

Recommended Isoleucine:Lysine ratios in different animal diets

An Ya Nan

CJ Bio, China

Introduction

The output of animals feed in China has been rising continuously for years, and the total feed output has reached 253 million tons in 2020. However, the long-term shortage of ingredient materials, which eighty percent of SBM in feed depended on import, has restricted the development of Chinese animal husbandry. In addition, the traditional diets have low feed utilization efficiency, increase the metabolic burden of the farmed animals, and also lead to the excessive discharge of nutrients, resulting in increasingly prominent environmental problems. So it is urgent to improve feed utilization efficiency, and decrease the usage of protein ingredient, especially SBM. Low crude protein diets is one of the solutions recognized widely so far. The reduced amino acids content of low protein diets was seriously insufficient to meet the animals' requirements. Commercially available crystalline amino acids compensate for the low crude protein.

Isoleucine is one of branched chain amino acids (BCAAs), which are important nutrition signals, such as protein synthesis, glucose homeostasis, gut health, anti-obesity, immunity and disease in animals. According to the ideal protein concept, amino acids relative to lysine were always used to express the animals need as formulating diets, which allows for most efficient utilization of protein of nitrogen. This article is aimed to summary the isoleucine:lysine ratios (Ile:Lys ratios) of different animal diets.

Broiler

The commercial availability of feed grade amino acids at economically feasible prices is primarily responsible for the successful minimisation of excess amino acids from protein ingredient. Generally, ideal protein concept is usually used to formulate diets, which express the need for critical amino acids relative to Lysine. This theoretically allows for the most efficient utilization of protein by maximizing nitrogen efficiency and retention and in turn, minimizing nitrogen excretion.

Isoleucine is a limiting amino acid for broilers in commercial diets. Previously, it has been demonstrated that in most practical diets, isoleucine and valine are often limiting after Thr, which is the third limiting amino acid after Met and Lys (Baker et al., 2002). Mack et al. (1999) recommended a digestible Ile:Lys ratio of 71% for improved live performance and carcass characteristics. Hale et al. (2004) observed a decrease in live performance of female broilers when fed diets with an digestible Ile:Lys ratio below 62% from 30 to 42 d of age.

What's more, it was reported that an improvement in breast meat yield of male Ross × Arbor Acres broilers when using L-Ile to supplement a diet marginal in this amino acid (Kidd et al., 2004). A positive response for feed conversion was observed when the digestible Ile:Lys ratio was 68.9%, whereas for increase breast meat yield and reduce abdominal fat percentage, a positive response was observed at a ratio of 71.7% (Mejia et al., 2011). In many studies, the Ile:Lys ratios recommended for broilers were more than 67% (Table 1). Higher Ile:Lys ratio may be needed for maximum carcass characteristics of commercial high-yield broilers.

Table 1. Recommended Ile/Lys ratio in broiler diets

Phase	Recommended ratio (%)	Reference
20 - 40d	71	Mack et al., 1999
30 - 42d	62	Hale et al., 2004
42 - 56d	61 - 73	Kidd et al., 2004
30 - 43d	68	Rostagno et al., 2011
28 - 42d	69 - 71	Meijja et al., 2011
7 - 21d	66	Tavernari et al., 2012
30 - 43d	68	
28 - 40d	69	Campos et al., 2012
22 - 42d	72	Duarte et al., 2015
30 - 43d	70	Campos et al., 2009

Layer

Isoleucine is an indispensable amino acid for normal growth and development of laying hens as well as egg production and egg mass. Isoleucine is a branch-chain amino acid like valine and leucine, but the low level of Ile in low protein meal predisposes Ile to becoming a limiting AA for bird growth in vegetable-based diets with lower protein levels (Fernandez et al., 1994; Kidd et al., 2004). Therefore, industrial Ile supplementation is essential in these diets (Mello et al., 2012). In corn-SMB diets, Ile is a limiting amino acid for laying hens, especially in low protein diets.

The amount of Ile is usually expressed as relative to lysine, not as percentage. The values of Ile:Lys ratios in layer diets were shown in Table 4. The Ile requirement of layer has been estimated frequently and the results were relatively various. CVB (1996) recommended that the dietary D Ile:Lys ratio of laying hens was only 79%, while Coon and Zhang (1999) recommended that the D Ile:Lys ratio was 86%, and NRC (1994) recommended that the Ile:Lys ratio was 94%. For 24 - 40 weeks Hy-line brown layers, When reaching the optimum laying performance, the recommended digestible D Ile/Lys ratio was 84% (Rocha et al., 2013). As the crude protein of laying diet was decreased from 18% to 16%, the crystallize amino acids, such as methionine, lysine, threonine and tryptophan, were added extraly into the diet and the Ile:Lys ratio was evaluated. The results showed that higher Ile:Lys ratio could improve feed intake, egg production and egg quality, and the optimal Ile:Lys ratio was differ from 82% - 88%.

Table 2. Recommended Ile:Lys ratios in layer diets

Recommended ratio (%)	Reference
94	NRC, 1994
80	CVB, 2018
86	Coon & Zhang, 1999
79	Lesson et al., 2005
79	Shivazad et al., 2002
84	Rocha et al., 2013
82 ~ 88%	Ilona et al., 2020

Piglet

The evidences showed that, for piglet, each 1% reduction of dietary crude protein could reduce total nitrogen emissions by approximately 8% to 10% without affecting growth performance (Qiao et al., 2007). Evidences indicated that Ile was a limited amino acid in corn-SBM diets, especially with low crude protein-amino acid balanced diets (Shivazad et al., 2002; Soumeh et al., 2014). It may be a better solution to decrease the dietary crude protein and supplement with limiting crystalline amino acids to reduce N excretion. Van Milguen et al. (2012) conducted an extensive meta-analysis study to determine the needs for this amino acid: diets containing blood meal or blood cells were found to have a higher requirement for isoleucine. This is because blood ingredients are rich in leucine, the excess of which is capable of activating the metabolic pathways that catabolize isoleucine. According to the meta-analysis study of piglet growth (Figure 1), the Ile:Lys ratio of 53% was established maximizing growth. As Ile:Lys ratios of two diets were improved to 53% from 47.1% or 49.8%, balanced diets (53% Ile/lys ratio) have a higher ADG, feed intake and efficiency, and the diets of increase from 47.1% to 53% Ile:Lys ratio showed a better piglet growth performance improvement than 49.8%.

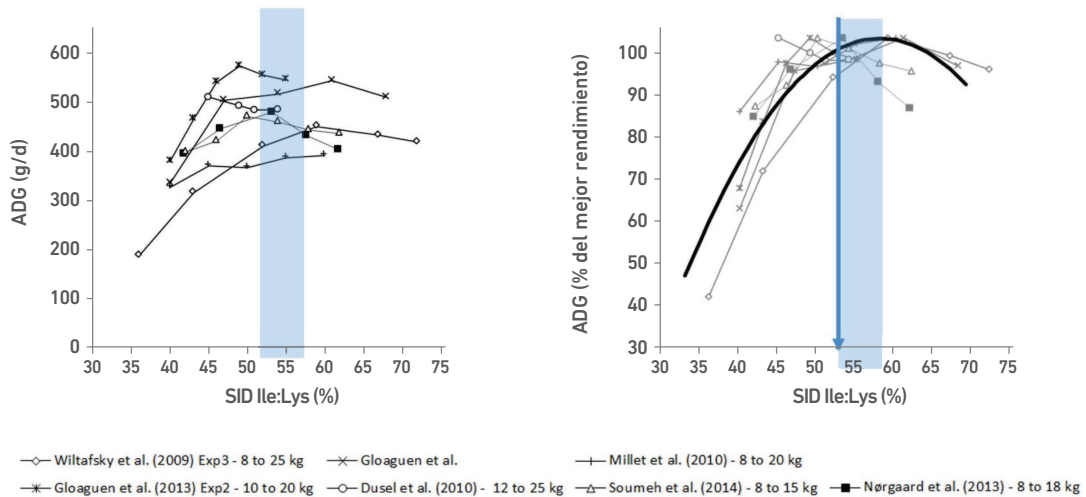


Figure 1. Results in piglet growth from different studies considering various Ile:Lys SID ratios

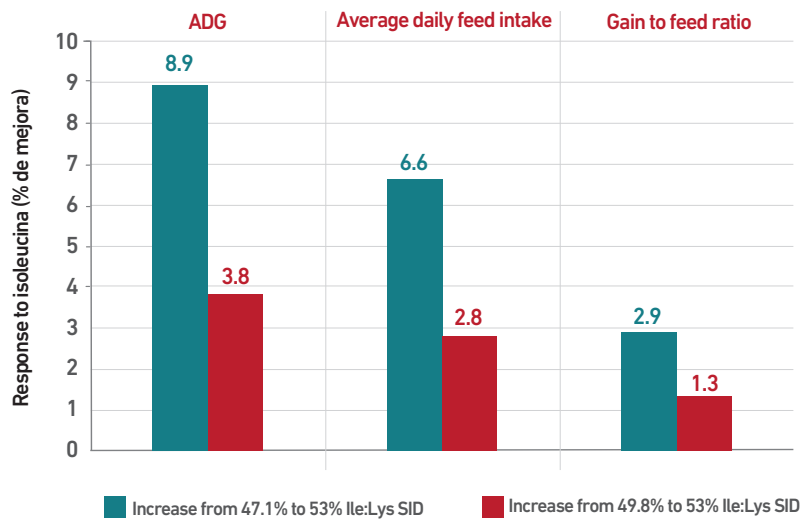


Figure 2. Pig response to increased Ile:Lys SID ratios

When the dietary crude protein was decreased from 20% to 17%, the growth performance was affected negatively even though extra crystal Lys, Met, Thr and Trp were added into the diet. As Val and Ile was supplemented to the low crude protein diet, the improvement of ADG and growth rate was observed in comparison to an unsupplemented control diet (Lordelo et al., 2008). Lordelo et al. (2008) recommended that the optimal Ile:Lys ratio was 61% in the low CP diet. The Ile:Lys ratio estimated by NRC (2012) was 51%, which was insufficient in commercial piglet diet. Kerr et al. (2004) researched Ile requirement of piglet and the results showed the Ile:Lys ratio of 60% was adequate for feed intake, daily gain, and feed efficacy.

Table 3. Recommended Ile:Lys ratio in piglet diets

Recommended ratio (%)	Reference
51	NRC, 2012
61	Lordelo et al., 2008
59	James et al., 2002
61	Becker et al., 1963
61	Kerr et al., 2004

Conclusions

For animals, Ile is an important limiting amino acid that could not be synthesized *in vivo*. It is necessary to supplement Ile to maintain the ideal protein profile and ensure maximum piglet growth as decreasing the crude protein of diet. There were much difference for dietary Ile:Lys ratio for broiler, layer and piglet. So much more researches about dietary Ile:Lys ratios are needed to evaluate in different stage of animals.

REFERENCES

- Shivazad, M., R. Harms, G. Russell, D. Faria, and R. Antar. 2002. Reevaluation of the isoleucine requirement of the commercial layer. *Poult. Sci.* 81:1869–1872.
- Soumeh, E.A., van Milgen, J., Sloth, N.M., Corrent, E., Poulsen, H.D., Nørgaard, J.V., 2014. The optimum ratio of standardized ileal digestible isoleucine to lysine for 8–15 kg pigs. *Anim. Feed Sci. Technol.* 198, 158–165.
- Mack S, Bercovici D, De Groote G, et al. Ideal amino acid profile and dietary lysine specification for broiler chickens of 20 to 40 days of age[J]. *British poultry science*, 1999, 40(2): 257-265.
- Hale L L, Pharr G T, Burgess S C, et al. Isoleucine needs of thirty-to forty-day-old female chickens: immunity[J]. *Poultry science*, 2004, 83(12): 1979-1985.
- Mejia, L., et al. "Digestible isoleucine-to-lysine ratio effects in diets for broilers from 4 to 6 weeks posthatch." *Journal of Applied Poultry Research* 20.4 (2011): 485-490.
- Tavernari F C, Lelis G R, Carneiro P R O, et al. Effect of different digestible isoleucine/lysine ratios for broiler chickens[J]. *Revista Brasileira de Zootecnia*, 2012, 41: 1699-1705.
- Duarte K F, Junqueira O M, Filardi R S, et al. Digestible isoleucine requirements for 22-and 42-day-old broilers[J]. *Acta Scientiarum. Animal Sciences*, 2015, 37: 23-28.
- Campos A M A, Rostagno H S, Nogueira E T, et al. Updating of the ideal protein for broilers: arginine, isoleucine, valine and tryptophan[J]. *Revista Brasileira de Zootecnia*, 2012, 41(2): 326-332.
- Rostagno H.S., Albino L.F., Donzele, J.L. et al. *Tabelas Brasileiras para Aves e Suínos - Composição dealimentos e exigências nutricionais*. 3.ed. Viçosa, MG, 2011.252p.
- Baker D. H., Batal A. B., Parr, T. M., et al. Augspurger, and C. M. Parsons. 2002. Ideal ratio (relative to lysine) of tryptophan, threonine, isoleucine, and valine for chicks during the second and third weeks posthatch. *Poult. Sci.* 81:485–494.
- Fernandez S R, Aoyagi S, Han Y, et al. Limiting order of amino acids in corn and soybean meal for growth of the chick[J]. *Poultry Science*, 1994, 73(12): 1887-1896.
- Mello H H C, Gomes P C, Rocha T C, et al. Determination of digestible isoleucine: lysine ratio in diets for laying hens aged 42-58 weeks[J]. *Revista Brasileira de Zootecnia*, 2012, 41: 1313-1317.
- Coon C, Zhang B. Ideal amino acid profile for layers examined[J]. *Feedstuffs (USA)*, 1999.
- Parenteau I A, Stevenson M, Kiarie E G. Egg production and quality responses to increasing isoleucine supplementation in Shaver white hens fed a low crude protein corn-soybean meal diet fortified with synthetic amino acids between 20 and 46 weeks of age[J]. *Poultry science*, 2020, 99(3): 1444-1453.
- Rocha T C, Donzele J L, Gomes P C, et al. Ideal digestible isoleucine: digestible lysine ratio in diets for laying hens aged 24-40 weeks[J]. *Revista Brasileira de Zootecnia*, 2013, 42(11): 780-784.
- Shivazad M, Harms R H, Russell G B, et al. Re-evaluation of the isoleucine requirement of the commercial layer[J]. *Poultry Science*, 2002, 81(12): 1869-1872.
- Marta Cirera. Low-protein diets and isoleucine requirements in pigs (2019).https://www.pig333.com/articles/isoleucine-requirements-in-low-protein-pig-diets_15225/.
- National Research Council. 1994. *Nutrient Requirements of Poultry*, 9th rev. ed. National Academy Press, Washington, DC.
- Parenteau I A, Stevenson M, Kiarie E G. Egg production and quality responses to increasing isoleucine supplementation in Shaver white hens fed a low crude protein corn-soybean meal diet fortified with synthetic amino acids between 20 and 46 weeks of age[J]. *Poultry science*, 2020, 99(3): 1444-1453.
- Lesson S, Summers J. *Commercial poultry nutrition*, university books. Guelph Ontario[J]. 2005.
- Spek J W. Standardized ileal digestible lysine requirement for laying hens[R]. Wageningen Livestock Research, 2018.