Effects of Acidified Fermentation By-Products and Anionic Salts on Acid-Base Status of Non-Lactating Dairy Cows

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Introduction

Milk fever (parturient paresis or parturient hypocalcemia) is an economically important disease of dairy cattle. Risk for developing milk fever is strongly influenced by pre-calving diet. Feeding acidogenic diets prior to calving has repeatedly been shown to significantly reduce the risk of milk fever. Diets can be made acidogenic either by addition of mineral acids or by supplementing with anionic salts. Such diets create a metabolic acidosis which is reflected in decreased urinary pH, increased urinary acid excretion, decreased blood bicarbonate concentrations, and decreased blood base excess. Changes in blood pH are minor because the acidosis is compensated. Acidosis improves calcium metabolism in parturient dairy cattle via bone buffering and improved vitamin D metabolism.

Dried condensed extracted glutamic acid fermentation product and dried corn fermentation solubles have been combined recently to create an acidified fermentation by-product feed (AFBP) commercially marketed as Bio-Chlor™. The AFBP is acidic because the glutamic acid and corn fermentation processes are stopped with strong acids (hydrochloric and sulfuric acids, respectively). No published studies in dairy cattle have evaluated the potential of an AFBP to influence acid-base balance and potentially reduce the risk of milk fever.

Materials and Methods

Eight pregnant, non-lactating, ruminally cannulated Holstein cows were assigned to two replicated 4 x 4 Latin squares with 14 day periods. Square 1 consisted of cows that had completed one lactation and square 2 consisted of cows that had completed either two or four lactations. Cows within squares were randomly assigned to treatment sequences. During week 1 of each period, cows received the control diet; and during week 2, they received one of four treatment diets - AFBP; $MgSO_4$ and NH_4Cl combination; $MgSO_4$, $CaCl_2$, and $CaSO_4$ combination; or the control diet. All diets except the control diet were approximately equal in acidogenic potential measured as dietary cation-anion difference (DCAD). These diets were all anionic, as evidenced by their negative DCAD values. Both the anionic diets and the control diet were formulated to provide similar amounts of energy (NE_L), crude protein, neutral detergent fiber, acid detergent fiber, Ca, P, and Mg. Diets were fed as a total mixed ration for ad libitum feed intake. Dry matter intake was measured daily.

Total urine collections were made using indwelling Foley catheters which were inserted on the next to last day of each experimental period. All urine produced during a 24 hour period was collected into 60 L plastic containers placed in ice baths. Urinary pH, volume, strong ion content, and net acid excretion (calculated from urinary bicarbonate, NH_4, and titratable acidity determinations) were measured. Blood samples for blood gas analysis (blood pH, pCO_2, bicarbonate, and base excess) were also collected on the last day of each experimental period.

Samples of whole ruminal contents were obtained at 0, 1, 3, 6, and 9 hours post-feeding on the last day of each experimental period. Ruminal pH, NH_4, and VFA concentrations were measured.

Results and Discussion

Dry matter intakes were very high for all diets (Table 1) compared to expected intakes for non-lactating Holstein cows. Intakes for the anionic diets were significantly lower compared to the control diet. All of the anionic diets tended to lower blood pH and pCO_2, but the differences were not significant. The anionic diets significantly decreased blood bicarbonate and base excess values. Anionic diets also significantly increased urinary volume, reduced urinary pH, increased urinary net acid excretion, increased urinary Ca excretion, and decreased urinary strong ion difference. The AFBP treatment significantly reduced urinary magnesium excretion. Although significant differences between anionic diets were inconsistent, the numerical ranking of treatment means for measures of acid-base status consistently indicated that the magnitude of acidosis was greatest for AFBP; intermediate for $MgSO_4$ and NH_4Cl; and lowest for the $MgSO_4$, $CaCl_2$, and $CaSO_4$.

All of the anionic diets significantly lowered ruminal pH and increased ruminal NH_4 concentrations; however, the magnitude of the effects was small relative to the normal range for ruminal pH and NH_4. Increased NPN found in the anionic diets may explain the increase in ruminal NH_4. Individual concentrations of VFA were not affected by dietary treatment.

Conclusions

Acidified fermentation by-products were at least as effective as, if not slightly better than, conventional anionic salts in producing an acidic response in non-lactating dairy cattle. Therefore, these products have the potential to reduce the risk of milk fever if fed prior to calving. All anionic diets reduced dry matter intake, which may have been a response to the systemic acidosis they induced. Anionic diets exerted only modest effects on ruminal fermentation.

References

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Table 1. Effect of acidified fermentation by-products and anionic salts on whole blood, urine, and ruminal fluid parameters.

Item	Dietary treatment: Control	AFBP[1]	$MgSO_4$ + NH_4Cl	$MgSO_4$ + Ca salts	SEM	Probability: Diet	Control vs. anionic
Feed intake:							
DMI, kg/day	16.0[a]	14.4[c]	15.4[ab]	14.9[bc]	0.26	.004	.002
Whole blood:							
pH	7.42	7.41	7.41	7.39	0.01	.449	.232
pCO_2, mm Hg	40.7	37.7	39.1	40.7	1.7	.590	.460
HCO_3^-, mM	26.0	23.7	24.2	24.6	0.6	.105	.021
Base excess, mM	1.69	-0.56	-0.18	-0.04	0.57	.065	.010
Urinary output:							
Liters/day	14.6[b]	15.3[b]	17.1[a]	15.0[b]	0.4	.002	.020
pH	8.33[a]	6.37[c]	6.89[bc]	7.20[b]	0.20	<.001	<.001
NAE[2], meq/day	-2843[b]	185[a]	-28[a]	-202[a]	123	<.001	<.001
Ca, g/day	0.92[b]	6.70[a]	7.87[a]	6.87[a]	0.78	<.001	<.001
Mg, g/day	6.94[a]	4.51[b]	7.56[a]	7.03[a]	0.42	.001	.257
SID[3], meq/day	4243[a]	1181[b]	1777[b]	1129[b]	218	<.001	<.001
Ruminal fluid:							
pH	6.23[a]	6.07[b]	6.14[b]	6.12[b]	0.03	.008	.002
NH_4, mM	11.7[b]	14.0[a]	14.0[a]	13.6[a]	0.68	.103	.016
Total VFA, mM	131[a]	121[b]	124[b]	135[a]	2.1	.001	.106

[abc] Means with different superscripts within row differ ($P < .05$)
[1]AFBP = acidified fermentation by-products feed.
[2]NAE (net acid excretion) equals ammonium plus titratable acidity minus bicarbonate.
[3]SID (strong ion difference) equals (Na + K) - (Cl + S).