Swine Nutrient Requirements

Nutritional requirements are defined as the amount of nutrients that pigs require to meet the needs for maintenance, growth, production, reproduction, and other functions. Generally, pigs require six classes of nutrients: carbohydrates, proteins, fats, minerals, vitamins, and water.

In animal populations and particularly in swine production, it is essential to distinguish between requirements and recommendations:

- **Nutritional requirements**: are determined for individual animals.
- **Nutritional recommendations**: are given for a population of animals.

Recommendations are often determined as the requirement of an average animal in the population. However, nutrient requirements vary between animals and the recommendations may not meet the requirement of a certain percentage of the population. Thus, recommendations often have a wider margin to take into account the variation in needs within a population.

Factors affecting nutrient requirements

Nutrient requirements are influenced by a combination of performance potential and feed intake. The nutrient concentration in the diet is adjusted according to feed intake to meet the requirements during each stage of production. Providing diets with nutrient levels below the requirements results in suboptimal performance, whereas feeding nutrients above the requirements increases feed cost and nutrient excretion. Thus, in order to ensure optimal production at an economical cost, it is important to understand the factors involved in nutrient requirement estimates and adjust the diet formulation accordingly.

Several factors affect the estimation of nutrient requirements in pigs. In fact, any factor that influences performance and feed intake is likely to affect nutrient requirements estimates. Generally, improvements in growth performance or productivity and decreases in feed intake are associated with increased demand for nutrient fortification in the diet to meet the requirements. Some of the most important factors are:

- Genetics and gender
- Dietary energy concentration
- Environmental temperature
- Health status
- Stocking density
- Feeding strategy and degree of competition for feed
- Variability of nutrient content and availability in ingredients
- Presence of molds, toxins, or anti-nutritional factors in the diet
- Inclusion of growth promoters or feed additives in the diet

Methods to estimate nutrient requirements

The most common approaches to estimate nutrient requirements are the factorial and empirical methods (Hauschild et al., 2010).

Factorial method

The nutrient requirements are obtained by combining the estimated requirements for maintenance and production. The factorial method uses a modeling approach from an average individual in the population and the requirements derive from equations that are usually a function of body weight and production parameters. Using this approach, the limitation lies on determining which animal should be used to estimate the requirements. For example, if the factorial requirement estimates for the average pig are applied to the population, because of natural between-animal variation approximately 50% of the population will not receive enough nutrients to express full growth potential. This method was used by the National Research Council to develop most of the recommendations published on the latest NRC (2012).

Empirical method

In the empirical method, dose-response or titration studies are conducted to determine the nutrient requirements. Dose-response studies are becoming increasingly popular to determine nutrient requirements because the estimates better represent the requirements of the population. The limitation of the empirical method lies on the application of requirement estimates to other populations or beyond the range of body weight.

In dose-response studies, different nutrient levels are tested. It is important to allocate most of the levels around an expected requirement and to include one level sufficiently high to produce the maximum response as well as one level sufficiently low to induce deficiency (**Figure 1**). The level associated with the best performance is determined through statistical analysis, which is crucial to accurately determine the nutrient requirement. Means comparisons are not an adequate method to analyze data from dose-response studies because it does not take into account the structure of treatment levels. Rather, modelling a response curve using linear and non-linear models is the most appropriate approach to determine a nutritional requirement. The response curve adapts to the shape of the data and indicates the nutrient level that maximizes or minimizes a performance criterion.

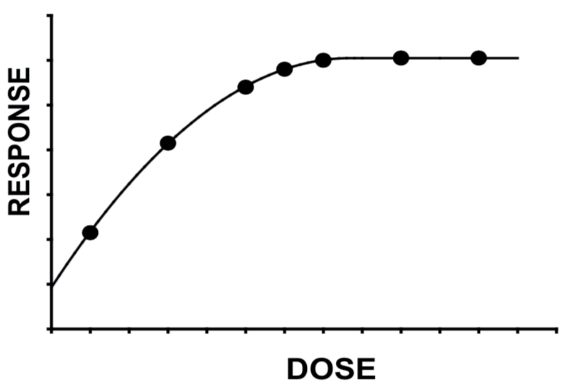

Figure 1. Distribution of nutrient levels in dose-response studies (Simongiovanni et al., 2012).

Estimating nutrient requirements

Nutrient requirements are often estimated under different conditions. The approach to estimate nutrient requirements is similar, but some particularities of amino acids, calcium, and phosphorus are detailed here.

Determining lysine requirements

The lysine requirements (**Table 1**) can be estimated by different methods that are preferentially selected based on the accuracy of requirement estimates, feasibility of implementation, and level of investment.

♦ From research data

Lysine requirements can be adapted from published research data from universities (**Figure 2**, KSU Lysine Recommendations), genetic suppliers, or feed companies. The lysine recommendations provided from research are usually derived from dose-response experiments and are often the best data available. But it is important to take into consideration the genetic line, level of growth rate and feed intake, health status, and housing conditions adopted in the experiment before applying the recommendations to a production system.

♦ From research within the production system

Lysine requirements can be derived from dose-response experiments conducted in research facilities within the production system. The lysine recommendations are most accurately determined by using this method because it better reflects the production system conditions. But it also requires more investment in research facilities and personnel expertise to conduct experiments.

♦ From protein accretion curves

Lysine requirements can be determined from curves of protein accretion derived from weights and ultrasound measurements of pigs within a production system (Smith et al., 1999). This method provides good estimates of farm-specific lysine recommendations because it reflects the conditions found in a commercial production system. The weighing and ultrasound scanning start earlier in the grower period and are collected past the normal market weights to ensure the lysine requirements at the beginning and end of the period are accurately estimated. Although this method is conducted under commercial facilities within the production system and does not require investment in research facilities, an ultrasound and a skilled technician are required to conduct the measurements and perform the modeling with precision.

♦ From growth rate and feed intake data

Lysine requirements can be estimated using growth rate and feed intake data. A simple rule of thumb is that grow-finish pigs require approximately 20 g of standardized ileal digestible (SID) lysine per kg of daily gain or 9 g per lb of daily gain (Main et al., 2008). Considering the growth rate and the feed intake of pigs in the production system, the lysine recommendations can be estimated to provide 20 g of SID lysine per kg of daily gain in diet formulation. This method is not as precise, but it provides a reasonable estimate of the lysine requirement.

Determining other amino acid requirements

The amino acid requirements are usually estimated by dose-response studies and the most common approach is to express the requirements as an amino acid ratio (**Table 1**). Amino acid ratio is a means of expressing the requirements for amino acids relative to the requirement for lysine. Lysine is used as a reference because it is typically the first-limiting amino acid in most swine diets and the proper concentration of lysine and other amino acids is essential for protein synthesis.

In dose-response experiments, the first limiting amino acid in the diet must be the amino acid for which the requirement is being estimated and the second limiting amino acid must be lysine. The supply of other amino acids and nutrients should meet or slightly exceed the requirements to avoid being a limiting factor. Using this approach, the requirement is determined at the point which both the tested amino acid and lysine are equally limiting and can, therefore, be expressed relative to lysine (Simongiovanni et al., 2012).

The requirements of amino acids relative to lysine can be often depicted as a diminishing returns model. This model can be used to determine which ratio provides 95 to 99% of the maximum performance and indicates the most economical amino acid ratio. Thus, the optimum amino acid ratio should be set by balancing the value accrued in performance to the incremental cost to increase the ratio.

Determining calcium or phosphorus requirements

The requirements of calcium or phosphorus are usually estimated by dose-response studies (**Table 2**). The estimation of requirements needs to take into consideration the calcium and phosphorus concentrations as well as the calcium:phosphorus ratio because of the close association between the minerals. Typically, wide calcium:phosphorus ratios or excessive calcium and marginal phosphorus concentration interfere with phosphorus absorption.

Table 1. Minimum standardized ileal digestible lysine and amino acid to lysine ratio for growing pigs and sows

	Growing pigs weight range, lb						Sows[4]	
SID amino acids[1]	15 to 25	25 to 55	55 to 130	130 to 175	175 to 220	220 to 285	Gestating	Lactating
Lysine, %[2]	1.35	1.25	1.08	0.88	0.78	0.70	0.60	1.05
Amino acid to lysine ratio, %[3]								
Methionine	28	28	28	28	28	28	28-29	28-29
Methionine + Cysteine	56	56	56	56	57	58	68-70	53-54
Threonine	62	62	62	62	63	64	74-76	63-64
Tryptophan	19	19	18	18	18	18	19-21	19-21
Isoleucine	52	52	52	52	52	52	58	56
Valine	67	67	68	68	68	68	71-76	64-70

[1]Minimum levels based on the NRC (2012) ingredient loading values.
[2]Minimum lysine levels considering a diet with 1,150 kcal NE/lb for growing pigs, 1,130 kcal NE/lb for gestating sows, and 1,160 kcal NE/lb for lactating sows.
[3]Minimum ratios to achieve approximately 95% of maximum growth performance. Minimum ratios of threonine, tryptophan, isoleucine, and valine can be greater depending on diet formulation.
[4]Data on amino acid requirements for contemporary sows is limited.

Table 2. Minimum calcium and phosphorus dietary levels for growing pigs and sows									
	Growing pigs weight range, lb							Sows[2]	
	12 to 15	15 to 25	25 to 50	50 to 130	130 to 175	175 to 220	220 to 285	Gestating	Lactating
Total calcium, %[1]	0.85	0.80	0.70	0.66	0.59	0.52	0.46	0.80	0.80
STTD phosphorus, %[1]	0.63	0.56	0.43	0.38	0.33	0.29	0.26	0.50	0.50

[1]Minimum levels based on the NRC (2012) ingredient loading values.
[2]Data on calcium and phosphorus requirements for contemporary sows is limited.

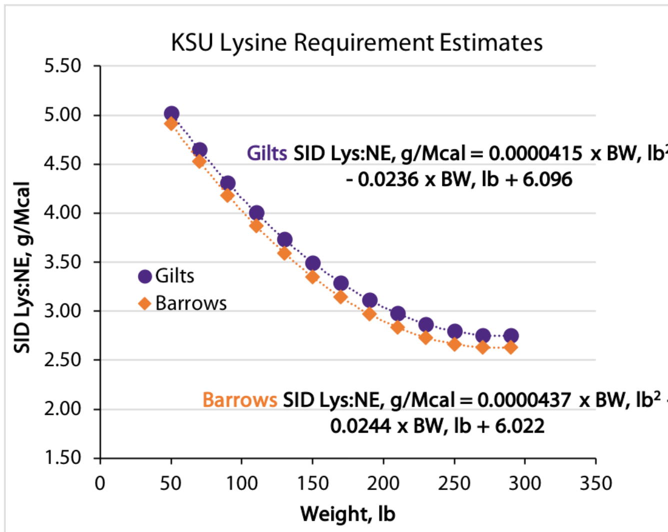

Figure 2. KSU lysine recommendations for grow-finish pigs (KSU Lysine Recommendations).

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