Effect of Sodium Bicarbonate and Magnesium Oxide in an Alfalfa-Based Total Mixed Ration Fed to Early Lactating Dairy Cattle[1]

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ABSTRACT

Forty-eight lactating Holstein cows were fed a total mixed ration of 57% concentrate and 43% forage (dry basis) for 12 wk postpartum. Treatments consisted of 1) no added buffers, 2) .4% MgO, 3) .8% $NaHCO_3$, and 4) .8% $NaHCO_3$ plus .4% MgO of the total ration DM. Body weight, DM intake, and milk yield and composition were unaffected by treatment. Gross efficiency of milk production was decreased by the addition of $NaHCO_3$ or MgO. Buffer supplementation had no effect on ruminal volatile fatty acid concentration or blood chemistries.

INTRODUCTION

Economic pressures during recent years have encouraged increased productivity of lactating dairy cows through increased concentrate feeding. Major detrimental changes in the rumen ecosystem occur when high levels of concentrates are fed. With increased concentrate feeding and corresponding decline in rumen pH, the number of amylolytic or starch-utilizing bacteria and acid-tolerant bacteria increase (6), and numbers of cellulolytic bacteria decrease (11). Under extreme conditions, metabolic upsets, such as lactic acidosis, occur.

Use of mineral buffers to counteract the detrimental effects associated with high concentrate feeding has given variable results. Differences in animal response to buffer supplementation may be due in part to 1) rate of reactivity of the buffer (16), 2) mode of action of the buffer (5), 3) manner and the degree to which the animal is physiologically stressed, 4) buffering capacity of the diet (3), or 5) physical form of the diet.

Most research involving the use of mineral buffers in rations for lactating dairy cows is being conducted in eastern and central states where both corn grain and corn silage are the primary components of the ration. In the western states, however, barley and alfalfa constitute the basal ration. The objective of this experiment was to determine the effectiveness of $NaHCO_3$ or MgO, or both when added to an alfalfa-barley based total mixed ration fed to early lactating dairy cattle.

MATERIALS AND METHODS

Forty-eight Holstein cows were grouped prior to calving according to expected calving date, previous milk production, and lactation number. Within blocks, cattle were assigned randomly to one of four treatments to provide 12 animals per treatment. Treatments consisted of control ration without added buffers, control plus .4% MgO, control plus .8% $NaHCO_3$, and control plus .8% $NaHCO_3$ and .4% MgO of the total ration DM. Diets were fed in a total mixed ration, using chopped alfalfa hay (5 cm theoretical chop) as the major forage and steam-rolled barley as the basal grain in the concentrate (Table 1). Treatments were fed immediately following parturition through 12 wk of lactation. All rations were offered ad libitum in amounts sufficient to allow at least 5 to 10% refusal. Beginning 2 wk prior to parturition, cattle were adjusted to the mineral buffers by feeding at half the rate as prescribed for lactation. Cattle had free access to water.

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TABLE 1. Ingredient and chemical composition of treatments.

Item	Treatment			
	Control	.4% MgO	.8% $NaHCO_3$	.4% MgO + .8% $NaHCO_3$
	% DM basis			
Corn silage	7.24	7.20	7.18	7.14
Alfalfa hay	36.13	35.99	35.84	35.70
Whole cottonseed	10.84	10.80	10.75	10.71
Wheat bran	10.03	9.99	9.95	9.91
Rolled barley	35.32	35.18	35.04	34.90
Dicalcium phosphate	.14	.14	.14	.14
MgO	...	.40	...	.40
$NaHCO_3$	...	...	.80	.80
Trace salt	.28	.28	.28	.28
Vitamin A[1]	.02	.02	.02	.02
	Nutrient analysis, 100% DM basis			
DM	76.00	77.82	79.11	77.41
CP	15.30	15.04	14.83	14.96
ADF	28.21	28.04	27.20	28.46
Calculated analysis				
Calcium	.79	.80	.79	.79
Phosphorus	.43	.43	.43	.43
Sodium	.26	.26	.48	.48
Magnesium	.31	.52	.32	.52

[1] Contains 30,000 IU vitamin A/g.

Twice daily milk yield was recorded and body weights were recorded on 2 consecutive d weekly. Composite milk samples from the a.m.-p.m. milking 1 d each week were analyzed for percentage fat, protein, and solids-not-fat using a Multispec M[4] infrared analyzer. Feed intakes and refusals were recorded daily. Weekly feed samples were taken, composited by month, analyzed for DM (1), CP (7), and ADF (15). Once weekly rumen fluid of cattle was obtained via stomach tube; rumen fluid was analyzed for VFA. Samples were prepared for analysis by adding 9 ml rumen fluid to 1 ml of 6 N HCl. Analyses were conducted on a Perkin-Elmer Series 3920 gas chromatograph using PT 10% AT-100 + 1% H_3PO_4 on Chromosorb W-AW (80/100 mesh) packing material. Blood samples were withdrawn via the tail vein once weekly at 4 h post a.m. feeding. Blood was collected in an airtight heparinized syringe and analyzed for pH, pCO_2, and CO_2 content and base excess (Corning™ pH/Blood Gas System, Model 165[5]). Plasma Mg (Technicon Autoanalyzer II[6]), Na, and K (Beckman Model E4A[7])[8] were determined on the same blood sample.

Data were analyzed according to a randomized complete block design using analysis of variance. Treatment means were tested by least significant difference if F-tests were significant (2). There were statistical differences among weeks in the study, but no consistent time function was detected, so differences among weeks will not be included in the results and discussion.

[4] Multispec Inc., Wheldrake, York, England.
[5] Corning Scientific Instruments, Medfield, MA.
[6] Technicon Co., Inc., Tarrytown, NY.
[7] Beckman Co., Inc., Palo Alto, CA.
[8] Mention of a trade name does not imply an endorsement or recommendation by Utah State University or US Department of Agriculture over similar companies or products not mentioned.

TABLE 2. Effect of treatment on body weight, DM intake, and milk yield and composition.

Measurement	Treatment				
	Control	.4% MgO	.8% $NaHCO_3$	.4% MgO + .8% $NaHCO_3$	SEM
Body weight, kg	584.40	577.30	568.70	561.40	14.40
DM intake, kg/d	20.80	21.90	22.30	21.90	.67
Milk yield, kg/d	31.60	31.10	30.30	32.10	.95
4% FCM, kg/d	30.00	29.40	28.60	30.20	.88
Milk fat, %	3.71	3.72	3.67	3.65	.08
Milk fat, kg/d	1.16	1.13	1.11	1.15	.04
Solids-not-fat, %	8.88	8.84	8.88	8.88	.07
Solids-not-fat, kg/d	2.80	2.73	2.69	2.85	.08
Milk protein, %	3.10	3.19	3.20	3.10	.05
Milk protein, kg/d	.98	.98	.96	1.00	.03
4% FCM/intake	1.42[a]	1.27[b]	1.20[b]	1.35[ab]	.05

[a,b]Means in the same row with different superscripts differ ($P<.05$).

RESULTS AND DISCUSSION

Body weights and DM intakes during the study were not significantly different among treatments (Table 2). These results suggest that palatability of the buffers, approximately 260 g per head per d, did not affect DM consumption. Thomas and Emery (14) reported decreased concentrate consumption when a combined total of 272 g of $NaHCO_3$ and MgO was added to only the concentrate portion of the diet. Teh et al. (13) fed mineral buffers at concentrations similar to those used in our experiment in a total mixed ration and found no difference in DM intake. These results demonstrate that fairly high amounts of mineral buffers can be fed in a total mixed ration without affecting palatability of the ration and reducing overall intake.

Milk production was unaffected by treatment (Table 2). Teh et al. (13) observed an increase in milk production when buffers were added to a total mixed ration in which ground corn and corn silage were the principal constituents of the ration. Milk production also increased when mineral buffers were added to rations containing 50% corn silage:50% concentrate (8). English et al. (4) found that weekly milk yield was not significantly affected by the addition of buffers when corn silage and hay crop silage plus corn silage were the sole forage sources. DePeters et al. (3) observed that alfalfa-based diets contained adequate amounts

TABLE 3. Effect of treatments on concentration of volatile fatty acids in the rumen.

Item	Treatment				
	Control	.4% MgO	.8% $NaHCO_3$	.4% MgO + .8% $NaHCO_3$	SEM
	Molar %				
Acetate	61.86	61.45	59.10	59.75	.57
Propionate	21.52	21.66	21.14	21.36	.47
Isobutyrate	1.03	1.15	1.50	1.42	.06
Butyrate	11.33	11.52	13.30	13.13	.30
Isovalerate	2.16	2.03	2.34	1.84	.11
Valerate	2.10	2.18	2.60	2.49	.12

TABLE 4. Effect of treatment on blood chemistry.

Parameter	Treatment				
	Control	.4% MgO	.8% $NaHCO_3$	.4% MgO + .8% $NaHCO_3$	SEM
Whole blood					
pH	7.47	7.48	7.49	7.46	.05
pCO_2, mm Hg	43.00	42.00	39.80	43.60	.70
CO_2 content, meq/L	31.90	31.10	30.40	31.70	.51
Base excess, meq/L	7.15	6.80	6.49	6.85	.46
Blood plasma					
Sodium, meq/L	140.60	139.90	139.60	140.90	.38
Potassium, meq/L	4.38	4.44	4.39	4.48	.05
Magnesium, mg%	2.71	2.73	2.78	2.78	.05

of endogenous buffers, which would mask beneficial effects from buffer supplementation.

In our study, milk components were unaffected ($P>.05$) by treatment. This parallels the findings of Rogers et al. (10) who found no difference in feed intake, milk yield, and milk composition when $NaHCO_3$ was added to diets containing approximately 46% concentrate and 54% alfalfa hay. Chopped versus long stem hay was likewise evaluated in this study (10) and demonstrated that $NaHCO_3$ addition did not improve milk production. In our study, the total mixed ration contained approximately 57% concentrate and 43% forage, with an ADF analysis approximating 27 to 28%. Inclusion of high energy, high ADF feed ingredients such as whole cottonseed and wheat bran and the high ADF content of alfalfa hay (40% ADF) meant it was not difficult for the ration to contain at least 21% ADF. Therefore, a lack of response to the added buffers was, in part, due to the fairly high fiber content of the total ration. Gross efficiency of milk production (kg 4% FCM/kg DM) was lower ($P<.05$) for the MgO and $NaHCO_3$ treatments (1.27 and 1.20, respectively). Stokes et al. (12) also found efficiency of milk production decreased when buffers were added.

The molar proportions of VFA were unaffected by buffer addition (Table 3). Similar results were observed by others (3, 10). Teh et al. (13) observed that acetate to propionate ratio increased with addition of $NaHCO_3$ and MgO in combination. Stokes et al. (12) fed cows in early lactation a ration containing 70% concentrate and 30% hay crop silage, thus providing marginal fiber intakes (9). With the addition of mineral buffers, milk fat percent tended to increase; also, 3.5% FCM was unaffected and $NaHCO_3$ addition had no apparent affect on total VFA concentration or profile.

Addition of buffers had no effect ($P>.05$) on blood chemistry (Table 4). However, blood potassium appeared to be higher in cattle supplemented with MgO. Similar trends have been observed by other researchers (13).

CONCLUSIONS

Inclusion of $NaHCO_3$, MgO, or $NaHCO_3$ plus MgO in a total mixed ration containing adequate fiber for dairy cows in early lactation had no effect on milk production or composition but decreased gross efficiency of milk production. These results indicate that value of buffers in dairy rations that contain adequate fiber may be questionable for cows in early lactation.

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REFERENCES

1 Association of Official Analytical Chemists. 1975. Official methods of analysis. 12th ed. Washington, DC.

2 Barr, A. J., J. H. Goodnight, J. P. Sell, and J. T. Helwig. 1976. A users guide to SAS 76. Sparks

Press, Raleigh, NC.

3 DePeters, E. J., A. H. Fredeen, D. L. Bath, and N. E. Smith. 1984. Effect of sodium bicarbonate addition to alfalfa hay-based diets on digestibility of dietary fractions and rumen characteristics. J. Dairy Sci. 67:2344.

4 English, J. E., T. J. Fronk, D. G. Braund, and J. E. Nocek. 1983. Influence of buffering early lactation rations with sodium bicarbonate and magnesium oxide and subsequent withdrawal or addition effects. J. Dairy Sci. 66:505.

5 Erdman, R. A., R. W. Hemken, and L. S. Bull. 1982. Dietary sodium bicarbonate and magnesium oxide for early postpartum lactating dairy cows: effects on production, acid-base metabolism, and digestion. J. Dairy Sci. 65:712.

6 Giesecke, D., and R. Geiges. 1974. Untersuchugen zur genese und biochemie der pansenacidose. Starke, amylaseaktivitat und aciditat. Zentralbl. Arbeitsmed. Arbeitsschutz 21:261.

7 Hach, C. C., S. V. Brayton, and A. B. Kopelove. 1985. A powerful Kjeldahl nitrogen method using peroxymonosulfuric acid. J. Agric. Food Chem. 33:1117.

8 Kilmer, L. H., L. D. Muller, and T. J. Snyder. 1981. Addition of sodium bicarbonate to rations of postpartum dairy cows: physiological and metabolic effects. J. Dairy Sci. 64:2357.

9 National Research Council. 1978. Nutrient requirements of dairy cattle. 5th ed. Natl. Acad. Sci., Washington, DC.

10 Rogers, J. A., L. D. Muller, T. J. Snyder, and T. L. Maddox. 1985. Milk production, nutrient digestion, and rate of digesta passage in dairy cows fed long or chopped alfalfa hay supplemented with sodium bicarbonate. J. Dairy Sci. 68:868.

11 Stewart, C. S. 1977. Factors affecting the cellulolytic activity of rumen contents. Appl. Environ. Microbiol. 33:497.

12 Stokes, M. R., L. L. Vandemark, and L. S. Bull. 1986. Effects of sodium bicarbonate, magnesium oxide, and a commercial buffer mixture in early lactation cows fed hay crop silage. J. Dairy Sci. 69: 1595.

13 Teh, T. H., R. W. Hemken, and R. J. Harmon. 1985. Dietary magnesium oxide interactions with sodium bicarbonate on cows in early lactation. J. Dairy Sci. 68:881.

14 Thomas, J. W., and R. S. Emery. 1969. Effects of sodium bicarbonate, magnesium oxide and calcium hydroxide on milk fat secretion. J. Dairy Sci. 52: 60.

15 Van Soest, P. J. 1967. Development of a comprehensive system of feed analysis and its application to forages. J. Anim. Sci. 26:119.

16 Wheeler, W. E., C. H. Noller, and J. L. White. 1981. Influence of rate of reactivity of calcitic limestones and level of calcium addition on utilization of high concentrate diets of beef steers. J. Anim. Sci. 53: 1120.