ENERGY SUPPLY AFFECTS LEUCINE UTILIZATION BY GROWING STEERS

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Introduction

In growing pigs, when protein supply is adequate, protein deposition increases with an increase in energy intake. However, when amino acid supply is limited, protein deposition does not respond to increases in energy intake. These relationships between energy, protein supply and protein deposition, which are observed in monogastric animals, have been described as protein- and energy-dependent phases of growth. These relationships indicate that energy supply does not affect the efficiency of amino acid utilization, allowing the assumption of a constant efficiency across a broad range of energy intake. Although this type of relationship is assumed for cattle by most of the nutrient requirements systems, our previous experiments indicate that energy supply increases the efficiency of methionine utilization, challenging the assumption of a single efficiency of amino acid use. It is unknown, however, if the positive effects of energy supply on methionine utilization are of similar magnitude for other amino acids. The objective of our study was to determine the effect of energy supply on leucine utilization in growing steers.

Experimental Procedures

Six ruminally cannulated Holstein steers (330 lb initially) were allocated in a 6 × 6 balanced Latin square design. The steers were limit-fed (5.1 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 additional energy supply (1.9 Mcal of gross energy/day) by ruminal infusion of 100 grams/day of acetic acid, 75 grams/day of propionic acid, and 75 grams/day of butyric acid, as well as abomasal infusion of 200 grams/day of glucose. In addition, all the steers received a basal infusion into the abomasum of a mixture containing all the essential amino acids; this was done to prevent limitations in protein synthesis by amino acids other than leucine, thereby allowing protein deposition to the point where either energy or leucine supply became limiting. The treatments were arranged as a 3 × 2 factorial, with the factors being three levels of leucine (0, 4, or 8 grams/day) and two energy levels (0 or 1.9 Mcal of gross energy/day). Energy supplementation was achieved by continuously infusing 100 g of acetate/day, 75 g of propionate/day, and 75 g of butyrate/day into the rumen and 200 grams/day of glucose into abomasum. Therefore, steers receiving the energy supplementation treatment received a total energy infusion of 3.8 Mcal of gross energy/day (1.9 Mcal/day from the basal infusion plus 1.9 Mcal/day from the treatment), whereas control steers received only 1.9 Mcal/day from the basal infusion.

Each experimental period consisted of two days for adaptation and four days for sample collection. Nitrogen balance was used as a measure to estimate protein deposition by the steers.

Results and Discussion

The interaction of leucine × energy supplementation tended to be significant (P=0.06) for nitrogen retention, indicating that the effects of increasing leucine supply were different depending on energy supplementation level (Figure 1). When energy was not supplemented, nitrogen retention was increased by increasing leucine supplementation from 0 to 4 grams/day, but there were no further changes with additional increases in leucine supplementation. These results indicate that the supplemental leucine requirement was, at most, not much greater than 4 grams/day in those conditions. On the other hand, when the steers received additional energy, there was a linear increase in nitrogen retention in response to leucine supplementation (Figure 1). Therefore, when steers received additional energy supply, the potential for protein deposition was greater, which increased the ability of the steers to respond to higher levels of supplemental leucine supply and, thus, the leucine requirement. Consequently, when steers were provided an additional 1.9 Mcal of gross energy/day, the supplemental leucine requirement was at least 8 grams/day.

When leucine was limiting (from 0 to 4 grams of leucine/day) the estimated incremental efficiency of supplemental leucine use was $\geq$ 26% for control and 30% for energy-supplemented steers. Those values are much lower than that predicted (66%) by the most recent National Research Council *Nutrient Requirements of Beef Cattle*. Additionally, the estimated efficiency of use of dietary leucine, when leucine was not supplemented, was numerically increased from 75% to 79% by energy supplementation. These results suggest that additional energy supply improved the efficiency of leucine utilization, challenging the assumption of a constant efficiency proposed by most of the nutrient requirement systems.

In previous studies with a similar experimental model, when methionine limited protein deposition, energy supplementation also increased the efficiency of methionine utilization. The improvement in efficiency of methionine use was greater than we observed here for leucine. These two essential amino acids are metabolized differently in the body, and these differences in metabolic pathways and the factors that regulate them may partially explain the differences in magnitude of response to energy.

Implications

The present study, in conjunction with our previous studies, indicates that the assumption of a constant efficiency of amino acid utilization for all the essential amino acids and across different levels of energy supply may not be appropriate for estimating amino acid requirements of growing steers. Thus, modeling of amino acid requirements in growing cattle may require consideration of the amount of dietary energy supplied.

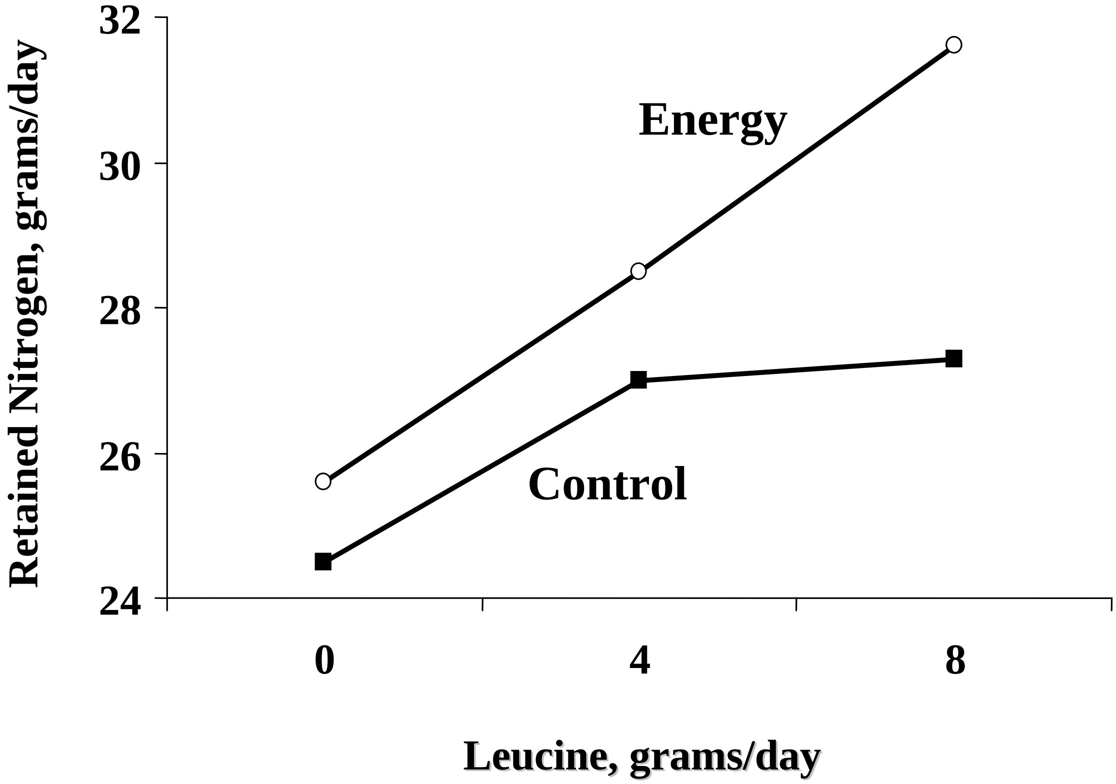

Figure 1. Effects of Energy [Control (none) or Energy (1.9 Mcal gross energy/day)] and Leucine Supplementation on Nitrogen Retention. Linear effect of leucine ($P<0.05$). Effect of energy ($P<0.05$). Interaction leucine × energy supplementation ($P=0.06$).