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SULFUR AMINO ACID UTILIZATION BY GROWING STEERS

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Summary

Two studies were conducted to evaluate sulfur amino acid requirements of growing steers. In trial 1, six ruminally cannulated steers (352 lb) were used to determine methionine requirements. Treatments were abomasal infusions of 0, 2, 4, 6, 8, or 10 g/day of L-methionine. Steers were fed 5.8 lb of a soyhull and wheat straw based diet. Continuous infusions of acetate, propionate, and butyrate into the rumen and of dextrose into the abomasum were made to increase energy. Amino acids other than methionine were infused into the abomasum to ensure that they did not limit steer performance. Nitrogen retention increased dramatically as methionine supplementation increased and, in the presence of excess cysteine, predicted a requirement of 4 g/day of supplemental L-methionine. Plasma methionine rose with methionine supplementation and predicted a supplemental methionine requirement of 2 g/day. In trial 2, five ruminally cannulated steers (429 lb) were used to determine how efficiently methionine is converted to cysteine in growing cattle. The experimental procedures were similar to those of trial 1, except steers received a basal supplement of amino acids containing 4 g/day L-methionine (requirement in the presence of excess cysteine established in trial 1) and no cysteine. Treatments consisted of abomasal infusions of 0, 1.62, or 3.25 g/day of L-cysteine or 2 or 4 g/day of additional L-methionine. Nitrogen retention was increased by methionine, but not by cysteine, suggesting that cysteine could supply less than one-half of the total sulfur amino acid requirement (methionine + cysteine) of growing steers.

(Key Words: Methionine, Cysteine, Steers, Requirement, Nitrogen Retention.)

Introduction

Methionine currently is thought to be potentially limiting for growth in cattle, but much previous research has relied on plasma amino acid levels as the sole response criteria. That research needs verification, because several factors other than amino acid status can affect plasma amino acid levels. Nitrogen retention provides a more precise estimate of the methionine requirement of growing cattle and also allows extrapolation to given levels of performance.

Cysteine is considered nutritionally nonessential, because the cysteine requirement of most species can be supplied by methionine via transsulfuration (methionine conversion to cysteine). It is important to know the efficiency of transsulfuration in growing cattle, so that we can better predict total sulfur amino acid (methionine plus cysteine) requirements. For most species, the cysteine requirement is about one-half of the total sulfur amino acid requirement and transsulfuration is assumed to be efficient, but little information exists for cattle. Our objective was to quantitate sulfur amino acid requirements of growing steers.

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Experimental Procedures

Trial 1. Six ruminally cannulated Holstein steers (352 lb) were utilized in a 6 × 6 Latin Square design, with treatments being graded levels of L-methionine (0, 2, 4, 6, 8, and 10 g/day). Each period was 6 days long, with 2 days used for treatment adaptation and 4 days for total collection of urine and feces. Blood samples were collected on the last day of each period. Steers were fed 5.8 lb of a diet containing 83% soyhulls, 8% wheat straw, and 1% urea. Volatile fatty acids (225 g acetate, 225 g propionate, and 56 g butyate/day) were infused continuously into the rumens and dextrose (150 g/day) was infused into the abomasums of steers to ensure that energy would not limit their ability to deposit protein. To ensure that amino acids other than methionine would not limit nitrogen retention, L-valine (21.2), L-leucine (29.6), L-isoleucine (21.6), L-lysine (41.1), L-histidine (9.2), L-arginine (19.6), L-threonine (21.2), L-phenylalanine (38.0), L-tryptophan (6.5), L-glutamate (152.8), and glycine (50.8 g/day) were infused into the abomasum. To estimate the specific requirement for methionine (i.e., under conditions where no methionine would be needed to meet cysteine needs), cysteine was included in the amino acid mixture at 12 g/day, a level assumed to exceed the steer's requirement. Problems with infusions resulted in less than six observations per treatment (Table 1).

Trial 2. Five ruminally cannulated Holstein steers (429 lb) were used in a 5 × 5 Latin Square design. Conditions for this trial were similar to those used in trial 1, except the amount of supplemental L-methionine found to maximize nitrogen retention in the presence of excess cysteine in trial 1 (4 g/day) was provided to all steers in the basal amino acid infusions. Also, cysteine was deleted from the basal amino acid infusions. Treatments were abomasal infusions of 0, 1.62, or 3.25 g/day of L-cysteine or 2 or 4 g/day of additional L-methionine. Cysteine was supplied in equimolar amounts to methionine. Diets were similar to those in trial 1. Ruminal infusions of 180 g acetate, 180 g propionate, and 45 g butyrate (per day) and abomasal infusions of dextrose (300 g/day) were provided. Nonsulfur amino acids were abomasally infused in amounts similar to those used in trial 1.

Results and Discussion

Trial 1. All increases in nitrogen retention resulted from decreased urinary nitrogen excretion. Nitrogen retention increased the most when steers were infused with up to 4 g/day of L-methionine, with some additional response as methionine supplementation increased to 10 g/day (Table 1). We conclude that the supplemental methionine requirement of these steers is 4 g/day in the presence of excess cysteine. Plasma methionine levels were lowest when steers were infused with 0 or 2 g/day of methionine, and increased linearly when higher levels were infused, which predicted a supplemental requirement of 2 g/day, a level below that predicted by the nitrogen retention data.

Trial 2. Nitrogen retention for growing steers increased in response to methionine infusion and was maximized at a total methionine level of 6 g/day (4 g basal plus 2 g supplemental; Table 2). Nitrogen retention was not affected by cysteine supplementation. The lack of response to cysteine supplementation suggests that cysteine did not spare any of the steers' requirement for methionine. Plasma methionine levels increased with methionine supplementation, but not with cysteine supplementation. If cysteine did spare methionine, we might expect an increase in plasma methionine levels as cysteine supplementation increased. Sulfur amino acid supplementation as methionine supported protein deposition better than did cysteine supplementation. The nonprotein functions of methionine (e.g., methyl group donor) may be quantitatively important enough to result in the higher requirement for methionine relative to cysteine. However, this conclusion may be limited to steers maintained under our experimental protocol.

Table 1. Effects of Supplementing L-Methionine to Growing Holstein Steers

	L-Methionine, g/day						
Item	0	2	4	6	8	10	SEM
Steers/treatment	4	4	4	4	3	4	
Intake N, g/d	100.1	97.8	99.5	95.3	100.2	102.9	
Fecal N, g/d	19.7	18.6	18.6	18.1	20.1	22.3	2.0
Urinary N[a], g/d	57.4	53.0	49.6	46.0	46.8	42.1	3.1
Retained N[a], g/d	22.9	26.2	31.3	31.1	33.2	38.5	4.1
Plasma methionine[a], µM	11.9	11.7	20.4	20.8	31.1	36.7	2.9

[a]Linear effect of methionine (P<.01).

Table 2. Effects of Supplementing L-Methionine or L-Cysteine to Growing Steers

		L-Methionine, g/d		L-Cysteine, g/d		
Item	0	2	4	1.62	3.25	SEM
Intake N, g/d	107.7	107.9	108.1	107.9	108.1	
Fecal N, g/d	20.8	20.8	20.7	20.5	21.0	.6
Urinary N[a], g/d	52.3	48.1	48.9	52.1	50.9	1.4
Retained N[b], g/d	34.6	39.0	38.5	35.3	36.2	1.3
Plasma methionine[c], µM	13.1	19.9	24.8	18.1	17.3	2.3

[a]Linear effect of methionine (P=.07), Quadratic effect of methionine (P=.11).
[b]Linear effect of methionine (P=.03), Quadratic effect of methionine (P=.09).
[c]Linear effect of methionine (P=.001).