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Summary

Various buffering materials including sodium bentonite, limestone, and sodium bicarbonate at 2% levels and alfalfa hay at 10% were included in high-concentrate diets for lambs previously accustomed to a brome hay diet. The effect of these materials on rumen function and acidosis during a rapid change from hay to the high-concentrate diets, and on rumen function and ration digestibility following adaptation were studied. Acidosis occurring on the third day of concentrate feeding, as evidenced by rumen pH and rumen concentrations of lactic acid and volatile fatty acids, was least severe in lambs fed 2% sodium bicarbonate or 10% alfalfa hay. Following adaptation, 2% sodium bicarbonate increased ration digestibility. Trends toward higher fecal pH and lower fecal starch concentrations were associated with all of the buffering materials, but they were not necessarily indicative of greater starch digestion which occurred only in the sodium bicarbonate treated lambs.

Introduction

A gradual increase in grain over a period of 2 to 4 weeks is commonly required before ruminant animals become adapted to high-concentrate diets. Various dietary materials including sodium bicarbonate, sodium bentonite, limestone and forage have been indicated as potential aids in the prevention of acidosis during adaptation. Benefits from feeding of these materials following adaptation have been less pronounced or lacking. Objectives of studies reported herein were (1) to investigate the effects of buffers and limited quantities of alfalfa hay on physiological and rumen fermentation changes occurring in lambs during the early phase of adaptation to high-concentrate diets and (2) to study ruminal and systemic parameters and nutrient utilization as influenced by buffers in the diets of lambs previously adapted to the high-concentrate diet.

Experimental Procedure

Twenty wether lambs weighing an average of 77 lb and accustomed to a diet of ground brome hay were placed in metabolism cages designed for collection of total urine and feces. They were assigned to five dietary treatments (4 lambs/treatment) as follows: control, 2% bentonite, 2% limestone, 2% sodium bicarbonate, and 10% alfalfa added to a concentrate diet. The concentrate diet consisted of 97% corn, 1.5% soybean meal, 1% limestone, and .5% trace mineral salt with 900 IU vitamin A and 9 IU vitamin E per lb diet. The treatment materials were added at the expense of the total diet.

Phase 1. During the intial 3 days (phase 1) on the high-concentrate diets, 2.42 lb of control diet, 2.47 lb of the bentonite, limestone and sodium bicarbonate diets, and 2.66 lb of the 10% alfalfa diet were offered to respective animals once daily. This allowed all treatment groups to receive identical amounts of the concentrate portion. Rumen and blood samples were taken 1 day before and 1, 2 and 3 days after feeding the experimental diets. Each day's samples were taken 6 hr postfeeding. The samples were analyzed for the constituents shown in the accompanying tables.

Phase 2. For phase 2, the same lambs used in phase 1, except the 10% alfalfa group, were kept in the metabolism cages and continued on the same diets until they appeared to be adapted to the concentrate diets; this occurred in 15 days. After 5 additional days of constant feed intake equivalent to 2 lb of the control diet daily, urine and feces were collected for 5 days to determine nutrient digestibility. On the last collection day at 6 hr postfeeding, blood and rumen samples were obtained from each sheep for the same analyses as were performed on the samples collected earlier during the adaptation period (phase 1).

Results and Discussion

Phase 1. Data obtained on day 3 for phase 1 are shown in table 1. All lambs consumed the entire daily ration on the first and second days. However, at day 3, animals given the all-concentrate control, 2% bentonite, or 2% limestone diets reduced consumption, while those fed 2% sodium bicarbonate or 10% alfalfa diets consumed all the daily ration.

Lambs fed the buffered or 10% alfalfa diets tended to maintain higher rumen pH than those fed the control diet. No lactate accumulations were obvious 6 hr postfeeding on day 1, but all lambs had elevated concentrations of lactic acid by day 3. Those receiving diets with buffers or 10% alfalfa hay tended to have lower levels of rumen lactate than those receiving the control diet. The effect was most obvious in the alfalfa hay-fed lambs where the average lactate value was only 1% as high as that of the controls. The lowest total rumen VFA value was associated with the highest degree of acidosis in the controls. However, the acetic/propionic ratio which was highly variable did not differ significantly between treatments.

Compared to the control, the buffer or hay treatments did not influence blood parameters. However, packed cell volume (PCV) decreased with time after concentrate feeding. A lower PCV in this instance is probably due to an increase in plasma volume from the influx of body water in the concentrate-fed lambs. The higher rumen lactate values occurring on day 3 of high-concentrate feeding appeared to exert very little influence toward increasing blood lactate above pretreatment values, but elevated urinary lactate values were seen at that time. Buffers or alfalfa hay which resulted in less rumen lactate generally reduced urinary lactate excretion. Urine from the sodium bicarbonate-fed lambs was alkaline while it was acidic for all others.

Phase 2. After 20 days adaptation (table 1), rumen pH values for lambs on the various treatments were 5.75 to 6.08 with a trend toward higher values for the buffer treatments. Rumen lactate values, that had been elevated in phase 1, returned to about the same low levels as those existing during the brome hay feeding period. Neither total VFA concentrations nor acetic/propionic ratios were affected by dietary treatment. Blood and urine parameters were likewise unaffected except for urine pH and lactate which were higher for the sodium bicarbonate-fed lambs.

Data pertaining to ration digestibilities, fecal starch, and pH are shown in table 2. Addition of 2% sodium bicarbonate improved dry matter, crude protein, nitrogen-free extract, and starch digestibility of the all-concentrate ration. Crude fiber digestibility was improved by 2% limestone and tended to be improved by bentonite and sodium bicarbonate.

Fecal starch percentage was generally reduced by the addition of buffers. Starch digestion was increased by sodium bicarbonate. Higher fecal pH was associated with each buffer treatment in the order of sodium bicarbonate > bentonite > limestone > control.

Conclusions

Of the sodium bentonite, limestone and sodium bicarbonate used at levels of 2% as dietary buffering materials in this study, sodium bicarbonate was most effective in preventing rumen and systemic changes associated with acidosis. However, 2% sodium bicarbonate was no more effective than 10% alfalfa hay in that regard. In this study, acidosis which was induced by high-concentrate feeding to nonadapted lambs occurred in 3 days. The fact that 10% alfalfa was effective in preventing severe acidosis when fed in addition to the same amount of concentrate as was fed the controls emphasizes the importance of even a small amount of this type of forage in lamb finishing diets.

In a digestion trial conducted after the control lambs and those receiving the three buffers were adapted to the high-concentrate diet, sodium bicarbonate improved ration digestibility. However, the lambs were fed on a limited basis to assure uniform intake of the diets, and the results may not be representative of those occurring under more liberal feeding. In past studies at the S.D. Agricultural Experiment Station, a level of 2% sodium bicarbonate has caused a long-term reduction in feed intake and subsequent animal performance. Thus, the possibility exists that reduced intake of fullfed, high-concentrate diets containing this level of sodium bicarbonate may become the major consideration in formulating long-term finishing diets for lambs.

TABLE 1. PRE- AND POST-ADAPTATION EFFECTS OF BUFFERS ON RUMINAL AND SYSTEMIC PARAMETERS[a]

Item	Treatment					
	Control	2% bento-nite	2% lime-stone	2% $NaHCO_3$	10% Alfalfa Hay	SEM[b]
Phase 1, day 3 pre-adaptation						
Avg feed intake, lb/day	1.54	2.31	1.85	2.46*	2.66*	.22
Rumen pH	5.06	5.43	5.60	5.71*	5.71*	.14
Rumen lactate, µg/ml	6006	2374	1494	538	57	1592
Rumen VFA, µmole/ml	28.3	50.8	47.9	84.3**	65.8*	8.3
Rumen acetic/propionic ratio	2.28	1.24	1.44	2.14	2.44	.66
Blood PVC, %	35	33	37	34	35	2.2
Blood lactate, µg/ml	557	385	378	299	302	70.3
Urine pH	6.15	5.47	6.08	8.51**	5.98	.38
Urine lactate, mg/day	4496	705*	530*	1915	399*	838
Phase 2, post-adaptation[c]						
Rumen pH	5.75	5.79	5.83	6.08		.21
Rumen lactate, µg/ml	9.6	7.3	14.2	10.3		2.15
Rumen VFA, µmole/ml	78.0	67.3	79.5	77.2		5.49
Rumen acetic/propionic ratio	2.36	2.14	2.78	2.54		.55
Blood PVC, %	34	35	34	34		1.3
Blood lactate, µg/ml	129	169	142	120		25.0
Urine pH	5.71	6.27	5.72	8.68**		.36
Urine lactate, mg/day	56	49	51	116*		14.9

[a] Each value is the average for 4 lambs.
[b] Standard error.
[c] Daily feed intake was restricted to an amount equivalent to 2 lb of the nonbuffered concentrate per lamb.
* Differs ($P < .05$) from control.
**Differs ($P < .01$) from control.

TABLE 2. EFFECT OF BUFFERS ON RATION DIGESTIBILITY, FECAL pH AND STARCH (PHASE 2, POST-ADAPTATION)[a]

Item	Treatment				
	Control	2% bentonite	2% limestone	2% $NaHCO_3$	SEM[b]
Digestion Coefficients, %[c]					
Dry matter	86.7	87.2	87.8	92.1*	1.11
Crude protein	75.4	73.7	75.9	83.1*	2.12
Crude fiber	34.3	52.5	59.0*	57.6	6.10
Ether extract	84.9	87.8	86.3	83.4	1.73
Nitrogen-free extract	90.9	93.1	92.7	95.1*	.76
Starch	94.4	96.3	96.1	97.4*	.87
Fecal starch, %[d]	32.8	20.9*	24.0	25.0	2.42
Fecal pH	6.56	6.94	6.69	7.09	.17

[a] Each value is the average for 4 lambs.
[b] Standard error.
[c] Daily feed intake was restricted to an amount equivalent to 2 lb of the nonbuffered concentrate per lamb.
[d] Dry matter basis.
* Differs ($P < .05$) from control.