# EFFECT OF SALT LEVEL IN A MONENSIN-CONTAINING ENERGY SUPPLEMENT ON RUMEN FERMENTATION OF STEERS GRAZING WHEAT PASTURE[1]

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## Story in Brief

Nine mature rumen cannulated steers were used in two separate wheat pasture grazing seasons to evaluate the effects of a monensin-containing energy supplement and level of salt on rumen fermentation. Within each year, steers were randomly allotted to three treatments as follows: (1) nonsupplemented, control, (2) 3 lb/day of a monensin-containing energy supplement with a low level of added salt (year 1) or no added salt (year 2), or (3) 3 lb/day of a similar monensin-containing energy supplement with added salt. Neither the monensin/energy supplement nor additional salt had an effect on rumen pH in either year. The monensin/energy supplement decreased ruminal fluid acetate and increased propionate proportions resulting in a decreased acetate to propionate ratio in both years. Level of salt supplementation did not significantly affect acetate to propionate ratios, but propionate proportion tended to be increased by additional salt in year 2. The ruminal response to the monensin/energy supplement was not enhanced by additional salt in this study where steers grazed wheat pasture containing about .04 % sodium and 1.9% potassium in the dry matter.

(Key Words: Monensin, Energy Supplementation, Wheat Pasture, Sodium.)

## Introduction

Monensin facilitates cation (Na and K) transfer across cellular membranes thereby preventing the growth of most gram positive bacteria. Rumen and dietary concentrations of these cations can theoretically dictate cation preference for transportation. High dietary K levels may inhibit the antimicrobial activity of monensin while increasing dietary Na levels appear to "stimulate the rumen environment" (Russell, 1987) possibly offsetting inhibition of antimicrobial effects. Depression of ionophore antimicrobial

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effects has been observed in the presence of high K levels *in vitro* (Dawson and Boling, 1987) with additional Na reversing this effect (Dawson et al., 1983). Supporting *in vivo* data is, however, variable.

Wheat pastures often contain high K levels. In studies reported by Horn et al. (1990 and 1992) and Beck et al. (1993), a self-limiting monensin-containing energy supplement, which contained 4% salt, has consistently increased daily weight gains of wheat pasture stocker cattle by about .5 lb over four studies (i.e., wheat pasture years). Mean supplement intake across sampling times within years and across years was 2.9 lb. This improvement in daily gain of .5 lb is greater than we have previously observed for hand-fed monensin-containing energy supplements with low levels of salt. The objective of this study was to examine effects of monensin-containing energy supplements with either low or additional levels (amounts) of salt on ruminal fermentation of cattle grazing wheat pasture.

## Materials and Methods

***Year 1.*** Nine mature, Hereford X Angus rumen cannulated steers grazed the same wheat pasture, and were randomly allotted to three treatments as follows: (1) nonsupplemented, control, (2) 3 lb/day of a monensin-containing energy supplement with .5% salt or (3) 3 lb/day of a similar monensin-containing energy supplement with 4% salt. The supplement containing .5% salt was the same as that fed every other day by Andrae et al. (1994) and the supplement containing 4% salt was the same as the self-limiting supplement used by Horn et al. (1990 and 1992) and Beck et al. (1993). Composition of the supplements is shown in Table 1. The 18-day experiment consisted of an initial 6-day adaptation period to wheat pasture, an 11-day period of adaptation to supplements and a 1-day rumen sampling period. Steers were fed supplements daily in individual stalls under a barn adjacent to wheat pasture beginning March 16, 1993. No other salt or mineral supplements were available to the steers throughout the experiment. On March 27, 1993, ruminal fluid was collected from each steer at two, four and six hours following supplementation. Steers were not allowed access to pasture or water during the sampling period to prevent dilution of rumen contents. Rumen pH was determined immediately following each sample collection with aliquots frozen for later ammonia (magnesium oxide distillation), osmolarity (freezing point depression), VFA (gas chromatography), and Na and K (atomic absorption spectrophotometry) analysis. Hand-clipped forage samples were collected on the day of rumen sampling, and were analyzed for crude protein, Na and K content.

***Year 2.*** Experiment 2 consisted of a 17-day wheat pasture and supplement adaptation period followed by a 1-day rumen sampling period, and was similar to Experiment 1. Nine mature rumen cannulated steers were randomly allotted

to three treatments as follows: (1) nonsupplemented, control, (2) 3 lb/day of ground corn containing 300 mg monensin, (3) same as treatment 2 plus 75 g of fine mixing salt. The amount of salt was selected as being similar to salt intake of steers consuming 4 lb/d of a supplement containing 4% salt. The experiment began on March 21, 1994, and supplements were placed directly into the rumen at approximatedly 0730 hours daily. Ruminal fluid samples were collected at two, four and six hours post-supplementation on April 7, 1994.

Data were analyzed as a split-plot experimental design using the GLM procedure of SAS (1985). Steer within treatment was used as the error term for orthogonal contrasts which compared 1) no supplement vs the average of the two monensin-energy supplements to determine "supplementation" effects and 2) low salt (or no salt) vs high salt supplements to determine sodium effects. The error mean square was used to test for treatment X time interactions. Means of each treatment were separated at each sampling time using LSMEANS when this interaction was deemed significant ($P<.20$).

## Results and Discussion

Main supplement effects for Years 1 and 2 are presented in Tables 2 and 3, respectively. Simple effects of supplements where there was a treatment X time interaction are shown in Table 4. There was no effect of supplement ($P>.20$) or salt level ($P>.53$) on rumen pH in either year. Rumen ammonia concentrations were not affected in Year 1, but both supplement ($P<.01$) and salt ($P<.05$) decreased rumen ammonia in the second year. Rumen ammonia concentrations in Year 2 are, however, much lower than those observed in Year 1. Rumen osmolarity was not affected in Year 1, but there was a treatment X time interaction ($P<.01$) in the second year. Rumen osmolarity decreased more rapidly in steers that received additional salt in Year 2. This more rapid decline in osmolarity could be related to the treatment X time interaction for rumen soluble Na concentrations which also decreased more rapidly in steers fed additional salt.

A treatment X time effect ($P<.10$) was detected for total VFA concentrations in Year 1. Total VFA concentrations declined ($P<.05$) over time for both control and low-salt treatments while VFA concentrations of steers fed additional salt remained constant. The proportion of acetate was lower ($P<.05$) for supplemented cattle in both years, but was not influenced by salt level ($P>.44$) in either year. Propionate proportion tended to increase ($P=.09$) in Year 1 and was increased ($P<.05$) in Year 2 by supplementation. There also was a tendency ($P=.07$) for the high salt level to increase propionate proportion in Year 2. The proportion of butyrate was not affected in Year 1 by either supplementation or salt level ($P>.46$), but there was a treatment X time interaction in Year 2 ($P<.12$) in which the proportion of butyrate of control

steers decreased at a more rapid rate than that of supplemented steers. Acetate to propionate ratios were decreased (P<.05) each year by supplementation similar to usual response observed with monensin supplementation (Richardson et al., 1976). Although mean acetate to propionate ratios were numerically lower at all sampling times with high salt supplements, this decrease was not significant in either Year 1 (P>.40) or Year 2 (P>.18). Supplementation resulted in an increase (P<.01) in rumen soluble sodium and a decrease (P<.05) in rumen soluble potassium in Year 1. This is shown by an increase (P<.01) in Na:K ratios with supplementation and a tendency (P=.06) for this ratio to increase with high salt supplements. In Year 2 there was a treatment X time interaction with rumen soluble Na (P<.01) and K (P<.05) levels. Sodium levels decreased over time with additional salt and increased over time for control and low-salt supplemented steers. Potassium levels for low-salt supplemented steers declined more rapidly with time than did the other two treatments. Sodium to potassium ratios were increased (P<.01) by salt supplementation in Year 2.

Mean (± std. dev., n=4) Na and K concentrations (% of DM) of hand-clipped forage samples were, respectively: .04±.01 and 1.78±.10 (year 1) and .03±.01 and 1.96±.23 (year 2). Forage K concentrations were lower than normally expected for wheat pasture, and may not have been high enough to inhibit antimicrobial effects of monensin. Stewart et al. (1981) reported K concentrations of wheat forage that ranged from about 2% to almost 5% of dry matter during the fall, winter, and early spring grazing periods.

The monensin-containing energy supplement decreased ruminal acetate to propionate ratios in both years. However, additional supplemental salt did not further improve the ruminal response from the monensin/energy supplement in cattle grazing wheat pasture in this study.

## Literature Cited

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**Table 1. Composition of supplements (% as-fed) in Year 1.**

| Supplement | Monensin low salt | Monensin high salt |
|---|---|---|
| Ingredient | | |
| Milo, ground | 66.65 | 62.78 |
| Wheat middlings | 21.00 | 21.00 |
| Molasses, sugarcane | 4.80 | 4.80 |
| Limestone | 4.00 | 4.00 |
| Dicalcium Phosphate | 2.55 | 2.55 |
| Fine mixing salt | .50 | 4.00 |
| Magnesium Oxide | .35 | .75 |
| Rumensin 60 Premix | .15 | .12 |
| Mg monensin/lb supplement | 90 | 75 |
| Supplement intake lb/day | 3.0 | 3.0 |

**Table 2. Effect of supplementation on ruminal fermentation of steers Year 1.**

| | | Monensin | Monensin | | Contrast, P-value | |
|---|---|---|---|---|---|---|
| Item | Control | low salt | high salt | SEM | Supplementation | Salt |
| Number of steers | 3 | 3 | 3 | - | - | - |
| pH | 5.83 | 5.62 | 5.78 | .17 | .55 | .53 |
| $NH_3$-N (mg/100ml) | 20.27 | 18.59 | 16.53 | 3.80 | .58 | .72 |
| Osmolarity (mOsmol/kg) | 313.94 | 345.72 | 342.61 | 15.61 | .17 | .89 |
| Acetate[a] | 56.38 | 51.42 | 52.71 | 1.11 | .02 | .44 |
| Propionate[a] | 21.12 | 25.20 | 28.79 | 2.39 | .09 | .33 |
| Butyrate[a] | 16.77 | 15.89 | 12.73 | 2.80 | .50 | .46 |
| Acetate:Propionate | 2.68 | 2.13 | 1.86 | .21 | .04 | .40 |
| Rumen Na (g/L) | 1.75 | 2.18 | 2.45 | .13 | .01 | .20 |
| Rumen K (g/L) | 2.10 | 1.67 | 1.36 | .15 | .02 | .19 |
| Na:K | .88 | 1.33 | 1.87 | .16 | .01 | .06 |

[a]mol/100mol

**Table 3. Effect of supplementation on ruminal fermentation of steers Year 2.**

| Item | Control | Monensin low salt | Monensin high salt | SEM | Contrast, P-value Supplementation | Salt |
|---|---|---|---|---|---|---|
| Number of steers | 3 | 3 | 3 | - | - | - |
| pH | 6.72 | 6.45 | 6.55 | .12 | .20 | .63 |
| $NH_3$-N (mg/100 ml) | 8.96 | 6.58 | 3.93 | .73 | .01 | .04 |
| Total VFA[a] | 94.18 | 107.78 | 97.17 | 7.03 | .37 | .33 |
| Acetate[b] | 67.12 | 65.25 | 65.82 | .48 | .04 | .44 |
| Propionate[b] | 16.76 | 18.45 | 20.15 | .56 | .01 | .07 |
| Acetate:Propionate | 4.02 | 3.56 | 3.28 | .13 | .01 | .18 |
| Na:K | 3.41 | 2.49 | 3.61 | .16 | .12 | .003 |

[a]mMol/L
[b]mol/100mol

**Table 4. Simple effects for variables with treatment X time interactions.**

| Item | Control | Monensin low salt | Monensin high salt | SEM |
|---|---|---|---|---|
| Total VFA (mMol/L) -Year 1 | | | | |
| 2h | $83.53^{b}$ | $111.01^{a}$ | $79.15^{bc}$ | 4.11 |
| 4h | $73.78^{bc}$ | $105.14^{a}$ | $75.40^{bc}$ | |
| 6h | $67.16^{c}$ | $81.48^{b}$ | $74.23^{bc}$ | |
| Osmolarity (mOsmol/kg) -Year 2 | | | | |
| 2h | $319.17^{bc}$ | $329.67^{ab}$ | $340.00^{c}$ | 3.58 |
| 4h | $298.50^{d}$ | $314.33^{c}$ | $301.33^{d}$ | |
| 6h | $286.50^{e}$ | $301.00^{d}$ | $277.00^{e}$ | |
| Butyrate (mol/100mol) -Year2 | | | | |
| 2h | $12.71^{ab}$ | $13.24^{a}$ | $11.70^{cd}$ | .19 |
| 4h | $11.40^{d}$ | $12.26^{bc}$ | $10.11^{ef}$ | |
| 6h | $10.53^{e}$ | $11.94^{cd}$ | $9.33^{f}$ | |
| Rumen Na (g/L) -Year 2 | | | | |
| 2h | $2.83^{cd}$ | $2.73^{e}$ | $3.09^{a}$ | .022 |
| 4h | $2.98^{b}$ | $2.85^{c}$ | $3.08^{a}$ | |
| 6h | $2.95^{b}$ | $2.81^{d}$ | $3.01^{b}$ | |
| Rumen K (g/L) -Year 2 | | | | |
| 2h | $1.01^{cd}$ | $1.35^{a}$ | $1.04^{c}$ | .017 |
| 4h | $.88^{e}$ | $1.15^{b}$ | $.86^{e}$ | |
| 6h | $.75^{f}$ | $.96^{d}$ | $.71^{f}$ | |

$^{a,b,c,d,e,f}$Means within variables with uncommon superscripts differ (P<.05).