Sodium bicarbonate in dairy rations

Edward J. DePeters □ Alan H. Fredeen □ Donald L. Bath

It's not needed when rations include alfalfa hay

Sodium bicarbonate ($NaHCO_3$) has been used in ruminant diets to buffer rumen conditions under situations of dietary or rumen acid stress. For example, sodium bicarbonate has been added to diets of sheep and cattle entering feedlots because of radical (dietary) adjustments from diets of high roughage to high grain, which are associated with rumen acidosis (reduced pH). However, the efficacy of sodium bicarbonate in buffering the rumen environment is variable.

Sodium bicarbonate has also been used in dairy cattle diets at the beginning of lactation. At 0.7 to 1.5 percent of the diet dry matter, it has improved feed intake and milk yield in early lactation when added to diets based on corn silage as the forage. In addition, improvement in dietary fiber digestibility has sometimes been observed and has been associated with the maintenance of a more favorable rumen pH (6.6 to 6.8) environment for cellulolytic microorganisms. Consequently, sodium bicarbonate can sometimes be partially effective in maintaining normal milk-fat percentages when high grain, milk-fat-depressing diets are fed. Improving the rumen environment for cellulolytic microorganisms shifts the rumen fermentation towards acetic acid production, which is favorable for milk fat synthesis.

There has been little work evaluating sodium bicarbonate in dairy diets based on alfalfa hay as the forage. Alfalfa hay differs from corn silage in at least three aspects that may reduce the need for supplemental buffers: (1) effective fiber level is higher in alfalfa; (2) alfalfa has a higher buffering capacity; and (3) unlike corn silage, alfalfa hay is not acidic when fed.

In these experiments, we added sodium bicarbonate to diets based on alfalfa hay as the forage to evaluate its effects on digestibility of dietary fractions and rumen characteristics when fed to dairy cows in early lactation.

We conducted two experiments at the dairy facility at University of California, Davis. In experiment 1, four Jersey cows in early lactation were fed complete mixed diets containing 0, 0.25, 0.5, and 0.75 percent sodium bicarbonate (table 1) in a Latin square design in which each cow received each diet for 21 days. Diets were 40 percent chopped alfalfa and 60 percent concentrate. Cows were fed and milked twice daily, and feed and fecal samples were collected for estimation of diet digestibility. Feed intake and yields of milk and milk components were recorded. Rumen samples were obtained by stomach tube from each cow two hours after feeding.

In experiment 2, four first-calf Holstein cows fitted with permanent rumen fistulas were fed complete mixed diets containing 0, 0.4, 0.8, and 1.2 percent sodium bicarbonate. Diets of 30 percent chopped alfalfa and 70 percent concentrate were fed in a Latin square design. Cows were fed twice daily and milked three times daily. Feed and fecal samples were taken for digestibility determination. Milk samples were collected at each milking. Rumen fluid was sampled at one hour before and at three, six, and nine hours after the morning feeding for each diet and animal.

Within each experiment, the addition of sodium bicarbonate to complete mixed diets containing alfalfa hay did not affect feed intake, milk yield, or milk composition (table 2). Feed intake and milk yield were high and normal for cows in early lactation. In both experiments, milk fat was normal and remained unchanged with sodium bicarbonate addition to the diets.

Apparent digestibility of dietary components was not affected by sodium bicarbonate in either experiment (table 3). In experiment 1, there were no differences in apparent digestibility of dry matter, crude protein, energy, or fiber fractions. Similarly, in experiment 2, apparent digestibility was not significantly affected, although there were small nonsignificant increases in digestibility of cellulose and acid detergent and neutral detergent fiber at 1.2 percent sodium bicarbonate. Previous reported research has shown either no change or an increase in fiber digestibility with sodium bicarbonate addition to diets with corn silage as the forage ingredient.

Molar percentages of rumen fluid volatile fatty acids were not affected by sodium bicarbonate in experiment 1 (table 4). The acetic-to-propionic ratio increased slightly with sodium bicarbonate addition, but all ratios were above the level associated with low milk fat. In experiment 2, molar percentage of acetic acid was markedly elevated and propionic acid was reduced in cows fed the diet containing 0.8 percent sodium bicarbonate when compared with the other diets. As a result, the acetic-to-propionic ratio was also significantly greater for that diet. As in experiment 1, the acetic-to-propionic ratios for all diets were above the level associated with milk fat depression, and milk fat was not affected by sodium bicarbonate addition to diets containing alfalfa.

Rumen pH was significantly affected by sodium bicarbonate addition to the diet (fig. 1). Diets containing 0 and 0.4 percent sodium bicarbonate were associated with a rapid decline in rumen pH following feeding for six hours. In contrast, diets containing 0.8 and 1.2 percent sodium bicarbonate showed rapid decreases in rumen pH during the first three hours after

TABLE 1. Ingredient and chemical composition of complete mixed diets for experiments 1 and 2

	Diet (% sodium bicarbonate)							
	Experiment 1				Experiment 2			
Component	0	0.25	0.5	0.75	0	0.4	0.8	1.2
	% dry matter							
Ingredient								
Alfalfa	40.0	40.0	40.0	40.0	30.0	29.88	29.76	29.64
Barley	30.7	30.4	30.0	28.8	—	—	—	—
Corn	—	—	—	—	30.0	29.88	29.76	29.64
Beet pulp	14.5	14.55	14.6	14.75	18.0	17.92	17.85	17.78
Cottonseed meal	6.5	6.5	6.6	7.6	13.0	12.95	12.89	12.84
Whole cottonseed	6.0	6.0	6.0	5.8	6.5	6.47	6.45	6.42
Fat	1.8	1.8	1.8	1.8	1.5	1.5	1.49	1.48
Trace mineral salt	.5	.5	.5	.5	.5	.5	.5	.5
Dicalcium phosphate	—	—	—	—	.5	.5	.5	.5
Sodium bicarbonate	—	.25	.5	.75	—	.4	.8	1.2
Chemical analysis								
Crude protein	17.3	17.7	17.6	17.7	18.2	17.6	17.7	18.0
Acid detergent fiber	23.1	23.6	22.6	23.2	19.1	20.0	20.2	20.7
Cellulose	17.6	17.9	17.0	17.5	14.8	15.6	15.7	16.2
Neutral detergent fiber	32.4	32.6	32.1	32.9	31.2	32.3	31.7	33.7
Ether extract	4.3	4.5	4.6	4.2	4.3	4.4	4.1	4.4
Lignin	4.8	5.0	4.6	4.7	4.3	4.4	4.4	4.4
Ash	6.9	7.8	7.3	7.8	6.5	6.4	6.6	7.1

TABLE 2. Performance of cows fed sodium bicarbonate during the week of fecal collections

	Diet (% sodium bicarbonate)							
	Experiment 1				Experiment 2			
Item	0	0.25	0.5	0.75	0	0.4	0.8	1.2
Dry matter intake								
lb/day	31.3	31.8	29.8	32.4	43.2	42.6	41.0	42.3
% body weight	3.7	3.7	3.5	3.8	3.4	3.4	3.3	3.4
Production								
Milk (lb/day)	44.3	43.9	44.5	45.2	70.8	67.9	69.0	68.4
Fat (%)	4.8	4.5	4.7	5.1	3.3	3.4	3.3	3.4
Protein (%)	3.8	3.8	3.7	3.7	3.1	3.2	3.1	3.1
Total solids (%)	14.5	14.1	14.2	14.6	12.2	12.1	12.1	12.3

TABLE 3. Apparent digestibility of complete mixed diets.

	Diet (% sodium bicarbonate)									
	Experiment 1					Experiment 2				
Item	0	0.25	0.5	0.75	SE*	0	0.4	0.8	1.2	SE*
					%					
Dry matter	71.9	72.0	71.5	71.5	±1.1	61.7	60.3	61.4	62.3	±2.1
Nitrogen	72.4	72.6	70.8	72.0	± .8	60.9	58.3	60.4	60.5	±2.0
Energy	71.1	71.5	70.5	70.4	±1.5	60.2	58.5	59.3	60.3	±2.3
Acid detergent fiber	47.0	48.7	46.6	46.9	±1.3	31.3	29.3	32.5	37.5	±3.9
Neutral detergent fiber	48.3	48.1	48.1	48.1	±2.4	37.5	36.4	37.0	44.4	±3.3
Cellulose	58.7	59.7	59.2	58.9	±1.6	45.0	45.7	47.5	51.4	±3.1

*SE is the standard error of the mean and indicates the amount of variation.

TABLE 4. Rumen fluid volatile fatty acids of Jersey cows two hours after feeding (experiment 1) and Holstein cows three hours after feeding (experiment 2)

	Diet (% sodium bicarbonate)							
	Experiment 1				Experiment 2			
Item	0	0.25	0.5	0.75	0	0.4	0.8	1.2
Volatile fatty acid (molar %)								
Acetic	63.5	63.1	64.6	64.2	64.4	64.4	66.3	64.8
Propionic	22.4	21.5	21.2	21.1	20.6	20.3	19.0	20.2
Butyric	12.0	13.1	12.0	12.6	12.6	12.7	12.3	12.5
Acetic:propionic ratio	2.8	2.9	3.0	3.0	3.1	3.2	3.5	3.2

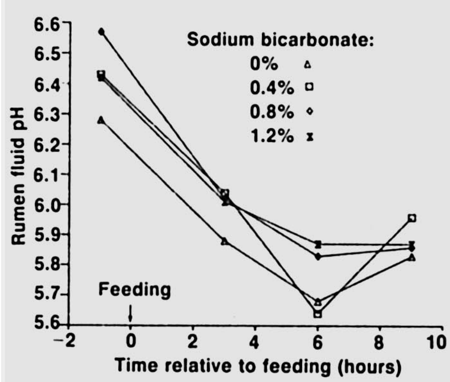

Fig. 1. The highest two levels of sodium bicarbonate provides a more stable rumen pH.

feeding followed by smaller changes until nine hours. Sodium bicarbonate at the highest two levels provided a more stable rumen environment in terms of pH. Although differences in cellulose digestibility were not significantly different (table 3), there were small improvements in cellulose digestibility observed for the 0.8 and 1.2 percent diets that may be associated with rumen pH. Rumen pH before feeding was also slightly higher for all diets containing sodium bicarbonate when compared with the control diet (no sodium bicarbonate).

In summary, adding sodium bicarbonate to complete mixed diets high in concentrate and containing chopped alfalfa hay did not affect digestibility of dietary components even though it elevated rumen pH. Milk fat also was not affected. Improved production responses have been reported with the inclusion of 0.8 percent sodium bicarbonate in the total diet dry matter or 1.5 percent in the concentrate dry matter of diets based on corn silage as the forage component. This would be approximately 0.4 to 0.5 pound sodium bicarbonate per cow per day in early lactation and 0.2 to 0.3 pound per cow per day in mid lactation. Our research indicated that when dairy rations contain alfalfa hay, there may not be as much need for supplemental sodium bicarbonate as is sometimes the case when corn silage is the only forage in the diet.

Edward J. DePeters is Assistant Professor, and Alan H. Fredeen is a graduate student, Department of Animal Science; Donald L. Bath is Extension Dairy Nutritionist, Animal Science Extension. All are with the University of California, Davis.

The authors acknowledge the support of Church & Dwight Company, Inc., Piscataway, New Jersey, in this research.

They're more resistant than cotton to ozone and sulfur dioxide

Air pollution causes moderate

Patrick J. Temple □ Kris A. Surano

More than 90 percent of the processing tomatoes grown in the United States are raised in California's Central Valley. Much of this acreage is in San Joaquin County, directly east, downwind, of the large urban-industrial complex around San Francisco Bay. Automobile exhaust and industrial emissions mix in the atmosphere and convert to smog (ozone) through photochemical processes. Prevailing westerly winds carry the pollution into the Central Valley. Increased industrialization and urban growth in the area add to the air pollution burden already present as a result of agricultural burning. Proposed fossil-fuel-burning power plants in the Sacramento Delta could further contribute to air pollution levels in this agriculturally rich area.

Some tomato cultivars are known to be highly susceptible to air pollution injury, although little is known of the effects of air pollution on tomato productivity. A major field study was begun in 1981 to determine the effects of ozone (O_3) and sulfur dioxide (SO_2), the major phytotoxic components of air pollution, on growth and yield of tomatoes. This experiment was conducted as part of the National Crop Loss Assessment Network (NCLAN) program. The objectives of NCLAN are to (1) develop dose-response equations that relate yields of major agricultural crops to exposure to ozone, sulfur dioxide, and their mixtures; and (2) use this information to assess the economic effects of air pollution on U.S. agriculture.

'Murrieta', the tomato cultivar used in these experiments, was released in 1974. Initial selection was conducted in the San Joaquin Valley, and final development