Short Communication: Effects of Subacute Ruminal Acidosis on Free-Choice Intake of Sodium Bicarbonate in Lactating Dairy Cows

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ABSTRACT

The effect of inducing subacute ruminal acidosis (SARA) on the free-choice intake of sodium bicarbonate (SB) was investigated in four midlactation Holstein cows in a switchover experiment with four 1-wk periods. The SARA was induced by replacing 25% of the ad libitum intake of total mixed ration (TMR) with pellets containing 50% ground wheat and 50% ground barley and restricting access to TMR from 0700 to 1700 h. Control consisted of feeding TMR ad libitum. Powdered SB was provided for ad libitum consumption. Rumen pH was measured continuously using indwelling pH probes. Induction of SARA reduced ($P < 0.05$) the average daily rumen pH from 6.08 to 5.87, increased ($P < 0.05$) the average duration of rumen pH below 6 from 547 min·d⁻¹ to 916 min·d⁻¹, and increased ($P < 0.05$) the average duration of rumen pH below 5.6 from 132 min·d⁻¹ to 397 min·d⁻¹ ($P < 0.05$) but did not significantly affect SB intake. Average intake of SB was 26.8 g·d⁻¹ during SARA and 34.5 g·d⁻¹ during control. These low SB intakes must not have substantially affected rumen pH. Sodium bicarbonate intake differed significantly ($P < 0.05$) between cows. These data indicate that cows did not select SB in order to attenuate SARA. (**Key words:** subacute ruminal acidosis, sodium bicarbonate, feed intake, dairy cow)

Abbreviation key: SARA = subacute ruminal acidosis, SB = sodium bicarbonate.

Subacute ruminal acidosis (**SARA**) is a common and economically important metabolic disorder of dairy cattle (Nocek, 1997; Garret et al., 1999). Due to the difficulty in diagnosing SARA, limited information on the incidence of this disorder exists (Garret et al., 1999). However, Oetzel et al. (1999) found an incidence of SARA of 20.1% in cows between 1 and 120 DIM on commercial dairy farms in Wisconsin. The SARA commonly occurs in early lactation dairy cows when the rumen has not yet adapted from a switch from a forage-based to a concentrate-based diet (Burrin and Britton, 1986; Britton and Stock, 1987). Fermentation of non-structural carbohydrates, such as starches and sugars, leads to production of large quantities of VFA and lactate that can accumulate in the rumen and subsequently decrease rumen pH (Briggs et al., 1957; Rumsey et al., 1970).

Sodium bicarbonate (**SB**) is a weak base that buffers hydrogen ions of organic acids (Ha et al., 1983). Dietary SB increases rumen pH and prevents rumen epithelium damage and ruminal stasis that often accompanies SARA (Kezar and Church, 1979). Studies involving SB in the diet of dairy cows have shown varying degrees of success in maintaining or increasing feed intake (Erdman, 1988).

Induction of SARA in lactating dairy cows increases the preference of long alfalfa hay over pelleted alfalfa (Keunen et al., 2002). As intake of long hay will result in more saliva production and rumen buffering than intake of pelleted alfalfa, this indicates that cows select feeds with high rumen buffering capacity in an attempt to prevent SARA. It has been proposed that ruminants increase their intake of SB in order to prevent low rumen pH. Cooper et al. (1995) suggested that ruminants will alter diet selection to attempt to correct manipulated decreases in rumen pH and increases in rumen osmolality. However, other studies have shown varying degrees of preference for SB (Cooper et al., 1996; Phy

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and Provenza, 1998a,b; James and Kyriazakis, 1999; Cumby et al., 2001). Of these, only Cumby et al. (2001) have done work involving SARA and dairy cows, using a pelleted form of SB. Anecdotal accounts suggest that cattle and sheep fed high-grain diets will readily consume powdered SB offered free choice (Phy and Provenza, 1998a). To date, to the best of our knowledge, no studies have been performed that have given the dairy cow ad libitum access to powdered SB during bouts of SARA. Given the results of Cooper et al. (1995) and Phy and Provenza (1998a,b), we hypothesized that inducing SARA in dairy cows would increase their intake of powdered SB offered free choice.

Four multiparous, ruminally fistulated Holstein dairy cows were housed in individual tie stalls at the Elora Dairy Research Centre in accordance with the guidelines of the Canadian Council of Animal Care. Cows averaged 691 ± 86 kg of BW and 175 ± 57 DIM at the beginning of the experiment. Average milk yield at the start of the experiment was 31 ± 6.7 kg·d⁻¹. The experiment was conducted as a switchover design with four periods of 1 wk. During each period, SARA was induced in two cows according to the protocol described by Keunen et al. (2002). The other two cows received a TMR for ad libitum intake (control). Each subsequent week treatments were switched. The SARA was induced by replacing 25% of the TMR DMI measured in the previous period with an equal amount of DM from grain pellets (50% wheat:50% barley) and restricting the availability of TMR between 0700 and 1700 h (Keunen et al., 2002).

Cows received a TMR that did not contain SB and had ad libitum access to fresh water. The TMR consisted of (as-fed basis) 46.0% corn silage, 16.5% high moisture corn, 19.0% mixed haylage, 5.0% mixed hay, and 13.5% lactating cow supplement. The lactating cow supplement contained (as-fed basis), 28.2% soybean hulls, 5.7% blood meal, 7.3% corn gluten meal, 11.5% soybean meal, 2.65% dicalcium phosphate, 3.2% calcium carbonate, 0.6% magnesium oxide, 1.7% salt, 1.3% Dynamate (22% S, 18% K, 11% Mg, IMC Feed Ingredients, Lake Forest, IL), 0.4% Dairyman's Edge (Yeast, LBJ Pakke Inc., Waddington, NY), 0.3% FFM Micro premix (dicalcium phosphate, calcium carbonate, magnesium oxide, trace minerals, vitamin A, vitamin D, vitamin E, Floradale Feedmill, Floradale, ON), 8.6% wheat shorts, 2.9% fish meal, 3.6% molasses, 0.2% Alimet (DL-Methionine Hydroxy Analogue, Novus, St. Louis, MO) 7.2% wheat grain, and 14.3% roasted soybeans. Feed intakes were determined daily and representative feed andorts samples were taken each day. The TMR samples were pooled by week and orts samples were pooled by weight for cow and week. The DM content of these samples were determined by drying in a 60°C oven for 48 h

(AOAC, 1990). The TMR samples were also analyzed for CP using the macro-Kjeldahl procedure (AOAC, 1990), ADF (AOAC, 1990), and NDF (Goering and Van Soest, 1970). Milk yields were recorded daily throughout the entire experiment.

Rumen pH was monitored continuously via in-dwelling pH probes using the method described by Cumby et al. (2001). Rumen pH was measured every second, but only average values over 60 s were stored and used for subsequent analysis. These data were summarized by calculating average pH, time below pH 6, and time below pH 5.6 area (time $\times$ pH below pH 6 and area below pH 5.6) for each 24-h period.

Each cow had its own 7.5-L bucket filled with SB (Arm & Hammer feed grade, Church and Dwight Co., Inc.) attached to a partition on one side of the feed manger throughout the experiment. The side of the manger that held the bucket was randomized before the start of the experiment to remove bias as to side of preference. In the week before the experiment, cows were allowed access to their bucket filled with SB so that animals were familiar with the bucket and its contents and to ensure that cows could readily access the SB. Spillage of SB was minimized by filling not more than the bottom 20% of the bucket with SB. During the experiment, cows had continuous access to the SB except for 1 h·d⁻¹ (0900 to 1000 h), where SB intake was determined for each cow. Each day cows received 600 g of fresh, dry SB in their bucket between 0900 and 1000 h. The following day, each bucket was removed and daily intake of SB was determined, with the remaining sample of SB put in a 60°C oven for 48 h to determine the DM. Daily DM intake of the SB was determined by subtracting the remaining dry SB from the initial known amount of SB (i.e., 600 g) at 100% DM.

Analysis of variance of weekly averages of pH data, SB intakes, DMI, and milk yields for each cow was conducted using the general linear models procedure (SAS, 1990) using a model for a crossover design with cow, diet, and week as fixed effects. A probability level of less than 0.05 was considered significant.

The TMR hay had a composition of (DM basis) 50.4% DM, 15.4% CP, 36.2% NDF, and 23.6% ADF. The wheat and barley pellet had a composition of (DM basis) 87.3% DM, 12.5% CP, 16.4% NDF, and 4.2% ADF.

Induction of SARA resulted in a significant drop ($P < 0.05$) in average daily rumen pH of 0.22 units (Table 1) and increased the duration of time with rumen pH below 6.0 from 547 ± 63.4 min to 915.7 ± 63.4 min. Duration of time with rumen pH below 5.6 was also increased from 131.9 ± 36.1 min to 397.0 ± 36.1 min. Cows on the SARA model also had a significantly greater area (min $\times$ pH·d⁻¹) below pH 6 (353.0 ± 31.9 vs. 151.8 ± 31.9) and below pH 5.6 (86.2 ± 12.5 vs. 30.3

Table 1. Summary of DMI and daily averages of continuous pH data by treatment.

	SARA ¹	Control	SE
DMI, kg·d ⁻¹	21.0	20.2	0.4
Average SB ² intake, g·d ⁻¹	26.8	34.5	3.6
Average pH	5.86 ^a	6.08 ^b	0.04
Time < pH 6.0, min·d ⁻¹	915.7 ^a	546.9 ^b	63.4
Area < pH 6.0, min × pH·d ⁻¹	353.0 ^w	151.8 ^x	31.9
Time < pH 5.6, min·d ⁻¹	397.0 ^w	131.9 ^x	36.1
Area < pH 5.6, min × pH·d ⁻¹	86.2 ^a	30.3 ^b	12.5

^{a,b}Different superscripts within row indicate $P < 0.05$.

^{w,x}Different superscripts within row indicate $P < 0.005$.

¹Subacute rumen acidosis.

²Sodium bicarbonate.

± 12.5) than the cows on the control treatment ($P < 0.05$). Rumen pH during SARA was similar to that observed in transition dairy cows in the first week postcalving by Plaizier et al. (1999) and that observed in cows experiencing SARA by Cumby et al. (2001) and Keunen et al. (2002). SARA did not significantly affect milk yields. These yields averaged 30.4 ± 0.5 kg·d⁻¹ (mean $\pm$ SE) during SARA and 29.5 ± 0.5 kg·d⁻¹ during control. Inducing SARA also did not significantly affect DMI. Dry matter intake was on average 21.0 ± 0.5 kg·d⁻¹ during SARA and 20.2 ± 0.5 kg·d⁻¹ during control periods (Table 1). Individual cow intakes of SB were highly variable and independent of treatment. SB intake was significantly ($P < 0.05$) different between cows, but inducing SARA did not significantly ($P = 0.17$) affect SB intake (Table 1). Intakes of SB averaged 34.5 ± 3.6 g·d⁻¹ for Control treatment periods and 26.8 ± 3.6 g·d⁻¹ for SARA periods (Table 1).

In the present study, SB was removed from the TMR and the free-choice intake of powdered SB appeared to be too low to provide sufficient rumen buffering and affect rumen pH (NRC, 2001). It is recommended that lactating dairy cows receive 0.6 to 0.8% of DMI buffer (SB) in their diet (~ 200 g·d⁻¹) (NRC, 2001). Only on 1 d during the entire experiment did one cow have a SB intake level (206 g) that would meet the recommended level of SB in the diet (0.9% SB of their DMI).

The nutritional model used to induce SARA in his study was also used by Plaizier et al. (2001), Keunen et al. (2002), and Krajcarski-Hunt et al. (2002). This induction of SARA reduced DM and NDF digestibility (Plaizier et al., 2001; Krajcarski-Hunt et al., 2002) and increased the preference for long alfalfa hay compared with pelleted alfalfa (Keunen et al., 2002). Hence, this level of SARA elicited animal responses.

Phy and Provenza (1998a) found that after feeding rolled barley, lambs preferred pellets with SB (2% as-fed basis) to pellets with sodium chloride and that following the consumption of a high-wheat diet, lambs increased their intake of SB in solution (2%). Phy and

Provenza (1998b) showed that intake of SB was effective in attenuating depressed feed intake associated with excessive consumption of rolled barley. Although rumen conditions were not measured in these studies, their findings suggest that a reduction of rumen pH increases the preference for SB.

Cooper et al. (1996) showed that inclusion of SB into high-energy density increased the feed intake of sheep. However, James and Kyriazakis (1999) observed that inclusion of 4% SB had no effect on diet selection in sheep offered a low- or a high-energy density feed. Cumby et al. (2001) induced SARA and gave cows the choice between pelleted feeds that contained either 4% SB or 4.5% NaCl. Cows preferred SB pellets over salt pellets and consumed on average 298 g·d⁻¹ of SB through the pellets. However, SB preference might have been due to aversion to the salt pellets, as after the removal of salt from the control pellets, cows preferred control pellets to SB pellets (J. L. Cumby, J. C. Plaizier, I. Kyriazakis, and B. W. McBride, unpublished observations). This would suggest adverse organoleptic properties of SB.

In the current study, the intake of SB was not sufficient enough in magnitude or duration to sufficiently impact the rumen pH and affect diet selection. Therefore, inadequate positive reinforcement would be present for the cows to select SB again and overcome the adverse organoleptic properties of the SB. Lack of SB preference was likely not due to insufficient rumen pH depression, as similar pH depression affected diet choice in previous studies.

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