The impact of barley- vs. corn-based diets with variable distillers fat inclusion levels on rumen α-amylase activity

F.E. Keomanivong[1], M.A. Rodenhuis[1], M.C. Ruch[1], M.S. Crouse[1], J.D. Kirsch[1], M.L. Bauer[1] and K.C. Swanson[1]

The objectives of this study were to determine the impact of barley- vs. corn-based diets with variable distillers fat levels on rumen starch digestibility, α-amylase activity and pH. The results indicate diets using corn as the primary grain source had increased levels of starch intake and disappearance. Lower-fat distillers grains appeared to cause an increase in ruminal α-amylase activity, with several interactions between the grain source and alternative DDGS options noted. No differences were found for pH among dietary treatments.

Summary

The current study utilized eight cannulated Holstein steers (1,576 ± 135.4 pounds) randomly assigned to four dietary treatments in a 2 × 2 factorial arrangement consisting of 1) rolled corn and low-fat dried distillers grain with solubles (DDGS), 2) rolled corn and moderate-fat DDGS, 3) rolled barley and low-fat DDGS and 4) rolled barley and moderate-fat DDGS. Diets were formulated to meet National Research Council (NRC) recommendations and were offered for ad libitum intake. The experiment was designed as a 4 x 4 Latin square with 24-day periods allowing for 10 days of intermediate dietary transition, seven days of dietary treatment acclimation and seven days of sample collection. Daily feed consumption was recorded, and samples of feed remaining in bunks were composited from each collection period to determine starch content. Rumen fluid was collected and analyzed for α-amylase activity and pH. Diets containing lower-fat DDGS had increased amylase activity (U/L rumen fluid and amylase/pound starch intake; $P \leq 0.05$). Interactions between grain source and DDGS fat level were observed for α-amylase activity (U/L rumen fluid and amylase/pound starch intake; $P \leq 0.03$); the DDGS fat level had a greater effect on amylase activity in barley- than corn-based diets. Although differences were noted between the grain source and distillers fat levels for amylase activity, no changes in pH were observed ($P \geq 0.13$).

Introduction

Dietary energy encompasses the greatest cost of the diet in finishing cattle diets. To provide sufficient amounts of energy, producers offer feeds high in starch. Corn is one of the most prevalent choices. Although barley has been shown to contain 5 to 10 percent less energy than corn (Milner et. al., 1995), it, too, is a common feed source because its starch is more available for rapid ruminal digestion.

This rapid digestion has been known for greater production of short-chain fatty acids (SCFA) within the rumen fluid (Aschenbach et al., 2011), which, unfortunately, sometimes can lead to acidotic conditions and, consequently, reduced rumen function of amylolytic bacteria and protozoa impeding the breakdown of starch (Stone et al., 2004). Despite this issue, barley has greater levels of protein, allowing for the possibility of reduced supplementation with barley-based diets.

Another common feed ingredient when formulating cattle diets is dried distillers grains with solubles. Increased demands in the ethanol industry have allowed for a greater shift in the production of this coproduct. During the manufacturing of ethanol, the starch component is lost through fermentation; however, fat and protein become concentrated.

Recently, another shift has occurred, and ethanol plants have begun implementing additional steps in processing to extract more fat from the grain to be used in other products such as biodiesel or vegetable oil (Saunders et al., 2009).

While more coproducts may be available for alternative uses, the reduced-fat DDGS may be associated with lower energy content as a livestock feedstuff. Therefore, the objective of this study was to determine the impact of corn- vs. barley-based grains in combination with low- vs. moderate-fat distillers grain on starch content and digestibility, as well as ruminal amylase activity and pH.

Experimental Procedures

The current study utilized eight cannulated Holstein steers (1,576 ± 135.4 pounds) randomly assigned to four dietary treatments in a 2 × 2 factorial arrangement consisting of 1) rolled corn and low-fat dried dis-

[1]Department of Animal Sciences, NDSU

tillers grain with solubles (DDGS), 2) rolled corn and moderate-fat DDGS, 3) rolled barley and low-fat DDGS and 4) rolled barley and moderate-fat DDGS. Diets were formulated to meet NRC recommendations and were offered for ad libitum intake.

The experiment was designed as a 4 x 4 Latin square with 24-day periods allowing for 10 days of intermediate dietary transition, seven days of dietary treatment acclimation and seven days of sample collection. Daily feed consumption was recorded, and samples of feed remaining in bunks were composited for each collection period.

Approximately 200 milliliters (mL) of rumen fluid was collected from days 3 to 5 in a manner to represent every other hour in a 24-hour cycle. Rumen pH was measured at the time of collection, and remaining samples were frozen immediately. Ruminal activity of α-amylase was determined using the procedure of Wallenfels et al. (1978) utilizing a kit from Teco Diagnostics (Anaheim, Calif.).

Results were analyzed using the Mixed procedure of SAS. The model included the effects of animal, period, source of grain (barley vs. corn), DDGS fat level (low vs. moderate), and the interaction between grain source × DDGS fat level. Statistical significance was declared when P ≤ 0.05.VF

Results and Discussion

Starch intake and disappearance (pounds/day) were greater ($P \leq 0.008$) in corn-based diets (Table 3). This is not surprising because the level of starch within these diets was slightly higher. A trend ($P = 0.09$) also existed for small intestinal starch disappearance (% duodenal flow) to be greater in diets containing corn.

Diets containing lower-fat DDGS had increased α-amylase activity (U/L rumen fluid and amylase/lb starch intake; $P \leq 0.05$; Table 4). This may be explained by the possibility that removing more fat results in a change in ruminal acetate-to-propionate ratios, which favors amylolytic bacterial growth.

Interactions between grain source and DDGS fat level were observed for α-amylase activity (U/L rumen fluid and amylase/pound starch intake; $P \leq 0.03$); the DDGS fat level had a greater effect on amylase activity in barley- than corn-based diets. Although differences were noted between grain source and distillers fat levels for amylase activity, no changes in pH were observed ($P \geq 0.13$; Table 4).

Acknowledgments

The authors thank the employees of the NDSU Animal Nutrition and Physiology Center for their assistance in data collection and animal care and handling. This project was funded by a grant from the North Dakota Corn Council.

Table 1. Dietary composition.

	Rolled Barley		Rolled Corn	
Dietary Component, % of DM	Low	Moderate	Low	Moderate
Rolled corn			50	50
Barley	50	50		
DDGS	25	25	25	25
Corn silage	20	20	20	20
Limestone	2	2	2	2
Urea			0.15	0.15
Salt	0.05	0.05	0.05	0.05
Vitamin premix	0.01	0.01	0.01	0.01
Mineral premix	0.05	0.05	0.05	0.05
Rumensin	0.02	0.02	0.02	0.02
Tylan	0.01	0.01	0.01	0.01
Fine-ground corn	2.46	2.46	2.61	2.61
Chromium oxide	0.25	0.25	0.25	0.25

Table 2. Analyzed nutrient concentration of diets (DM basis).

	Rolled Barley		Rolled Corn	
Dietary Component, % of DM	Low	Moderate	Low	Moderate
Dry matter, % of as fed	65.1	65.9	67.6	66.3
Organic matter, % of DM	93.7	93.8	94.0	93.9
Crude protein, % of DM	6.32	6.19	6.01	6.09
Neutral detergent fiber, % of DM	15.4	15.4	14.8	15.3
Acid detergent fiber, % of DM	28.5	31.0	26.2	29.6
Ether Extract, % of DM	11.0	11.6	9.46	10.1
Calcium, % of DM	2.39	2.35	2.54	2.60
Phosphorus, % of DM	0.939	0.856	0.940	1.09
Starch, % of DM	2.35	3.03	3.24	4.35

Literature Cited

Aschenbach J.R., G.B. Penner, F. Stumpff and G. Gabel. 2011. Ruminant Nutrition

Symposium: Role of fermentation acid absorption in the regulation of ruminal pH. J. Anim. Sci. 89:1092–1107.

Milner, T.J., J.G.P. Bowman and B.F. Sowell. 1995. Effects of barley variety or corn on feedlot performance and feeding behavior. Proc. West. Sect., Am. Soc. Anim. Sci. and West Branch Can. Soc. Anim. Sci. 46:539-542

Saunders, J.A., and K.A. Rosentrater. 2009. Properties of solvent extracted low-oil corn distillers dried grains with solubles. Biomass and Bioenergy 33:1486–1490.

Stone W.C. Nutritional approaches to minimize subacute ruminal acidosis and laminitis in dairy cattle. J. Dairy Sci. 2004;87:E12–E26.

Wallenfels K., P. Foldi, H. Nierman, H. Bender and D. Linder. 1978. The enzymic synthesis, by transglucosylation of a homologous series of glycosidically substituted maltooligo-saccharides, and their use as amylase substrates. Carbohydr Res 61, 359–368.

Table 3. Starch intake and disappearance for steers consuming barley- vs. corn-based diets with variable distillers fat inclusion levels.

	Barley		Corn			*P*-value		
Item	Low	Moderate	Low	Moderate	SEM	Grain	Distillers	Grain * Distillers
Intake, lb/d	15.0	15.3	18.3	16.6	0.69	0.002	0.29	0.10
Disappearance, lb/d	14.8	15.2	17.7	16.1	0.71	0.008	0.31	0.10
Apparent ruminal, % intake	86.3	86.5	88.4	88.4	1.40	0.17	0.95	0.94
Small intestinal, % duodenal flow	67.1	56.3	75.2	68.7	7.45	0.09	0.13	0.64
Total tract, % intake	95.1	95.5	95.1	95.9	1.03	0.71	0.29	0.66

Table 4. The impact of barley- vs. corn-based diets with variable distillers fat inclusion levels on rumen amylase activity and pH.

	Barley		Corn			*P*-value		
Item	Low	Moderate	Low	Moderate	SEM	Grain	Distillers	Grain * Distillers
Amylase, U/L rumen fluid	1154[a]	845[b]	1058[a]	1048[a]	108	0.45	0.02	0.03
Amylase/lb. starch intake	54.9[ac]	39.2[bd]	42.1[be]	45.5[cde]	5.73	0.42	0.05	0.01
Amylase/lb. starch disappearance	50.8	40.1	47.7	46.4	5.63	0.69	0.14	0.24
Rumen pH	5.82	5.90	5.92	5.93	0.056	0.13	0.24	0.37

[a,b,c,d,e] Superscripts indicate differences.