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# We need to start thinking about more than essential amino acid requirements.

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An increased understanding of essential amino acid requirements has led to the ability to reduce dietary protein content while maintaining animal performance. However, it is possible that non-essential amino acids/dietary nitrogen may become limiting in low protein diets. A further understanding of how dietary protein/non-essential amino acid content influences amino acid utilization and growth is key to maximizing animal performance while reducing the cost and environmental impact of animal agriculture.

In general, retention of dietary nitrogen in pigs ranges from 30% to 60% of intake (Dubeau et al., 2011; NRC, 2012) with much of this inefficiency the result of catabolism of excess or unbalanced amino acids (AA) intake (Moughan, 1999). This catabolism represents an energetic cost to the animal, reducing performance, and results in an increase in nitrogen excretion into the environment. Advances in our understanding of nutrient requirements (i.e., AA) in pigs and characterization of nutrient content of ingredients have led to significant improvements in

performance and reduction in nutrient excretion and feed costs in pig production. While previous diets were formulated with high crude protein (CP) to meet lysine requirements, resulting in excess levels of other AA (Wang et al., 2018), use of crystalline AA and the introduction of the 'ideal protein concept' has

*(We need to start thinking... cont'd on page 3)*

## Inside This Edition



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*(We need to start thinking ... cont'd from page 1)*
allowed for more precise formulation of swine rations while reducing CP content. The current trend in swine nutrition is to formulate lower protein diets supplemented with essential AA (EAA), which have been shown to increase utilization efficiency and reduce nitrogen excretion into the environment (Gloaguen et al., 2014).

The benefits of reducing dietary protein content can be significant. Every 1 percentage point reduction in dietary protein results in a 3% reduction in protein ingredient utilization, reducing feed costs (Wang et al., 2018). Moreover, for the same reduction in dietary protein there is also an 8-10% reduction in ammonia emissions from feces and urine (NRC, 2012) and reduced odour emissions (Hayes et al., 2004), improving environmental impact and animal and worker well-being. Reductions in dietary protein have also been used to reduce the incidence of post-weaning diarrhea (Heo et al., 2009; Jha and Berrocoso, 2016). However, these benefits may quickly be lost if pig performance is not maintained (e.g., reduced growth performance, increased carcass fatness). It is now fairly well accepted that a reduction in dietary protein of 3% from NRC (1998) recommendations while supplementing with crystalline AA can maintain pig performance. Further reductions (> 3%) in dietary protein content have provided conflicting results (Wang et al., 2018) and generally result in significantly decreased growth performance despite supplementation with EAA (Guay et al., 2006; Yue et al., 2008; Roux et al., 2011; Gloaguen et al., 2014). Increased carcass fatness has also been observed at current NRC (2012) recommendations for dietary protein (Tuitoek et al., 1997; Kerr et al., 2003).

A major assumption behind these low protein diets is that pigs are capable of producing sufficient amounts of non-essential AA (NEAA) to meet their demands for growth and so only need to be supplied with a source of EAA. However, to date there is insufficient evidence that this is the case (Wu et al., 2014) and may explain why growth performance is improved in low protein, supplemented diets but still tends to be lower than in animals receiving a normal protein diet. For example, Guay et al. (2006), Gloaguen et al. (2014), and Jansman et al. (2016) observed reduced growth performance in grower and nursery pigs fed low protein diets (< 15% CP) even though a sufficient amount of EAA had been added. This suggests that NEAA may become essential when dietary protein is below a critical level (Wang et al., 2018). For instance, Jansman et al. (2016) concluded that protein can be reduced in post-weaned to approximately 16% CP before performance is negatively affected.

The reduction in performance regardless of EAA supplementation suggests that a minimum amount of NEAA (or total dietary nitrogen) is required in diets in order to maximize nitrogen retention (i.e., growth; Heger et al., 1998; Wu, 2014). This reduced performance regardless of EAA supplementation may also be the result of EAA being catabolized as a source of nitrogen for endogenous production of NEAA. Indeed, current estimates of EAA requirements are largely the result of studies in which a traditional level of dietary protein was used. These recommendations, therefore, may not reflect requirements in low protein, crystalline AA supplemented diets. This concept was demonstrated in multiple studies in which Heger et al. (1998) determined the optimal dietary nitrogen (i.e., crude protein) content that is required to maximize AA utilization using the EAA to total nitrogen ratio (EAA:TN). In multiple species, it was determined that an EAA:TN of approximately 0.50 is required to maximize utilization. Reduced performance in diets with a lower ratio having insufficient EAA to meet requirements, and a greater ratio indicating insufficient NEAA.

> "Ensuring both AA and nitrogen/protein requirements are met ensure maximum efficiency and growth performance"

While EAA requirements need to be met through inclusion of those specific AA in the diet, the source of nitrogen to meet dietary NEAA/nitrogen needs may not be as critical. The ability of pigs to utilize non-specific forms of nitrogen, as well as reiterating the importance of nitrogen specifically, has been demonstrated in a series of studies examining the use of non-protein nitrogen and NEAA supplementation of low protein diets (i.e., >0.50 EAA:TN). Mansilla et al. (2015) initially demonstrated that nitrogen absorbed from the hindgut can be utilized to improve whole-body nitrogen retention in pigs fed a diet deficient in NEAA. They further showed that nitrogen from ammonia (as ammonium chloride) was as efficient as free AA or intact protein for improving growth in pigs fed diets deficient in NEAA (Mansilla et al., 2017) and that ammonia-nitrogen improves the endogenous production of NEAA (Mansilla et al., 2018).

The nutrition research group at the Prairie Swine Centre has received funding from the Government of Saskatchewan through the Agriculture Development Fund to further investigate the importance of dietary nitrogen. The objectives of this series of studies will be to investigate the impact of dietary nitrogen content on essential amino acid requirements and amino acid utilization efficiency and to evaluate the effectiveness of alternative source of nitrogen to improve growth performance of pigs. The information gained from these studies will be used to provide recommendations to refine diet formulations to optimize nitrogen retention and lean gain in growing pigs.

### Conclusions
While our understanding of requirements for EAA is very well established, the requirement of pigs for NEAA and nitrogen has largely been ignored. An insufficient supply of nitrogen/dietary protein will likely reduce the efficiency with which EAA are used for lean gain. Failure to account for this will lead to subsequent negative effects on growth performance, feed costs, days to market, and carcass value. By ensuring both AA and nitrogen/protein requirements are met, producers will be able to maximize efficiency and growth performance while reducing environmental impact and feed costs.

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