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Effects of feeding a high-fiber byproduct feedstuff as a substitute for barley grain on rumen fermentation and productivity of dairy cows in early lactation

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ABSTRACT

The objective of the study was to evaluate effects of partial substitution of dietary grain with wheat dried distillers grains with solubles (DDGS) on dry matter intake (DMI), sorting behavior, rumen fermentation, apparent total-tract nutrient digestibility, plasma metabolites, and milk production of dairy cows in early lactation. Sixty-one Holstein cows, including 13 ruminally cannulated cows, were blocked by parity and calving date and assigned to 1 of 2 experimental diets immediately after calving until 12 wk in lactation. The control (CON) diet contained 43% barley silage, 17.3% dry-rolled barley grain, and 39.7% concentrate mix on a dry matter basis, and wheat DDGS replaced dry-rolled barley grain in the DDGS diet. Dietary starch content was 29.2 and 19.1% for CON and DDGS diets, respectively. Despite the 10-percentage-unit difference in dietary starch content, cows fed the DDGS diet did not increase ruminal pH. A significant treatment by parity interaction was observed for DMI; feeding the DDGS diet decreased DMI of multiparous cows compared with CON (20.1 vs. 21.3 kg/d) but increased that of primiparous cows (16.2 vs. 14.7 kg/d). Although milk yield was not affected by treatment, cows fed the DDGS diet had lower apparent total-tract digestibility of starch compared with CON (81.9 vs. 91.2%) and tended to have higher plasma concentrations of nonesterified fatty acids (173 vs. 143 mEq/L). High-fiber byproduct feedstuffs such as wheat DDGS can be used as a partial substitute for grains in diets of dairy cows in early lactation but the substitution may not mitigate rumen acidosis problems and may decrease energy intake of multiparous cows in early lactation.

Key words: early lactation, starch, high-fiber byproduct, wheat dried distillers grains with solubles (DDGS)

INTRODUCTION

High-producing dairy cows often experience negative energy balance after calving (Grummer, 1995; NRC, 2001). High-grain diets are usually fed to cows in early lactation to increase their energy intake, but that often increases the incidence of acidosis and laminitis (Nocek, 1997) and decreases milk production (Krause and Oetzel, 2006). Most high-producing dairy cows are at risk of SARA, a common digestive disorder (Nocek, 1997) usually caused by feeding a diet containing highly fermentable carbohydrates with insufficient physically effective fiber (NRC, 2001). Early lactating dairy cows have greater risk of rumen acidosis because their diets change from a high-forage to a high-starch diet immediately after calving. When cows are fed rapidly fermentable grain, their DMI often decreases because of excess acid production in the rumen (Allen, 2000). The reduction in DMI caused by subclinical acidosis often decreases energy intake, and may worsen negative energy balance. Therefore, it is challenging to maximize energy intake of dairy cows in early lactation without causing SARA.

Dried distillers grains with solubles (**DDGS**) is a byproduct of the ethanol industry that contains high CP and digestible NDF (Schingoethe et al., 2009). Although DDGS is widely accepted as a dietary protein source, some researchers used DDGS to replace grain in the diet fed to dairy cows. Janicek et al. (2008) used DDGS to replace both forage and concentrate and found that DMI and milk production increased linearly with increasing dietary allocations of DDGS (0, 10, 20, and 30%), indicating that DDGS might be an option as a substitute for grain to increase DMI and energy intake. However, Ranathunga et al. (2010) used soyhulls and DDGS to replace corn grain, and they found that DMI decreased linearly as dietary NDF content increased, but milk production was not affected; causes for this discrepancy are not known. Feeding DDGS to replace grain in dairy diets would reduce dietary starch concentration and increase NDF concentration, and ruminal pH would also be expected to increase. Zhang et al. (2010) found that ruminal pH tended to increase when wheat DDGS was used to replace barley grain at

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20% of dietary DM in the diets for mid-lactation dairy cows.

Maximizing energy intake of dairy cows in early lactation without causing SARA is a challenge, but the effects of feeding high-fiber byproducts as a substitute for grain on productivity of dairy cows in early lactation have not been extensively studied. Based on previous research using cows in mid lactation, we hypothesized that reducing the dietary starch content by replacement of barley grain with wheat DDGS would increase ruminal pH, DMI, and milk production of dairy cows in early lactation. The objective of the study was to evaluate effects of dietary starch content, which was accomplished by partial substitution of dietary grain with wheat DDGS, on DMI, sorting behavior, rumen fermentation, apparent total-tract nutrient digestibility, plasma metabolites, and milk production of dairy cows in early lactation.

MATERIALS AND METHODS

This experiment was conducted at the Dairy Research and Technology Center at the University of Alberta (Edmonton, Alberta, Canada). All procedures were preapproved by the Animal Care and Use Committee for Livestock at the University of Alberta and conducted according to the guidelines of the Canadian Council of Animal Care (2009).

Diets, Animals, and Experimental Design

Two experimental diets were formulated for this study. The control (**CON**) diet contained 43% barley silage, 17.3% dry-rolled barley grain, and 39.7% concentrate mix on a DM basis, and wheat DDGS replaced dry-rolled barley grain in the DDGS diet (Table 1). As wheat DDGS contained more CP and fat compared with barley grain, dietary contents of beet pulp, corn gluten meal, urea, and vegetable oil were adjusted to decrease the differences in dietary CP and fat concentrations between the CON and DDGS diets. Both diets were formulated according to NRC (2001) to meet or exceed the nutritional requirements for early lactating cows (650 kg of BW) producing 45.0 kg of milk/d with 3.50% milk fat and 3.00% milk protein. Particle size distribution of the TMR was determined for 3 d each week by using the Penn State Particle Separator. Both diets had similar physically effective factors, but the DDGS diet had more fine particles collected in the pan (28.0 vs. 10.8%). The DM concentration of barley silage and concentrate mixes were determined weekly and diet formulations adjusted if necessary.

Sixty-one Holstein cows (22 primiparous and 39 multiparous cows) were blocked by parity and calving date and assigned to 1 of 2 experimental diets (n = 30 for CON; n = 31 for DDGS) immediately after calving until 12 wk in lactation. Of the 61 cows used in this study, 13 multiparous cows were ruminally cannulated (n = 6 for CON; n = 7 for DDGS). Data were removed from any week when cows had health problems and were treated with antibiotics. Cows were housed individually in tie stalls and allowed to exercise outside for 2 h daily except on weekends. All cows were fed experimental diets as TMR and had free access to water. Cows were fed once daily at 105 to 110% of expected intake. Cows were milked in their stalls twice daily at 0400 and 1600 h.

Data and Sample Collection

Data and samples were collected on Tuesday, Wednesday, and Thursday every week. The amount of feed offered was recorded, and diet ingredients and TMR were sampled daily during the sample collection periods. At the end of the sample collection period, daily samples were composited to obtain a representative sample for each week. Orts were sampled from each

Table 1. Ingredients, nutrient composition, and particle size distribution of experimental diets[1]

Item	CON	DDGS
Ingredients, % of DM		
Barley silage	43.0	43.1
Corn grain, rolled	21.6	21.6
Barley grain, rolled	17.3	—
Wheat DDGS	—	17.2
Corn gluten meal	8.3	—
Urea	0.3	—
Beet pulp	3.2	12.3
Vegetable oil	2.4	1.9
Mineral and vitamin mix[2]	3.9	3.9
Nutrient composition		
DM, %	50.1	50.0
OM, % of DM	89.1	89.1
CP, % of DM	17.3	19.4
NDF, % of DM	27.2	30.5
Starch, % of DM	29.2	19.1
Ether extract, % of DM	3.7	4.4
NFC, % of DM	33.9	38.3
S, % of DM	0.24	0.54
Particle size distribution, % as fed		
19 mm	16.5	16.5
8 mm	27.5	28.3
1.18 mm	45.2	27.2
Pan	10.8	28.0
Physically effective factor[3]	44.0	44.8

[1]CON = control diet; DDGS = diet containing wheat-based dried distillers grains with solubles at 17% of dietary DM.

[2]Mineral and vitamin mix contained 1.73% Ca, 0.47% P, 1.14% Na, 0.50% Mg, 2.14% Cl, 1.66% K, 0.75 mg/kg of Co, 16.6 mg/kg of Cu, 0.63 mg/kg of I, 396 mg/kg of Fe, 56.3 mg/kg of Mn, 0.31 mg/kg of Se, 55.7 mg/kg of Zn, 22.6 kIU/kg of vitamin A, 2.3 kIU/kg of vitamin D, 74.7 IU/kg of vitamin E.

[3]Determined as the proportion of particles retained on 19- and 8-mm sieves (Lammers et al., 1996).