EFFECTS OF DIETARY FIBER AND DIETARY BUFFER VALUE INDEX ON RUMINAL CONDITIONS IN LACTATING DAIRY COWS

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Story in Brief

The influence of dietary buffer value index and dietary acid detergent fiber content on ruminal fluid pH, buffering capacity and buffer value index was measured. Four lactating Holstein cows (2 primiparous, 2 multiparous) averaging 72 ± 60 days postpartum were used in a 4x4 Latin square with 3-wk experimental periods. The four total mixed diets contained one of two acid detergent fiber concentrations (16 and 21% of diet dry matter) and one of two buffer value indexes (calculated from analysis of individual dietary ingredients to be -200 and 0). Milk fat content and fat yield tended to be increased by high acid detergent fiber; protein yield tended to increase with low buffer value index and low acid detergent fiber. Although the high acid detergent fiber diets increased ruminal fluid pH, they reduced buffering capacity; because the magnitude of the pH increase was greater than the reduction in buffering capacity, ruminal fluid buffer value index was increased by added dietary acid detergent fiber. The high buffer value index diets reduced ruminal fluid pH and increased ruminal fluid buffering capacity; again, the effects on pH outweighed those on buffering capacity, so that the ruminal fluid buffer value index paradoxically decreased as the dietary buffer value index increased. We conclude that ruminal fluid buffer value index increases as dietary acid detergent fiber increases, likely due to reduced ruminal concentrations of fermentation acids or increased saliva secretion. Because our diets with the highest buffer value index produced the lowest ruminal fluid buffer value indexes, dietary buffer value index must be studied further before it can be included in any model purporting to predict the need for supplemental dietary buffers.

(Key Words: Acid Detergent Fiber, Buffer Value Index, Rumen pH, Buffering Capacity.)

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

	Diets			
Ingredient	Low BVI Low ADF	Low BVI High ADF	High BVI Low ADF	High BVI High ADF
Alfalfa hay	10.08	23.84	35.36	42.92
Sorghum silage	24.98	21.87	4.84	4.21
Cottonseed, whole	.....	1.96	.....	8.59
Corn, ground shelled	43.36	30.61	45.78	36.20
Soybean meal	18.24	9.61	7.48	.....
Corn distillers grains	.....	9.56	5.22	6.98
Limestone	.79	.18	.22	.....
Dicalcium phosphate	.54	.50	.52	.53
Trace mineralized salt	.39	.37	.30	.30
Magnesium oxide	.08	.07	.08	.08
Dynamate[a]	.39	.36	.20	.20
Megalac[b]	1.16	1.08	.....	.....
Nutrient[c]				
DM	50.50	45.90	75.60	78.20
CP	17.20	19.10	17.30	16.90
NE_L, Mcal/kg	1.76	1.74	1.76	1.79
ADF	16.05	21.11	16.10	21.08
NDF	24.40	31.43	25.08	31.08
Ca	.94	.78	.89	.88
P	.42	.43	.37	.40
Mg	.44	.37	.33	.33
K	1.27	1.20	1.20	1.18
S	.32	.34	.27	.26
Na	.23	.22	.20	.21
Cl	.43	.41	.36	.35
BVI, calculated	-203	-202	-2.1	-3.7

[a] Double sulfate of K and Mg.

[b] Calcium salts of fatty acids.

[c] NE_L, ADF and NDF were calculated from tabular values; all other values are from feed analysis.

Introduction

Ruminal fluid acid-base status is affected by both dietary acid-base status and the fiber content of the diet. The objective of this study was to evaluate the relationships among the total diet buffer value index (BVI), acid detergent fiber (ADF) content of the diet, and ruminal fluid acid-base status during a 12-h period postfeeding. If the total diet BVI and ADF content can be used to predict the ruminal fluid acid-base status, one could predict when supplemental dietary buffers would be most beneficial.

Materials and Methods

Four ruminally-fistulated Holstein cows averaging 72 ± 60 days postpartum in a 4x4 Latin square with 3-wk experimental periods were fed four diets containing 2 ADF concentrations (16 and 21%) and 2 BVI (-200 and 0). Diets consisted of a mixture of three forages (alfalfa hay, sorghum silage and whole cottonseed), three concentrates (ground shelled corn, soybean meal and corn distillers grain), five mineral sources (limestone, dicalcium phosphate, trace mineralized salt, magnesium oxide and double sulfate of K and Mg) and a protected fat source (Megalac; Church & Dwight Co., Inc.).

The feed pH, buffering capacity (BC), and BVI are summarized in Table 2. The pH values were similar to those recorded by Jasaitis et al. (1987); hay and concentrates had a high pH compared to the fermented products (silage and distillers grains). They observed that BC was high for alfalfa hay, intermediate for protein concentrates, and lowest for energy concentrates. Although we analyzed only single samples, we observed similar trends.

On the morning of the last day of each experimental period, ruminal fluid was collected from the ventral sac of the rumen with a vacuum pump at feeding and every 30 min thereafter for 12 h postfeeding. The ruminal fluid was immediately filtered through 4 layers of cheesecloth and analyzed for pH and BC.

Results and Discussion

The dry matter intake by cows was similar among diets and was not significantly affected by dietary BVI or ADF content (Table 3). Although milk yield was not affected by dietary ADF, yield was slightly higher for low BVI diets. Milk fat percentage was not affected by dietary BVI, but it tended to be higher for high ADF diets. This could be due to the fact that cellulose degradation yields acetate, a precursor of milk fat. Milk protein production tended to be higher for low dietary BVI and low ADF diets.

Table 2. Acid-base status of individual feed ingredients[a].

Ingredient	pH	H+ neq/L	BC,[b] meq/L	BVI
Sorghum silage	3.96	110,290	8.8	-1011
Cottonseed, whole	6.78	167	1.3	99
Corn, ground shelled	6.21	623	.7	94
Soybean meal	6.86	137	3.2	99
Corn distillers grain	4.44	36,476	3.5	-264
Limestone	9.65	.22	62.5	112
Dicalcium phosphate	3.41	393,110	44.0	-3822
Alfalfa hay	5.87	1,343	5.8	88
Trace mineralized salt	6.92	120	.2	99
Magnesium oxide	11.2	.01	3.4	101
Dynamate[c]	8.89	1.3	.3	100
Megalac[d]	7.14	72	.0	99

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[a] H^+ = hydrogen ion concentration, BC = buffering capacity, BVI = buffer value index.

[b] Milliequivalents of H^+ required to change pH from 7 to 5.

[c] Double sulfate of K and Mg.

[d] Calcium salts of fatty acids.

Ruminal fluid pH was affected by both dietary BVI and ADF content (Figure 1). Paradoxically, the high BVI diets reduced ruminal fluid pH, especially between 2.5 and 5.5 h postfeeding. However, the high BVI/low ADF diet clearly was responsible for most of that reduction. Ruminal fluid acidity (Figure 2) was higher for the low ADF diets throughout the postfeeding interval; this effect is demonstrated more clearly by ruminal fluid H^+ concentration than by ruminal pH.

Ruminal fluid BC (Figure 3) was increased by diets with either a high BVI or low ADF content. The influence of dietary BVI on ruminal fluid BC was more logical than its effect on ruminal fluid pH. This increase in ruminal fluid BC may have been caused by the higher BC of the dietary ingredients or by the positive effect of alfalfa hay on rumination and saliva flow into the rumen. However, the increase in ruminal fluid BC was most evident for the high BVI/low ADF diet (Figure 3). Moreover, high ruminal fluid BC was observed for both low ADF diets; because this response was most evident during the interval postfeeding in which fermentation would be most active (4

Table 3. Least squares means and orthogonal contrasts for DMI, milk yield and milk composition as affected by dietary buffer value index (BVI) and dietary ADF content.

	Low BVI Low ADF	Low BVI High ADF	High BVI Low ADF	High BVI High ADF	SE[a]	BVI		ADF		SE	Effect
						Low	High	Low	High		
DMI, kg	21.4	20.0	21.4	21.0	.9	20.7	21.2	21.4	20.5	.6	NS[a]
Milk yield, kg	33.9	32.7	31.6	31.3	1.2	33.3	31.5	32.8	32.0	.8	NS
Fat, %	2.78	3.39	2.97	3.20	.24	3.08	3.09	2.87	3.29	.17	NS
Fat, kg	.90	1.01	.93	.97	.11	.96	.95	.92	.99	.08	NS
Protein, %	3.11	2.91	2.97	2.87	.09	3.01	2.92	3.04	2.89	.07	NS
Protein, kg	1.06	.93	.92	.88	.07	.99	.90	.99	.90	.05	NS

[a] $P > .10$.

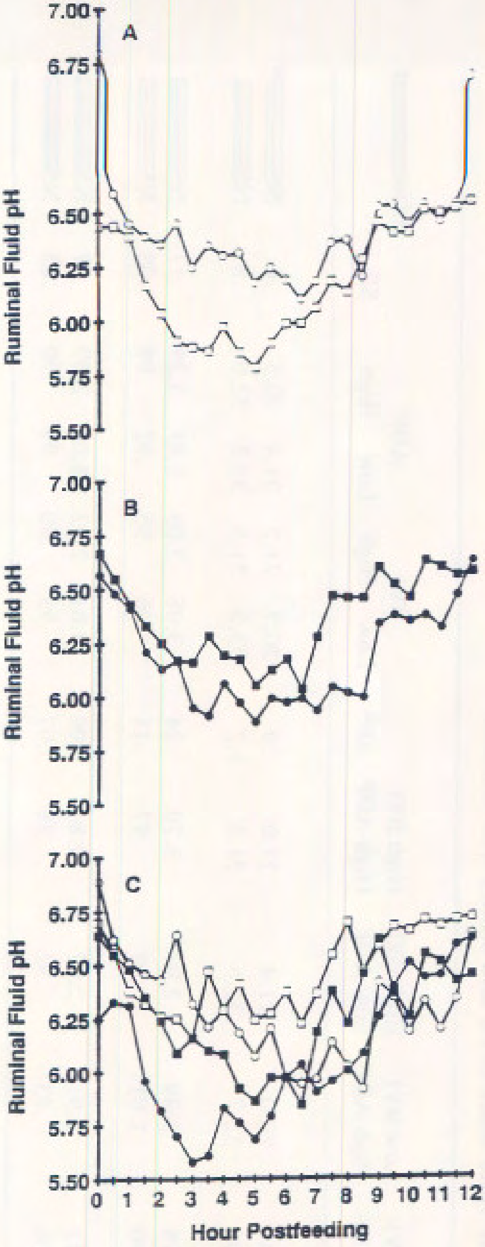

Figure 1. Ruminal fluid pH for 12 h postfeeding as affected by dietary BVI (panel A), dietary ADF content (panel B), and individual diets (panel C). Panel A - open circle = low BVI, open square = high BVI; Panel B - solid circle = low ADF, solid square = high ADF; Panel C - open circle = low BVI/low ADF, open square = low BVI/high ADF, solid circle = high BVI/low ADF, solid square = high BVI/high ADF.

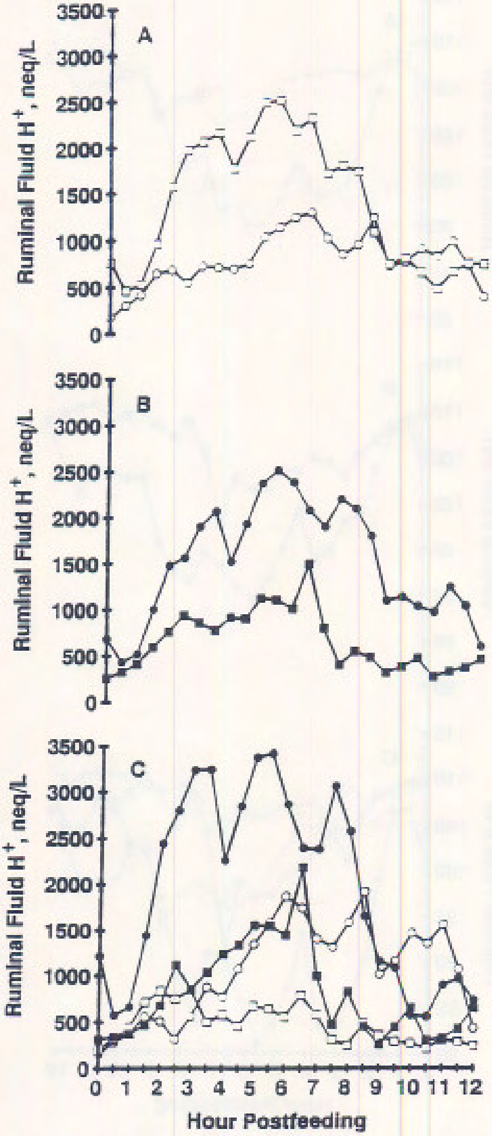

Figure 2. Ruminal fluid hydrogen ion concentration for 12 h postfeeding as affected by dietary BVI (panel A), dietary ADF content (panel B), diet (panel C). Panel A - open circle = low BVI, open square = high BVI; Panel B - solid circle = low ADF, solid square = high ADF; Panel C - open circle = low BVI/low ADF, open square = low BVI/high ADF, solid circle = high BVI/low ADF, solid square = high BVI/high ADF.

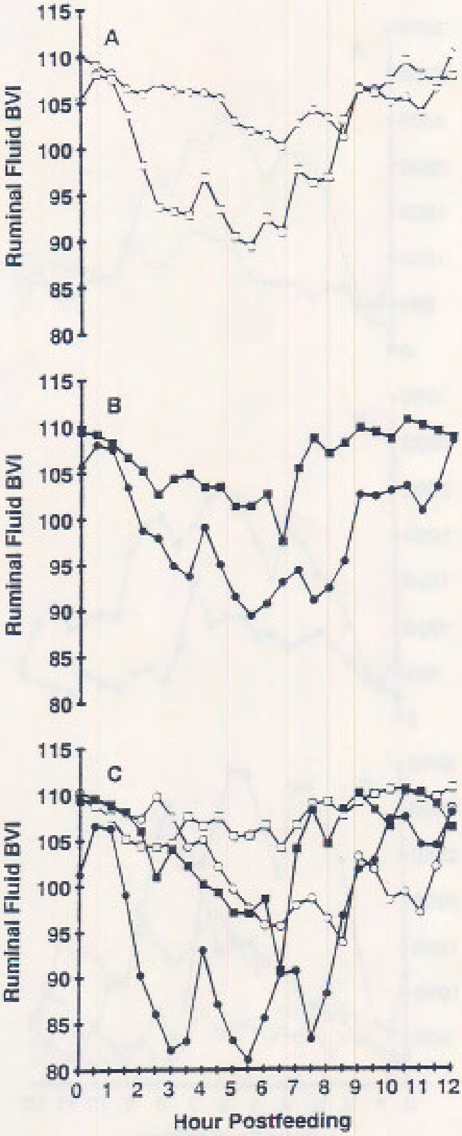

Figure 3. Ruminal fluid buffering capacity for 12 h postfeeding as affected by dietary BVI (panel A), dietary ADF content (panel B), diet (panel C). Panel A - open circle = low BVI, open square = high BVI; Panel B - solid circle = low ADF, solid square = high ADF; Panel C - open circle = low BVI/low ADF, open square = low BVI/high ADF, solid circle = high BVI/low ADF, solid square = high BVI/high ADF.

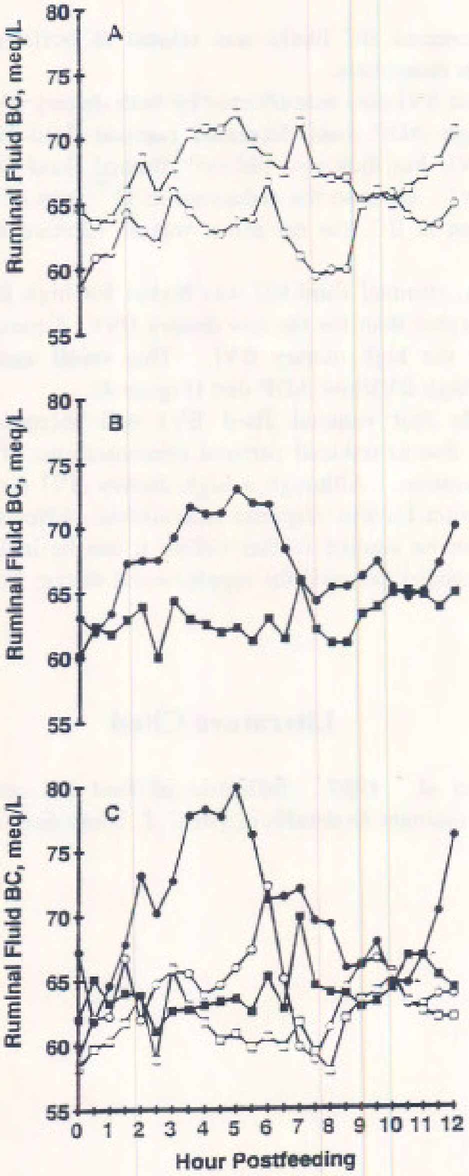

Figure 4. Ruminal fluid buffer value index for 12 h postfeeding as affected by dietary BVI (panel A), dietary ADF content (panel B), diet (panel C). Panel A - open circle = low BVI, open square = high BVI; Panel B - solid circle = low ADF, solid square = high ADF; Panel C - open circle = low BVI/low ADF, open square = low BVI/high ADF, solid circle = high BVI/low ADF, solid square = high BVI/high ADF.

to 6 h), the increased BC likely was related to buffering by fermentation endproducts from these diets.

Ruminal fluid BVI also was affected by both dietary BVI and ADF content (Figure 4). High ADF diets decreased ruminal fluid H^+, which elevates ruminal fluid BVI, but they also reduced ruminal fluid BC, which decreases ruminal fluid BVI. Because the reduction in H^+ was of a larger magnitude than the reduction in BC, the net effect was an increase in BVI for the high ADF diets.

In our study, ruminal fluid BC was higher for high BVI diets; however, H^+ was much higher than for the low dietary BVI. Hence, ruminal fluid BVI was reduced by the high dietary BVI. This result again was attributable primarily to the high BVI/low ADF diet (Figure 4).

We conclude that ruminal fluid BVI will increase as dietary ADF increases, likely due to reduced ruminal concentrations of fermentation acids or increased salivation. Although a high dietary BVI reduced ruminal fluid BVI, no explanation for this response is available. Effects of dietary BVI on ruminal BVI must be studied further before it can be included in any model that purports to predict the need for supplemental dietary buffers.

Literature Cited

Jasaitis, D. K. et al. 1987. Influence of feed ion content on buffering capacity of ruminant feedstuffs in vitro. J. Dairy Sci. 70:1391.