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Branched-chain amino acids for growing cattle limit-fed diets based on soybean hulls

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Abstract

This study evaluated the effects of branched-chain amino acids on nitrogen retention and plasma branched-chain amino acid concentrations. Five ruminally cannulated Holstein steers (387 lb) were used in a 5 x 5 Latin square. Steers were limit-fed soybean hull-based diets twice daily (7.5 lb/day, as fed basis). Energy in the form of acetate (400 grams/day) was continuously infused into the rumen. Treatments were continuous abomasal infusions of 1) 115 grams/day of a mixture of 10 amino acids, 2) 10 amino acid mix with leucine removed, 3) 10 amino acid mix with isoleucine removed, 4) 10 amino acid mix with valine removed, and 5) 10 amino acid mix with all three branched-chain amino acids removed. Nitrogen retention decreased (P<0.06) in response to removal of leucine, valine, or all three branched-chain amino acids. Changes in nitrogen balance of growing cattle limit-fed soybean hull-based diets demonstrate limitations in the basal supply of leucine and valine, but not isoleucine.

Keywords

Cattlemen's Day, 2001; Kansas Agricultural Experiment Station contribution; no. 01-318-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 873; Beef; Leucine; Isoleucine; Valine; Steers

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BRANCHED-CHAIN AMINO ACIDS FOR GROWING CATTLE LIMIT-FED DIETS BASED ON SOYBEAN HULLS

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Summary

This study evaluated the effects of branched-chain amino acids on nitrogen retention and plasma branched-chain amino acid concentrations. Five ruminally cannulated Holstein steers (387 lb) were used in a 5 × 5 Latin square. Steers were limit-fed soybean hull-based diets twice daily (7.5 lb/day, as fed basis). Energy in the form of acetate (400 grams/day) was continuously infused into the rumen. Treatments were continuous abomasal infusions of 1) 115 grams/day of a mixture of 10 amino acids, 2) 10 amino acid mix with leucine removed, 3) 10 amino acid mix with isoleucine removed, 4) 10 amino acid mix with valine removed, and 5) 10 amino acid mix with all three branched-chain amino acids removed. Nitrogen retention decreased ($P<0.06$) in response to removal of leucine, valine, or all three branched-chain amino acids. Changes in nitrogen balance of growing cattle limit-fed soybean hull-based diets demonstrate limitations in the basal supply of leucine and valine, but not isoleucine.

(Key Words: Leucine, Isoleucine, Valine, Steers.)

Introduction

For optimal lean muscle growth in cattle, the supply of postruminal amino acids (metabolizable protein) needs to meet animal requirements. Therefore, the deficiency of a single dietary essential amino acid may limit cattle growth. Although several reports suggest that methionine is often first-limiting, other amino acids, such as lysine, arginine, histidine, or threonine, have also been reported as limiting. However, there is little research to support these findings.

Recent research at Kansas State University demonstrated that an inadequate supply of a branched-chain amino acid mixture containing leucine, isoleucine, and valine restricted protein deposition of cattle limit-fed soybean hull-based diets. It was unclear, however, which of the branched-chain amino acids were limiting. In the current study, we evaluated the effects of individual branched-chain amino acids on lean muscle growth that was estimated from nitrogen retention and on plasma branched-chain amino acid concentrations in cattle limit-fed soybean hull-based diets.

Experimental Procedures

Five ruminally cannulated steer calves averaging 387 lb initial body weight were housed in individual metabolism crates and were fed 7.5 lb/day as fed basis of a soybean hull-based diet that consisted of 72% soybean hulls, 19% alfalfa, 5% molasses, and 4% minerals/vitamins in equal portions twice daily. To supply additional energy without increasing ruminal microbial growth, steers received continuous infusions of acetate into the rumen at a rate of 400 grams/day.

A 5 × 5 Latin square design was used, with 7-day periods; 3 days for adaptation to treatments and 4 days for collection of feces and urine. Treatments were abomasal infusions of 115 grams/day of a mixture of 10 amino acids, or the 10 amino acid mixture with the branched chain amino acids, leucine, isoleucine, valine, or all three of these amino acids removed. The daily 10 amino acid mixture infusion consisted of : Lleucine (20 g), L-isoleucine (10 g), L-valine (10 g), L-lysine (15.8 g), L-methionine (10 g), L-threonine (10 g), L-phenylalanine (10 g), L-arginine (10 g), L-histidine (7.4 g), and L-tryptophan (4.9 g). Infusions into the abomasum were made by extending flexible tubing through the rumen cannula and reticulo-omasal orifice.

On days 4 through 7 of each period, total feces and urine were collected for determination of nitrogen balance. Blood samples for plasma amino acid analysis were collected from the jugular vein of each steer.

Results and Discussion

Because protein in soybean hulls is mostly degraded and utilized by rumen microbes, microbial protein is the primary source of amino acids supplied to the small intestine of cattle fed soybean hull-based diets. Limit feeding such a diet created a situation where both the energy and protein (amino acid) supplies were inadequate and likely limited performance. To evaluate limitations in the amino acid supply from the basal diet, we ensured that energy would not be the first nutrient to limit performance by supplying energy in the form of acetate. Also, to evaluate which single amino acids from the basal diet restricted performance, we ensured that performance was not limited by any of the other essential amino acids by abomasally infusing the steers with mixtures of those essential amino acids. Infusing a mixture that supplies slight excesses of all 10 essential amino acids allowed the steers to perform at a rate that should not have been restricted by inadequate supplies of any essential amino acids. Measuring changes in nitrogen balance when a single amino acid is removed from the 10 amino acid mixture determined if the basal supply of that amino acid by the soybean hull-based diet was inadequate and therefore limiting. No change in nitrogen balance when an amino acid is removed from the 10 amino acid mixture would demonstrate that the removed amino acid was not limiting.

Nitrogen retention decreased ($P<0.05$) when all three branched-chain amino acids were removed from the 10 amino acid mixture (Table 1). Nitrogen retention also decreased in response to the removal of leucine ($P<0.06$) or valine ($P<0.05$), but the removal of isoleucine had no effect. Thus the basal supplies of leucine and valine were deficient and may limit animal performance.

Removal of all three branched-chain amino acids from the mixture of 10 amino acids decreased ($P<0.05$) plasma concentrations of these branched-chain amino acids (Table 1). Removal of leucine alone decreased its plasma concentrations ($P<0.05$), but increased plasma concentrations of both isoleucine and valine ($P<0.05$). However, removal of isoleucine or valine decreased ($P<0.05$) only their own concentrations in plasma, and did not significantly alter plasma concentrations of the other branched-chain amino acids. These decreases in plasma leucine, isoleucine, and valine concentrations demonstrate that their supplies exceeded the requirements when steers were infused with these amino acids in the 10 amino acid mixture.

The nitrogen balance results demonstrate that the branched-chain amino acids, leucine and valine, but not isoleucine, are limiting when ruminal microbial protein is the primary source of amino acids to the small intestine of growing steers.

Table 1. Effects of Removing Leucine, Isoleucine, Valine, or All Three Branched-Chain Amino Acids from Postruminal Amino Acid Infusions on Nitrogen Balance and Plasma Branched-Chain Amino Acid Concentrations of Growing Steers

	Treatments[a]					
Item	10AA	-LEU	-ILE	-VAL	-BCAA	SEM
Steers/treatment	5	4	5	5	5	
Nitrogen	---------------- grams/day ----------------------					
Intake	76.5	74.2	75.4	75.3	72.1	-
Fecal	27.9	28.5	27.7	29.0	28.8	0.74
Urinary	22.9	22.8	22.9	23.8	22.1	0.81
Retained	25.7	23.1[c]	24.8	22.4[b]	21.2[b]	0.79
Plasma	------------------ µM ------------------------					
Leucine	200	60[b]	190	217	60[b]	7.8
Isoleucine	148	296[b]	55[b]	154	88[b]	14.5
Valine	298	530[b]	289	123[b]	162[b]	20.8

[a]10AA = mixture of 10 essential amino acids; -LEU = leucine removed from 10AA; -ILE = isoleucine removed from 10AA; -VAL = valine removed from 10AA; -BCAA = leucine, isoleucine, and valine removed from 10AA.
[b]Different from 10AA ($P<0.05$).
[c]Different from 10AA ($P<0.06$).