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LIMITING AMINO ACIDS FOR HOLSTEIN STEERS FED SOYBEAN HULL-BASED DIETS

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Summary

A study was conducted to determine the limiting amino acids for cattle fed soybean hull-based diets. Ruminally cannulated Holstein steers (335 lb) were maintained in metabolism crates, fed the same basal diet (73% soyhulls, 19% alfalfa), and given the same intraruminal infusions (400 g/day acetate to increase energy supply without increasing microbial protein supply). Steers were infused into the abomasum with a complete mixture of the 10 essential amino acids or the mixture with histidine; tryptophan; arginine; phenylalanine; or the three branched-chain amino acids (leucine, isoleucine, and valine) removed. Nitrogen retention was reduced by removal of either histidine or the branched-chain amino acids, suggesting that those amino acids were limiting.

(Key Words: Steers, Soybean Hulls, Amino Acids.)

Introduction

Previous research demonstrated that for cattle fed soybean hull-based diets, methionine was the first limiting amino acid, lysine was also limiting, but threonine was not limiting. The current study used similar methods to evaluate the possibility that other essential amino acids also limit lean growth of steers fed soybean hull-based diets.

Experimental Procedures

Six ruminally cannulated Holstein steers (335 lb initial body weight) were used in a 6 × 6 Latin square design. Steers were maintained in individual metabolism crates and fed 7.5 lb/day of the same diet (Table 1) in equal portions at 12-hour intervals.

Table 1. Diet Composition[a]

Ingredient	% of Dry Matter
Soybean hulls	72.4
Alfalfa	19.2
Molasses	4.7
Monocalcium phosphate	1.6
Sodium bicarbonate	.8
Magnesium oxide	.3
Limestone	.4
Trace mineralized salt[a]	.2
Vitamin mixture[b]	.2
Elemental sulfur	.2

[a]Composition (%): NaCl (95 to 99); Mn (>.24); Fe (>.24); Mg (>.05); Cu (>.032); Zn (>.032); I (>.007); Co (>.004).
[b]Supplied per lb diet dry matter: 2000 IU vitamin A, 1000 IU vitamin D, and 26 IU vitamin E.

All steers received intraruminal infusions of acetate (400 g/day) supplied through an infusion line terminating in the rumen, in order to increase the energy supply without increasing the microbial protein supply. Treatments (Table 2) were abomasal infusions of a complete mixture of the 10 essential amino acids or the same mixture with either the branched-chain amino acids (leucine, isoleucine, and valine); histidine; phenylalanine; tryptophan; or arginine removed. The abomasal amino acid infusions were supplied continuously by a peristaltic pump through tubing that passed through the ruminal cannula and into the abomasum. Each period was 7 days long with 3 days for

adaptation to treatments and 4 days for total collection of feces and urine.

Representative samples of the basal diet were collected in each period. During days 3 to 7, total fecal and urine outputs were collected daily, and samples were saved for later analysis. Diet, feces, and urine were analyzed for nitrogen to calculate nitrogen retention. On day 7 of each period at 3 hours postfeeding, jugular blood was collected and analyzed for plasma urea and amino acid concentrations.

Results and Discussion

Nitrogen balance data are presented in Table 3. Urinary and fecal nitrogen excretions were statistically similar among all treatments, but nitrogen retention decreased (P<.05) when histidine or branched-chain amino acids were removed from the infused mixture. This indicates that without those amino acids, less lean tissue was deposited. Nitrogen retention was depressed to similar magnitudes when either histidine or the branched-chain amino acids were removed, indicating that these amino acids were co-limiting.

Our report is among the first to directly implicate histidine as a limiting amino acid for growing cattle. Other researchers have reported that histidine was limiting for sheep when the sole source of metabolizable protein was microbial protein. Branched-chain amino acids have been studied little, so few data exist to indicate whether or not they are limiting.

Plasma urea nitrogen (Table 4) was numerically highest when histidine was removed from the infusate, reflecting the decrease in nitrogen retention. However, similar changes in plasma urea were not observed for branched-chain amino acids, whose removal also decreased nitrogen retention. As expected, plasma concentrations of individual amino acids (Table 4) decreased when they were removed from the infusate.

In previous studies, methionine was determined to be the first limiting amino acid for steers fed a soybean hull-based diet. In the current study, the similar reductions in nitrogen retention that occurred when histidine or branched-chain amino acids where removed from the infusate suggest that these amino acids were co-limiting. In an earlier study, reductions in nitrogen retention in response to deletion of lysine were of a magnitude similar to those observed when histidine and the branched-chain amino acids were deleted, suggesting that lysine also could be co-limiting. Further delineation of the limiting amino acid sequence will be difficult, because nitrogen retention responses to removal of lysine, histidine, and the branched-chain amino acids are so similar.

Our data suggest that growing cattle fed diets low in undegradable intake protein should benefit from the addition of feedstuffs that would increase the postruminal supply of these limiting amino acids.

Table 2. Amino Acid Treatments (g/day)

	Treatment					
Item	Control	-HIS	-PHE	-TRP	-BCAA	-ARG
L-Methionine	10	10	10	10	10	10
L-Lysine-HCl[a]	20	20	20	20	20	20
L-Threonine	10	10	10	10	10	10
L-Histidine-HCl-H_2O[b]	10	-	10	10	10	10
L-Phenylalanine	10	10	-	10	10	10
L-Tryptophan[c]	5	5	5	-	5	5
L-Leucine	20	20	20	20	-	20
L-Isoleucine	10	10	10	10	-	10
L-Valine	10	10	10	10	-	10
L-Arginine	10	10	10	10	10	-

[a]Feed grade, provided 15.8 g/day lysine. [b]Provided 7.4 g/day histidine. [c]Feed grade, provided 4.9 g/day tryptophan.

Table 3. Effects of Removing Amino Acids from Postruminal Infusions on Nitrogen Retention in Growing Cattle

	Treatment						
Nitrogen, g/day	Control[1]	-HIS[2]	-PHE[3]	-TRP[4]	-BCAA[5]	-ARG[6]	SEM
Total intake	76.5	74.6	75.3	75.9	71.9	72.8	
Fecal	29.2	30.5	29.8	28.7	29.0	27.7	1.0
Urinary	18.8	20.0	19.5	19.9	18.6	18.5	.9
Retained	28.5	24.1[a]	26.1	27.4	24.4[a]	26.6	1.0

[1]Mixture of 10 essential amino acids.
[2]Histidine removed.
[3]Phenylalanine removed.
[4]Tryptophan removed.
[5]Leucine, isoleucine, and valine (branched-chain amino acids) removed.
[6]Arginine removed.
[a]Different from control (P<.05).

Table 4. Effects of Removing Amino Acids from Postruminal Infusions on Plasma Amino Acid and Urea Concentrations in Growing Cattle

	Treatment						
Amino Acid, μ*M*	Control[1]	-HIS[2]	-PHE[3]	-TRP[4]	-BCAA[5]	-ARG[6]	SEM
Histidine	88	30[a]	79	81	94	87	4.1
Phenylalanine	66	70	34[a]	67	71	68	3.6
Tryptophan	36	31	34	18[a]	34	34	2.5
Leucine	175	181	173	177	53[a]	194	10.2
Isoleucine	141	139	142	148	90[a]	150	7.6
Valine	288	290	286	270	172[a]	313	12.1
Arginine	124	117	116	118	138[a]	72[a]	3.5
Urea N, m*M*	1.31	1.65	1.34	1.42	1.38	1.38	.14

[1]Received mixture of 10 essential amino acids.
[2]Histidine removed.
[3]Phenylalanine removed.
[4]Tryptophan removed.
[5]Leucine, isoleucine, and valine removed.
[6]Arginine removed.
[a]Different from control (P<.05).