

Investigating the optimal isoleucine to lysine ratio in pig diets

Diana Siebert

CJ EUROPE GmbH

Abstract

Low crude protein diets have lots of advantages, however, to avoid the animals performance plummeting, the amino acid requirements have to be met correctly. Typically, a ratio of amino acids to lysine should be maintained. The branched chain amino acids including valine, isoleucine and leucine, are sharing a common metabolism. The excess of leucine in the diet can influence the requirements of valine and isoleucine. There is conflicting information available about the optimal isoleucine to lysine ratio. Based on the available literature and established nutritional recommendation standards, an optimal standardized ileal digestible isoleucine to lysine ratio of 53 - 55 % is suggested for pigs.

Background

Nutritionists may formulate low crude protein (CP) diets for swine diet because it has several advantages. First, balancing for amino acids instead of CP will reduce excretion of excessive dietary nitrogen to the environment [1]. Second, especially when raw material prices are high, protein rich materials are the most expensive ingredients. Thus, low CP diets are more economical. Third, an excess of protein in the diet is associated with diseases like post-weaning diarrhea [2-4]. To ensure the amino acid (AA) requirements of the animals are met in a CP reduced feed, it is necessary to supplement the crystalline AAs in the diet. Commercial pig diets are routinely supplemented with lysine (Lys), methionine (Met), threonine (Thr), and tryptophan (Trp). In plant-based diets, isoleucine (Ile) is expected to be the sixth limiting AA (after valine (Val) for pigs [5-7].

Several factors, such as gender, production stage, or health status, may influence the requirements. Because the branched chain AAs are sharing a common catabolism [8], dietary interactions between these amino acids potentially influence their requirements [9]. Literature shows a clear evidence that a deficiency in Ile leads to a decrease in feed intake and consequently to poor performance in nursery piglets [10], however, there is conflicting information about the accurate Ile requirement.

Metabolism of isoleucine

BCAAs account for about 30 % of the essential AAs in the muscle, showing their importance for muscle development. Unlike other AAs, BCAAs are not primarily metabolized in the liver but in the muscle. Val, Leu, and Ile share a common metabolism because they are degraded by the same enzymatic system in a two-step process. First, the BCAAs get degraded by the BCAA Transaminase (BCAT) to form branched-chain α -keto acids (BCKA). In a second step, BCKAs undergo oxidative decarboxylation catalyzed by BCKA dehydrogenase (BCKDH) complex enzyme.

Thus, BCAAs in the diets need to be balanced. Especially a leucine (Leu) oversupply may affect the requirement of Val and Ile because Leu acts as a stimulator for the common enzyme system [9] and consequently reduces the availability of Val and Ile. However, an excess of Leu seems to have a bigger impact on Ile, rather than Val. Especially blood-byproducts are very high in Leu and extremely low in Ile, which creates a strong imbalance between the BCAAs when these products are used in piglet diets.

Isoleucine requirements

Considering the established nutritional recommendation standards (Table 1), the optimal digestible Ile to Lys ratio varies between 51 (Danish nutrient standards, 2020) and 58 (BSAS, 2003).

Tabel 1. Overview of suggested isoleucine:lysine ratios, estimated by established nutrient standards

Reference	Phase [kg]	Suggested SID Ile:Lys	Suggested SID Leu:Lys
NRC, 2012	75	53	101
BSAS, 2003	10 – 120	58	100
FEDNA, 2013	20 – 100	55	100
Danish nutrient standards, 2020	30 – 115	51 – 53	96 – 100

In a study using 24 – 39 kg pigs, Ile to Lys ratios were investigated in diets with moderate Leu content [14]. The optimum SID Ile to Lys ratio was approximately 54% for pigs fed diets containing non-excess levels of Leu. In an earlier study [15], the optimal Ile to Lys ratio in starter pigs from 7 – 11 kg was investigated in diets with 7.5 % spray-dried blood cells (SID Leu to Lys 162 %). On average, SID Ile to Lys ratio was estimated to be 61 % [15]. In two growth assays [10] the effect of diet composition on the optimal Ile to Lys ratio in 8 – 25 kg pigs were compared using either spray-dried blood cells or corn gluten feed as protein source. SID Ile to Lys for ADG and ADFI was estimated to be 59 % in case the diet contains 7.5 % spray-dried blood cells (SID Leu to Lys 160 %). In contrast, when using corn gluten feed (SID Leu to Lys 102 %) an optimal SID Ile to Lys of 54 % was observed. The authors concluded that the Ile requirements derived from studies using blood-byproducts are not applicable for diets with other protein sources [10].

In a meta-analysis [16], the Ile requirement of growing pigs was investigated. The presence of blood products in a diet had a significant influence on Ile requirement. Blood products have very low Ile concentration, but very high concentration of Leu, phenylalanine and histidine. Especially excess Leu seems to increase the requirement for Ile. Consequently, in diets with and without blood products an optimal SID Ile to Lys ratio of 55 % and 50% was suggested, respectively.

Conclusions

Information about the Ile requirement in pigs is limited and sometimes conflicting. Especially the use of blood products in the diet has an impact on the estimated Ile requirements. Based on the available literature, an optimal SID Ile to Lys ratio of 53 % – 55 % is suggested. When a diet contains high amounts of Leu, a higher SID Ile to Lys may be necessary.

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