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Reciprocal combinations of barley and corn grains in oil-supplemented diets: Feeding behavior and milk yield of lactating cows

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ABSTRACT

The effect of barley-based (BBD) or corn-based diets (CBD), or their equal blend (BCBD) on dry matter (DM) intake, feeding and chewing behavior, and production performance of lactating dairy cows was evaluated. Nine multiparous Holstein cows (75.6 ± 11.0 d in milk) were used in a triplicate 3 × 3 Latin square design with 21-d periods. Forage-to-concentrate ratio (40:60), forage neutral detergent fiber (20% of DM), total neutral detergent fiber (>29% of DM), and geometric mean particle size (4.3 mm) were similar among treatments. Meal patterns, including meal size and intermeal interval, were not affected by the dietary treatments and DM intake (25.6 kg/d) was not different among treatments. Ether extract intake increased linearly with increasing amount of the corn grain in the diets. Due to similar feed intake, actual milk (48.6 kg/d), 4% fat-corrected milk (36.8 kg/d), and fat- and protein-corrected milk (38.1 kg/d) yields were not affected by treatments. Average milk protein percentage and yield were 2.83% and 1.37 kg/d, respectively, and were not different across treatments. Milk fat percentage increased linearly with increasing amount of corn grain in the diets and was greater in CBD relative to BCBD but not BBD (2.31, 2.28, and 2.57%, for BBD, BCBD, and CBD, respectively). However, milk fat yield tended to show a linear increase as the amount of corn grain included in the diets increased. Results indicated that changing diet fermentability by replacing barley grain for corn grain in oil-supplemented diets did not influence feeding patterns and thereby no changes in feed intake and milk yield occurred.

Key words: barley and corn grain, feeding and chewing behavior, dairy cow

INTRODUCTION

Dietary type of grain (barley vs. corn) resulted in varied DMI and milk yield responses in different research experiments. Overton et al. (1995) fed dairy cows diets containing 5 different ratios of starch from ground shelled corn grain and steam-rolled barley grain and found that DMI and milk yield decreased as the ratio of starch from steam-rolled barley grain increased, which was because of increased ruminal digestibility of starch from barley grain. Khorasani et al. (2001) also fed 3 different ratios of barley and corn grain to dairy cows and reported that substitution of barley grain with corn grain resulted in a quadratic response in DMI and milk yield. Overton et al. (1995) but not Khorasani et al. (2001) reported that milk fat percentage was affected quadratically by the proportion of barley grain and corn grain in the diets, such that the percentage of fat was greatest when diets contained barley grain and corn grain in ratios of 100:0 and 0:100 and was lowest when blends of barley grain and corn grain were fed to cows. In our recent experiment (Kargar et al., 2013), cows fed barley-based diets tended to increase DMI and had numerically greater milk yield compared with cows fed corn-based diets. Furthermore, grain type did not affect milk fat concentration and yield (Kargar et al., 2013). Increasing ruminal digestion of starch can increase milk yield through increased total-tract digestibility of feed and increased microbial protein synthesis, if acidosis is avoided with sufficient concentration of physically effective fiber in the diet (Allen, 2000; Beauchemin and Yang, 2006). Accordingly, greater ruminal fermentation is more of interest to increase energy intake and also microbial protein yield, but DMI is reduced. Therefore, it is important to understand mechanisms by which DMI and milk yield are influenced when cows are fed diets containing grains differing in expected ruminal fermentability.

Feed intake is a function of both meal size and intermeal interval, determined by satiety and hunger, respectively (Allen, 2000; Kargar et al., 2013). Type of grain and its starch susceptibility to ruminal digestion has a contradictory effect on meal patterns (Oba

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and Allen, 2003; Kargar et al., 2013). Diets high in ruminally degraded starch (e.g., high-moisture corn grain vs. dry corn grain) decreased DMI by decreasing meal size without affecting milk yield and ruminating time (Oba and Allen, 2003). However, barley-based diets (**BBD**) increased ruminating time by increasing rumination duration compared with corn-based diets (**CBD**; Kargar et al., 2013). Therefore, investigation of feeding behavior when cows are fed diets containing grains differing in expected ruminal fermentability is required to clarify regulation mechanisms for feed intake.

Forage particle size is considered as one of the key determinants of the physical effectiveness of diets in dairy cows, as it promotes stratification of digesta in the reticulorumen, which positively affects eating and ruminating activities as well as rumen buffering (Mertens, 1997; Nasrollahi et al., 2012). All these processes are critical to maintain proper rumen function and optimize digestion, feed intake, and nutrient utilization (NRC, 2001; Tafaj et al., 2007; Nasrollahi et al., 2012). Furthermore, previous studies have reported that the effects of forage particle size are also related to the degradation properties of the diet (Silveira et al., 2007; Nasrollahi et al., 2012). For example, it has been shown that for the same forage particle size in the diet, the physiological responses obtained are different when these diets are based on barley grain versus corn grain (Beauchemin and Rode, 1997; Nasrollahi et al., 2012). In an experiment, Nasrollahi et al. (2012) concluded that feeding of long versus fine alfalfa hay (theoretical length cut of 30 vs. 15 mm) is more critical for barley- versus a mixture of barley- and corn-based diets to avoid reduction of feed intake and fiber digestion in mid-lactation dairy cows. In a constant level of forage particle size (theoretical length cut of 30 mm), however, it is not known whether changing diet fermentability (using grains different in expected ruminal fermentation) when supplemented with unsaturated oil would affect lactational performance and eating and ruminating activities. Most experiments that have considered the effect of grain type and fat supplementation of the diet have used a type of rumen-inert fat (Sadri et al., 2009; Nasrollahi et al., 2012). Therefore, it remains unclear how performance and behavior of dairy cows would be influenced by changing fermentability of diets supplemented with unsaturated oil.

Oil supplements are commonly used for increasing energy density of diets fed to high-producing dairy cows. Previous experiments have shown that feeding oil supplements (e.g., $\leq$2% of dietary DM) to dairy cows, particularly when diets contain a high level of concentrate, could maintain or improve lactation performance with minimal interference on fermentation and nutrient intake (Kargar et al., 2010, 2012, 2013). Furthermore, addition of oil to the diet increased energy density without sacrificing dietary fiber concentration and increased rumen acid production, thus stabilizing rumen pH relative to the addition of grain (Kargar et al., 2010, 2012).

The objective of this work was to evaluate the effect of substituting barley grain with corn grain on feed intake, lactational performance, and feeding and chewing behavior of Holstein cows fed high-concentrate diets supplemented with oil. We hypothesized that a barley-based diet would decrease intake and, thereby, milk yield, relative to a corn-based diet through signaling decreased meal size or increased intermeal interval.

MATERIALS AND METHODS

All procedures were conducted under protocols approved by the Isfahan University of Technology (**IUT**) Laboratory Animal Care Advisory Committee (Isfahan, Iran). The experiment was conducted in Lavark at the Farm Animal Research and Teaching Unit of IUT.

Animals, Experimental Design, and Treatments

Nine lactating multiparous Holstein cows (BW = 656.0 $\pm$ 49.0 kg; parity = 2.7 $\pm$ 0.7; mean $\pm$ SD) 75.6 $\pm$ 11.0 DIM and producing 49.2 $\pm$ 3.2 kg of milk/d with 3.00% fat and 2.91% protein were used in a replicated 3 $\times$ 3 Latin square design with 21-d periods. Each experimental period consisted of a 16-d diet adaptation period and a 5-d collection period. Cows were grouped into 3 squares of 3 cows each based on milk yield and DIM (i.e., 3 cows with the roughly similar milk yield and DIM were considered as a square). Cows within square were randomly assigned to dietary sequences to minimize carryover effects. Therefore, cows received 1 of the 3 following experimental diets: (1) barley-based diet (**BBD**), (2) barley- and corn-based diet (**BCBD**), and (3) corn-based diet (**CBD**; Table 1). Cows were housed individually in box stalls (4 $\times$ 4 m) located in a roofed area with open sides. Each box stall was equipped with a concrete feed bunk and automatic water troughs. Clean wood shavings and sand were used for bedding and refreshed twice daily. Cows were allowed to exercise in an outdoor lot daily from 1700 to 1800 h. Barley and corn grains were selected, as dairy cow diets in Iran and many places in the world typically contain any one or combinations of these cereal grains as the principal source of energy. Grains were ground using a hammer mill with 3-mm screen size (model 5543 GEN; Isfahan Dasht, Isfahan, Iran). The BBD and CBD contained 33.3 and 28.0% barley grain and corn grain as the sole types of grain, respectively, whereas BCBD had an