INFLUENCE OF INFUSION DOSE OF SODIUM BICARBONATE ON PERFORMANCE OF LACTATING DAIRY COWS

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Story in Brief

Four ruminally cannulated, lactating Holstein cows were assigned to a 4x4 Latin square to monitor the effects of intraruminal sodium bicarbonate infusion on lactational performance. Cows were infused with 3.8 liters of water or sodium bicarbonate (110, 220, or 330 grams) dissolved in 3.8 liters of water, twice daily; infusion was administered at a constant rate from 2 to 4 hours postfeeding. All cows had access to their diet containing sorghum silage and concentrate in a 35:65 ratio (dry matter basis) for 2 hours, twice daily. Although milk yield tended to increase linearly with increasing sodium bicarbonate infusion dose, other measures of lactational performance generally were not affected by sodium bicarbonate infusion. This suggests that the influence of this buffer may vary, depending upon the route of admininstration.

(Key Words: Sodium Bicarbonate, Dairy Cow, Milk, Intake.)

Introduction

Previous studies have evaluated the influence of intraruminal infusion of sodium bicarbonate on ruminal fluid acid-base status and lactational performance of dairy cows; these studies were designed specifically to examine various infusion intervals (Hogue et al., 1991) and the presence of supplemental dietary sodium bicarbonate (Aslam et al., 1991). The objective of the present study was to evaluate the influence of the infusion dose of sodium bicarbonate on measures of lactational performance.

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Introduction

Both a low ruminal fluid hydrogen ion concentration (H^+) and a high buffering capacity (BC; resistance to change in H^+) appear important during periods of rapid fermentation in the rumen. A buffer value index (BVI) has been developed (Tucker et al., 1992) which increases when either ruminal fluid H^+ is reduced or BC is increased. Researchers have compared the influence of $NaHCO_3$ to that of a multielement buffer (MEB; Rumen-Mate^R, Pitman-Moore, Terre-Haute, IN) on ruminal acid-base status and lactation performance (Solorzano et al., 1989; Staples et al., 1988). The objective of this study was to evaluate the influence of $NaHCO_3$ and MEB on lactation performance and ruminal acid-base status of dairy cattle as characterized by alterations in the ruminal fluid BVI.

Materials and Methods

Five ruminally fistulated, primiparous and multiparous lactating Holstein cows averaging 123 $\pm$ 21 d postpartum were assigned randomly to treatments in a 5 x 5 Latin square with 3-wk experimental periods. Treatments were a basal diet (Table 1) without supplemental buffers (control), basal diet with 1.5% $NaHCO_3$ (BIC-DT), basal diet with 1.5% MEB (MEB-DT), basal diet with $NaHCO_3$ solution poured into the rumen via cannula twice daily at 2 h postfeeding (BIC-CN), and basal diet with MEB solution poured into the rumen via cannula twice daily at 2 h postfeeding (MEB-CN). The buffer solutions for BIC-CN and MEB-CN were prepared by mixing the respective buffers in 3.8 L of water. The amount of buffer used in each dose was equivalent to .75% of expected total daily DMI as predicted from the average daily DMI from the previous week. Control cows and those receiving dietary buffers were dosed intraruminally with 3.8 L water twice daily at 2 h postfeeding.

Milk yield was measured daily throughout the study; milk samples were collected weekly during consecutive p.m. and a.m. milkings. Ruminal fluid was collected at 30-min intervals for 12 h beginning at 0350 on the last day of each experimental period; this fluid was analyzed immediately for pH, BC and BVI.

Table 1. Ingredient and nutrient composition of diets (DM basis).

	Diet		
Ingredient, %	Basal	$NaHCO_3$	MEB
Sorghum silage	32.04	31.98	31.98
Corn grain, ground	43.96	42.56	42.56
Soybean meal, 44% CP	20.64	20.60	20.60
Sodium bicarbonate	...	1.50	...
MEB[a]	...	...	1.50
Limestone	1.07	1.07	1.07
Dicalcium phosphate	.87	.86	.86
Dynamate[R] [b]	.35	.35	.35
Trace mineralized salt	.54	.53	.53
Megalac[R] [c]	.52	.52	.52
Vitamin A and E premix[d]	.02	.02	.02
Nutrient analyses, %			
DM	45.1	46.5	44.8
CP	15.8	16.7	16.3
NE_L, Mcal/kg[e]	1.74	1.71	1.71
ADF	21.0	19.4	19.8
NDF	31.1	29.7	34.0
Ca	.81	.76	.72
P	.44	.47	.45
Mg	.35	.34	.54
Na	.26	.73	.43
K	1.22	1.18	1.43
S	.31	.27	.36

[a] MEB = multielement buffer, Rumen-Mate[R]; Pitman-Moore, Inc., Mundelein, IL.
[b] Double sulfate of K and Mg; Pitman-Moore, Inc., Mundelein, IL.
[c] Calcium salts of fatty acids; Church & Dwight Co., Inc., Princeton, NJ.
[d] Contains 30 million I.U. Vitamin A and 500,000 I.U. Vitamin E/kg.
[e] Calculated from National Research Council values for individual feedstuffs.

Results and Discussion

Ruminal Fluid Acid-Base Status

Ruminal Fluid H^+. Postprandial alterations in ruminal fluid acid-base status are presented in Table 2. Ruminal fluid H^+ concentration increased for the control diet until 4 to 6 h postfeeding, probably the result of higher concentrations of fermentation acids; after 6 h, H^+ dropped rapidly. Addition of either $NaHCO_3$ or MEB to the diet tended to attenuate the increase in ruminal fluid acidity from 0 to 6 h (Table 2); H^+ tended to be lower for $NaHCO_3$. Although dosing $NaHCO_3$ via ruminal cannula had an immediate effect on ruminal fluid acidity (Table 2), no effect was evident for MEB-CN. The reduction in H^+ accompanying intraruminal infusion of $NaHCO_3$ disappeared within several hours after it was infused. Compared to the control diet, MEB-DT slightly reduced ruminal fluid acidity from 6 to 12 h postfeeding, perhaps a result of slow release of its acid-neutralizing capacity.

Ruminal Fluid Buffering Capacity. Ruminal fluid BC averaged 2 meq/L lower for control cows from 6-12 h than for 0-6 h postfeeding (Table 2). This response is similar to that for BIC-DT and MEB-CN, but BC for MEB-DT increased with time postfeeding, potentially a result of slow release of its buffering chemicals. Ruminal fluid BC decreased by over 6 meq/L from 0 to 6 h to 6 to 12 h postfeeding for BIC-CN; this large reduction may have resulted from a combination of the sharp increase in BC during infusion for this treatment and a feedback response to increased ruminal fluid or plasma osmolarity, inhibiting endogenous buffer secretion. Of the four buffer treatments, dosing $NaHCO_3$ intraruminally at 2 h postfeeding (Table 2) was most effective in maintaining ruminal fluid BC during the 4 to 6 h postfeeding interval during which ruminal fluid acid content typically is highest.

Ruminal Fluid Buffer Value Index. The period from 0 to 2 h postfeeding represents the interval during which ruminal fluid acid-base status is affected most dramatically by dietary acidity. During this interval, each of the buffer treatments tended to increase BVI relative to the control (Table 2), although this response was most evident for BIC-DT.

From 2 to 6 h postfeeding, alterations in ruminal acid-base status likely reflect the production of acid by ruminal fermentation; BVI for the control diet was 5 units lower during this interval than during 0 to 2 h postfeeding (Table 2). The BIC-CN was most effective in maintaining BVI from 2 to 4 h postfeeding, but compared to the control, BIC-DT and MEB-DT also tended to increase BVI; MEB-CN was not effective in maintaining BVI from 2 to 6 h postfeeding.

Buffer additions via the diet or ruminal cannula had no effect on ruminal fluid BVI from 6 to 12 h postfeeding, although BVI tended to be highest for

Table 2. Least squares mean alterations in ruminal fluid acid-base status postfeeding.

	Treatment							
	1 Control	2 Dietary $NaHCO_3$	3 Dietary MEB[a]	4 Cannula $NaHCO_3$	5 Cannula MEB	SE	Effect	*P* value
Ruminal fluid H^+, neq/L								
0-2 h	623	412	564	532	600	85		NS[b]
2-4 h	1051	564	771	465	1153	216	1 vs. 4	.079
4-6 h	1047	638	610	997	1156	250		NS
0-6 h	895	512	625	670	959	156		NS
6-12 h	451	454	387	619	718	164		NS
Ruminal fluid buffering capacity, meq/L								
0-2 h	71.2	74.0	75.6	74.7	72.6	1.6	1 vs. 3	.070
2-4 h	71.0	68.2	67.8	74.3	69.3	1.1	1 vs. 2	.094
							1 vs. 3	.059
							1 vs. 4	.054
4-6 h	68.5	64.0	62.0	69.4	65.7	1.6	1 vs. 2	.078
							1 vs. 3	.016
0-6 h	69.9	68.8	68.2	73.2	69.3	.6	1 vs. 3	.083
							1 vs. 4	.003
6-12 h	67.9	67.7	71.6	67.4	67.9	2.4		NS

Table 2. (Continued)

	Treatment							
	1 Control	2 Dietary $NaHCO_3$	3 Dietary MEB[a]	4 Cannula $NaHCO_3$	5 Cannula MEB	SE	Effect	*P* value
Ruminal fluid buffer value index								
0-2 h	108.0	110.7	109.5	109.6	108.5	1.0	1 vs. 2	.086
2-4 h	103.7	108.0	105.8	110.2	102.3	2.2	1 vs. 4	.055
4-6 h	103.2	106.4	106.3	103.9	101.6	2.4		NS
0-6 h	105.0	108.6	107.4	107.9	104.3	1.6		NS
6-12 h	109.1	109.0	110.5	107.3	106.4	1.9		NS

[a]MEB = multielement buffer.
[b]$P > .10$.

MEB-DT and lowest for MEB-CN (Table 2). The mean ruminal fluid BVI for control cows increased by 4 units from 0 to 6 h, to 6 to 12 h postfeeding; slightly less change was observed for MEB-DT and MEB-CN during this interval. The BVI was very consistent during these two intervals for both $NaHCO_3$ treatments; the change for BIC-DT was only .4 units. We believe that maintaining a stable ruminal acid-base status throughout the postfeeding interval should provide a favorable environment for microbial growth, resulting in increased DMI and milk yield by the cow.

Animal Performance

Dry matter intake was similar for all treatments (Table 3). Milk yield was not affected significantly by treatment, although it was somewhat lower for BIC-DT and MEB-CN. Yield of 4% FCM tended to be highest for MEB-DT and lowest for BIC-DT, with BIC-DT being lower (P = .094) than control. Milk fat percentage tended to be higher for MEB than $NaHCO_3$ diets and was highest for MEB-DT; fat yield tended to be highest for MEB-DT and lowest for BIC-DT. Milk protein content (P = .054) and protein yield (P = .074) were somewhat lower for MEB-CN than for the control cows; the reason for this is not apparent, but addition of MEB to the diet of lactating dairy cows has reduced milk protein content previously (Solorzano et al., 1989). In our study, milk fat percentage tended to be highest for MEB-DT (Table 3).

In summary, addition of either buffer to the diet reduced ruminal fluid hydrogen ion concentration from 0 to 6 h postfeeding. Only $NaHCO_3$ was effective in reducing ruminal fluid acidity when dosed via cannula. Addition of buffers via ruminal cannula retards the drop in ruminal fluid acidity that normally occurs from 6 to 12 h postfeeding; this may be related to a feedback mechanism inhibiting salivary buffer secretion. The ruminal fluid BVI increased for control, MEB-DT and MEB-CN cows from early (0 to 6 h), to later (6 to 12 h) postfeeding; values for $NaHCO_3$ during these two intervals were not changed. Based upon the ruminal fluid BVI, $NaHCO_3$ appeared to provide the most stable ruminal acid-base status throughout the postfeeding interval.

Table 3. Least squares mean DMI, milk yield, and milk composition.

	Treatment							
	1 Control	2 Dietary $NaHCO_3$	3 Dietary MEB[a]	4 Cannula $NaHCO_3$	5 Cannula MEB	SE	Effect	*P* value
DMI, kg	19.4	19.4	19.4	19.0	19.5	.4	NS[b]	
Milk Yield, kg	25.6	24.0	25.7	26.0	24.1	.7	NS	
4% FCM, kg	22.9	21.3	23.6	22.9	21.8	.6	1 vs. 2	.094
Fat, %	3.26	3.19	3.41	3.18	3.35	.08	NS	
Fat, kg	.85	.78	.89	.84	.81	.03	NS	
Protein, %	3.18	3.17	3.17	3.14	3.06	.04	1 vs. 5	.054
Protein, kg	.81	.76	.82	.82	.74	.03	1 vs. 5	.074

[a]MEB = multielement buffer.
[b]$P > .10$.

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