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Hay to Reduce Dietary Cation-Anion Difference for Dry Dairy Cows

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ABSTRACT

Timothy grass has a lower dietary cation-anion difference [DCAD = (Na + K) – (Cl + S)] than other cool-season grass species. Growing timothy on low-K soils and fertilizing it with $CaCl_2$ could further decrease its DCAD. The objective of this study was to evaluate the effects of feeding low-DCAD timothy hay on dry dairy cows. Six nonpregnant and nonlactating cows were used in a replicated 3 × 3 Latin square. Treatments were as follows: 1) control diet (control; DCAD = 296 mEq/kg of dry matter); 2) low-DCAD diet based on low-DCAD timothy hay (L-HAY; DCAD = –24 mEq/kg of dry matter); and 3) low-DCAD diet using HCl (L-HCl; DCAD = –19 mEq/kg of dry matter). Decreasing DCAD with L-HAY had no effect on dry matter intake (11.8 kg/d) or dry matter digestibility (71.5%). Urine pH decreased from 8.21 to 5.89 when L-HAY was fed instead of the control. Blood parameters that decreased with L-HAY were base excess (–0.4 vs. 3.8 m*M*) and HCO_3^- (23 vs. 27 m*M*), and blood parameters that increased were Ca^{2+} (5.3 vs. 5.1 mg/dL), Cl^- (30.5 vs. 29.5 mg/dL), and Na^+ (60.8 vs. 60.1 mg/dL). Compared with the control, L-HAY resulted in more Ca in urine (13.4 vs. 1.2 g/d). Comparing L-HAY with L-HCl, cow dry matter intake tended to be higher (11.5 vs. 9.8 kg/d), and blood pH was higher (7.37 vs. 7.31). Urine pH; total dry matter; Ca, K, P, and Mg apparent absorption; and Ca, K, Na, Cl, S, P, and Mg apparent retention were similar. Absorption as a percentage of intake of Na and Cl was lower for L-HAY as compared with L-HCl. In an EDTA-challenge test, cows fed L-HAY regained their initial level of blood Ca^{2+} twice as quickly as the control treatment (339 vs. 708 min); there were no differences between L-HAY and L-HCl. This experiment confirms that feeding low-DCAD hay is an effective means of decreasing the DCAD of rations and obtaining a metabolic response in dry dairy cows.

Key words: dietary cation-anion difference, nonlactating cow, hay, blood calcium

INTRODUCTION

Clinical hypocalcemia, also known as milk fever, is a widespread metabolic disorder that affects about 5.2% of dairy cows at calving (USDA, 2002). This condition can be fatal if not treated, and cows with milk fever are susceptible to other metabolic disorders, including retained fetal placenta, displaced abomasums, and mastitis (Curtis et al., 1983; Gröhn et al., 1989), as well as decreased milk yield (Block, 1984). The subclinical form of milk fever affects 50% of all cows at calving and 66% of those in their third lactation or greater (Beede et al., 1992). Up to 22% are still deficient in Ca 10 d after calving (Goff et al., 1996). Subclinical hypocalcemia may also increase the risk of dairy cows developing other metabolic disorders (Huber et al., 1981; Oetzel et al., 1988).

Decreasing the DCAD of precalving rations can reduce the incidence of milk fever (Dishington, 1975; Charbonneau et al., 2006). Anionic salts (Vagnoni and Oetzel, 1998), commercial products (Vagnoni and Oetzel, 1998), and HCl (Goff and Horst, 1998; Goff et al., 2004) have all proven effective at reducing the DCAD of dry cow diets. Horst and Goff (1997) and Horst et al. (1997) suggested that decreasing the amount of K in forage fed to cows before calving can also prevent hypocalcemia. Tremblay et al. (2006), in comparing 5 cool-season grasses, concluded that timothy had the lowest DCAD. Fertilizing with chloride could further decrease timothy hay DCAD (Pelletier et al., 2007).

There is limited research on the absorption and retention of minerals by dry cows in relation to DCAD. Most studies examine Ca, Mg, and P absorption and retention and do not relate marked differences to DCAD (Wang and Beede, 1990; Kume et al., 2001). Schonewille et al. (1994b) evaluated the apparent absorption of Ca, Mg, and P for diets with high (276 mEq/kg) and low DCAD (–170 mEq/kg) and found an increase in Ca absorption, and a tendency for increased Mg absorption, in cows fed a low-DCAD diet. Two studies (Leclerc and Block, 1989; Delaquis and Block, 1995) reported the

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apparent absorption and retention of Ca, Mg, P, Na, K, Cl, and S. In those experiments, all diet treatments had a positive DCAD. Leclerc and Block (1989) measured the apparent absorption of minerals over a long duration (pre- and postcalving). Delaquis and Block (1995) tested a slight variation in DCAD (481 vs. 327 mEq/kg). In both studies, only small differences were observed in apparent absorption and retention of the minerals. Further research is needed to determine how mineral absorption and retention relates to DCAD difference in dry cow rations.

The objective of our study was to evaluate the effects of a low-DCAD timothy hay diet on DMI, acid-base metabolism, and apparent absorption and retention of minerals in dry dairy cows. Our hypothesis was that timothy hay fertilized with $CaCl_2$ would be as effective as HCl at lowering the DCAD of dry cow rations and preventing hypocalcemia. Dry dairy cows were fed normal- or low-DCAD timothy hay to evaluate the effects of low-DCAD hay on DMI and blood and urine components. The low-DCAD timothy hay treatment was also compared with a positive control treatment that used HCl to decrease DCAD. The apparent digestibility of fiber, N, and minerals, as well as the apparent retention of N and minerals, was evaluated for all 3 treatments.

MATERIALS AND METHODS

Hay Production

Two types of timothy hay were produced on 2 different fields. Low-DCAD hay was produced on a field with low soil K content (101 kg/ha), and high-DCAD hay was produced on a field with a soil K content of 289 kg/ha. Before the start of spring growth, both fields received 80 kg of N/ha, and, based on the recommendations of Pelletier et al. (2007), the field for low-DCAD hay received 140 kg of Cl/ha as $CaCl_2$. Hay from spring growth was cut at the early heading stage and conserved in small bales in a barn equipped with a hay drier.

Cows, Diets, and Experimental Design

Six multiparous nonpregnant and nonlactating Holstein cows were used in a replicated 3 × 3 Latin square design with 2-wk periods. All cows were fed, as TMR, chopped timothy hay, ground corn, corn gluten meal, and a mixture of vitamins and minerals. Treatments were (Table 1) as follows: 1) high-DCAD diet (control); 2) low-DCAD diet, using only low-DCAD hay as forage (L-HAY); and 3) low-DCAD diet, using HCl to decrease the DCAD of the control diet (L-HCl). To prevent excessive DMI depression, rations should not exceed a maximal DCAD diminution of 2,300 mEq/d that can be achieved using anionic salts (Oetzel and Barmore, 1993). For that reason, low-DCAD hay had to be mixed to high-DCAD timothy hay in the control and L-HCl diets (Table 1); diets formulated with only the high-DCAD timothy hay obtained a DCAD too high to be decreased with HCl alone to the same level as L-HAY. Content differences between hay were also diminished using this mixture, which made the control and L-HAY treatments more comparable in terms of chemical composition (Table 2). Concentrated HCl was diluted with water and molasses (acid:water:molasses; 10:10:4.5, vol/vol/vol) twice a week and added daily to the L-HCl diet. Cows fed control and L-HAY received the same proportion of water and molasses (water:molasses; 10:4.5, vol/vol) in their diet as the cows on L-HCl. Diets were formulated based on NRC (2001) recommendations for transition cows; they all provided a similar level of NE_L (1.48 Mcal/kg) and CP (14.6%). Rations were fed once a day, in the morning, to provide 10% orts on an as-fed basis according to the intake of the previous day. Before the experiment began, a 2-wk acclimation period was set aside for cow adaptation to the experimental feeds. The experimental protocol was approved by the Laval University Animal Care Committee, and animals were cared for according to the guidelines of the Canadian Council of Animal Care (1993).

Table 1. Ingredients of experimental diets[1] (%, DM basis)

Item	Control	L-HAY	L-HCl
High-DCAD hay	55.5	0	54.9
Low-DCAD hay	23.0	78.5	22.7
Ground corn	14.6	14.6	14.4
Corn gluten meal	5.2	5.2	5.1
Molasses	1.1	1.1	1.1
HCl	0	0	1.1
Vitamins and minerals[2]	0.6	0.6	0.6

[1]Control = high-DCAD treatment; L-HAY = low-DCAD treatment using low-DCAD hay; L-HCl = low-DCAD treatment using HCl.

[2]Mineral composition: Ca = 16.28%; *P* = 0.01%; Na = 14.96%; Cl = 23.04%; Mg = 0.88%; K = 0.05%; S = 0.02%; Cu = 993 mg/kg; Mn = 4 mg/kg; Zn = 3,599 mg/kg; Fe = 1,500 mg/kg; Co = 8.28 mg/kg; I = 66.23 mg/kg; Se = 110.08 mg/kg; vitamin A = 1,382 UI/kg; vitamin D = 264 UI/kg; vitamin E = 13,418 UI/kg.

Measurements and Sampling

Forage, TMR, Orts, and BW. Feed intake was recorded daily. Forages and TMR were sampled on d 8, 9, and 10 of each period, and orts were sampled the following day. Samples were kept at –20°C for chemical analysis. Cow BW was recorded twice: at d 11 and 14 of each period.

Feces. Total fecal excreted was weighed and sampled twice daily: 10 h postfeeding and at feeding the next morning on d 8, 9, and 10. The first sample was kept