet

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ABSTRACT

Exogenous amylase supplementation can increase starch and fiber digestibility in lactating dairy cows. We evaluated the effect of exogenous amylase supplementation on diets with high starch concentration (32% of dry matter). Twenty-eight Holstein cows (171 ± 80 d in milk, 4 primiparous) received a standard diet for 14 d and then a treatment for 63 d, in a covariate-adjusted randomized block design with repeated measures over time. Treatments were amylase [0.5 g of Ronozyme RumiStar (DSM Nutritional Products, Basel, Switzerland) per kg of total mixed ration dry matter] or control. The diets contained (% of dry matter): 39.4% corn silage, 11.2% rehydrated and ensiled mature corn grain, and 11.7% finely ground mature corn. Amylase increased milk yield (32.3 vs. 33.0 kg/d) and reduced dry matter intake (20.7 vs. 19.7 kg/d), increasing feed efficiency (1.52 vs. 1.63). Amylase also increased milk lactose synthesis (1.49 vs. 1.56 kg/d) and plasma glucose concentration (59.3 vs. 68.6 mg/dL). Secretions of milk fat and protein did not differ. Although milk urea N did not differ, amylase reduced the concentration of urea N in blood, suggesting an increase in ruminal starch degradation. However, the total-tract apparent digestibility of starch (96.3% of intake) and neutral detergent fiber (44.4% of intake), ruminal fermentation profile, and microbial yield estimated by urinary allantoin excretion did not differ. Cows fed amylase sorted in favor of long feed particles and against short particles, had shorter chewing activity (780 vs. 699 min/d), and had fewer meals per day (11.5 vs. 9.7). Amylase improved the feed efficiency of lactating cows fed a high-starch diet; the enzyme increased milk yield and reduced intake.
Key words: feed efficiency, intake, sorting behavior, starch digestibility

INTRODUCTION

Dietary starch is important to maximize ruminal microbial yield (Hall and Herejk, 2001) and is a major contributor to the energy required for lactation by dairy cattle. The supplementation of lactating cows with exogenous amylase stable in rumen fluid (Klingerman et al., 2009) can increase ruminal starch digestibility (Nozière et al., 2014). Increased ruminal starch availability may increase ruminal microbial yield and feed efficiency by intake regulation induced by increased liver oxidation of propionate (Allen et al., 2009). However, increased ruminal starch digestion can undesirably induce ruminal acidosis, leading to reductions in ruminal microbial synthesis and milk solids secretion (Oba and Allen, 2003a).

The effect of nutritional strategies on ruminal starch digestibility seems to be dependent on the type of starch in the diet. Oba and Allen (2003b) observed that the increase in ruminal starch digestibility when high-moisture corn replaced finely ground mature corn in high (32%) and low (21%) starch diets was 24.2 and 12.6 percentage units, respectively, suggesting that the ruminal capacity to digest more resistant starch sources is limited. The accumulation of VFA after 6 h of ruminal in vitro fermentation was increased when amylase was added to flint corn but had no effect on floury corn (Klingerman et al., 2009). The total-tract digestibility of NDF has also been improved by exogenous amylase supplementation (Gencoglu et al., 2010; Weiss et al., 2011), supposedly by increased ruminal availability to fiber digesting bacteria of starch hydrolysis products (Cotta, 1988; Tricarico et al., 2008).

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Long-term effects of amylase supplementation on lactation performance, DMI, and feed efficiency of lactating cows have been inconsistent. The supplementation of a 21% starch diet with amylase for 10 wk increased milk yield, had no effect on DMI, and tended to increase the milk to DMI ratio (Ferraretto et al., 2011). Gencoglu et al. (2010) observed a reduction in DMI, no effect on milk yield, and an increase in feed efficiency when a 21% starch diet was supplemented with amylase for 12 wk. Weiss et al. (2011) supplemented amylase to lactating cows fed a 26% starch diet containing coarsely ground corn for 14 wk and did not detect changes in milk yield, DMI, and feed efficiency. The long-term effect of amylase supplementation to diets with a high starch concentration has not been evaluated. High-starch diets may be an economic alternative when corn prices are low and may be more responsive to amylase supplementation than low-starch diets. The objective of this experiment was to evaluate the 9-wk supplementation of lactating cows fed a 32% starch diet from corn silage, finely ground corn, and rehydrated and ensiled corn grain with exogenous amylase. We hypothesized that adding exogenous amylase to the high-starch diet would increase the milk to DMI ratio and the digestibility of starch.

MATERIALS AND METHODS

The experiment was conducted from August 20 to November 4, 2012, in an open-walled, sand-bedded tiestall barn with fans and high-pressure sprinklers at the Better Nature Research Center (http://www.holandesflamma.com.br/) under a protocol approved by the University of Lavras Bioethics Committee in Utilization of Animals.

Cows, Experimental Design, and Treatments

Twenty-eight Holstein cows (171 ± 80 DIM at the beginning of the experiment, 4 primiparous) were milked 3 times per day starting at 0500, 1300, and 2000 h in an herringbone parlor and the TMR for each treatment was mixed 2 times per day in a 1.2-m^3 stationary vertical mixer (Unimix 1200, Casale, São Carlos, Brazil). New feed was offered at 0600 and 1300 h in amounts to allow for 7 to 10% of the offered amount as daily refusal and was pushed up at least 10 times per d. Cows were individually fed the same TMR for a 14-d standardization period. On d 9 to 14 of this period, DMI, milk yield, and solids concentration, MUN, BW, and BCS were measured and used as covariate in the statistical model. Then, cows were paired blocked primarily by parity (1 vs. >1) and secondarily by milk yield and randomly assigned within blocks to a treatment for 63 d of a comparison period. Treatments were control or amylase. The exogenous amylase produced by *Bacillus licheniformis* (Ronozyme RumiStar, DSM Nutritional Products, Basel, Switzerland) was mixed with ground corn and added to the TMR (0.5 g of enzyme per kg of TMR DM) to achieve 300 Kilo Novo units of amylase activity/kg of TMR DM. One Kilo Novo unit is the amount of enzyme that releases in a 2-step α-amylase/α-glucosidase reaction, 6 μmol of *p*-nitrofenol per min from 1.86 m*M* ethylidene-G7-*p*-nitrophenyl-maltoheptaoside at pH 7.0 and 37°C (Jung and Vogel, 2008). The TMR mixer was completely unloaded after the mixing of each diet, and the control treatment was mixed before amylase. The dosage of enzyme was based on previous studies that demonstrated efficacy (Klingerman et al., 2009; Gencoglu et al., 2010).

Data Collection and Laboratory Procedures

Feed intake was calculated individually as the difference between feed offered and orts recorded daily. The DM concentration of the corn silage and of the rehydrated corn grain silage were monitored weekly with a Koster Moisture Tester (Koster Crop Tester Inc., Brunswick, OH) and the TMR was adjusted accordingly. Rehydrated and ensiled corn is the product of homogeneous addition of water to ground mature kernels to obtain more than 30% moisture concentration for ensiling (Andrade Filho et al., 2010), capable of increasing ruminal starch fermentation by prolamin degradation (Ferraretto et al., 2015). Samples of feeds and orts per cow were obtained daily and frozen for the formation of weekly composites based on equal as-fed amounts of daily samples. Composite samples were dried in forced-air oven at 55°C for 72 h and ground to pass a 1-mm mesh screen (Wiley mill, Thomas Scientific, Swedesboro, NJ). The DM concentration was determined by drying at 100°C for 24 h. The CP concentration was determined with a micro Kjeldahl apparatus (method 984.13; AOAC International, 2012), ash by incineration at 550°C for 8 h, the ash-free NDF by filtration in porous crucibles with heat-stable α-amylase and sodium sulfite (Van Soest et al., 1991), and the ether extract as in AOAC International (2012; method 920.39). The NFC fraction was calculated: 100 − (CP + ether extract + ash + NDF). Starch was analyzed enzymatically according to Hall (2009). The nutrient composition of the consumed TMR was calculated as the total nutrient intake of the cows (offered minus refusals) divided by the total DMI of the treatment. The ingredient composition of the offered TMR was