J. Dairy Sci. 96:1–11
http://dx.doi.org/10.3168/jds.2013-6771

Subacute ruminal acidosis and total mixed ration preference in lactating dairy cows[1]

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ABSTRACT

Subacute ruminal acidosis (SARA) is a condition where the pH of the rumen becomes abnormally acidic because of increased and altered production of volatile fatty acids. The objective of this experiment was to determine how a SARA challenge affects total mixed ration selection in dairy cows. In this study, 8 multiparous, lactating, ruminally cannulated Holstein cows were given a choice between a long-forage-particle-size diet with slow-fermenting starch (LC) and a short-forage-particle-size diet with fast-fermenting starch in a crossover design. Cows were allowed to adapt to this feeding scheme and were then subjected to a rumen challenge to induce a bout of SARA. The rumen challenge successfully decreased rumen pH and altered rumen volatile fatty acid profiles. Daily average rumen pH decreased from 6.02 to 5.77, and average minimum rumen pH decreased from 5.59 to 5.28. In addition, following the rumen challenge, concentrations of acetate, butyrate, and valerate, and acetate-to-propionate ratio increased. In response to the rumen challenge, intake of LC increased from the baseline level of 18.1% of total daily dry matter intake to 38.3% for that day. During the first recovery day after the rumen challenge, LC intake moderated to 28.0% of total daily dry matter intake. On the second recovery day, LC intake returned to baseline levels at 18.6%. These results indicate that cows are able to alter their diet preference for higher physically effective fiber and slower starch fermentability during a bout of SARA and that they can effectively fully recover from this type of SARA within 72 h when appropriate diets are available.

Key words: acidosis, diet selection, particle size, sorting

INTRODUCTION

Subacute ruminal acidosis is a major concern in the modern high-producing dairy cow. It is defined as a moderately depressed rumen pH in the range of 5.5 to 5.0 (Nocek, 1997; Krause and Oetzel, 2006). Krause and Oetzel (2006) suggested that 3 major causes of SARA exist in dairy herds: excessive intake of rapidly fermentable carbohydrates, inadequate ruminal adaptation to a highly fermentable diet, and inadequate ruminal buffering caused by inadequate dietary fiber or inadequate physical fiber. The negative effects of SARA are vast and varied; ranging from decreased DMI (Britton and Stock, 1987; Nocek, 1997) and reduced feed efficiency (Huntington, 1993; Nocek, 1997) to decreased milk fat yield (Nocek, 1997) and contributing to lameness (Nocek, 1997; NRC, 2001; Stone, 2004). A study that evaluated 154 cows in 14 Wisconsin dairy herds determined that 20.1% of lactating cows had SARA when tested using rumenocentesis (Oetzel et al., 1999). In a case study of a 500-cow dairy in central New York State, Stone (1999) estimated that SARA could cost up to $475/cow per year in lost milk production and components only. Clearly, SARA warrants extensive research and management.

Several studies have examined diet and feed selection changes when sheep or lambs were subjected to acidotic rumen conditions. For example, in a study by Phy and Provenza (1998b), lambs were fed a meal of rolled barley and then offered a choice of flavored (onion or oregano) rabbit pellets that either contained $NaHCO_3$ and lasalocid or NaCl. The authors determined that after a grain meal, lambs preferred rabbit pellets that contained $NaHCO_3$ and lasalocid over pellets that contained NaCl. Another study by Phy and Provenza (1998a) examined the effect that eating a meal of rapidly fermentable feed had on the preference for rapidly fermentable feed later in the day. Lambs fed a lower amount (400 g) of rolled barley for a meal exhibited equal preference for rolled barley and alfalfa pellets (52 and 48% of total intake respectively) during the next 4 h. However, when a higher amount (1,200 g) of rolled barley was fed, the lambs increased their preference for alfalfa pellets over rolled barley (71 and 29% of total

Received March 7, 2013.
Accepted June 26, 2013.
[1]This research was a component of NC-1042, Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprise.
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intake, respectively) during this same time (Phy and Provenza, 1998a). All of these results show that lambs prefer feeds that attenuate acidosis after a grain meal to maintain ruminal health.

In addition, studies have examined the influence of SARA in dairy cows on eating behavior. Keunen et al. (2002) conducted an experiment where 25% of DMI of cows being fed a TMR was replaced by wheat and barley pellets to induce SARA. The choice of 2 feeds (long alfalfa hay and alfalfa pellets) was then offered 2 times per day for 30 min each. Cows with SARA increased their consumption of long alfalfa hay over alfalfa pellets compared with their consumption without SARA; 85 and 60% of test feeds were consumed as long alfalfa hay for SARA and non-SARA cows, respectively (Keunen et al., 2002). DeVries et al. (2008) used a rumen challenge model to induce SARA in early and mid-lactation Holstein cows. The rumen challenge consisted of restricting feed to 50% of ad libitum DMI for 1 d and then feeding 4 kg of barley and wheat, after which cows had ad libitum access to TMR. Changes in eating behavior were measured by determining the particle size distribution of offered feed and refusals and calculating a selection index for each particle fraction. After the rumen challenge, cows in both groups changed their sorting behavior. DeVries et al. (2008) determined that early lactation cows generally increased their sorting for medium particles and against short and fine particles and exhibited no change in sorting long particles. Mid-lactation cows exhibited variable responses with sorting activity changing with day and period. DeVries et al. (2008) suggested that both early and mid-lactation cows altered their sorting behavior to consume a diet that would help attenuate their bout of SARA.

Despite evidence of dairy cattle altering their eating behavior or diet choice based on their rumen environment, no research has been published where cattle had access to 2 distinct diets to observe the influence of SARA on diet preference and eating behavior. Therefore, the objective of this experiment was to induce a bout of SARA in lactating dairy cows that had ad libitum access to 2 distinct diets that varied in forage particle size and starch fermentability and to determine how SARA affects TMR selection in dairy cows.

MATERIALS AND METHODS

Diets, Cows, and Experimental Design

Cows used in this research were cared for and maintained according to a protocol approved by The Pennsylvania State University Institutional Animal Care and Use Committee (University Park). Eight lactating, multiparous, ruminally cannulated, Holstein cows averaging 219 ± 61 DIM and 44 ± 7 kg of milk production/d, weighing 702 ± 56 kg, and with parity of 3.13 ± 0.99 (mean ± SD) were studied. The trial consisted of two 7-d adaptation periods, followed by 8-d collection periods in a crossover design.

For the duration of the study, cows were fed 2 different diets simultaneously: a long-particle-size-diet with slowly fermentable starch (**LC**) and a short-particle-size-diet with fast starch fermentability (**SF**). Diets were offered to cows in tie-stall feed bunks divided into halves via a plywood panel that eliminated cross-contamination of TMR. The side of the feed bunk that the diets were offered was alternated each day to limit the possibility for bias of bunk location or relationship to water bowls. The 2 rations fed contained identical ingredients and proportions, but varied in the particle length of corn silage and the particle size of dry ground corn. The LC diet included long corn silage (**LCSLG**) and dry cracked corn (**CC**) and the SF diet included short corn silage (**SCSLG**) and dry fine ground corn (**FC**). Ingredients and their percentage of ration DM were corn silage (42.6), dry ground corn (22.2), alfalfa haylage (15.4), canola meal (9.4), roasted split soybeans (7.1), mineral/vitamin mix (2.5), salt (0.4), and Optigen (Alltech Inc., Nicholasville, KY; 0.4).

The corn silage hybrid was Pioneer 34M78 (Pioneer Hi-Bred International Inc., Johnston, IA) that was planted on April 19, 2010, and harvested on August 30, 2010. Corn silage was harvested with a John Deere 6750 forage harvester (John Deere, Moline, IL) equipped with a kernel processor set at approximately 6.35 mm. The cutterhead of the harvester used 16 knives (maximum capacity is 48 knives) with the length-of-cut transmission at its highest setting to produce a theoretical length of cut of 47.1 mm. After harvesting, corn silage was ensiled in an Ag-Bag (Ag-Bag, St. Nazianz, WI) and allowed to ferment for 62 d before beginning the study. Corn silage that was removed from the Ag-Bag and mixed into TMR without further processing was considered LCSLG. A cut-and-throw type, single-row forage harvester that was modified to operate on a trailer and be fed manually with a 25 horsepower V-Twin small gas engine was used to reduce the particle size of corn silage to produce SCSLG. Corn silage was rechopped twice through the custom forage chopper on a daily basis to minimize the chemical variance between LCSLG and SCSLG. Dry corn was ground through a Roskamp roller mill (California Pellet Mill Co., Crawfordsville, IN) to produce the CC used in this study. This corn was then ground further with a Case International 1250 grinder-mixer (Case IH, Racine, WI) using a 3.18-mm screen to produce FC. Diets were mixed