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Dietary Amino Acid Utilization for Body Protein Deposition — Current and Future Research

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Summary and Implications

In modern pork production it is important to maximize the animal's potential for daily lean gain by increasing the body protein deposition with as little wastage of the ingested amino acids as possible. Therefore, it is important to maximize the efficiency with which dietary amino acids are used for protein deposition or lean gain. This efficiency is measured by using nitrogen balance studies or comparative slaughter procedures. Supplementing swine diets with crystalline amino acids and replacing part of the dietary protein can reduce diet cost and will also reduce the amount of nitrogen excreted in manure. However, it has been demonstrated that the efficiency of utilization of crystalline amino acids may be lower than that of amino acids bound in protein. Although the reasons for this are unclear, it may be associated with the frequency of feeding and differences in the rate of absorption between the two sources of amino acids. Research in progress is designed to investigate the efficiency with which crystalline lysine is utilized for protein deposition in nursery pigs. This research will obtain additional information about the relative utilization of crystalline and protein-bound amino acids.

Amino Acid Utilization for Body Protein Deposition

Body proteins are continuously being formed (protein synthesis) and broken down (protein degradation). In an adult animal, synthesis and degradation are equal and body protein is neither gained or lost. However, in a growing animal, synthesis exceeds degradation and this results in protein deposition or accretion. Dietary indispensable amino acids are used for a variety of metabolic processes in the body and are precursors for a wide range of biologically active compounds, but it is protein deposition that accounts for the greatest amino acids use. The efficiency with which absorbed amino acids are used for protein deposition depends on several factors including genetic differences and whether the amino acid intake is limiting or in excess of the requirement. In growing-finishing pigs consuming diets that are limiting in protein, the most limiting acid will be used more efficiently than other amino acids, and it is the efficiency of utilization of this amino acid that will affect how well the overall dietary protein is used.

Nitrogen Balance and Comparative Slaughter Trials

The efficiency of amino acid utilization is typically measured using either N (nitrogen) balance studies or comparative slaughter trials (body composition is measured). The two methods yield different results. Estimates of N retention are higher when measured by the N balance technique than when measured by the comparative slaughter technique. Some studies have estimated values of 8.96 and 7.51 g of protein retained per g of lysine intake by using nitrogen balance and slaughter trials, respectively. The differences are larger at low than at high rates of protein deposition. The main explanation for the discrepancy between the two methods is that N losses in feces and urine are usually underestimated in N balance studies, with a consequent overestimation of N retention.

Crystalline Amino Acids vs Protein-bound Amino Acids

Recent evidence has indicated that the efficiency of utilization of crystalline amino acids may be lower than the efficiency of amino acid utilization from intact protein. One study reported that the efficiency for tryptophan was 54% for protein-bound tryptophan but only 14% for crystalline tryptophan. Others have found that the efficiency of utilization of crystalline tryptophan may be only 50% of protein-bound tryptophan.

The reasons for the poor efficiency of crystalline tryptophan are unknown, but in one study pigs were fed three times daily and it is possible that infrequent feeding may have contributed to the lower efficiency. Similar results have been observed when feeding dietary lysine infrequently. Crystalline lysine in diets fed once daily is used 50% less efficiently than crystalline lysine in similar diets fed more frequently (i.e., twice or more per day).

The reduced efficiency of crystalline amino acid utilization has been attributed to the rapid absorption of

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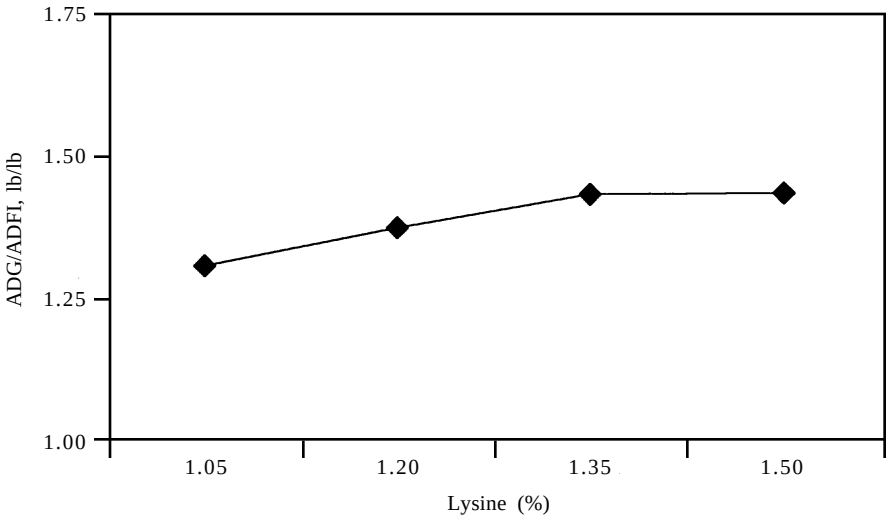

Figure 1. Feed efficiency (lb/lb) of nursery pigs fed four concentrations of dietary lysine.

crystalline amino acids relative to amino acids derived from intact protein such as soybean meal. Free amino acids are absorbed more rapidly than those bound in protein, which probably provides an unbalanced pattern of amino acids to muscle and affects growth performance in pigs by decreasing protein synthesis. If crystalline amino acids are absorbed too quickly the temporary excess of absorbed amino acids at the tissue level may result in oxidation losses of the free amino acids and degradation in the liver. Studies indicate improvements in growth performance in pigs fed soybean meal supplements (protein-bound lysine) diets in comparison to pigs fed lysine-supplemented diets. However, these differences were attributed to gut fill because no differences in carcass weight were detected. Therefore, the strategy is to balance the arrival of the protein-bound amino acids and free amino acids at the site of absorption.

Reduced efficiency of amino acid utilization resulting from differences in the time course of absorption between protein-bound and crystalline lysine has not been observed under ad libitum feeding conditions. It is unlikely that differences in absorption rate explain differences in utilization of the lysine under ad libitum feeding conditions because of the continual supply of amino acids that are absorbed. However, further research is needed to examine the relationship between feeding level and crystalline amino acid utilization.

Current Research

We are currently investigating the efficiency with which crystalline lysine is utilized for protein deposition in nursery pigs. A preliminary 28-day study was conducted to develop a lysine-deficient diet using 96 nursery pigs (11 lb initial body weight and 15 day old). The dietary treatments consisted of the basal diet (1.05% lysine) and three concentrations of total lysine: 1.20%, 1.35%, and 1.50%. These concentrations were achieved by adding crystalline lysine to the basal diet. Pigs were grouped on the basis of initial weight and allotted at random to 16 pens within a nursery facility. There were six pigs per pen (three barrows and three gilts). Pigs were allotted to four dietary treatments with four replications (weight blocks) per treatment (24 pigs per treatment). Average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (ADG/ADFI) were measured weekly. At the end of the study all pigs were bled to determine plasma urea concentration. As expected, lysine was limiting in the basal diet and supplementation with crystalline lysine increased ADG ($P = 0.05$) and ADG/ADFI ($P < 0.001$). However, no differences were observed for ADFI. A linear response ($P < 0.001$) for ADG/ADFI indicated that diets with 1.05 and 1.20% lysine were limiting and the requirement was approximately 1.35% (Figure 1). Plasma urea nitrogen (PUN) decreased as the lysine concentration in the diet increased. A higher concentration of PUN was estimated in pigs fed the diet with 1.05% lysine in comparison with pigs fed diets 1.20 and 1.35% lysine ($P < 0.05$) and 1.50% lysine ($P < 0.01$). These results indicate that nitrogen retention improved when the higher concentration of lysine was fed.

Future Research

We are now studying the efficiency with which crystalline lysine and the lysine present in soybean meal are used for body protein deposition in nursery pigs. Studying the efficiency of amino acid utilization under ad libitum feeding conditions will be important to determine whether crystalline amino acids are used less efficiently than amino acids in intact protein. If it is true, future studies must be focused on looking at alternatives to improve the amino acid utilization from crystalline sources, taking into account that the use of crystalline amino acids can provide environmental and economical advantages.

Take Home Points

1) Supplementing low-protein diets with crystalline amino acids at adequate concentrations can offer environmental and economical benefits. Several factors can affect the utilization of dietary amino acids and differences in the rate of absorption probably occur between crystalline and protein-bound amino acids. This may affect growth performance in pigs.
2) During certain situations, crystalline amino acids may be used less efficiently than the amino acids in intact protein. Therefore, careful use of crystalline amino acids must be made to ensure that they are utilized as efficiently as possible.

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