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IMPACT OF DIETARY SALT CONCENTRATION ON WATER INTAKE AND PHYSIOLOGICAL MEASUREMENTS OF FEEDLOT CATTLE

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Story in Brief

Nine ruminally cannulated heifers (510 kg) in a triplicated 3 x 3 Latin square were given ad libitum access to an 80% concentrate diet based on cracked corn with one of three levels of supplemental salt (0, .25, .50% of DM). Water intake was not significantly increased by added salt, water intakes averaged 14 and 30% more with the .25 and .5% salt levels than without added salt. Daily dry matter intakes also tended to increase with added salt (8.9, 10.2 and 10.4 kg with 0, .25, .50% salt, respectively). The water to dry matter intake ratio was not altered significantly (4.45, 4.15 and 4.53 kg water/kg dry matter consumed with 0, .25, .50% salt, respectively). Arterial blood pH tended to respond quadratically. Arterial partial pressure of oxygen increased, while carbon dioxide decreased linearly with added salt. Added salt decreased arterial blood and ruminal potassium increased the ruminal concentration of sodium. Added salt linearly increased percentages of butyrate and isobutyrate leading to an increased energy charge of ruminal VFA. Higher salt concentration, though not altering the dietary cation anion balance of the ration, decreased blood base excess and thereby might increase likelihood of acidosis.

Key Words: Salt, Intake, Beef Cattle

Introduction

Dietary salt (NaCl) was used as a mineral supplement for hundreds of years before its composition was known. Its low price, convenience and availability have made it the preferred way to supplement sodium and chloride. Salt is used frequently to limit feed intake of highly palatable feeds such as grain and supplement (Lusby, 1993).

In the past, feeding recommendations for minerals have been set to maximize animal growth rate, milk yield and reproduction (Beede, 1998). However, high levels of salt in feed will increase the sodium and chloride concentrations in urine and feces. These nutrients can limit its application of waste to soils in low rainfall or irrigated areas due to increased salinity of the soil (Van Horn et al., 1994; Eghball and Power, 1994). Hence, we need to understand function, metabolism and interaction of minerals in the animal.

The objectives of this experiment were 1) to test the impact of dietary salt concentration on intake of water and feed by feedlot cattle, 2) to examine the impact of dietary salt on ruminal parameters and mineral concentrations, and 3) to measure physiological responses in urine and blood (venous and arterial) to dietary salt level.

Materials and Methods

Nine (510 kg) ruminally cannulated heifers in individual pens were assigned to three 3 x 3 Latin squares. These animals were given ad libitum access to a concentrate diet (Table 1) with fresh feed added daily (8:30 a.m.) in each 21-d period of each Latin square (14 d adaptation, 7 d to sample and measurement). The three treatments were addition of 0, .25 and .50% of Kansas rock salt #4 containing at least 96% NaCl to the diet. Chemical composition of these diets is shown in Table 1. Concentrations of sodium in the total diet were .02, .12 and .22% as compared with an estimated requirement that must not exceed

.06-.08%.

Total amount of feed provided and orts were weighed daily. Water was provided free choice in large barrels and water intake was measured daily.

Within 2 hr after being drawn, a 10 ml sample of arterial blood was analyzed in a Critical Blood Analyte for pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), bicarbonate (HCO_3), base excess (BE), sodium (Na^+) and potassium (K^+).

On d 21 total ruminal contents were removed mechanically using a vacuum device. Ruminal contents were screened twice (.63 x .63 and .31 x .31 cm square pore mesh) manually to separate ruminal particles from liquid contents. Ruminal fluid pH was measured immediately. The non-glucogenic ratio (NGR) was calculated as (acetate + 2 x butyrate)/propionic.

Period, animal and treatment were used as sources of variation and the statistical analyses were performed using the GLM procedure of SAS (1990). Linear and quadratic effects of salt were tested using contrast statements.

Results and Discussion

Dry Matter and Water Intake. Average DMI, though not significantly (P=.17) altered by dietary salt concentration, tended to increase (8.94, 10.25 and 10.42 kg/head/d, respectively) as level of dietary salt was increased (0, .25 and .50%). The increase in DMI from 0 to .5% of salt was 16%. Water intake (WI) also tended to increase (P=.12) with dietary salt concentration (36, 42, and 48 L/d). Between 0 and .50% of salt, WI increased about 30%.

The WI/DMI ratio was not affected by any treatment (Table 2). The WI/DMI was 8 to 9% less for the .25% of salt treatment (4.15) when compared with the 0 and .50% treatments (4.45 and 4.53 respectively). Therefore, less water per kg of DM was consumed by the animals on the .25% treatment. To examine this relationship more closely, WI was regressed on DMI; the regression equation after removing the effects of animal and period was WI(L)= .075 + 4.234x(kg of DM) ± 1.15 (P<.01; r^2=.857). This shows a close relationship between DMI and WI in this experiment. This suggests that the response in WI to added salt was driven primarily by DMI.

Ruminal Parameters. Dietary salt level (Table 3) did not affect ruminal pH, amounts and proportion of total ruminal contents in liquid and solid phases. Total volatile fatty acids (VFA) and their molar proportions are presented in Table 4. Neither total VFA□s, acetate, propionate nor acetate to propionate ratio (A:P) were affected by the treatments.

The molar proportion of butyrate was significantly (P<.05) lower for the control (8.47) than for the .25 and .50% treatments (10.81 and 11.17 respectively). There was a linear trend for butyrate (P<.03) and isobutyrate (P<.06) to increase with level of dietary salt. This change in the butyrate molar proportion led to a linear increase (P<.05) in the energy charge (EC; 2 butyrate to acetate ratio) of ruminal VFA. No differences were found either in valerate, isovalerate and NGR (Table 3).

In Table 4 the least squares means for ruminal fluid mineral concentration are presented. The sodium concentration increased with level of dietary salt but potassium decreased linearly. Chloride responded quadratically to increasing level of salt (P<.05). Magnesium concentration was significantly (P<.05) higher in the 0% treatment (223 ppm) than in the .25 and .50% treatments (132.1 and 165.5 ppm, respectively), presumably driven by high ruminal K concentrations with the 0% treatment decreased Mg absorption which thereby increased its concentration in ruminal fluid. The ratio of Na:K in the rumen increase as level of dietary salt increased.

Arterial Blood Parameters. The arterial pH responded quadratically to the level of dietary salt (P=.09) (Table 5.). Base excess also tended to respond quadratically (P=.10) to dietary salt level. Potassium concentration of blood decreased linearly (P=.06) as dietary salt level was increased.

Concentration of salt in a high concentrate feedlot diet increased ruminal Na concentration but decreased ruminal and blood potassium concentrations. Stimulation of water intake by high salt levels (.5%), may be physiologically important from the standpoint of amounts of fluid that animals excrete and waste management but also will dilute urinary components that may cause urinary calculi.

Literature Cited

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Table 1. Ingredients and chemical composition of diets fed (dry matter basis).

Treatment	0	.25	.50
Ingredient, %			
Dry rolled corn	63.40	63.24	63.08
Cottonseed hulls	14.76	14.72	14.69
Soybean meals (44 %)	10.19	10.16	10.14
Dehydrated alfalfa pellets	6.17	6.15	6.14
Cane molasses	4.25	4.24	4.23
Ground limestone	.57	.57	.57
Dicalcium phosphate	.55	.55	.55
Salt	--	.25	.50
Urea (46%)	.11	.11	.11
Total	100	100	100
Mineral composition, %			
Sodium	.02	.12	.22
Potassium	.83	.83	.83

Chloride	.13	.28	.43
Calcium	.55	.55	.55
Phosphorus	.32	.32	.32
Magnesium	.13	.13	.13
Sulfur	.15	.15	.15

Table 2. Dry matter intake (DMI), water intake (WI) and ratio for heifers receiving different levels of salt.

	Treatment		
Salt, %	0	.25	.50
DMI, kg.	8.94	10.25	10.47
WI, L.	36.46	41.60	47.58
WI/DMI, L/kg	4.45	4.15	4.52

Table 3. Ruminal VFA, pH and liquid and solid contents from heifers receiving 0, .25 and .50 % salt diets.

	Treatment			
Salt, %	0	.25	.50	
VFA (molar %)				
Acetate	57.7	57.2	55.1	
Propionate	28.3	26.4	27.9	
Butyrate	8.47	10.81	11.17	L**
Isobutyrate	1.19	1.28	1.33	L*
Isovalerate	2.86	3.03	3.04	
Valerate	1.44	1.32	1.47	
A/P	2.18	2.42	2.11	
Total VFA, mmol/L	117	123	123	

NGR	2.8	3.32	2.95	
EC	.30	0.38	0.41	L**
Rumen pH	5.78	5.96	5.81	
Rumen contents				
Total kg	36.2	40.8	37.0	
Solid %	17.6	15.9	17.6	
Liquid %	82.4	84.1	82.4	
L=linear effects; **P<.05; *P<.10.				

Table 4. Mineral concentration centrifuged ruminal fluid from heifer receiving 0, .25 and .50 % salt diets.

	Treatment			
Salt, %	0	.25	.50	
Ruminal fluid				
Na, ppm	1393	2125	2132	L***
K, ppm	3411	2520	2420	L**
Cl, ppm	432	273	321	Q**
Ca, ppm	97	85	111	
P, ppm	1092	1111	1174	
Mg, ppm	211	156	182	Q**
S, ppm	64	71	73	
Ratio Na/K, ppm/ppm	.54	1.00	1.00	L***
L=linear effects; Q=quadratic effects;***P<.01; **P<.05.				

Table 5. Arterial blood parameters from heifers receiving 0, .25 and .50% salt diets.

	Treatment			
Salt, %	0	.25	.50	
VFA (molar %)				
PH	7.422	7.440	7.421	Q*
PCO_2 mmHg	38.56	37.62	36.83	L*
PO_2 mmHg	92.23	96.13	98.36	L*
Na mmol/L	139.1	139.7	139.2	

K mmol/L	4.30	4.08	3.99	L*
BE mmol/L	1.48	2.33	.48	Q*
HCO_3 mmol/L	25.11[ab]	25.61[a]	23.93[b]	

[a,b]Means with different superscripts within row P<.10.

L=linear effects; Q=quadratic effects;*P<.10.

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