The importance of nitrogen for growth

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– Nutrition

After energy, protein is the second most expensive nutrient in swine rations but utilization tends to be low. Retention of dietary nitrogen in pigs ranges from 30% to 60% of intake with much of this inefficiency the result of catabolism of excess amino acid/protein intake or unbalanced amino acid supply. This catabolism represents an energetic cost to the animal, reducing performance, and results in an increase in nitrogen excretion into the environment. Due in part to the contribution of dietary protein to total feed costs and the environmental impact of feeding excess protein, considerable research has been conducted to determine dietary requirements for essential amino acids.

While essential amino acid requirements are well-defined, there has been a general lack of research into requirements for non-essential amino acids and total dietary nitrogen. With the increased availability of affordable crystalline amino acids, it has become possible to feed reduced protein diets while maintaining essential amino acid content and growth performance. However, the endogenous production of non-essential amino acids requires a source of nitrogen, therefore, in situations where total dietary nitrogen is limited, as could be the case in reduced protein diets with supplemental crystalline amino acids, essential amino acids will be used to meet requirements for non-essential amino acid production.

A concept familiar to ruminant nutritionists is the provision of sources of non-protein nitrogen (i.e., urea and ammonia) and reliance on production of amino acids by rumen microbes. In addition to dietary supplementation with non-protein nitrogen, it has been well established in both non-ruminant and ruminant animals that a proportion of urea produced from amino acid catabolism enters the gastrointestinal tract where gut microbes are capable of utilizing the urea for amino acid production. This process, referred to as urea recycling, represents an important salvage mechanism to improve nitrogen retention during times of protein deficit, and presents an opportunity to both reduce feed costs and improve efficiency. However, the contribution of microbial amino acid production to meeting amino acid requirements in non-ruminants is not clear.

In order to more fully understand the utilization of nitrogen for lean gain in growing pigs, a series of studies were performed at the University of Guelph. These studies were designed to determine the ability of pigs to utilize sources of non-protein nitrogen under a variety of dietary conditions.

> "pigs are capable of utilizing non-protein nitrogen for body protein deposition and growth"

Study 1 – Utilization of non-protein nitrogen in pigs fed a diet limiting in an essential amino acid

A nitrogen-balance study was performed to determine the impact of infusion of urea or casein in the hindgut on whole-body nitrogen retention in growing pigs (n = 10; 22 ± 1.8 kg initial body weight) fed a valine-limiting diet (cornstarch-soybean meal based). Pigs were assigned to receive an infusion of saline (control), urea, or casein (40% of dietary protein intake) into the cecum in a Latin square design. Fecal and urine output were measured daily and samples obtained for determination of nitrogen output and nitrogen retention. A continuous infusion of isotopically labelled urea (15N15N-urea) was given for determination of urea production, urea excretion, and urea recycling. It was hypothesized that nitrogen is absorbed from the hindgut as ammonia which may contribute to the amino acid supply of the pig through urea recycling and microbial amino acid production in the small intestine. The majority of the infused nitrogen was absorbed and protein deposition (114, 128, and 130 g/d; $P < 0.01$) was improved with infusion of both casein and urea, but did not differ between the two treatments. Urea flux and urinary nitrogen excretion increased similarly for both nitrogen infusions indicating that nitrogen absorbed from the hindgut is in the form of ammonia. The efficiency of utilizing nitrogen absorbed from the hindgut was approximately 18%. This indicates that while pigs can utilize non-protein nitrogen to correct an essential amino acid deficiency, this is likely not efficient enough to be a viable dietary alternative.

Study 2 – Utilization of non-protein nitrogen in pigs fed a nitrogen-limiting diet

A nitrogen-balance study was performed to determine the impact of infusion of urea or casein in the hindgut on whole-body nitrogen retention in growing pigs (n = 9; 17 ± 0.3 kg initial body weight) fed a cornstarch-soybean meal based diet formulated to be limiting in non-essential amino acids (high essential to total nitrogen ratio) but met requirements for essential amino acids. Pigs were assigned to receive an infusion of saline (control), or urea at 1.5 g/d or 3.0 g/d into the cecum in a Latin square design. Fecal and urine output were measured daily and samples obtained for determination of nitrogen output and nitrogen retention. A continuous infusion of isotopically labelled urea (15N15N-urea) was given for determination of urea production, urea excretion, and urea recycling. It was hypothesized that nitrogen absorption from the hindgut can be used for endogenous non-essential amino acid production and increase body protein deposition in pigs fed a diet deficient in non-essential amino acids. Whole-body nitrogen retention (4.86, 6.40, and 7.75 g/d; $P < 0.01$) and average daily gain (267, 314, and 360 g/d; $P < 0.05$) were improved with increasing amounts of urea infused into the hindgut but there was no impact on urea kinetics. The efficiency of utilization of nitrogen in this study was nearly 100% for both amounts of urea infused indicating that non-protein nitrogen absorbed from the hindgut can be used efficiently for body protein deposition under conditions of dietary non-essential amino acid deficiency.

Study 3 – Dietary supplementation with ammonia and growth performance

A study was performed to determine the effect of addition of different sources of nitrogen to a diet limiting in non-essential amino acids on growth performance of growing pigs. A total of 36 growing pigs (15 ± 1.0 kg initial body weight) were fed a cornstarch-casein based diet deficient in non-essential amino acids (control) but met requirements for essential amino acids and supplemented with either urea, ammonium citrate, glutamate, or a mix of non-essential amino acids, each at two levels (1.37 or 2.75% additional dietary protein). Average daily gain (367, 399, 404, and 402 g/d; $P < 0.01$) and gain:feed (0.38, 0.42, 0.42, 0.42 kg/kg; $P < 0.01$) was lowest when supplemental urea was provided but was similar on all other sources of non-essential nitrogen and improved with increasing level of nitrogen provided (363, 387, 429 g/d ADG for 0, 1.37, and 2.75%, respectively; $P < 0.001$). These results indicate that pigs can utilize a source of non-protein nitrogen as efficiently as non-essential amino acids for growth when fed a diet deficient in total nitrogen.

Overall, these studies demonstrate that pigs are capable of utilizing non-protein nitrogen for body protein deposition and growth in diets limiting in either essential amino acids or total nitrogen. However, the results from these studies need to be interpreted with caution since conditions under which utilization were measured (for example, use of cornstarch based diets) do not replicate commercial practices. With increased use of alternative ingredients and co-products with potentially lower protein digestibility and continued use of crystalline amino acids in reduced-protein diets, it may become increasingly important to consider total dietary nitrogen supply and, therefore, further research into nitrogen utilization is required.

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Further reading:

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