January 2007

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Summary

Angus crossbred yearling steers (n = 180) were used to evaluate effects of feeding additional potassium and sodium on performance and tympanic temperature of steers under heat stress and seasonal summer conditions. Steers were assigned one of four treatments: 1) control; 2) potassium (diet containing 2.10% $KHCO_3$); 3) sodium (diet containing 1.10% NaCl); or 4) potassium and sodium (diet containing 2.10% $KHCO_3$ and 1.10% NaCl). Daily water intake was increased and dry matter intake to daily water intake ratio was decreased for cattle fed potassium and potassium and sodium rations. Tympanic temperatures did not differ among dietary treatments under thermoneutral or hot environmental conditions.

Introduction

Potassium and sodium play important roles in maintaining osmotic pressure within cells, controlling the passage of nutrients into cells, and water metabolism. A deficiency of these ions may result in impaired cellular function and reduced coping ability to heat stress. As ambient temperatures approach body temperatures, the amount of heat dissipated through sweating and increased urinary output are key physiological processes for maintaining body temperature. Potassium and sodium are excreted from the body via urine and sweating. This study was designed to evaluate the effect of additional potassium and sodium in the diet on the ability of cattle to manage heat stress in the feedlot.

Procedure

Angus crossbred yearling steers (n = 180) were received at Haskell Ag Lab near Concord, Neb. Two days post-receiving, steers were weighed, implanted (Ralgro; Shering-Plough Animal Health, Kenilworth, N.J.), vaccinated (Vision 7 and Titanium 5 PHM Bac 1; Intervet, Millsboro, Del.), treated for external parasites (Saber; Schering-Plough Animal Health, Kenilworth, N.J.), and ear tagged for individual identification. Forty-three days after receiving, cattle were individually scored for body condition score (BCS) by two observers. Upon initiation of trial (50 days post-receiving), steers were implanted with Revalor-S (Intervet, Millsboro, Del.) and average body weight on two consecutive days used as the initial weight (mean BW = 1,069 lb). Steers were stratified by BCS and weight, and randomly assigned to one of 24 pens.

Pens were blocked by location and assigned to one of four diet treatments: 1) control; 2) potassium (diet containing 2.10% $KHCO_3$); 3) sodium (diet containing 1.10% NaCl); or 4) potassium and sodium (diet containing 2.10% $KHCO_3$ and 1.10% NaCl). In addition, slight adjustments in roughage type were made in an attempt to elevate dietary cation anion difference (DCAD) in the diets containing added potassium.

Feed and water intakes were recorded daily. Body weights were obtained on days 0, 35, and 67 (day before slaughter). Due to a scheduling problem at the packing plant, carcass data were unable to be obtained. Tympanic temperatures (TT) were recorded using Stowaway XTI® data loggers and thermistors (Onset Corporation, Pocasset, Mass.). The thermistor was inserted approximately 4 to 5 inches into the ear canal until the tip was near the tympanic membrane. The loggers recorded temperatures at 1-hour intervals in 24 animals from eight pens (two pens/treatment; three animals/pen) during days 18 to 22 and days 41 to 46. The same animals were used in both periods. Days 18 to 22 was designated as a thermoneutral (TNL) period, while days 41 to 46 were broken down into two periods; moderately hot (MHOT – days 41 to 43) and hot (HOT – days 44 to 46).

Performance data was analyzed using the mixed procedures of SAS. The model included potassium, sodium and the potassium by sodium interaction. Tympanic temperatures were analyzed using a

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Table 1. Diet composition, dry matter basis.

Treatment[a]:	Control	K	Na	KNa
Ingredient				
Alfalfa	8.00	5.00	7.00	2.50
Corn Silage	4.50	4.50	4.0	7.00
Dry Rolled Corn	80.50	80.40	80.55	78.30
Dry Supplement	2.00	2.00	2.00	2.00
Liquid Supplement	4.50	4.00	4.00	3.50
Soybean Meal	0.50	2.00	1.35	3.50
$KHCO_3$	--	2.10	--	2.10
NaCl	--	--	1.10	1.10
Estimated Nutrient Composition (NRC, 2000)				
Crude Protein, %	13.4	13.4	13.4	13.4
NEg, mcal/lb	0.638	0.638	0.638	0.638
Potassium, %	0.75	1.54	0.73	1.53
Sodium, %	0.12	0.10	0.54	0.52
DCAD, meq/100g[b]	9.13	29.38	8.59	28.8

[a]Control = control; K = potassium added to diet; Na = sodium chloride added to diet; KNa = potassium and sodium chloride added to diet.
[b]DCAD = meq (% in diet/equivalent weight) of [(Na + K) – (CL + S)].

repeated measures model that included sodium, potassium, time of day, period, and all possible interactions. The specified term for the repeated statement was animal within period.

Results

The addition of $KHCO_3$ had a tendency ($P<0.10$) to reduce DMI from days 0 to 34 (Table 3). However, daily water intake (DWI) was increased ($P<0.05$) and DMI/DWI ratio was decreased ($P<0.05$) when $KHCO_3$ was added to the diet. The addition of sodium decreased ($P<0.05$) ADG and increased ($P<0.05$) F/G for days 35 to 67. The combined feeding of potassium and sodium tended to reduce ($P=0.09$) overall ADG, when compared to the other three treatments.

Weather conditions that correspond with the weigh dates (days 0 to 34 and days 35 to 67) and TT observation periods (days 18 to 22 and days 41 to 46) are presented in Table 2. A heat wave occurred during days 44 to 46, so that period was divided into the two three-day periods (MHOT and HOT). Initial analyses revealed significant potassium by sodium by time of day ($P=0.01$) and potassium by sodium by period effects ($P=0.02$). However, when TT were compared within each hour (Figure 1), there were no significant differences ($P>0.10$) among treatments in any given hour. The interaction is significant because of the differing daily cycles in TT for the treatments. Namely, sodium may have a lower peak TT and the potassium and sodium combination treatment TT may drop off faster during the late evening hours. When TT were compared within each period (Table 4), no significant treatment effects ($P>0.10$) were found. The tendency for the potassium and sodium combination treatment group to have a lower TT may be due to the lower DMI and greater DWI that was found in that group. Also, the addition of $KHCO_3$ increased DCAD from below 10 meq to near 30 meq. Increased

Table 2. Weather conditions[a].

	Temperature						
	High	Low	Avg	RH, %	THI[b]	Windspeed, mph	Solar radiation, Ly
day 0 to 34	83.67	62.15	72.91	71.31	70.6	9.81	555.52
day 35 to 67	85.67	62.83	74.25	77.06	72.2	7.24	507.28
day 18 to 22[c]	84.58	63.72	74.15	72.59	71.7	10.46	617.44
day 41 to 43[c]	88.47	65.46	76.96	81.44	75.0	9.51	585.89
day 44 to 46[c]	93.24	71.83	82.53	75.10	79.2	8.14	579.56

[a]Solar radiation recorded from a weather station located 1 mile north and ½ mile west of feedlot. Other recordings taken from weather station located in feedlot.
[b]Temperature Humidity Index (THI), calculated as THI = AvgTemp – (0.55-(0.55*(RH/100)))*(AvgTemp-58)
[c]Weather for periods that correspond to tympanic temperature recording. Heat stress was denoted at thermoneutral for days 18 to 22 (TNL), moderately hot days 41 to 43 (MHOT), and hot for days 44 to 46 (HOT).

Table 3. Performance data.

	Treatment[a]					P-value		
	Control	K	Na	KNa	SEM	K	Na	K*Na
Weights, lb[b]								
day 0	1070	1067	1069	1070	4.2	0.81	0.78	0.61
day 34	1193	1188	1208	1189	9.2	0.25	0.43	0.49
day 67	1280	1275	1283	1260	9.1	0.15	0.53	0.35
ADG, lb								
day 0 to 34	3.61	3.58	4.04	3.50	0.19	0.15	0.38	0.20
day 35 to 6	2.64	2.62	2.32	2.15	0.14	0.51	0.01	0.60
day 0 to 67	3.09	3.11	3.20	2.82	0.11	0.12	0.46	0.09
DMI, lb								
day 0 to 34	23.21	22.95	23.06	21.42	0.55	0.09	0.13	0.21
day 35 to 67	22.53	22.32	22.05	21.97	0.46	0.75	0.38	0.89
day 0 to 67	22.88	22.64	22.57	21.69	0.48	0.26	0.20	0.51
Feed/Gain								
day 0 to 34	6.66	6.67	5.92	6.46	0.32	0.40	0.15	0.41
day 35 to 67	8.68	8.70	9.60	10.28	0.49	0.49	0.02	0.51
day 0 to 67	7.44	7.36	7.08	7.73	0.27	0.33	0.99	0.19
DWI, gal								
day 0 to 34	7.48	9.26	6.84	9.67	0.78	0.02	0.89	0.53
day 35 to 67	8.62	10.39	7.18	10.43	0.73	0.01	0.37	0.35
day 0 to 67	8.03	9.81	7.01	10.04	0.74	0.01	0.60	0.42
DMI/DWI[c]								
day 0 to 34	3.25	2.49	3.42	2.26	0.34	0.02	0.94	0.58
day 35 to 67	2.72	2.15	3.07	2.13	0.23	0.01	0.49	0.44
day 0 to 67	2.97	2.31	3.23	2.20	0.27	0.01	0.80	0.50

[a]Control = control; K = potassium added to diet; Na = sodium chloride added to diet; KNa = potassium and sodium chloride added to diet.
[b]All weights are full weight.
[c]Pair of pens served as experimental unit for daily water intake (DWI) and DMI/DWI.

Table 4. Tympanic temperatures within logger period.

	Treatment[a]					
Item[b]	Control	K	NA	KNa	SEM	P-value
TNL	102.3	102.2	102.1	102.1	0.15	0.56
MHOT	102.3	102.3	102.1	102.1	0.15	0.93
HOT	103.4	103.4	103.5	103.2	0.15	0.76

[a]Control = control; K = potassium added to diet; Na= sodium chloride added to diet; KNa = potassium and sodium chloride added to diet.
[b]TNL = thermoneutral; MHOT = moderately hot; HOT = hot.

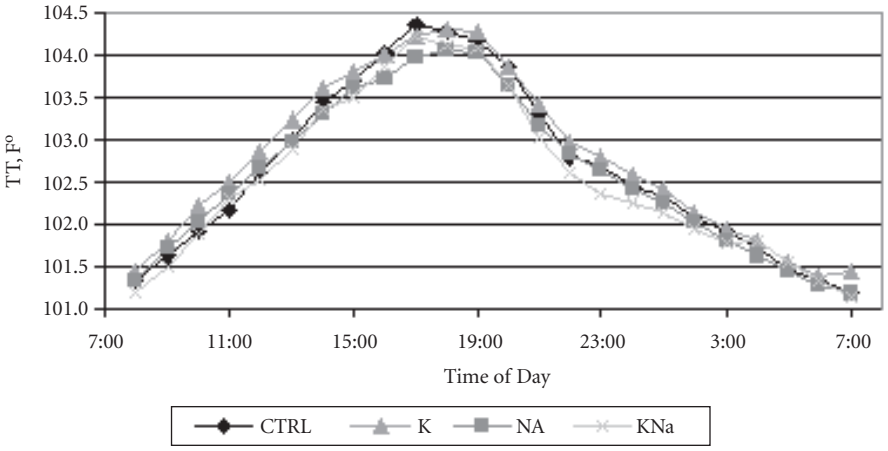

Figure 1. Tympanic Temperatures (TT) within Time of Day[a]. Differences within each hour are not significant ($P > 0.05$).
[a]CTRL = control; K = potassium added to diet; Na = sodium chloride added to diet; KNa= potassium and sodium chloride added to diet.

DCAD levels are generally thought to aide in maintaining body electrolyte balance during hot weather as well as aid in the reduction of acidosis. The increased water intake could possibly be attributed to the increased DCAD levels.

Overall, additional $KHCO_3$ at the 2% level or NaCl at the 1% level did not improve performance or heat stress tolerance with these diet formulations. However, the addition of $KHCO_3$ did enhance water intake.

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