J. Dairy Sci. 98:1–13
http://dx.doi.org/10.3168/jds.2014-8103

Effect of corn silage particle size and supplemental hay on rumen pH and feed preference by dairy cows fed high-starch diets[1]

A. D. Kmicikewycz and A. J. Heinrichs[2]
Department of Animal Science, The Pennsylvania State University, University Park 16802

ABSTRACT

The objectives of this experiment were to determine the effects of corn silage particle size and supplemental hay on rumen pH and feed preference in lactating dairy cows experiencing a bout of subacute ruminal acidosis (SARA). In this study, 12 lactating (8 ruminally cannulated), multiparous Holstein cows averaging 91 ± 40 d in milk and weighing 695 ± 95 kg (mean ± SD) were randomly assigned to a replicated 4 × 4 Latin square. During each of the four 21-d periods, animals were offered 1 of 4 diets that were chemically similar but varied in corn silage particle size and supplemental second cutting orchardgrass hay: short corn silage total mixed ration (TMR; ST); short corn silage TMR with 5.6% supplemental hay (SH); long corn silage TMR (L); and long corn silage TMR with 5.6% supplemental hay (LH). Cows were allowed to adapt to this feeding scheme for 14 d, and cannulated cows were then subjected to a rumen challenge to induce a bout of SARA by restricting feed before the challenge and providing 4 kg of ground wheat via the rumen cannula. Although baseline pH was low, the SARA challenge lowered ruminal pH further for all cows regardless of diet. Daily average rumen pH decreased from 5.44 and 5.45 to 5.33 and 5.38 for ST and SH, respectively, and from 5.64 and 5.54 to 5.47 and 5.39 for L and LH, respectively, from baseline to challenge phase. Following the rumen challenge, rumen concentrations of acetate, propionate, butyrate, and valerate increased. Decreasing corn silage particle size significantly increased TMR and total DMI during all phases of the model. Feeding short corn silage TMR increased milk, protein, and lactose yields. Cows fed supplemental hay had increased fat yield and protein concentration in the milk and responded minimally to the effects of particle size selection when challenged with SARA. Cows consuming short corn silage TMR changed feed preference for longer forage particles during the course of the SARA challenge. During the recovery phase, however, cows refused an average of 13.5% of the offered TMR and 78.7% of the supplemental hay. These results indicate that cows did not prefer the supplemental hay regardless of corn silage particle size during a bout of SARA, which may have been due to the possible adaptation of a low ruminal pH throughout the study.

Key words: acidosis, diet selection, particle size, ruminal pH

INTRODUCTION

High-producing dairy cattle require large amounts of dietary energy to meet the demands of increased milk production. In the United States, to accommodate this energy requirement, it has often been economical for producers to feed large amounts of cereal grains to provide energy to rumen microbes and their host. Cereal grains contain large quantities of highly fermentable carbohydrates that can result in a build-up of organic acids in the rumen and reduce rumen buffering (Kleen et al., 2003; Stone, 2004), causing a depression in rumen pH. Subacute ruminal acidosis occurs when rumen pH is below 5.5 for more than 3 h/d (Kleen et al., 2003; Stone, 2004; Gozho et al., 2005).

Subacute ruminal acidosis is a prevalent problem in the United States and an economic concern for producers. In a case study conducted on a 500-cow New York farm, Stone (1999) calculated a cost of $400 to $475 lost income per cow per year due to SARA. Based on reduced milk yield and efficiency of production, premature culling, and death loss (Krause and Oetzel, 2005), it has been estimated that SARA costs the US dairy industry $500 million to $1 billion/yr, with a cost per affected cow of $1.12/d (Enemark, 2008). Based on the substantial economic and health effects of SARA, it has grown to be an important nutritional disorder of dairy cattle and requires critical attention and management.

Simulating SARA conditions by withholding feed for 12 to 24 h or reducing intake has been studied to move toward solutions to this costly disorder (Keunen et al., 2002; Dohme et al., 2008; Krause et al., 2009). Ruminants will select a diet to help maintain a healthy

Received March 3, 2014.
Accepted October 2, 2014.
[1]This research is a component of NC-2042; Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.
[2]Corresponding author: ajh@psu.edu

ruminal environment when given the opportunity to do so (Cooper et al., 1996). Growing evidence indicates that dairy cows will select feeds with high ruminal buffering capacity in an attempt to attenuate effects of very low ruminal pH. Keunen et al. (2002) demonstrated that lactating dairy cows induced with SARA increased their preference for long alfalfa hay over pelleted alfalfa. DeVries et al. (2008) determined that early lactation cows fed barley silage and chopped grass-legume hay-based diets generally increased their sorting for medium particles and against short and fine particles and exhibited no change in sorting long particles when challenged. Maulfair et al. (2013) simultaneously fed cows either a diet with long corn silage and dry cracked corn or a diet with short corn silage and dry fine ground corn, and cows were then challenged with a bout of SARA. Intake of the long corn silage diet increased from a baseline day of 18.1% of total daily DMI to 38.3% for that day in response to the rumen challenge. These studies suggest that early lactation cows can alter their sorting behavior and diet preference for higher physically effective fiber during a rumen challenge, which may help attenuate the effects of SARA.

Despite evidence of the ability of dairy cattle to alter their eating behavior or diet choice based on their rumen environment, no research has been published observing the influence of SARA on the diet preference and DMI of lactating dairy cows fed diets differing in corn silage particle size and hay availability. Therefore, the objectives of this experiment were to induce a bout of SARA in lactating dairy cows that had ad libitum access to 4 distinct high starch diets that varied in corn silage particle size and supplemental hay and to determine how SARA affects TMR feed preference in lactating dairy cows under this situation.

MATERIALS AND METHODS

Cows, Experimental Design, and Diets

The experimental protocol was reviewed and approved by The Pennsylvania State University Institutional Animal Care and Use Committee (PSU IACUC #39245). Twelve lactating (8 ruminally cannulated), multiparous Holstein cows averaging 91 ± 40 DIM, weighing 695 ± 95 kg (mean ± SD) were used. Animals were housed in individual stalls, milked twice per day at 0500 and 1700 h, and fed once per day at approximately 0800 h for a 10% refusal rate except for the restriction phase of the SARA model. The experimental design consisted of 3 replicated 4 × 4 Latin squares with a 2 × 2 factorial arrangement of treatments. Two squares were composed of ruminally cannulated cows and were used for all rumen measurements, whereas all squares were used for production and intake data.

Cows were randomly assigned to 1 of 4 treatments. Treatments were designed to study the effects of 2 lengths of corn silage and 2 levels of hay supplementation: short corn silage TMR with 0% supplemental hay (**ST**), short corn silage TMR with 5.6% (DM basis) supplemental hay (**SH**), long corn silage TMR with 0% supplemental hay (**L**), and long corn silage TMR with 5.6% supplemental hay (**LH**). Diets were offered to cows in tie-stall feed mangers divided into halves via a plywood panel that eliminated cross-contamination of TMR and supplemental hay. Except for altering corn silage particle size and offering supplemental hay, the 4 treatment diets contained identical ingredients (Table 1). Diet composition was calculated based on the formulated proportions and actual nutrient composition of each ingredient. The supplemental hay was high-quality, unprocessed second cutting orchardgrass (*Dactylis glomerata* L.; Table 2) and was fed at 5.6% of the TMR on a DM basis at 0800 h. Dietary starch concentrations for long corn silage TMR was 26.0% (dry basis) and 29.4% for short corn silage TMR. Rations were balanced to meet or exceed NRC (2001) requirements for cows producing 52.2 kg of milk/d containing 3.4% fat and 3.0% true protein assuming a DMI of 29.1 kg/d. Water was available for ad libitum consumption. Feed was pushed up 4 times per day at 1230, 1600, 2400, and 0200 h.

The corn silage variety used in this study was Dekalb DKC 52–59 (Monsanto Company, St. Louis, MO) and was planted on May 12, 2011, and harvested on September 19, 2011. Corn silage was harvested with a John Deere 6750 self-propelled forage harvester (John Deere, Moline, IL). The cutterhead of the harvester used 12 and 48 knives (maximum capacity is 48 knives) with the length-of-cut transmission at its highest setting to produce a theoretical length of cut of 62.7 and 5.33 mm for the long and short corn silage, respectively. After harvesting, corn silage was ensiled in an Ag-Bag (Ag-Bag, St. Nazianz, WI) and allowed to ferment 7 mo before being fed.

The study consisted of four 21-d periods with 14 d of adaptation followed by a 7-d collection period. Dry matter intake of the 3 consecutive days immediately following the adaptation phase (d 15 to 17) was averaged to determine baseline DMI and designated as the baseline phase. Baseline feed preference and rumen conditions were determined on d 17. On d 18, feed intake for all cows was restricted to 75% of the previous day's TMR intake. Following feed restriction, on d 19 at 0745 h, 4 kg (as fed) of finely ground wheat was thoroughly mixed into the rumen digesta of 8 cows via the rumen cannulas, initiating SARA and providing a