J. Dairy Sci. 93:3231–3242
doi:10.3168/jds.2009-3005

Effects of partially replacing barley silage or barley grain with dried distillers grains with solubles on rumen fermentation and milk production of lactating dairy cows

S. Z. Zhang,* G. B. Penner,*[1] W. Z. Yang,† and M. Oba*[2]
*Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, T6G 2P5, Canada
†Agriculture and Agri-Food Canada, Research Centre, Lethbridge, AB, T1J 4B1, Canada

ABSTRACT

Dried distillers grains with solubles (DDGS) has been commonly used as a dietary protein source for lactating dairy cows. However, there is a paucity of data evaluating the use of DDGS as a partial replacement of forage or grain. The objective of this study was to determine the effects of partially replacing barley silage or barley grain with corn/wheat-based DDGS on dry matter intake (DMI), chewing activity, rumen fermentation, and milk production. Six ruminally cannulated lactating Holstein cows were used in a replicated 3 × 3 Latin square design with 21-d periods. Cows were fed the control diet (CON: 45% barley silage, 5% alfalfa hay, and 50% concentrate mix), a low forage (LF) diet or a low grain (LG) diet, in which barley silage or barley grain was replaced by DDGS at 20% of dietary dry matter, respectively. All diets were formulated to contain 18% crude protein and fed as total mixed rations. Compared with CON, cows fed the LF diet had greater DMI (26.0 vs. 22.4 kg/d), yields of milk (36.4 vs. 33.0 kg/d), milk protein (1.18 vs. 1.05 kg/d), and milk lactose (1.63 vs. 1.46 kg/d), but milk fat yield was not affected. The LF diet decreased chewing time compared with the CON diet (29.7 vs. 39.1 min/kg of DMI), but did not affect rumen pH and duration of rumen pH below 5.8. Compared with CON, feeding the LG diet tended to increase minimum and maximum rumen pH, but did not affect DMI, milk yield, and milk composition in this study. These results indicate that a partial replacement of barley silage with DDGS can improve the productivity of lactating dairy cows without negatively affecting rumen fermentation and milk fat production. Barley grain can also be partially replaced by DDGS in diets for lactating dairy cows without causing negative effects on productivity.

Received December 17, 2009.
Accepted March 31, 2010.
[1]Current address: Department of Animal and Poultry Science, University of Saskatchewan, Saskatoon, SK, S7N 5A8, Canada.
[2]Corresponding author: moba@ualberta.ca

Key words: barley silage, barley grain, dried distillers grains with solubles

INTRODUCTION

Dried distillers grains with solubles (**DDGS**) is high in CP concentration and has been commonly used as a dietary protein source for lactating dairy cows. In addition to its high CP concentration, DDGS is also high in NDF content, ranging from 32% (Anderson et al., 2006) to 44% (Kleinschmit et al., 2006) with an average of 38% (NRC, 2001). Because of the high NDF content, DDGS may be used as a partial replacement of forage for ruminants. However, physical characteristics such as small particle size and high particle density result in lower physical effectiveness compared with forages (Clark and Armentano, 1993). There are currently a limited number of studies evaluating the potential of using DDGS as a partial replacement for forage. Penner et al. (2009) reported an increase in milk production for dairy cows fed wet wheat/corn distillers grains as a partial replacement of barley silage, but also reported decreased milk fat concentration and total chewing activity. These data imply that partial replacement of barley silage with distillers grains may predispose cows to rumen acidosis. However, to our knowledge there is no study examining ruminal fermentation when DDGS is included as a partial replacement of forage in diets for dairy cows.

In addition to a high NDF concentration, the NDF from DDGS is highly digestible (Getachew et al., 2004), and the NE_L value of DDGS is high: 1.94 and 2.35 Mcal/kg of DM for wheat- and corn-DDGS, respectively (Nuez Ortin and Yu, 2009). As such, DDGS may serve as an energy source partially replacing grain in diets for lactating dairy cows. In addition, as the starch concentration of DDGS is lower than grain, partially replacing grain with DDGS in diets for lactating dairy cows is expected to decrease the risk of rumen acidosis. Use of DDGS as a substitute for corn grain was studied in a previous study (Grings et al., 1992). However, effects of feeding DDGS were confounded by different dietary CP concentrations in their study. There are little data available to assess the feeding value of DDGS as an energy source for dairy cows.

The objective of this study was to evaluate the effects of partially replacing barley silage or barley grain with DDGS on DMI, milk yield and milk composition, chewing activity, and rumen fermentation of lactating dairy cows.

MATERIALS AND METHODS

Animals, Diets, and Experimental Design

This experiment was conducted at the Dairy Research and Technology Center at the University of Alberta. All procedures were preapproved by the Faculty Animal Policy and Welfare Committee at the University of Alberta and conducted according to the guidelines of the Canadian Council of Animal Care (Ottawa, Ontario, Canada).

Six multiparous lactating Holstein cows, each fitted with a ruminal cannula, were used. Cows were blocked by stage of lactation and assigned to 1 of 3 dietary treatments in a replicated 3 × 3 Latin square design balanced for carryover effects. Stage of lactation was used as a blocking variable because 3 cows were in mid lactation (76 ± 26 DIM; 605 ± 49 kg of BW) and the other 3 cows were in late lactation (244 ± 41 DIM; 726 ± 67 kg of BW). Each period consisted of a 15-d diet adaptation period and a 6-d data and sample collection period. The treatments were control (**CON**: 45% barley silage, 5% alfalfa hay, and 50% barley-based concentrate mix), and low forage (**LF**) and low grain (**LG**) diets in which barley silage or barley grain was replaced by DDGS at 20% of dietary DM, respectively (Table 1). The DDGS was produced from 70% corn and 30% wheat (Husky Energy, Lloydmister, Saskatchewan, Canada). The same batch of DDGS was used throughout the study. Diets were formulated according to NRC (2001) to meet the nutritional requirements for a 670-kg cow producing 40 kg of milk/d with 3.5% milk fat and 3.2% milk protein. Because the CP concentration was higher for DDGS than for barley grain or barley silage, experimental diets contained variable amounts of nonforage and nongrain feedstuffs (i.e., canola meal, corn gluten meal, beet pulp, and urea) to make the experimental diets isonitrogenous. This approach was expected to minimize confounding effects that would be caused by different dietary allocations of grain or forage when it was not evaluated as a treatment. Cows were housed individually in tie stalls and allowed to exercise for 2 h daily throughout the experiment except for weekends and during sample collection periods. Cows were fed experimental diets as TMR once daily at 0800 h and had free access to fresh water. Animals were fed at 105 to 110% of expected feed intake. The amounts of feed offered and refused were recorded daily during sample collection periods. Samples of feed ingredients and orts were collected daily during sample collection periods and composited by period for feed ingredients, and by period and by cow for orts. The DM concentrations of barley silage and alfalfa hay were determined twice weekly and used to adjust dietary formulation if necessary. Dietary forage NDF concentration was 24.2, 14.6, and 24.4%, and dietary starch concentration was 27.7, 23.7, and 17.1% for the CON, LF, and LG diets, respectively (Table 2).

Table 1. Ingredients of experimental diets

	Diet[1]		
Ingredient, % of DM	CON	LF	LG
Alfalfa hay	5.1	5.0	5.1
Barley silage	44.6	24.8	44.6
DDGS[2]	—	20.1	20.1
Rolled barley	35.2	35.1	15.1
Canola meal	3.1	—	—
Corn gluten meal	5.6	0.4	0.5
Beet pulp	2.5	10.8	11.1
Urea	0.1	0.2	—
Premix[3]	1.0	1.0	1.0
Limestone	1.0	1.1	0.8
Salt	0.5	0.5	0.5
Magnesium oxide	0.1	0.1	0.1
Dicalcium phosphate	1.2	0.9	1.1

[1]CON = control; LF = low forage; LG = low grain.

[2]Dried distillers grains with solubles: a blend of 70% corn- and 30% wheat-based dried distillers grains with solubles; 85.4% DM, 6.2% ash, 34.1% CP, 9.8% ether extract, and 32.8% NDF.

[3]Contained 0.10% Ca; 0.60% P; 11.50% Na; 0.30% Mg; 10 mg/kg of F; 80 mg/kg of I; 5,000 mg/kg of Zn; 31,000 mg/kg of Mn; 1,170 mg/kg of Cu; 6.2 mg/kg of Co; 1,265 kIU/kg of vitamin A; 142 kIU/kg of vitamin D; 3,800 IU/kg of vitamin E.

Cows were milked twice daily at 0400 and 1600 h. Milk was sampled at both milkings on d 19, 20, and 21 of each period. Cows were weighed after the morning milking on 2 consecutive days immediately before the start of experiment and on the last 2 d of each period. Body condition score was determined by 2 experienced individuals separately at the beginning of the experiment and at the end of each period using a 5-point scale (1 = thin and 5 = fat; Wildman et al., 1982) and averaged.

Chewing Activity and Sorting Behavior

Chewing activities were monitored for 24 h on d 16 of each period. Eating and ruminating activities were recorded every 5 min and each activity was assumed to continue for the entire 5-min interval between ob-