EFFECTS OF CALCIUM CHLORIDE ON PREPARTUM UDDER EDEMA AND PLASMA AND URINE ELECTROLYTES IN HOLSTEIN HEIFERS

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Story in Brief

Twenty six nulliparous Holstein heifers were blocked according to pedigree estimate of breeding value to examine the effects of feeding $CaCl_2$ prepartum on udder edema and plasma and urine electrolytes. Heifers were assigned to diets containing either 1.5% $CaCl_2$ (DM basis) or 2.2% limestone. Diets were formulated to be identical, except for the calcium source. Severity of udder edema was evaluated independently by two people on a daily basis throughout the experiment utilizing a 10-point rating system (0 = no edema, 10 = severe edema). Udder edema and body weight were not significantly affected by the addition of $CaCl_2$. Dry matter intake tended to be lower throughout the prepartum period for heifers consuming the $CaCl_2$ diet than for heifers consuming the control diet. Plasma creatinine tended to be higher and urine creatinine tended to be lower for heifers consuming $CaCl_2$, possibly indicating dehydration of extracellular fluid. Calcium chloride significantly increased urine calcium and chloride and plasma chloride, while decreasing blood pH, urine pH and plasma calcium. This would suggest that feeding $CaCl_2$ at 1.5% of DM may also help prevent milk fever.

(Key Words: Udder Edema, Calcium Chloride, Dietary Cation-Anion Balance, Acid-Base Status.)

Introduction

Udder edema can be costly to dairy producers by increasing the strain on the supporting ligaments, which may lead to pendulous udders and

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increased risk of injury and mastitis. This may lead to premature culling of top genetic animals or the possibility of antibiotic residues in the milk from the treatment of mastitis. With the new antibiotic residue laws beginning to be strictly enforced, preventive treatment programs need to be developed.

Calcium chloride has been shown to reduce slightly the severity of edema in nulliparous heifers (Lema et al., 1992). Because calcium chloride also lowers the dietary cation-anion balance (DCAB), it may prove beneficial in decreasing the incidence of milk fever. The objective of the present study was to examine the relationship between udder edema and blood and urine electrolyte concentrations when feeding calcium chloride to nulliparous heifers for three weeks prepartum.

Materials and Methods

Twenty six nulliparous Holstein heifers averaging 592 $\pm$ 14 kg body weight were blocked according to pedigree estimate of breeding value and assigned to a diet containing either 2.2% limestone (control) or 1.5% $CaCl_2$ (Table 1). All heifers were fed the control diet beginning four weeks before their predicted calving dates. Beginning three weeks prepartum, thirteen heifers were fed the experimental diet. Diets consisted of sorghum silage and grain and were identical except for the calcium source. Udder edema was scored daily by two people using a ten point rating system (0 = no edema, 10 = severe edema; Tucker et al., 1992). The average of the edema scores was used for analysis. Body weights and body condition scores were recorded weekly.

Blood and urine samples were collected every Wednesday at approximately 4, 3, 2, and 1 wk prepartum, and within 12 h after calving. Blood was analyzed for pH, pO_2, pCO_2, creatinine, Ca, P, Mg, K, Na, and Cl content. Raw urine was utilized for urine pH, P, and Cl analyses. Acidified urine was analyzed for creatinine, Ca, Mg, K, and Na content. Statistical analysis was conducted by week, with block and dietary treatment included in the model.

Results and Discussion

Body weight was not significantly affected by the addition of calcium chloride to the diet. Dry matter intake (DMI) decreased for both groups as expected calving date approached; however, DMI of heifers receiving $CaCl_2$

Table 1. Ingredient and nutrient composition of diets (DM Basis).

	Control	$CaCl_2$
Ingredient		
Sorghum silage	61.18	61.61
Shelled corn, ground	25.44	25.61
Soybean meal, 44%	10.72	10.79
Trace mineralized salt[a]	.19	.19
IMC Dynamate[b]	.28	.29
Limestone	2.19	
$CaCl_2$, 78%		1.51
Analyzed nutrient composition		
DM	38.6	36.7
CP	12.5	11.6
NE_L, Mcal/kg[c]	1.52	1.50
ADF	24.8	26.5
NDF	39.1	39.9
Ca	1.05	.77
P	.26	.23
Mg	.34	.33
K	.95	.95
S	.23	.23
Na	.09	.09
Cl	.32	1.29
meq(Na + K) - (Cl + S)/ 100g diet DM	4.9	-22.4
Meq(Na + K) - (Cl)/ 100g diet DM	19.3	-8.1

[a]Contained 92% NaCl, .250% Mn, .200% Fe, .033% Cu, .007% I, .005% Zn, and .0025% Co.

[b]Double sulfate of potassium and magnesium, Pitman-Moore, Inc., Mundelein, IL.

[c]Estimated.

was lower throughout the trial than for heifers receiving the control diet (Figure 1). The addition of $CaCl_2$ may decrease the palatability of the diet, reducing DMI (Lema et al., 1992).

Feeding a negative DCAB may result in metabolic acidosis (Wang and Beede, 1992). As blood pH decreases, H^+ concentration increases. Blood HCO_3^- combines with H^+ to buffer the excess acid, decreasing blood HCO_3^- content. Blood HCO_3^- was significantly lower throughout the prepartum period for heifers receiving the $CaCl_2$ diet (Table 2). As HCO_3^- decreases, the respiratory and renal systems attempt to minimize the change in the pCO_2/HCO_3^- ratio. Even though respiration rate was not measured in our study, pCO_2 levels would be decreased by increased ventilation. Blood pCO_2 concentrations were lower during week two prepartum for heifers consuming the $CaCl_2$ diet and tended to be lower during the entire trial for heifers consuming $CaCl_2$.

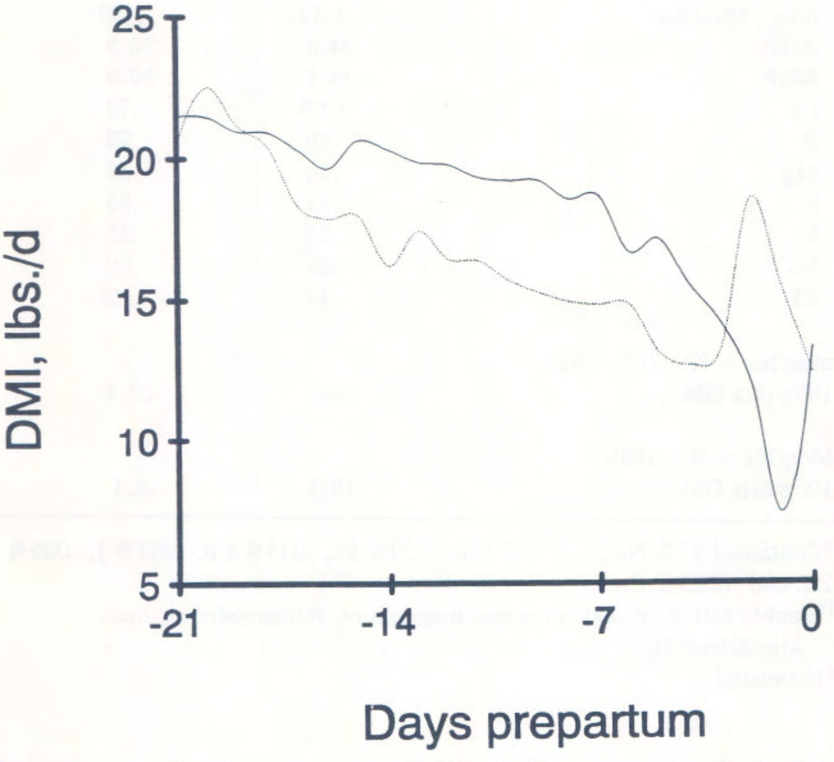

Figure 1. Least squares mean DMI for heifers consuming $CaCl_2$ (····) or limestone (-) prepartum.

Table 2. Least squares means for blood and urine acid-base status and electrolytes for 3 weeks prepartum and at calving for heifers consuming limestone (control) or $CaCl_2$ diets.

	Week	Control	$CaCl_2$	SE	*P*
Blood pH	-3	7.426	7.376	.008	.015
	-2	7.435	7.360	.005	<.001
	-1	7.433	7.393	.008	.005
	0	7.449	7.424	.008	.063
Blood HCO_3^-,mm Hg	-3	29.2	23.7	.989	.024
	-2	27.9	21.9	.501	<.001
	-1	28.1	24.8	.960	.031
	0	30.7	27.1	.781	.007
Blood PCO_2,mm Hg	-3	45.9	41.7	1.2	.084
	-2	43.0	40.1	.8	.031
	-1	43.5	41.7	.9	.180
	0	45.6	42.6	.8	.019
Blood PO_2,mm Hg	-3	31.5	29.1	.7	.099
	-2	31.6	34.1	.7	.033
	-1	32.1	33.9	1.8	.505
	0	38.0	34.7	2.0	.263
Urine pH	-3	8.33	6.23	.31	.012
	-2	8.03	5.57	.11	<.001
	-1	7.94	5.81	.15	<.001
	0	7.43	6.27	.19	.082
Plasma creatinine,mg/L	-3	14.85	15.07	.76	.860
	-2	16.04	17.00	.48	.188
	-1	16.21	18.08	.53	.029
	0	16.48	18.65	.65	.036
Urine creatinine,mg/L	-3	1397	1030	184	.266
	-2	1768	1195	133	.011
	-1	2179	1616	190	.058
	0	1293	947	208	.269

Table 2. (continued)

Plasma calcium,meq/L	-3	4.93	4.85	.06	.468
	-2	4.88	4.88	.07	.988
	-1	4.75	4.77	.05	.830
	0	4.56	4.46	.07	.221
Urine calcium,meq/L	-3	1.67	22.13	2.805	.009
	-2	3.44	17.64	1.674	<.001
	-1	2.12	8.83	1.002	<.001
	0	3.25	6.56	1.652	.190
Plasma sodium,meq/L	-3	151.40	141.62	3.5	.077
	-2	153.20	146.59	2.7	.110
	-1	156.56	145.63	4.0	.075
	0	146.27	142.18	2.6	.289
Urine sodium,meq/L	-3	9.29	22.96	4.4	.051
	-2	8.19	17.41	3.0	.048
	-1	11.53	8.93	5.3	.736
	0	35.68	16.01	11.3	.251
Plasma chlorine,meq/L	-3	107.4	111.6	1.1	.075
	-2	107.4	114.5	.4	<.001
	-1	109.9	113.3	.8	.012
	0	107.5	109.4	1.2	.280
Urine chlorine,meq/L	-3	62.0	204.4	19.3	.009
	-2	50.4	162.3	10.8	<.001
	-1	39.0	100.5	13.6	.008
	0	69.9	116.7	21.3	.159

[a]Urine mineral concentrations expressed as:
((urine mineral concentration (meq/L))/(urine creatinine concentration (mg/L)))*1000.

The addition of $CaCl_2$ to prepartum diets did not significantly reduce the severity of udder edema (Figure 2). Development of edema appeared to be retarded during the first week of feeding $CaCl_2$. However, edema scores increased rapidly afterwards.

Addition of $CaCl_2$ significantly reduced urine pH throughout the prepartum period (Table 2). Plasma creatinine concentrations tended to increase as the expected calving date approached for heifers consuming $CaCl_2$. Urine creatinine concentrations tended to be lower throughout the prepartum period for heifers consuming $CaCl_2$ (Table 2) and were significantly lower at two weeks and one week prepartum ($P < .06$). Because the excretion rate of creatinine must equal the production rate of creatinine, the increased plasma creatinine concentrations may indicate a decrease in plasma volume, while the decreased urine creatinine concentrations would indicate an increase in urine output. A decrease in plasma volume would lower blood hydrostatic pressure and increase blood osmotic pressure, which may increase net absorption of extracellular fluid. The decreased urine creatinine concentrations and

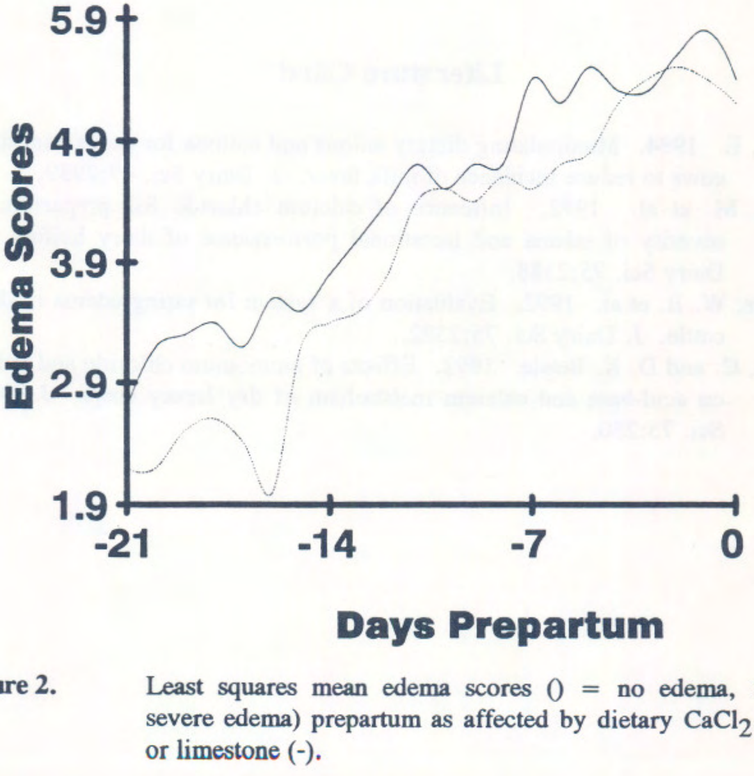

Figure 2. Least squares mean edema scores (0 = no edema, 10 = severe edema) prepartum as affected by dietary $CaCl_2$ (····) or limestone (-).

increased plasma creatinine concentrations suggest that $CaCl_2$ does possess diuretic properties, even though udder edema scores were not significantly different. Plasma magnesium and phosphorous and urine magnesium and phosphorous concentrations were high ($P < .08$) for heifers consuming $CaCl_2$. Plasma calcium levels were not affected by diet; however, urine calcium levels were significantly increased throughout the prepartum period by the low DCAB. The increased excretion of calcium may be in response to increased calcium absorption from the intestines and(or) increased mobilization of calcium from bone.

In summary, addition of 1.5% $CaCl_2$ did not significantly reduce the development of udder edema. Dry matter intake tended to be lower for heifers consuming the $CaCl_2$ diet. Plasma creatinine tended to be higher and urine creatinine tended to be lower for heifers consuming $CaCl_2$, possibly indicating dehydration of extracellular fluid. Plasma calcium was unaffected by treatment. However, the increase in urine calcium may be in response to increased intestinal calcium absorption and mobilization of calcium from bone. Because both of these responses would increase the calcium available for metabolism, feeding $CaCl_2$ at 1.5% of DM may be helpful in preventing parturient paresis.

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