# POTASSIUM LEVELS AND DIGESTIBILITIES IN FEEDLOT STEERS

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## Story in Brief

Effect of potassium (K) level on site and extent of digestion was investigated with four cannulated steers receiving a 90 percent concentrate rolled corn diet with 10 percent cottonseed hulls as a roughage source. Four levels of potassium [.48 (control), .64, .79, and .95 percent of diet dry matter] with supplemental potassium from potassium chloride were fed in a 4 x 4 latin square design experiment. Ruminal, duodenal, and fecal pH were not significantly different (P>.05). Ruminal ammonia nitrogen concentration was greatest for the .95K diet. Ruminal organic matter (OM), starch, and nitrogen digestibilities did not differ significantly (P>.05), but tended to be greatest for the .95K diet (70.3, 83.1, and 54.8 percent), lowest for the .79K diet (62.0, 76.6, and 42.2 percent), and intermediate for the .48K and .64K diets. Post ruminal digestibilities of organic matter, starch and nitrogen tended to be the greatest at the .79K level. Although fluid dilution and particulate passage rates were not significantly affected by K level, the overall correlation of ruminal liquid (CoEDTA) with solids (Yb-labeled corn) passage rates was positive (r=.46; P<.07). Ruminal starch digestion was inversely related to fluid dilution rate (r=-.36; P<.18) and to particulate passage rate (r=-.65; P<.01). Microbial efficiency was maximized at the .79K level (16.4 percent) and was lowest at the .95K level of supplementation (12.2 percent). Statistical analysis revealed a significant cubic effect (P<.02) of K on microbial efficiency being greatest with .79 percent K in the diet.

[Key Words: Feedlot, Potassium Chloride, Steers, Site of Digestion, Passage Rate.]

## Introduction

Early research indicated that potassium (K) levels of .5-.6 percent in the ration dry matter was adequate for rapid weight gains in finishing steers (Roberts and St. Omer, 1965). Currently, K recommendations for growing and finishing steers range from .5-.7 percent ration dry matter, with a suggested value of .65 percent (NRC, 1984). Because most concentrate feeds are below this percentage, K supplementation of high concentrate rations is a common practice.

Previous trials at Oklahoma State University suggest that with increased K supplementation levels, feedlot performance may be increased. Limited research suggests K supplementation might benefit the animal in several ways: 1) through maintenance of a desirable moisture content of the rumen fluid for bacterial fermentation (Ward, 1966); 2) by enhancing ruminal digestion, particularly of fiber (Zinn et al., 1983); 3) through buffering since K may be converted to $KHCO_3$ in the rumen (Zinn and Owens, 1983); 4) by stabilizing feed intake (Zinn et al., 1981);

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and 5) through increasing water intake and water turnover rate (Ward, 1966). The objectives of this study were to examine the influence of various KCl supplementation levels on the site and extent of digestion and on ruminal passage rates.

## Materials and Methods

Four dairy steers (254 lb) fitted with ruminal and duodenal cannulas were used in a 4 x 4 latin square design experiment to study site and extent of digestion of a high concentrate, complete, mixed diet. The control diet (C) had no supplemental K (Table 1), but was calculated to contain .48 percent K. Potassium chloride replaced rolled corn in the test diets to produce test diets which contained .64, .79, and .95 percent K on a DM basis. All diets contained chromic oxide as an indigestible marker at .3 percent above the total ration. Steers were fed twice daily at 0800 and 2000 hr, and daily DM intake was 2.25 percent of body weight.

Table 1. Complete mixed diet compositions.

| Ingredient | Percent of Dry Matter |
|---|---|
| Corn Dent #2, Rolled | 80.54 |
| Cottonseed Hulls | 10.36 |
| Soybean Meal, Solvent process | 4.03 |
| Cottonseed Meal, Solvent process | 2.01 |
| Calcium Carbonate | 1.00 |
| Salt | .30 |
| Urea | .56 |
| Cane Molasses | .25 |
| Trace Minerals | .01 |
| Vitamin A-30 | .01 |
| Rumensin, 60 gram per pound | .02 |
| Tylan, 10 gram per pound | .04 |
| Corn grain | .87-.0 |
| Potassium chloride[a] | .0-.87 |
| Chromic oxide | .3 |

[a]To provide .64, .79, and .95 percent dietary potassium from added potassium chloride (.29, .58, and .87 percent).

Periods lasted 14 days with sampling on days 13 and 14. One-hundred grams of ytterbium labeled corn was added to each diet at 2000 hr on day 11 to estimate particulate passage. A fluid marker (CoEDTA) was intraruminally dosed prior to the morning feeding on day 13. Rumen samples were obtained via cannula on day 13 before dosing and 1, 3, 6, 9, and 12 hr post feeding. Samples from the duodenum and rectum were obtained 39, 45, 51, 57, 66, 72, 78, and 84 hr after feeding ytterbium-labeled corn. Feed samples were collected on days 11-14. Feed, ruminal fluid, duodenal, and rectal samples were subjected to all or part of the following analyses: pH, dry matter (DM), Kjeldahl nitrogen (N), ammonia-N ($NH_3$-N), nucleic acid-N (NAN), ash, starch, chromium, ytterbium, and cobalt.

## Results and Discussion

Mean ruminal, duodenal, and fecal pH (Table 2) did not differ significantly (P>.05) with increasing K supplementation levels. However, fecal pH tended to be higher with K levels of .64 percent or greater. In this trial ruminal and fecal pH in all treatments was higher than expected for a 90 percent concentrate ration. However, this may be related to modest feed intake level which should reduce the incidence of subacute and acute digestive disturbances. Duodenal pH was similar to other reports in which similar concentrate levels were fed. Since pH was not increased with added KCl, increased buffering capacity of ruminal contents seems unlikely.

Table 2. Mean digestive tract measurements.

| Item | Diet | | | |
|---|---|---|---|---|
| | .48%K | .64%K | .79%K | .95%K |
| Ruminal pH | 6.22 | 6.17 | 6.24 | 6.21 |
| Duodenal pH | 2.33 | 2.39 | 2.33 | 2.34 |
| Fecal pH | 6.30 | 6.47 | 6.54 | 6.45 |
| Ruminal ammonia-N, mg/dl | 3.5[b] | 3.8[ab] | 3.7[ab] | 5.6[a] |
| Ruminal fluid | | | | |
| Dilution rate, %/h | 4.14 | 5.15 | 4.61 | 6.00 |
| Volume, liter | 12.7 | 10.8 | 12.0 | 10.5 |
| Particulate passage rate, %/h | 4.32 | 3.37 | 3.80 | 4.03 |

[a,b]Means in a row with different superscripts differ (P<.05).

Ruminal ammonia-N (Table 2) was greater (P<.05) for steers receiving .95 than those fed .48 percent K. This may be due to increased ruminal N degradation or reduced use of ammonia-N for synthesis of microbial protein. Microbial N (MN) entering the duodenum tended to be greater for the .48K and .79K (23.2 and 23.4 g/day) than with the .64K and .95K diets (20.7 and 21.0 g/day). Also ruminal fluid dilution rates tended to be lower with the .48K and .79K diets (Table 2). Ruminal fluid volumes were not significantly different (P>.05). Rumen volume and ruminal fluid dilution rate were inversely related (r=-.88; P<.0001); rumen volume and particulate passage rate also were inversely related (r=-.45; P<.08). Urinary excretion of K may have increased water intake and rumen fluid dilution rate, but this was not measured in this study. Water intake and urine excretion volume usually are directly related to K intake. Ruminal liquid and solids passage rates were correlated positively (r=.46; P<.07).

Table 3. Site and extent of digestion of diets varying in percent potassium.

| Item[c] | Diet .48%K | .64%K | .79%K | .95%K | Contrast[d] |
|---|---|---|---|---|---|
| Organic matter, % | | | | | |
| Ruminal | 67.9 | 66.9 | 62.0 | 70.3 | - |
| Post ruminal (apparent) | 14.5 | 18.7 | 22.4 | 15.7 | - |
| Total tract | 82.4 | 85.6 | 84.4 | 86.0 | - |
| Starch, % | | | | | |
| Ruminal | 82.4 | 80.7 | 76.6 | 83.1 | - |
| Post ruminal | 13.1 | 16.7 | 19.8 | 13.9 | - |
| Total tract | 95.5 | 97.4 | 96.4 | 97.1 | - |
| Nitrogen, % | | | | | |
| Intake, g/d | 46.1 | 45.3 | 46.1 | 46.2 | - |
| Duodenal, g/d | | | | | |
| Total, g/d | 50.6 | 48.9 | 53.0 | 45.2 | - |
| Microbial, g/d | 23.2 | 20.7 | 23.4 | 21.0 | - |
| Feed, g/d | 23.9 | 24.9 | 25.7 | 20.8 | - |
| Total tract digestibility, % | 71.0 | 74.0 | 72.3 | 75.1 | - |
| Microbial efficiency, g MN/kg organic matter fermented | 13.8[ab] | 12.4[b] | 16.4[a] | 12.2[b] | C |

[ab]Means in a row with different superscripts differ (P<.05).
[c]Digestion measures, % of intake.
[d]Indicative of linear (L), quadratic (Q), and or cubic (C) effect (P<.05).

Although dietary level of K had no significant (P>.05) impact on ruminal organic matter digestibility, ruminal organic matter (OM) digestion coefficients (Table 3) tended to be higher for the .95K ration (70.3 percent) and lower for the .79K diet (62.0 percent). Zinn (1983) found enhanced ruminal OM digestion with increased K supplementation, particularly with rations containing more fiber. Ruminal OM digestibility and particulate passage rate were negatively correlated (r=-.64; P<.01). Rumen fluid dilution rate also was inversely related to ruminal OM digestion (r=-.31; P<.24).

Post ruminal OM digestion did not differ significantly (P>.05) with K level of the diet. At the .79K level, post ruminal OM digestion tended to be greatest. This may be due to compensation for decreased ruminal OM digestion with this diet. Total tract OM digestion did not differ significantly (P>.05) but total tract OM digestion tended to increase with increasing dietary K in agreement with previous potassium trials (Zinn and Axe, 1983).

Ruminal and total tract N digestibility (Table 3) was not significantly different (P>.05) but tended to be greatest with .95K supplementation. A negative correlation (r=-.52; P<.04) existed between particulate passage rate and ruminal N digestibility.

Statistical analysis revealed a significant cubic effect (P<.02) with microbial efficiency tending to decrease as levels of K in the diet increased. Microbial efficiency was higher at .79 K than at the .95 K level (P<.05). Elevated liquid and particulate passage rates may inhibit the efficiency of microbial growth and decrease flow of MN from the rumen if time of fermentation is inadequate for maximum microbial colonization. However, ruminal OM digestibility and microbial efficiency were negatively correlated (r=-.95; P<.0001). Relative rates of 1) microbial dilution, 2) feed removal, 3) fermentation rate and capacity, and 4) lag time for fermentation are needed to assess the total effect of altered dilution rates on microbial output from the rumen (Goetsch and Owens, 1984). Lower dilution and particulate passage rates may enhance the proportion of duodenal chyme which is microbial protein but decrease microbial efficiency. This may be due to marker problems or reflect ruminal flow conditions more optimal for efficient microbial growth. Ward (1966) has also proposed that potassium increases the osmotic pressure of the rumen fluid and functions to maintain a desirable moisture content in the rumen fluid which could increase bacterial fermentation.

Ruminal starch digestion (Table 3) did not differ (P>.05) with K level but was 7 percent greater for the .95K diet than the .79K diet. Incorporation of starch into microbial protein might be involved. Post-ruminal starch digestion inversely related to ruminal starch digestion. Whether this was due to increased digestion in the small intestine or increased fermentation of starch in the small intestine plus colon was not determined in this study. Total tract starch digestion paralleled total tract OM digestion. Ruminal starch digestion was negatively correlated with fluid dilution rate (r=-.63; P<.18) and with particulate passage rate (r=-.65, P<.01); particulate passage rate was also inversely related to total starch digestion (r=-.63; P<.01).

Results from this trial indicate that a moderate level of K supplementation (.79 percent K diet dry matter) tended to increase icrobial efficiency (P<.02). However, total tract OM, starch, and N digestibilities did not differ significantly. K supplementation to the .95K level shifted greater OM, starch, and nitrogen digestibility to the rumen and tended to reduce microbial efficiency. A moderate K level (.79 percent) shifted starch and N digestibility to the post ruminal tract and maximized microbial efficiency. Further research is needed to determine the optimum K supplementation to maximize microbial efficiency and extent of digestion. The relationship of potassium intake to water intake, particulate passage rate, rumen fluid dilution rate, and water turnover rate ust be examined to understand the physiological importance of the K level in the diet.

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