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Effect of feeding system and grain source on lactation characteristics and milk components in dairy cattle

M.-C. Ferland,* M.-A. Guesthier,* R. I. Cue,* R. Lacroix,*† S. A. Burgos,* D. Lefebvre,*† and K. M. Wade*[1]
*Dairy Information Systems Group, Department of Animal Science, McGill University, Ste. Anne de Bellevue, QC, Canada H9X 3V9
†Valacta, Ste. Anne de Bellevue, QC, Canada H9X 3R4

ABSTRACT

The objective of this study was to examine the effect of feeding systems [component and total mixed rations (TMR)] and dietary grain sources (barley, commercial concentrate, corn grain, and high-moisture corn) on lactation characteristics and milk composition. A total of 852,242 test-day records, information on animal characteristics, feed composition, and feeding systems from 104,129 Holstein cows in 4,319 herds covering a period of 5 yr were obtained from Quebec's Dairy Herd Improvement Association (Valacta). We performed descriptive statistics and graphical representations of the data for each type of feeding system and grain source by parity (1 to 3). The milk records were binned in 15-d in milk blocks. Mixed models using a combination of forward and backward stepwise selections were developed to predict milk and milk component yields. The TMR-fed cows had greater yield of milk, fat, protein, and lactose and lower milk urea N (MUN) concentration than component-fed cows at all parities. Cows fed a TMR had higher peak milk yields and greater persistency after peak lactation compared with component-fed cows. In addition, greater yields of milk fat and protein from peak to mid-lactation were found in TMR-versus component-fed cows. In general, greater milk fat and protein yields as well as lower MUN concentration were observed in cows fed corn grain or high-moisture corn compared with barley or commercial concentrate, but parity influenced these relationships. The feeding system by day in milk blocks interaction was significant in models of milk and components yields for all parities, but only for second-lactation cows for MUN concentration. This means that effect of TMR and component feeding differs with stage of lactation. In conclusion, feeding TMR and corn-based diets are associated with greater yield of milk and milk components under commercial conditions.

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[1]Corresponding author: kevin.wade@mcgill.ca

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INTRODUCTION

Bovine milk composition is of interest to dairy producers, processors, and consumers alike. Indeed, the overall profitability of the entire dairy industry would benefit from matching the production of milk components to their demand (Kennelly and Glimm, 1998; Bittante et al., 2015). This goal has motivated research in manipulation of milk components and prediction of their yield. Three main options exist to alter milk composition: cow nutrition and management, cow genetics, and dairy processing (Walker et al., 2004). Of these, only nutrition allows for relatively rapid changes in the milk composition at the cow level and it is the most suitable method to meet changing market demands.

The method or sequence of feeding can have an effect on milk yield and composition. Feeding forages first has been hypothesized to allow the formation of a fiber mat in the rumen, stimulating salivation and rumen motility (Nocek, 1992; NRC, 2001). Indeed, lower milk fat percentages were observed for cows given supplements on a pasture system compared with cows receiving a TMR (White et al., 2001; Bargo et al., 2002). However, in some studies (Nocek, 1992; Macleod et al., 1994), no effect on rumen fermentation characteristics or milk production was found when legume forages were fed first. Kolver and Muller (1998) observed only a numerical decrease in the milk fat percentage between cows consuming only pasture and those receiving a TMR. Similarly, Ferris et al. (2006) found no effect of feeding system on milk yield, milk fat, or milk protein percentage. Larkin and Fosgate (1970) showed that both component- and TMR-feeding systems have resulted in similar milk protein percentages. Nevertheless, some researchers (Coppock et al., 1981; Hutjens, 1996) have suggested that milk components can increase when cows are fed a TMR When fed twice a day, cows receiving a TMR tended to have greater milk fat percentage than component-fed cows (Kennelly, 1996).

In addition to feeding systems, the source and conservation method of grains can influence milk composition. According to the NRC (2001), milk fat percentage, ruminal pH, and ruminal VFA profile are altered by increased starch availability in the rumen, even when the concentration of dietary NDF is not changed. Indeed, several studies have reported differences in milk composition in response to the type of grain fed. For example, McCarthy et al. (1989) and Casper et al. (1990) reported greater milk yields for cows fed corn grain as compared with cows fed barley. Kargar et al. (2014) reported a linear increase in milk fat yield when corn replaced barley in oil-supplemented rations. Wilkerson et al. (1997) demonstrated an increase in milk yield for cows fed high-moisture corn versus dry ground corn and found that ruminal digestibility of high-moisture corn was greater than dry ground corn. Similarly, Lykos et al. (1997) showed that increasing the rate of NSC digestion from 6 to 7.9%/h increased milk yield by 2.5 kg/d. However, some studies have also shown that milk yield is not affected by the type of grain or the amount of ruminally degradable starch (Clark and Harshbarger, 1972; Oliveira et al., 1993; Slots et al., 2009).

Most of the knowledge we have so far regarding the effect of feeding system and grains on milk production comes from feeding trials using a small number of cows under controlled conditions. However, the effect of these factors, if any, under commercial conditions over an entire lactation is not known. Although most existing nutritional studies in dairy cows are limited to a few factors, many more factors can be studied simultaneously using large-scale test-day records that include corresponding feed information. Therefore, we combined Quebec's DHIA (Valacta, Sainte-Anne-de-Bellevue, Quebec, Canada) feed database with their milk-recording data with the objective of finding relationships between feed and milk components in dairy cattle. We hypothesized that milk yield, composition, and lactation curves are affected by both the type of feeding system and grain used as an energy source.

MATERIALS AND METHODS

More than 15 million test-day records covering a 5-yr period (January 2000 to October 2005) were extracted from the Valacta database. In addition, files containing information on lactation performance, feed composition, feeding systems, and animal characteristics covering the same period were also extracted from the Valacta database. The records obtained from Valacta were converted into SAS files for editing and statistical analyses using SAS software, version 9.3 (SAS Institute, 2011). Several rounds of data editing and file merging were carried out to combine the information on a test-day record basis. The analyses focused on 2 different feeding systems (component and TMR) and on 4 different types of grains fed as energy sources (barley, commercial concentrate, corn grain, and high-moisture corn).

Collection of Feed Information

The methods for collection of feed information have been described in detail elsewhere (Bilal et al., 2016). Briefly, the test-day records contained information on the feed code (representing feed type), estimate of feed intake for each feed, and percentage chemical composition of each feed. The feed information was collected at the farm by trained technicians from Valacta. All herds were tiestall herds, which facilitated individual feeding. Automatic feeders, which weighed and delivered the various concentrates to each cow at various times during the day, were used in 46% of the herds. In the remaining herds, the amounts of the various concentrates delivered to each cow were determined from the number and size of scoops of each concentrate delivered by the dairyman to each cow. The amounts of concentrates fed to each cow in herds with automatic feeders were very accurate; in the remaining herds, amounts fed were less accurate but within 0.5 kg/d. Forages were fed on a group basis, typically consisting of about 15 cows. The amount of forage fed to each cow were estimated by apportioning the amount fed to the group on the basis of the cow's weight, stage of lactation, and production level relative to the group average. In all, 163 different types of feed were represented in the data set, and the average number of different types of feed fed to an individual cow on a test day was 5.7. The chemical composition (DM, CP, ADF, NDF, and RUP) of the various feeds was determined by near-infrared reflectance spectroscopy by Valacta or supplied by the feed supplier/manufacturer; NE_L was determined for each feed by applying a standard prediction equation to the chemical composition of the feed (NRC, 2001).

Data Editing and File Merging

The first step of data editing was to identify and remove outliers for feed chemical composition in the test-day feed file. For each observation (a single feedstuff for a specific herd-cow-test-day), the values for each of the feed composition variables (% DM, CP, RUP, NEL, ADF, NDF, NSC, fat, Ca, P, Mg, K, Na, and Cl) were tested against minimum and maximum values obtained from the Valacta feed reference library. Observations with 1 or more feed composition variables outside predetermined ranges were deleted from the test-day feed file. Subsequently, for any observations with the same