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Dietary grain source and oil supplement: Feeding behavior and lactational performance of Holstein cows

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ABSTRACT

Effects of grain source and dietary oil supplement on dry matter intake (DMI), feeding, chewing behavior, and production performance of lactating dairy cows were evaluated using eight multiparous Holstein cows (77 ± 22.1 days in milk; mean ± SD) in a duplicated 4 × 4 Latin square design with a 2 × 2 factorial arrangement of treatments. Experimental diets contained either ground barley or ground corn supplemented with either fish oil or soybean oil at 2% of dietary dry matter (DM). Geometric mean particle size of dietary treatments was 4.1 mm. Dry matter intake tended ($P=0.09$) to be greater for barley- vs. corn-based diets (23.2 vs. 22.3 kg/d), but was reduced for the fish oil compared to soybean oil supplemented diets (21.1 vs. 24.3 kg/d; $P<0.001$). This reduction in DMI was attributed to smaller meal size (1.24 vs. 1.55 kg of DM; $P=0.004$) and slower eating rate (0.082 vs. 0.098 kg of DM/min; $P<0.001$) for fish oil compared to soybean oil supplemented diets. Main treatment effects interacted ($P=0.005$) for DMI of particles retained on 19 mm sieve but not for sorting index. Eating rate (0.090 kg of DM/min) was similar between barley- and corn-based diets, however, rumination time was greater for barley- compared to corn-based diets as result of longer rumination bout duration (32.5 vs. 28.5 min/bout; $P=0.01$). Barley- compared to corn-based diets increased total chewing time by 71 min (709 vs. 638 min) for cows fed fish oil, but not for cows fed soybean oil. Grain source did not affect milk yield or milk composition. Compared to soybean oil, fish oil negatively affected milk yield (40.4 vs. 43.4 kg/d; $P=0.01$), and thereby, both milk fat (0.91 vs. 1.26 kg/d; $P<0.001$) and protein (1.23 vs. 1.33 kg/d; $P=0.007$) production. However, feed efficiency (milk yield/DMI) was greater in fish oil compared to soybean oil supplemented diets (1.94 vs. 1.80; $P=0.003$). Results indicated that grain source and oil supplement can interact to affect feeding and chewing behavior, but not lactational performance of lactating cows.

1. Introduction

High-producing dairy cows require large amounts of concentrates that are rich in energy and crude protein to meet their nutrient requirements. Cereal grains and oil supplements are commonly used for increasing energy density of diets fed to high-producing dairy cows. Dietary grain source (barley vs. corn) resulted in varied DMI and milk production responses in different research studies. Several studies (Khorasani et al., 1994; Silveira et al., 2007; Mohammed et al., 2010) reported lower DMI for cows fed diets based on barley than those fed diets based on corn. However, other investigators (Beauchemin and Rode, 1997; Casper et al., 1999; Sadri et al., 2009) observed no

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differences in DMI for cows fed either barley- or corn-based diets. Similar relationships apply between barley and corn grain feeding and milk yield. Beauchemin and Rode (1997), Sadri et al. (2009), and Mohammed et al. (2010) reported that feeding barley instead of corn did not impact milk yield, while Casper et al. (1999) and Silveira et al. (2007) reported lower milk yields for cows fed barley- than for those fed corn-based diets.

Some dairy producers are reluctant to supplement dairy cows' diets with available and sometimes cost competitive unsaturated fat sources such as yellow grease, soybean oil, and fish oil, because of the belief that these products will cause lower DMI and milk yield due to their interference with rumen fermentation and fiber digestibility. However, several experiments showed that unsaturated fat sources such as yellow grease (Kargar et al., 2010 and 2012), and even plant and marine oils (Donovan et al., 2000; AbuGhazaleh et al., 2002; Alizadeh et al., 2012) could maintain or improve lactation performance with minimal interference on fermentation.

Feed intake is a function of both meal size and inter-meal interval, determined by satiety and hunger, respectively (Allen, 2000). Meal patterns may be influenced by the source of grain and its starch susceptibility to ruminal digestion (Oba and Allen, 2003) and also oil supplement (Allen, 2000; Harvatine and Allen, 2006; Kargar et al., 2010). Diets high in ruminally degraded starch (e.g. high-moisture corn vs. dry corn) decreased DMI by decreasing meal size without affecting milk yield and ruminating time (Oba and Allen, 2003). However, barley-based diets increased ruminating time by increasing rumination duration and show a tendency to increase the number of meals consumed in a day as compared to corn-based diets (Beauchemin and Rode, 1997). Although the effect of grain fermentation in the rumen vs. in the lower gut on DMI has been extensively investigated, few experiments have evaluated the impacts of grain fermentability on feeding behavior. 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. Furthermore, Allen (2000), in a meta-analysis, indicated different hypophagic effects of oil supplements that differed in fatty acid source, form, and type. Harvatine and Allen (2006) also reported that the reduction in DMI from unsaturated oil supplements characterized by decreased meal size without an increase in inter-meal interval. Compared with hydrogenated palm oil, however, cows fed yellow grease maintained DMI and improved milk yield with shortened inter-meal intervals (Kargar et al., 2010 and 2012). Although many experiments observe daily DMI, few have reported feeding and chewing behavior of cows supplemented with oil sources. We hypothesized that both barley-based diets and fish oil supplemented diets would decrease intake through signaling decreased meal size or increased inter-meal interval. Hence, the specific objective of this experiment was to determine the effects of, and interactions between, grain source and oil supplement on the feed intake, feeding and chewing behavior, and lactational performance in early- to mid-lactation Holstein cows.

2. Materials and methods

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

2.1. Animals, experimental design and treatments

Eight lactating multiparous Holstein cows (parity = 3.3 ± 1.3 and days in milk = 77 ± 22.1; mean ± SD), were used in a replicated 4 × 4 Latin square design with 25-d periods. Each experimental period consisted of an 18-d diet adaptation period and a 7-d collection period. Cows within a square were assigned randomly to dietary treatments. Cows were blocked into 2 squares of 4 cows each based upon milk production, and days in milk, and within blocks were assigned to 1 of the 4 experimental diets with a 2 × 2 factorial arrangement: (1) BF = barley-based diet supplemented with fish oil at 2% of dietary DM, (2) BS = barley-based diet supplemented with soybean oil at 2% of dietary DM, (3) CF = corn-based diet supplemented with fish oil at 2% of dietary DM, and (4) CS = corn-based diet supplemented with soybean oil at 2% of dietary DM (Table 1). Treatment diets were randomly assigned after blocking to minimize carry over effects. Cows were housed individually in box stalls (4 × 4 m^2) designed in a roofed area with open sides that were equipped with a concrete feed bunk and automatic waterers. 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 since 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). Experimental diets contained 28.5 and 31.2% of cereal grain in corn- and barley-based diets, respectively, as the sole source of grain. The main protein sources for the experimental diets were soybean meal, canola meal, and corn gluten meal (Table 1). Soybean meal vs. canola meal and also corn grain vs. barley have greater energy values and thereby metabolizable energy allowable for milk (NRC, 2001). To more closely match metabolizable energy content of the diets, soybean meal was used mainly in barley-based diets wheras canola meal was used mainly in corn-based diets. Soybean and fish oils were added to the concentrate such that experimental diets would contain 4–5% fat, on a DM basis. The forage to concentrate ratio of the diets was 40:60. The forage component of the experimental diet was a mixture of corn silage and chopped alfalfa hay. However, beet pulp was included in all dietary treatments at the level (4.22% of dietary DM) which provided some additional digestible fiber. Alfalfa hay was chopped by a machine conventionally used for separation of cereal grains from straw (Golchin Trasher Hay Co., Isfahan, Iran). Diets were formulated to meet or exceed the Cornell Net Carbohydrate and Protein System (version 5.0) nutrient allowance for a lactating dairy cow weighing