Effects of potassium in steers on feed consumption and growth with and without the influences of gustatory and olfactory cues¹

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The effects of potassium on feed consumption and growth in young steers were investigated by methods that precluded or included the gustatory and olfactory cues provided by potassium. Two groups of steers differentially depleted of potassium were injected intraruminally with either potassium solution or water over 22 days and then fed a ration adequate in potassium for 20 days. Steers injected with potassium consumed more feed (potassium-deficient ration) and displayed superior growth than control animals during the depletion period. When an adequate potassium ration was fed, feed consumption and growth rates of control animals increased markedly. Throughout the study, high serum potassium reflected the potassium status of the animals. It was concluded that, in this study, taste and smell of potassium, though important, were not essential in the regulation of feed intake.

Diets deficient in potassium produce abnormal food intake (anorexia) in steers and in other mammals (Cannon, Frazier, & Hughes, 1952; Campbell, 1964; Welt, Hollander, & Blythe, 1960; Devlin, Roberts, & St. Omer, 1969). The sensory modalities of taste and smell are thought to play important roles in the consummatory behavior of animals (Richter, 1942; Milner & Zucker, 1965). To the authors' knowledge, however, there are no reports on the role of taste and smell in the nutrition of steers and other mammals fed rations deficient in potassium.

Two questions were asked in the work reported here. First, do steers initially depleted of potassium feed themselves and increase their weights normally for prolonged periods of time without sensing (by smell and taste) adequate potassium in their ration and without the act of oral ingestion of potassium? Second, do they respond appropriately and rapidly to an abrupt increase in ration potassium?

MATERIALS AND METHODS

Twelve yearling Hereford steers were initially divided into two equal preexperimental groups. The animals were adjusted for 110 days to a semi-purified basal ration, fed ad lib (St. Omer &

Roberts, 1967). The levels of potassium (as K_2CO_3) added to the rations of Groups 1 and 2 were, respectively, 0.25% and 0.47% of the air-dry ration (a potassium level of 0.6% was optimum for rapid growth; St. Omer, 1965). All animals had free access to water containing negligible potassium (0.13 mEq/liter). No bedding was provided to preclude the possible intake of it and the potassium it contained. At the end of 110 days, Group 2 was fed the low potassium (0.25%) ration of Group 1 for a period of 14 days, following which each group was randomly, but equally, divided into a control (1a and 2a) and an experimental (1b and 2b) group, in order to control for the different initial physiological planes of potassium depletion produced in both groups (Table 1). All animals had free access to food and water throughout the experiment.

The consummatory (appetite) trial consisted of a 22-day depletion period, and a 20-day recovery period. During the depletion period, all animals were fed the 0.25% potassium ration. Each steer in the experimental groups received (every 2nd day) 50 g potassium (1,281.1 mEq) as K_2CO_3 dissolved in 100 ml of deionized water. The steers in the control groups, however, each received (every 2nd day) an intraruminal injection of 100 ml of deionized water. Throughout the recovery period, the ration of all steers contained the optimal potassium level of 0.6%.

Daily feed consumption was recorded and body weight of each steer was obtained at the onset and termination of each period. In addition jugular blood samples (with one exception) were collected during the onset and termination of each period. The exception consisted in collecting post-depletion blood samples the 1st day of recovery. This allowed for complete

assimilation of the terminal injections and precluded artificial elevation of serum potassium levels.

Sodium and potassium analyses were made on samples of rations, serum, and tap water by flame photometry.

Statistical analyses of the data were by analysis of variance (Steel & Torrie, 1960).

RESULTS AND DISCUSSION

Inspection of Table 2 indicates that, during the depletion period, steers (Groups 1b and 2b) receiving the intraruminal injection of potassium showed greater acceptance of the identical low potassium ration than control animals (Groups 1a and 2a) injected with deionized water. The increased consumption of the ration by experimental groups is reflected in their superior weight gains (Table 2). Group 1b steers showed a significant ($p < 0.05$) increase in average body weight gain over its control (Group 1a steers lost an average of 14.4 kg). The lack of a significant gain in body weight by Group 2b steers over control animals (Group 2a) emphasizes the fact that the initial physiological plane of body potassium is an important factor controlling food consumption. It must be recalled that all Group 2 animals, unlike those of Group 1, were initially in a higher physiological plane of body potassium (Table 1). The data obtained during the depletion period, however, indicated that the taste and smell of potassium in the ration was not essential for the normal regulation of food intake in young steers.

During the subsequent 20-day recovery period, there was a general increase in feed intake by all animals. The control groups approximately doubled their previous feed consumption (Table 2). The overall rate of weight gain of the control steers (Groups 1a and 2a) was higher than that of the experimental steers (Groups 1b and 2b). The difference in weight between Control Group 2a and Experimental Group 2b was significant ($p < 0.05$). These results are in general agreement with those of Cannon et al (1952). He observed that protein-depleted rats, when fed a complete ration, effectively recovered their initial loss of weight. When potassium was

Table 1
Effects of Low Dietary Potassium on Various Physiological Parameters of Steers Over a 110-Day Pre-experimental Period

Item	Group 1*	Group 2	Sig.
Ration potassium per cent	0.25	0.47	
Number of steers	6.0	6.0	
Av. initial weight, kg	282.2	281.4	
Av. total gain, kg	9.9 ± 18.37	98.8 ± 14.14	< .05
Av. daily feed, kg	3.82	6.28	
Av. feed/kg gain, kg	42.44	6.98	
Serum potassium, mEq/l	3.71 ± 0.82	4.11 ± 0.09	< .05
Serum sodium, mEq/l	144.17 ± 1.52	146.67 ± 1.56	Not sig.

* Group 1 manifested typical symptoms of severe K deficiency viz: partial inanition, pica, and muscle weakness.

Table 2
Effects of Potassium on Physiological Parameters When Steers Were Injected Intraruminally with Either Water or Potassium Solution and Then Fed a Ration Containing 0.6% Potassium

Item	Group 1a (r + w)*		Group 1b (r + K)*		Sig.	Group 2a (r + w)*		Group 2b (r + K)*		Sig.
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
(Period 1; 22 Days Depletion)										
Av. original body weight	285.1		279.5			351.9		339.0		
Av. change in body weight (kg)	-14.4	± 8.9	39.8	± 10.8	< .05	9.0	± 17.0	23.6	± 0.8	Not sig.
Av. daily feed (kg)	2.17		4.12			3.78		4.39		
Serum Na (mEq/l)	136.7	± 3.5	142.0	± 1.0	Not sig.	141.0	± 0.9	142.3	± 1.5	Not sig.
Serum K (mEq/l)	3.50	± 0.57	4.57	± 0.07	< .05	3.96	± 0.01	4.55	± 0.20	< .05
(Period 2; 20 Days Recovery)										
	(R)*		(R)*			(R)*		(R)*		
Av. original body weight (kg)	270.7		319.3			360.9		362.6		
Av. change in body weight (kg)	38.9	± 16.5	45.3	± 3.8	Not sig.	62.5	± 2.1	25.4	± 10.9	< .05
Av. daily feed (kg)	5.17		8.54			7.57		7.12		
Serum Na (mEq/l)	133.7	± 5.8	145.0	± 1.7	Not sig.	147.7	± 1.3	140.3	± 2.7	Not sig.
Serum K (mEq/l)	4.30	± 0.20	4.57	± 0.07	Not sig.	4.52	± 0.03	4.25	± 0.25	Not sig.

Groups 1a and 1b were initially in a lower physiological plane of body potassium than Groups 2a and 2b

* Injections: W, water; K, potassium; Ration potassium: r, 0.25%; R, 0.60%

omitted from the ration, the rats displayed poor appetite and did not gain weight. The results of the recovery period suggested that for the management of the natural consummatory behavior gustatory and olfactory cues are important. They probably are crucial for discrimination between rations deficient or adequate in potassium under natural conditions.

Throughout this study, serum potassium concentrations reflected the potassium status of the animals. In general, the data suggested that the extent of ration consumption depended upon adequate quantities of potassium entering the rumen either orally or via intraruminal injection. This suggests that the potassium effect of feed consumption is probably directly related to changes in blood potassium. It is likely that a change in potassium concentration of the arterial blood perfusing the taste buds is, in some way, responsible for the effect of potassium on modulating feed consumption. Further research will be required to establish the role of changes in blood potassium on feed consumption.

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NOTES

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Time-dependent memory storage: An alternative interpretation of some data¹

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Mice were administered a single-shock trial on a step-down apparatus. For half the animals, step-down latency was again determined at selected times following shock; for the other half, activity level was

measured at comparable times. For both step-down latency and activity level, there was a systematic relation between the measure and time-following-shock. Further, these two measures were inversely related. This latter result indicates that step-down performance and activity covary and are possibly related to a single organismic other-than-memory variable.