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Effects of Dietary Amylase and Sucrose on Productivity of Cows Fed Low-Starch Diets

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Summary
Exogenous amylase, sucrose, or a combination was used in diets with reduced starch content. The trial was performed in 48 lactating Holstein cows, and milk yield, milk composition, and dry matter intake were measured. Treatments did not affect production traits, but with slightly decreased feed intake and slightly greater milk production in amylase-fed cows, the calculated value of amylase in this study was $0.37/cow per day.

Key words: enzyme, milk production, nutrition, feed intake

Introduction
Inclusion of exogenous amylase in diets for high-producing cows is designed to enhance the utilization of carbohydrates present in feeds. In non-ruminant animals, the salivary glands secrete amylase in the saliva to begin breaking down starch as soon as food enters the mouth. In contrast, ruminants do not have salivary amylase, so starches are degraded largely by the microbial population in the rumen.

Addition of exogenous amylase has been evaluated primarily as a method to increase starch degradability. Adding exogenous amylase, however, may improve productivity of lactating cows independent of effects on total tract starch digestion. Previous studies have suggested that the primary benefit of exogenous amylase is an increase in neutral detergent fiber (**NDF**) digestibility, possibly by promoting the growth and cellulolytic activity of fiber-digesting bacteria.

The objective of this study was to evaluate dry matter (**DM**) intake, milk production, and milk components in lactating dairy cows fed amylase, 2% sucrose, or both in a low-starch diet.

Experimental Procedures
Forty-eight multiparous Holstein cows (between 70 and 130 days in milk) were blocked by parity and stage of lactation. Blocks of cows were assigned randomly to each of 4 pens (12 cows/pen). Pens were then randomly assigned to treatment sequence in a 4 x 4 Latin square design balanced for carryover effects.

Treatments were a control diet formulated for 33% NDF, 18% crude protein, 22% starch, and 4% sugar (Table 1). The 3 treatments were: (1) a control diet containing amylase (Rumistar, DSM Nutritional Products, Parsippany, NJ) added at 500 parts per million, (2) a sucrose diet with sucrose replacing corn grain at 2% of DM, and (3) a sucrose diet with amylase added at 500 parts per million. Each diet was delivered as a total mixed ration (**TMR**), and corn silage DM was determined twice weekly to adjust its inclusion rate. Cows were fed once daily for ad libitum intake and milked 3 times daily throughout the experiment. Treatment periods were 28 days, with 24 days for diet adaptation and 4 days for sample and data collection. Dry matter intake and milk yield were recorded daily.

During the final 4 days of each period, samples of orts, feed ingredients, and TMR were collected daily, composited by period, and analyzed to determine ash, neutral detergent fiber (**NDF**), crude protein, ether extract, total sugars, and starch content. Milk samples were collected at each milking during those 4 days and analyzed for concentrations of fat, true protein, lactose, urea, nitrogen, and somatic cells. Particle size was measured on 2 days and body condition scores (**BCS**; 1=thin and 5=fat) were measured at the beginning and at the end of each 28-day period.

Results and Discussion

The nutrient analyses for the treatment diets are shown in Table 2. Concentrations of NDF were relatively large for mid-lactation cows, but this was by design. The experiment was intended to assess responses to added sucrose and/or amylase in low-starch diets. Crude protein concentrations were approximately 16.5%, which was more than adequate based on observed milk urea nitrogen (**MUN**) concentrations (Table 3). Nutrient analysis indicated that the targeted replacement of 2% corn grain with sucrose was achieved. Furthermore, the diets that included amylase seemed to have greater sugar content (0.2 to 0.5%) than the treatments that lacked the enzyme, suggesting possible enzyme activity during feed storage. Table 2 also shows particle size distributions of the diets determined by using the Penn State Particle Separator. According to the guidelines for this system, the top sieve should retain between 6 and 10% of the diet, whereas in the present study the top sieve retained around 20% of DM for all the treatments, which demonstrated that the diets had large concentrations of effective fiber.

The results obtained from the milk component analysis and production of cows fed the treatment diets are detailed in Table 3. The DM intake was not altered by treatment. A tendency for an amylase by sucrose interaction was observed for milk protein content ($P = 0.06$), reflecting slightly smaller milk protein concentrations for amylase and sucrose treatments compared with control and amylase + sucrose treatments. This interaction was not observed for milk protein yield (data not shown). Solids-corrected and fat-corrected milk yield variables were not altered by treatment, although the direct effect of amylase approached significance in both cases (both $P = 0.13$), suggesting possible small increases with amylase supplementation (approximately 1.3 lb/day).

Feed efficiency for the control diet (energy-corrected milk/DM intake, or **ECM/DMI**) was 1.50; either amylase (1.57) or sucrose (1.60) treatment alone numerically increased efficiency, but the combination of the two resulted in feed efficiency identical to the control diet. Although this interaction was not significant, these results provide no evidence of synergistic benefits for the combination of amylase with high sugar content in lactation diets.

In addition to production responses to these diets, the economic impacts of the diets were modeled. Using local milk component values and estimated feed costs for Kansas in March and April 2011, both gross milk income and cost of feed for each treatment were calculated (Table 4). The two diets that contained sucrose were more expensive than the other diets because of the very high cost of this experimental ingredient, making these comparisons somewhat unrealistic. On the other hand, by adding amylase to the ration, solids-corrected milk production was slightly greater despite a decrease in DMI, resulting in an estimated increase in income over feed cost of $0.37/cow per day (if no cost is attributed to the amylase treatment). Therefore, based on these results, dairy nutritionists theoretically would be justified to incorporate amylase into diets if the added cost is less than $0.37/cow daily.

In contrast with previous studies in which exogenous amylase significantly improved feed efficiency of cows fed low-starch diets, we did not observe any significant effects of amylase, sucrose, or their interaction on intake, productivity, body condition, or feed efficiency in mid-lactation cows fed low-starch, high-fiber diets. Nevertheless, the small but economically meaningful numeric increases in feed efficiency with amylase and sucrose treatments were consistent with previously observed improvements in fiber digestibility in response to similar treatments. Based on feed efficiency responses, our results may indicate that amylase is not as advantageous in diets that are already high in sugar content. The inconsistencies between our findings and those of some previous studies highlight some unexplained interactions of amylase with animal or dietary factors.

Table 1. Ingredient composition of diets[1]

	Treatment[2]	
Ingredient	Control	Sucrose
Corn silage	38	38
Alfalfa hay	28	28
Wet corn gluten feed	10	10
Ground corn	8	6
Sucrose	-	2
Whole cottonseed	4	4
Expeller soybean meal	6	6
Soybean meal	2	2
Micronutrient premix	4	4

[1] Values are expressed as a percentage of diet dry matter.
[2] Each diet was tested with and without amylase added.

Table 2. Nutrient composition of diets

	Control		Amylase	
% of dry matter (DM)	Control	Sucrose	Control	Sucrose
DM, % as-fed	57.0	55.6	54.7	56.8
Organic matter	91.5	91.6	91.3	91.4
Crude protein	16.5	16.5	16.5	16.3
Neutral detergent fiber	35.6	35.2	35.4	34.9
Starch	21.4	20.6	21.4	20.9
Sugars	6.3	8.4	6.8	8.6
Ether extract	3.2	3.0	3.2	3.0
Particle size				
Top, %	20.3	20.2	21.4	21.1
Bottom, %	27.0	27.8	28.1	27.6
Middle, %	36.3	35.3	33.5	33.9
Pan, %	16.4	16.7	17.0	17.4

Table 3. Sugar and amylase effects on productivity in low-starch diets

	Control		Amylase			*P*-value		
Item	Control	Sugar	Control	Sugar	SEM	Amylase	Sugar	Interaction
Dry matter intake (DMI), lb/day	51.8	48.9	50.5	52.7	2.9	0.42	0.89	0.11
Milk yield, lb/day	75.6	75.0	76.9	76.1	2.6	0.21	0.35	0.93
Milk fat, %	3.67	3.69	3.66	3.72	0.092	0.70	0.22	0.56
Milk protein, %	3.02	2.99	3.00	3.03	0.026	0.42	0.88	0.06
Milk lactose, %	4.78	4.77	4.78	4.77	0.028	0.90	0.19	0.95
Milk urea nitrogen, mg/dL	16.88	16.74	16.37	16.59	0.48	0.45	0.93	0.67
SCC linear score	2.08	2.01	2.34	1.97	0.27	0.53	0.21	0.38
SCM[1], lb/day	71.2	70.5	72.1	72.1	2.9	0.13	0.49	0.64
ECM[2], lb/day	77.6	76.7	78.5	78.5	2.9	0.13	0.51	0.59
Body condition score change/28 days	0.013	-0.012	-0.010	-0.116	0.045	0.17	0.18	0.37
ECM:DMI	1.50	1.60	1.57	1.50	0.12	0.82	0.77	0.19

[1] Solids-corrected milk = (12.3 × fat yield) + (6.56 × SNF yield) - (.0752 × milk yield); Tyrell and Reid (1965).

[2] Energy-corrected milk = (.327 × milk yield) + (12.86 × fat yield) + (7.65 × protein yield); Dairy Record Management Systems (2010).

Table 4. Estimated profitability of the treatments

	Control		Amylase[1]	
$/cow per day	Control	Sucrose	Control	Sucrose
Gross milk income	15.63	15.46	15.84	15.82
Feed cost	6.17	6.38	6.01	6.87
Income over feed cost	9.46	9.08	9.83	8.95

[1] Feed costs for amylase diets do not include any cost for the enzyme.