Importance of Methionine Source in Poultry Feed

Abstract

Since the crude protein (CP) content in animal diets has a great influence on nitrogen emission, the trend to lower the CP level is getting more attention, and increasing number of countries implemented legislation to limit CP content in animal feed. The supplement of crystalline amino acids is pivotal to maintain proper amino acid balance while lowering CP. Methionine is the first limiting amino acid in poultry diets, and several types are available for feed industry. Each methionine source shows a different bioavailability, growth performance. It is well established that L-methionine has the best relative bioavailability among various sources. Consequently, when using L-methionine, one can expect better results even with a reduced methionine content in the feed compared to DL-methionine or other methionine analogues supplemented diet.

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Introduction

Global warming has brought a new environmental challenge to the animal industry and realizing carbon neutrality is one of the major goals for sustainable animal production.
Nitrogen from livestock feces can be converted to nitrate nitrogen in the soil and then to nitrous oxide (N_2O), which is 280 to 310 times more potent than carbon dioxide (CO_2) in causing the greenhouse effect (IPCC, The Intergovernmental Panel on Climate Change).

Crude protein (CP), particularly indigestible protein, is linearly associated with nitrogen emission by the animal industry. In order to reduce CP, many studies have been conducted for more than a decade, and clearly established Nuseveral benefits such as reduction in feed cost and nitrogen emission. For your reference, Korea has submitted the “2030 Nationally Determined Contributions (NDC)” and the “2050 Long-term low greenhouse gas Emission Development Strategies” to the UN. In line with this, the notification on the reduction of crude protein in livestock feed was implemented from December 29, 2021. Amino acids supplementation becomes more essential when reducing the CP level in animal diets. If amino acids are not present in an appropriate ratio, optimal protein synthesis or metabolism cannot be realized.

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Role of methionine in poultry feed

Methionine is an essential amino acid as it is not synthesized in the animal body. Methionine is the first limiting amino acid in poultry feed because it is required at a high level for the growth of feathers and optimum protein synthesis.

Methionine in poultry feed has many physiological functions other than body protein synthesis. As already widely known, methionine is converted into cysteine, which becomes a component of glutathione, an antioxidant in the body. Therefore, it has been known that methionine acts as a precursor and has the function of reducing oxidative stress in the body (Riedijk et al., 2007).
The various physiological functions of methionine are shown in Figure 1.

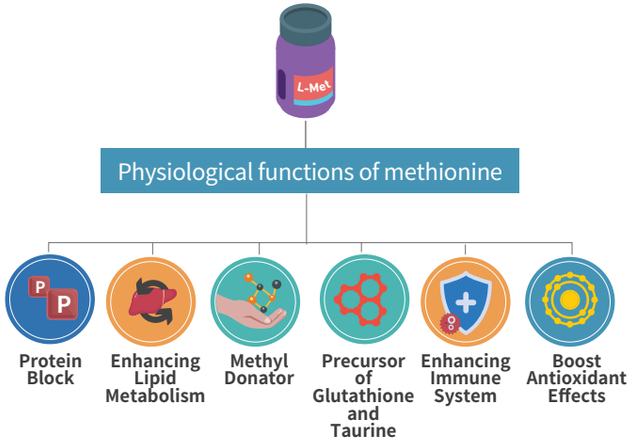

Figure 1. Physiological functions of methionine in livestock.

Methionine not only plays a role in protein synthesis but also has various phy-siological functions.

Conversion of D-Methionine to L-Methionine in poultry body

Currently, due to a lack of recognition of methionine source (or due to other decision factors), DL-methionine is used which is produced by chemical synthesis containing D-methionine and L-methionine in a ratio of 50:50.

D-type and L-type amino acids are optical isomers, like the palm of both sides of the hand, with the same structural formulas but opposite binding directions. However, since all plants and animals in the natural environment can use methionine in the L-form, D-methionine must be converted to L-methionine after absorption. Figure 2 shows the conversion of D-methionine to L-methionine in the liver.
For this conversion, two essential enzymes are required. The first one is D-Amino acid oxidase (DAAO). Through the action of DAAO, the amino group is separated from D-methionine, and through the action of the transsminase, the amino group is combined in the opposite direction, eventually completing the conversion to the L-methionine.

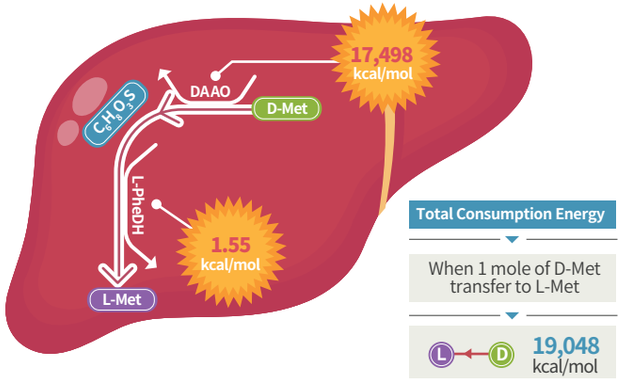

Figure 2. The conversion process of D-methionine to L-methionine

Two enzymatic actions are required, and the amino group must be separated and then recombined. In this process unnecessary energy is wasted.

In general, it is known that the DAAO is expressed in the mucosal epithelium, liver and kidney of chickens, and the conversion is easily performed. However, D'Aniello et al. (1993) demonstrated that all animals are born without the DAAO enzyme at birth.
The expression of DAAO starts to increase as the animal grows, but as shown in Figure 3, it takes quite a while to work sufficiently in the body. From the results, it was found that D-methionine is hardly available in young chickens, and absorbed D-methionine remains in body tissues in a free form. The remaining free D-methionine is considered to inhibit the synthesis of other essential enzymes, resulting in the inhibition of livestock growth.
Therefore, when DL-methionine is consumed, it is considered that the bioavailability is naturally inferior to L-methionine. Methionine hydroxyl analogs, available as a liquid methionine, are also used in the industry, and the methionine conversion rate of these analogs is reported very low about 65 to 88%, particularly lower bioavailability in a cysteine-rich diet such as a diet used feather meals.

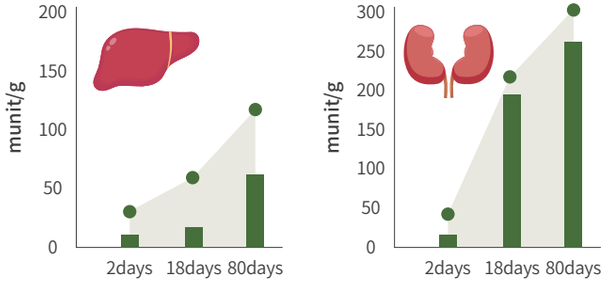

Figure 3. Expression of D-amino acid oxidase in the animal body (mice).

This enzyme, the expression level is significantly low at birth, begins to function as livestock grows. (D'Aniello et al., 1993)

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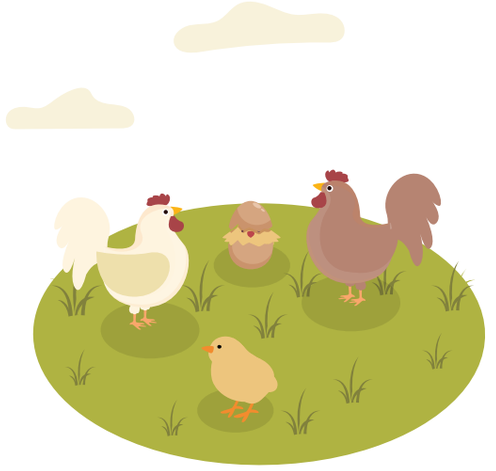
Conversion of D-Methionine to L-Methionine in poultry body

With the development of livestock breeding and feed technology, the age to slaughter is getting shorter, and the importance of the early-stage growth rate is getting more attention among nutritionists. In particular, broilers have a short life cycle (around 30 days) until slaughter compared to the actual lifespan, so it may contribute to the lower bioavailability of D-methionine in feed. It is a well-known fact that the performance of the first week of the broiler has a great influence on the overall performance. A chick that weighs only 40g at birth can achieve its target performance only when it reaches a weight of 180g, a 4.5-fold increase at the age of the first week. If the body weight is 10 g less than the target at seven days of age, the weight may be reduced by 60 to 70 g at the time of slaughter at 35 days.

Therefore, using D-methionine, which is lower in bioavailability than L-methionine at a young stage, may have a significant impact on overall profitability

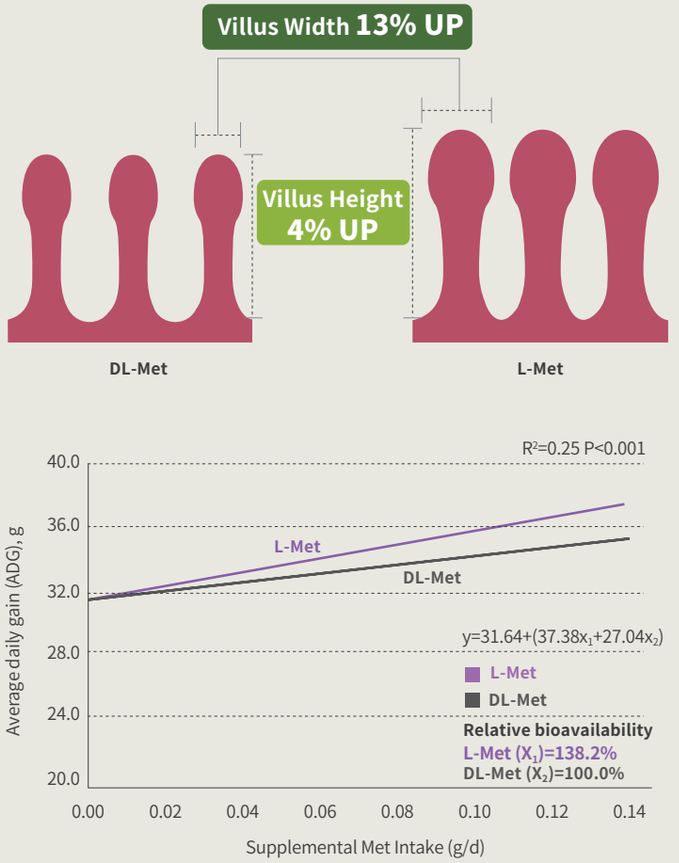


Difference between DL-methionine and L-methionine in poultry feed

About 45% of absorbed methionine is used in the intestinal mucosa, which proves that there is a high correlation between methionine and intestinal development. In this regard, it has been proven that increased glutathione in the intestinal mucosa has a great effect on the development of intestinal villi. As mentioned earlier, glutathione is a substance that plays an important role in the antioxidant mechanism, including cysteine.
The higher the efficiency of methionine, the higher the rate of conversion to cysteine, and thus the higher the amount of glutathione synthesis (Shen et al., 2015).

In an experiment verifying the above, it was demonstrated that villi development in chickens fed with L-methionine was significantly improved compared to chickens fed with DL-methionine (Shen et al., 2015).
In the results of analyzing the villus tissues in each of the two groups, significantly higher glutathione was detected in the L-methionine-fed group, and both the villous height and width were improved in the L-methionine-fed group (Figure 4). Based on the histological analysis results and daily weight gain, the relative bioavailability of L-methionine is considered to be 38.2% higher than DL-methionine.

Figure 4. Comparison of intestinal villi and daily weight gain in broilers fed DL-methionine and L-methionine (Shen et al., 2015)



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Establishment of methionine requirement based on bioavailability of L-Met

Most of the current nutrition guides for methionine in poultry diets have been evaluated/established when DL form is the only available source of methionine for feed industry. Based on the previous review of the bioavailability between methionine sources, a direct comparison trial was conducted.
The trial aimed to elucidate if the lower content of L-methionine in broiler feeds can achieve an equal or superior performance compared to DL-Met supplemented diet at 100% requirement.
The result showed that using a 15% less L-methionine achieved a comparable performance to the current requirement of DL-methionine (Figure 5).

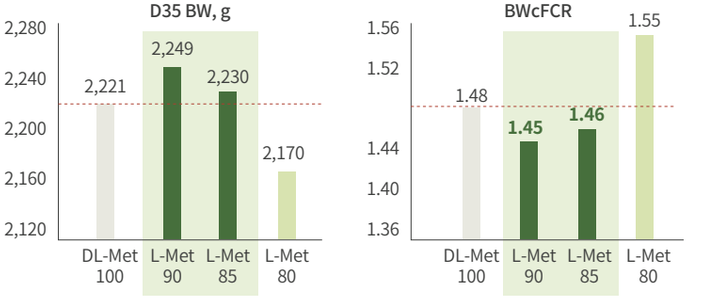

Figure 5. Comparison of 35d growth performance of Cobb 500 broiler between the inclusion of DL-methionine and L-methionine. Malaysia, Universiti Putra Malaysia, 2017

CJ BIO has newly launched L-Met Eco (a 95% L-methionine product) based on abovementioned and many other studies.
The content was set at 95% instead of 85%, in consideration that a 10% safety margin is required as methionine contents in feed ingredients are fluctuating. Therefore, 95% of L-methionine in broiler feeds is sufficient to weight-to-weight substitution with a 99% DL-methionine product.

The results of the direct comparison of 99% of DL-methionine and 95% of L-methionine products are shown in Figure 6 (weight-to-weight substitution). The feed conversion rate (FCR) in the starter phase was significantly lower, and the 28d body weight was improved by 1.4% in the L-Met 95% group.

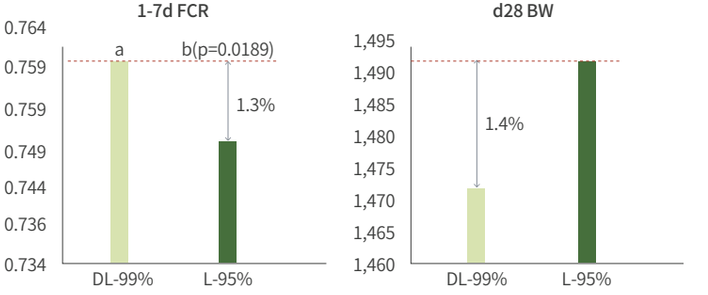

Figure 6. Comparison of growth performance for broiler chickens with the inclusion of equal amounts of 99% DL-methionine and 95% L-methionine (CJ internal trial, 2021).

In addition, CJ 95% L-methionine (L-Met eco) reduces greenhouse gas emissions compared to its existing products through process optimization, so it is an environmentally friendly product that can contribute to the sustainability of the livestock industry.

L-MET *eco*

Conclusion

Methionine is a nutrient that plays a very important role as the 1st limiting amino acid in poultry diets. Methionine, primarily used in protein synthesis, is known to play a variety of functional roles.
In particular, the appropriate choice of methionine source is important for maximizing growth, particularly at the early stage of growth. There are various sources of supplemental methionine, and all types of methionine can be used for protein synthesis and other biological functions only when they are converted into L-methionine in the body. Of course, the bioavailability between them is different. Therefore, when choosing a methionine source, its bioavailability must be carefully reviewed to fulfil the genetic potential of chickens. Based on theoretical and empirical data, when using L-methionine broiler diets, even if the methionine content in the diet is less than the current DL-methionine guideline, it is possible to achieve the target result. Accordingly, economic and environmental benefits can be expected through the use of L-methionine products in broiler diets.

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