EFFECTS OF ENERGY LEVEL ON METHIONINE UTILIZATION BY GROWING STEERS

G. F. Schroeder, E. C. Titgemeyer, M. S. Awawdeh, and D. P. Gnad

Summary

The objective of this study was to evaluate the effect of energy level on amino acid utilization in growing steers. Six ruminally cannulated Holstein steers (503 lb) were limit-fed (6.2 lb/day dry matter) a diet based on soybean hulls (83%), wheat straw (7.6%), and cane molasses (4.1%). The treatments consisted of the infusion of two methionine levels (0 or 3 g/d) and three energy levels (0, 1.3, or 2.6 Mcal ME/day) in a 2 x 3 factorial arrangement. Energy was supplied through ruminal infusion of acetate, propionate, and butyrate and through abomasal infusion of glucose and fat in increasing amounts. No interactions between methionine and energy level were observed. Nitrogen balance was increased by methionine supplementation, indicating that this amino acid limited protein deposition. A linear increase in nitrogen retention was found with the increase in energy. These improvements in protein deposition were related to reductions in urinary nitrogen excretion, reduced plasma-urea concentrations, and greater circulating concentrations of insulin and insulin-like growth factor-I. The results of this study suggest that amino acid utilization can be improved by increasing energy. These effects could be partly explained by variations in plasma concentration of key hormones involved in the control of protein deposition.

Introduction

Energy supply affects protein deposition when the amino acid supply is not limiting. In pigs, when energy is limiting, protein deposition does not respond to increases in dietary protein supply. However, when energy supply is adequate, protein deposition increases with an increase in dietary protein intake. This type of relationship between energy and protein supply and protein deposition, which is observed in monogastric animals, has been described as protein- and energy-dependent phases of growth. These relationships indicate that exact dietary amino acid requirements can be specified for each level of protein deposition. Although this type of relationship is assumed for cattle by most nutrient-requirements systems, it has seldom been studied. The objective of our study was to determine the effect of energy supply on methionine utilization in growing steers.

Experimental Procedures

Six ruminally cannulated Holstein steers (503 lb initially) were allocated in a 6 x 6 balanced Latin square design. The steers were limit-fed (6.2 lb/day dry matter) a diet based on soybean hulls (83%), wheat straw (7.6%), cane molasses (4.1%) and vitamin-mineral mix. All steers received supplemental energy by ruminal infusion of 400 g/day of acetic acid. The treatments were arranged as a 3 x 2 factorial, and consisted of two methionine levels (0 or 3 g/day) and three energy levels [0 (**0x**), 1.3 (**1x**), or 2.6 (**2x**) Mcal ME/day; Table 1]. The amounts of methionine were selected in the range of linear response for our experimental model. Ruminal infusion of acetate, propionate, and butyrate and abomasal infusion of glucose and fat allowed increases in the energy supply to the animal without increasing ruminal protein synthesis.

Table 1. Energy Sources Infused

	Energy Level		
Energy sources, g/day	0	1x	2x
Acetate	0	90	180
Propionate	0	90	180
Butyrate	0	30	60
Glucose	0	30	60
Fat[a]	0	30	60
Energy, Mcal ME/day	0	1.3	2.6

[a]Composed of 20% C18:0, 50% C18:1, and 30% corn oil.

The basal diet was formulated to provide a low protein:energy ratio, small amounts of ruminally undegradable protein, and enough ruminally available nitrogen to support adequate microbial growth. Feed restriction maintained a limited supply of amino acids to create a limitation in methionine, such that a response to its supplementation could be achieved. A mixture containing all of the essential amino acids except methionine was continuously infused abomasally to prevent limitations in protein synthesis by an amino acid other than methionine. Thus, protein deposition should be limited by methionine supply. Nitrogen balance was used as a measure to estimate protein deposition by the steers.

Results and Discussion

The interaction between methionine and amount of supplemental energy was not significant (P>0.10) for any variable analyzed. As expected, the infusion of 3 g/day of methionine increased nitrogen retention (Figure 1), indicating that this amino acid was limiting protein deposition. If we assume that the empty body of Holstein steers contains 19.7% protein, the extra 4.2 g/day nitrogen retained would represent an increase of 0.29 lb/day in daily gain. If we assume that nitrogen retained is directly converted to protein deposition (nitrogen retention x 6.25) and that protein in the whole empty body contains 2% methionine, the calculated efficiency of methionine utilization was 17%. This estimate for efficiency of methionine use is similar to what we have observed in other research trials.

Increasing the energy supply linearly increased nitrogen retention regardless of methionine infusion (Figure 1). This improvement in nitrogen retention was related to a decrease in urinary nitrogen excretion without changes in fecal nitrogen output. The results indicate that increasing energy supply increased protein deposition, even when there was a clear limitation in protein supply, suggesting that energy level affects the efficiency of amino acid utilization. The increases in nitrogen retention as energy supplementation increased would represent added gains of about 0.15 and 0.33 lb/day, respectively, for 1x and 2x compared with 0x.

Dietary dry matter digestion was linearly decreased with the increase of energy supply (Table 2). These results could be associated with the increasing amounts of volatile fatty acids infused into the rumen that could reduce ruminal fiber digestion. Because of the decrease in diet digestibility (Table 2), the increases in total energy supply may have been slightly less than the planned amounts.

Plasma urea concentration decreased linearly with the increase of energy supply and with the addition of methionine (Table 2), agreeing with the increase in nitrogen retention (Figure 1) and the reduction in urinary nitrogen excretion. Plasma insulin concentration increased quadratically with energy. Insulin-like growth factor I (**IGF-I**) concentration was linearly increased with the increase in energy, with no effects of supplemental methionine (Table 2). Enhancement in the circulating concentrations of insulin and IGF-I has been associated with a decrease in muscle protein breakdown and an increase in protein synthesis, resulting in a greater protein deposition.

Overall, nitrogen retention was increased linearly with the increase in energy supply, even when methionine was deficient. These results suggest that the efficiency of amino acid utilization was improved by increasing energy supply. The increase in nitrogen retention could be partly explained by changes in plasma concentration of some key hormones involved in the regulation of protein deposition.

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Table 2. Effects of Energy Supply and Methionine Supplementation on Diet Digestion and Blood Metabolites

		0 g/d L-Methionine			3 g/d L-Methionine			
Item	Energy =	0x	1x	2x	0x	1x	2x	SEM[a]
Dry matter digestibility, %[a]		75.5	73.0	69.7	75.5	74.6	73.8	1.5
Blood metabolites								
Urea, mM [a, b]		2.95	2.65	2.20	2.63	2.29	1.90	0.24
Glucose, mM		4.66	4.89	4.92	4.71	4.86	4.80	0.15
Insulin, ng/mL [c]		0.39	0.52	0.46	0.38	0.43	0.39	0.04
IGF-I, ng/mL [a]		691	728	734	698	764	902	80

[a]Linear effect of energy supply ($P<0.05$).
[b]Effect of methionine ($P<0.05$).
[c]Quadratic effect of energy supply ($P<0.05$).

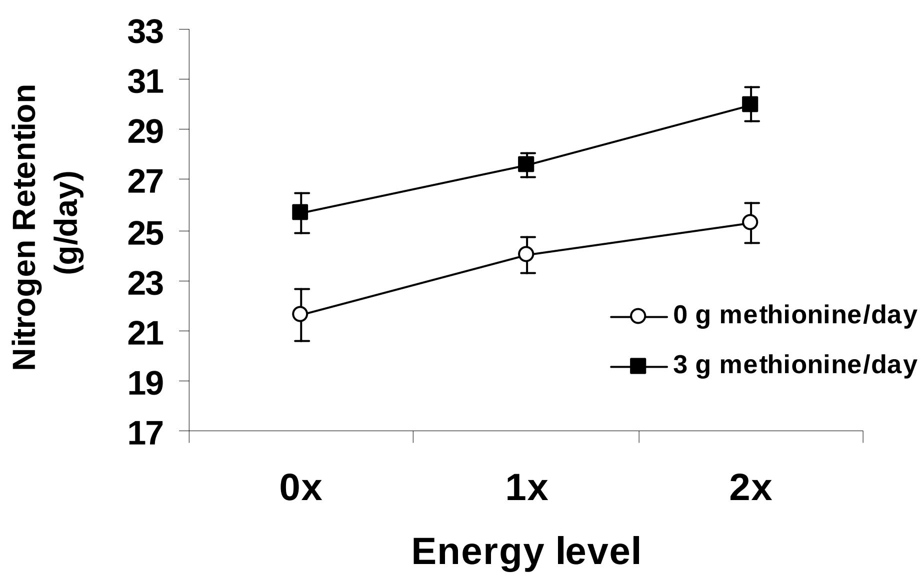

Figure 1. Effects of Energy Supply and Methionine Supplementation on Nitrogen Retention. Effect of methionine ($P<0.05$). Linear effect of energy supply ($P<0.05$).