

## **Possibilities for feeding low-protein diets to weanling and growing pigs**

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### **Introduction**

The interest in feeding low-protein diets to growing pigs has increased during recent years. There are several reasons for this interest, but among the advantages of feeding low protein diets are the following:

1. Reduced N excretion from pigs in the manure
2. Reduced ammonia generation from the manure
3. Reduced water intake by the pigs, which in turn leads to a reduced manure volume
4. Less energy used for deamination of excess AA, which increases the NE of the diet
5. Less N in the hindgut of the pig, which reduces the risk of scouring

The first two advantages are related to concerns about environmental pollution caused by swine production, and the last advantage becomes more relevant if in-feed antibiotics are no longer used. Advantages # 3 and 4 are mainly related to reducing costs of swine production. Whatever the reason for feeding low-protein diets is, this approach will only be successful if a few basic nutritional concepts are honored. It is the objective of the present contribution to review these concepts.

### **Formulating conventional and low protein diets**

In conventional diet formulation, protein feed ingredients are usually added to diets until the requirement for the first limiting AA is met. Therefore, in the traditional corn-soybean meal diet, soybean meal is added until the requirement for lysine is met. Because lysine is the first limiting AA this means that the requirement for all other indispensable AA is also met. In reality, the inclusion of all AA except lysine will exceed the requirement. The advantage of this approach for formulating diets is that if the requirement for lysine is known then diets can be formulated to this requirement and one does not have to worry about the requirement for other AA. This will be true as long as diets based on corn and soybean meal are used. If alternative ingredients or by-products are included in the formulations then lysine may not always be the first limiting AA and care should be taken to make sure that the requirement for all AA is being met. The disadvantages of the traditional approach for diet formulation is that the AA that are supplied in excess of the requirement need to be deaminated by the pigs, which takes energy and also results in increased N being excreted in the manure and increased ammonia production from the manure. This may lead to increased pollution, increased generation of odor, and increased water usage by the pigs.

With the availability of crystalline sources of lysine, threonine, methionine, and tryptophan at prices that often can compete with conventional protein sources, the traditional approach for diet formulation is being challenged. Diets that contain lower concentrations of soybean meal, and thus crude protein, can result in pig performance that is similar to that obtained on traditional diets provided that these diets are fortified with crystalline AA to meet the requirement (Kerr et al., 1995; Tuitoek et al., 1997; Canh et al., 1998). In using this approach, the requirements for not only lysine, but also for most other indispensable AA needs to be known. Formulating low protein diets, therefore, represents additional challenges compared with formulating diets based on only corn and soybean meal. The fact that the AA requirements of pigs are influenced by a number of factors such as genetic background, gender, health status, energy intake, etc., increases the challenge of formulating diets that meet the requirements for all AA.

### **Standardized ileal digestibility**

Formulating low protein diets does not mean formulating low AA diets, but because the excess inclusion of many AA is avoided, the inclusion of most AA comes much closer to the requirement of the animal. Knowing the exact requirement of all indispensable AA for pigs, therefore, becomes much more critical. Two important tools are available in diet formulations that can help formulate diets that meet the requirements of all AA, but at the same time avoid over-formulation.

The first of these tools is the usage of standardized ileal digestibility (SID) values for AA in diet formulation. These values are available for all commonly used feed ingredients. The advantage of formulating diets using SID is that the accuracy of diet formulation is increased. If values based on apparent ileal digestibility are used, then low-protein feed ingredients such as cereal grains are often underestimated, which in turn makes it difficult to accurately predict the digestibility of a mixed diet. On the other hand, if SID values are used, then mixed diets can be accurately formulated based on the SID values for AA obtained in the individual feed ingredients because these values are additive when feed ingredients are mixed together (Stein et al., 2005). As a consequence, using values for SID in diet formulations increases the accuracy and it becomes more likely that diets with AA concentrations close to the animal's requirement are formulated.

### **Ideal Protein**

The second important tool that is available for formulating low protein diets is to use the concept of an ideal protein in diet formulations. Briefly, this concept assumes that because protein synthesis is an all or nothing event, the AA needed by pigs can be expressed in a fixed ratio to one another regardless of the production level of the animals. That means that if the requirement of one AA is increased, then the requirement of all AA is increased. Usually, the requirement for all indispensable AA is expressed relative to lysine and if the requirement for lysine is known then the requirement for all other indispensable AA can be calculated. Using this concept means that to formulate diets that accurately meet the requirements of the animals, one need to know only two things: The correct AA profile for the weight group of pigs in question, and the lysine requirement of

these pigs. Several different Ideal Protein ratios have been suggested, but the ratios most widely used are the ratios proposed in the so-called Illinois Ideal Protein (Baker, 1997). In the Illinois Ideal Protein, three different ratios are suggested depending on the weight of the pig, i.e., from 10 to 20 kg, from 20 to 50 kg, and from 50 to 110 kg (Baker, 1997). The reason the ratios change is that heavier pigs use a greater proportion of the dietary AA for maintenance rather than lean protein synthesis. The ideal ratio for maintenance is different from the ideal ratio for lean meat production, and as a greater proportion of the dietary AA are used for maintenance, the ideal profile of the entire diet will change. Once the ideal ratios have been chosen, one only need to know the lysine requirement for the pigs, because the requirement for all other indispensable AA can be calculated. In particular when low protein diets are formulated, this concept becomes a valuable tool.

### **Formulating low protein diets**

If diets are formulated using the above principles and with the addition of crystalline sources of lysine, threonine, methionine, and tryptophan, it is usually possible to reduce the dietary crude protein concentration by 3 – 4 percentage units. At this point, isoleucine becomes the first limiting AA, although it has been suggested that valine may become limiting in diets fed to nursery pigs (Mavromichalis et al., 2001). Crystalline sources of isoleucine and valine are not available at prices that make it possible to include them in commercial diets. Protein sources such as soybean meal are, therefore, included in the diet to meet the requirement for isoleucine and valine, and the additional requirements for lysine, methionine, threonine, and tryptophan can be met from crystalline sources of these AA. Several studies have been published in which these principles were followed and the crude protein concentration was reduced by up to four percentage units, without reducing pig performance or carcass composition (Cahn et al., 1998; le Belegro et al., 2002; Kerr et al., 2003).

A reduction of the dietary crude protein concentration by four percentage units means that up to 0.40% of crystalline lysine needs to be included in the diet along with varying quantities of crystalline threonine, methionine, and tryptophan. Whether or not it is economical to include crystalline AA at these levels or not depends on ingredients costs in each situation, but if formulated correctly such diets will not result in reduced pig performance. However, it is well accepted that reducing dietary crude protein concentrations results in reduced N concentration in the manure and reduced ammonia emission. As a rule of thumb, for each percentage unit, dietary crude protein is reduced, the N excretion from the pig will be reduced by 8-10% and the ammonia emission will be reduced by 10 – 12% (Cahn et al., 1998). There is, therefore, no doubt that from an environmental point of view, there are advantages of reducing dietary crude protein.

### **Effect of low protein diets on reducing diarrhea in weanling pigs**

It is well recognized that excess crude protein in the large intestine of weanling pigs increases the risk of these pigs developing diarrhea and scouring (Goranson et al., 1995). It is, therefore, possible to reduce the risk of pigs developing diarrhea if low protein diets are fed during the immediate post weaning period. As the industry is moving

towards feeding systems that do not include in feed antibiotics, this option often becomes the preferred strategy to prevent diarrhea. As was the case for growing pigs, the crude protein in diets formulated to weanling pig may be reduced by approximately four percentage units without compromising AA levels if crystalline sources of lysine, threonine, methionine, and tryptophan are included in the formulations. This approach may reduce dietary crude protein from 23 to approximately 19%. If potato protein is used in the formulation, it may be possible to formulate diets with 18% crude protein that will meet the requirement for all AA. However, to prevent scouring, it may sometimes be necessary to formulate diets containing only 15 to 16% crude protein. If such diets are formulated, the inclusion of AA will be approximately 20% below the requirement for weanling pigs. Unpublished data from South Dakota State University indicate that this will reduce the average daily gain of the pigs by 30 to 40 grams per day during the initial two weeks post weaning. However, if the pigs are allowed access to diets that contain normal or increased concentrations of crude protein after the initial two weeks post weaning, then they may compensate enough to catch up with the pigs that were fed to the requirement throughout the post weaning period (Table 1). It is, therefore, possible to use this strategy to reduce scouring and post weaning diarrhea in pigs.

## **Conclusion**

There are environmental and health advantages to feeding pigs low protein diets. Research conducted during recent years document that pig performance may be maintained in animals fed diets in which crude protein is reduced by up to four percentage units if these diets are balanced with crystalline sources of lysine, threonine, methionine, and tryptophan. Formulating diets based on standardized ileal digestible AA and using the concept of the ideal protein will make it possible to meet the requirement of all indispensable AA without undersupplying the animals. As a rule of thumb, for each 1% the dietary crude protein is reduced, the N excretion and the ammonia emission from the pigs may be decreased by 8 – 10 and 10 – 12%, respectively. If low protein diets are fed to weanling pigs, the incidence of diarrhea may be reduced. Sometimes it may be necessary to reduce the crude protein to 15% to prevent diarrhea. If that is the case, then pig performance may be compromised during the immediate post weaning period, but pigs will compensate during the following period, if they are allowed access to a high protein diet. This strategy, therefore, may be used to help improve pig health during the post weaning period.

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**Table 1.** Effects of reducing the crude protein level during the immediate post weaning period on pig performance <sup>a, b</sup>

Item	Diet	Diet 2	Diet 3	Diet 4
CP, d 0-14, %	20.8	20.8	15.7	15.7
Lys, d 0-14, %	1.35	1.35	1.15	1.15
CP, d 14-35, %	17.5	19.3	17.5	19.3
Lys, d 14-35, %	1.15	1.34	1.15	1.34
ADG, d 0-14, g	171	180	148	129
ADG, d 14-35, g	516	529	499	535
ADG, d 0-35, g	377	389	359	373
G:F, d 0-14, g/g	0.68	0.70	0.65	0.55
G:F, d 14-35, g/g	0.65	0.70	0.64	0.73
G:F, d 0-35, g/g	0.66	0.70	0.65	0.70

<sup>a</sup> Data are means of six observations per treatment.

<sup>b</sup> Data from Stein et al., 2003 (unpublished).