

# Norlysine

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## summary

Norlysine, also referred to as L-lysine, is a non-standard amino acid with the molecular formula  $C_6H_{14}N_2O_2$ . Known for its essential role in protein synthesis and various metabolic processes, norlysine is significant in both human nutrition and animal health. It exists primarily in its L-form, which is biologically active and essential for the growth and development of many organisms. Its structural characteristics, including a chiral carbon and a side chain of  $(CH_2)_4NH_2$ , classify it as a basic, charged amino acid when in solution.[\[1\]\[2\]\[3\]](#)

This amino acid is particularly notable for its contributions to dietary adaptations among various species, impacting their metabolic response to differing protein levels. For instance, studies have shown that omnivores and herbivores can effectively modulate their amino acid metabolism in response to varying protein diets, a feature that underlines the biological versatility of norlysine in promoting health and adaptability in different dietary contexts.[\[4\]](#) In addition to metabolic functions, norlysine is crucial for immune response enhancement, supporting the synthesis of essential proteins such as antibodies and cytokines, thereby playing a vital role in maintaining immune health across species.[\[4\]](#)

Norlysine is predominantly obtained from animal-derived food sources, including red meat, dairy products, and eggs, although it can also be sourced from certain plant foods, notably legumes and wheat germ. Its dietary significance extends to supplementation, where it is often used to promote various health benefits, including support for calcium absorption, collagen production, and mitigation of herpes simplex virus outbreaks.[\[5\]\[6\]\[7\]\[8\]](#) However, excessive intake can lead to gastrointestinal disturbances, and caution is advised for individuals with existing health conditions, particularly those affecting kidney function.[\[9\]\[10\]\[11\]](#)

In agricultural contexts, norlysine is recognized for its importance in animal nutrition, particularly in livestock production. It serves as a crucial supplement to enhance growth rates and feed efficiency while minimizing environmental impacts associated with manure nitrogen content. As the demand for sustainable farming practices grows, the inclusion of lysine in animal diets is increasingly viewed as an essential strategy for optimizing animal health and productivity.[\[12\]\[13\]\[14\]](#) Overall, norlysine's multifaceted roles underscore its importance in both health and agricultural systems, marking it as a compound of significant nutritional and economic relevance.

## Chemical Structure

Norlysine, chemically known as L-lysine, is an amino acid with the molecular formula  $C_6H_{14}N_2O_2$  and a molecular weight of 146.1876 g/mol[\[1\]\[2\]](#). Its structural formula consists of an amino group, an amino group, and a side chain of  $(CH_2)_4NH_2$ , classifying it as a basic, charged aliphatic amino acid when dissolved in water at physiological pH[\[3\]\[15\]](#). The compound has a CAS Registry Number of 56-87-1 and features a chiral carbon, existing as two enantiomers; however,

biological activity is predominantly associated with the L-lysine form, which has the ~~α~~carbon in the S configuration[3][5].

The IUPAC Standard InChIKey for L-lysine is KDXKERN SBIXSRK-RXMQYKED-SA-N, facilitating its identification in chemical databases[1][3]. Structurally, lysine is amphipathic due to the combination of its charged side chain and long hydrophobic carbon tail, allowing it to interact variably with its environment, influencing protein structure and stability through hydrogen bonding and salt bridges[3][16].

L-lysine can exist in multiple forms, including its hydrate and various hydrochloride forms, such as L-lysine hydrochloride, which further highlights its chemical versatility[1][2][15].

## Biological Role

Norlysine, a non-standard amino acid, has several biological functions that are crucial for the metabolism and overall health of organisms. One significant aspect of norlysine is its role in the regulation of amino acid (AA) metabolism and its implications in dietary adaptations among different species.

## Metabolic Adaptation

Norlysine plays a role in metabolic adaptation to varying protein diets. Most omnivores and herbivores can adjust to low-protein diets by increasing food intake and reducing AA catabolism, whereas they may initially reduce food intake in response to high-protein diets before up-regulating AA-catabolic enzymes. For instance, rats can modulate the activities of these enzymes effectively, showcasing their adaptability in different dietary conditions[4]. However, other species, such as dogs, show less efficiency in metabolic adaptation to protein intake changes, as evidenced by unchanged rates of leucine oxidation despite varying protein intake levels[4].

## Immune Response Enhancement

Amino acids, including norlysine, are vital for immune responses in animals. They contribute to the synthesis of proteins, such as antibodies and cytokines, which are critical for immune functionality. For instance, the supplementation of specific amino acids, like arginine, has demonstrated beneficial effects on the immune system of cats when incorporated into low or high-protein diets[4]. Moreover, the administration of alanyl-glutamine in dogs has been shown to enhance the phagocytic activity of leukocytes, highlighting the importance of amino acids in immune modulation[4].

## Nutritional Significance

Norlysine, similar to other amino acids found in animal-derived products, provides essential nutrients that support growth, development, and immune function. For example, animal proteins are rich in amino acids like lysine, cysteine, methionine, and proline, which are relatively low in plant-based proteins. These amino acids are crucial for both innate and acquired immune responses, thereby mitigating the

risk of infections in animals[4]. Furthermore, certain animal-sourced food products, such as spray-dried animal plasma, are rich in immunoglobulins and other functional molecules that bolster the immune defense mechanisms in pets[4].

## Dietary Sources

Lysine is an essential amino acid that plays a crucial role in various biological functions, including protein synthesis, hormone production, and immune function. It is predominantly found in animal products, which serve as the primary sources for most individuals. Key dietary sources of lysine include red meat, chicken, eggs, and fish, such as cod or sardines[5]. Additionally, dairy products like Parmesan and cottage cheese are also rich in lysine, making them beneficial for those seeking to meet their daily requirements through animal-based foods[5].

For vegetarians and vegans, lysine can be adequately obtained from plant-based sources, particularly legumes and wheat germ, which are good alternatives for those avoiding animal products[5]. Beans, lentils, and soybeans are excellent sources of lysine, offering a viable protein option for those following plant-based diets[5]. Brewer's yeast and spirulina, a type of algae, are other notable sources of lysine, often available in powdered or tablet forms for supplementation purposes[5].

While most people, including vegetarians, receive sufficient lysine from their typical diets without the need for additional supplements, those interested in supplementation may consider doses of up to 3 grams per day as safe[5]. However, increasing the dosage to 10–15 grams may lead to digestive issues such as diarrhea, nausea, or stomach cramps[5]. Overall, a balanced diet incorporating both animal and plant sources can effectively provide the necessary lysine for optimal health.

## Applications

### Animal Nutrition

Lysine is a crucial amino acid in animal nutrition, particularly for livestock production, where it plays a vital role in ensuring optimal growth, development, and immune function.[12] Due to the deficiency of lysine in many traditional feed sources, supplemental lysine has become increasingly popular among farmers to enhance animal diets.[12][13] The inclusion of lysine in diets for various species, including poultry, swine, and aquatic animals, significantly improves overall health and productivity.[13] This is particularly important as feed costs account for a substantial portion of total production expenses in animal farming, often ranging from 50% to 60% of total costs.[17]

### Benefits in Livestock Production

Supplementing lysine helps to achieve more efficient feed utilization, leading to faster growth rates and better feed efficiency in livestock. Animals with balanced amino acid levels experience healthy growth, which is critical for both meat and dairy production.-

[\[18\]](#) Furthermore, lysine supplementation can reduce the nitrogen content of manure, thereby mitigating environmental impacts associated with livestock farming.[\[14\]](#)

## Use in Animal Feed

Feed-grade lysine is regarded as an essential tool in modern animal production systems. Its application not only helps animals grow more efficiently but also supports farmers in managing costs and reducing the environmental footprint of their operations.[\[14\]](#) By incorporating lysine into feed formulations, producers can maximize the nutritional value of plant-based feedstuffs, contributing to a more sustainable approach to animal husbandry.[\[19\]](#)

## Human Health

In addition to its agricultural applications, lysine also has important implications for human health. It is utilized in dietary supplements aimed at supporting various health benefits, including calcium absorption, collagen formation, muscle protein synthesis, and anxiety reduction.[\[6\]](#)[\[7\]](#) Lysine is particularly noted for its effectiveness in preventing the recurrence of herpes simplex virus outbreaks by inhibiting arginine, which the virus requires for replication.[\[8\]](#)

## Cosmetics and Pharmaceutical Uses

Lysine is also incorporated into cosmetic products due to its role in collagen synthesis, which is essential for maintaining skin health.[\[20\]](#) Moreover, lysine-based supplements are widely used in the pharmaceutical industry, reflecting its significance in both human nutrition and health maintenance.[\[20\]](#)

## Health Benefits and Risks

Lysine, an essential amino acid, plays a significant role in various bodily functions and offers numerous health benefits. Some of the most noted advantages of lysine include its potential to improve conditions such as herpes simplex, lower blood pressure, and mitigate anxiety and stress levels[\[5\]](#)[\[6\]](#). Additionally, lysine is known to assist in the absorption of calcium and the production of collagen, which is vital for maintaining skin, tendon, and bone health[\[7\]](#)[\[21\]](#)[\[22\]](#).

## Risks and Side Effects

While lysine is generally safe for most people, excessive intake can lead to gastrointestinal issues such as nausea, stomach pain, and diarrhea[\[9\]](#)[\[15\]](#)[\[10\]](#). A provisional no-observed-adverse-effect level has been established at 6.0 g/day for humans, as higher doses have been associated with significant gastrointestinal discomfort[\[15\]](#)[\[10\]](#).

## Allergic Reactions and Kidney Issues

Some individuals may experience allergic reactions to lysine supplements, which can manifest as rash, itching, or swelling of the face and throat[\[10\]](#). Additionally, those with preexisting kidney conditions should exercise caution, as high doses may lead to increased creatinine levels, indicating impaired kidney function[\[10\]\[11\]](#).

## General Considerations

It is important to consult with a healthcare professional before starting any lysine supplementation, especially for those with existing health conditions or those taking other medications[\[9\]](#). Proper medical guidance can ensure that the benefits of lysine are maximized while minimizing potential risks.

## Health Benefits

### Treatment of Herpes Simplex

Lysine supplementation has been shown to be effective in treating herpes simplex infections. Studies indicate that it may reduce the frequency and severity of outbreaks[\[5\]\[6\]](#).

### Cardiovascular Health

Research suggests that lysine can lower blood pressure, potentially benefiting those with hypertension[\[5\]](#). Its role in improving the body's overall ability to absorb vitamins further supports cardiovascular health by enhancing nutrient uptake[\[5\]\[23\]](#).

### Anxiety and Stress Reduction

Lysine has been reported to help reduce anxiety and stress levels, contributing to overall mental well-being[\[5\]\[6\]](#). This could be particularly beneficial in managing stress-related conditions.

## Related Compounds

### Amino Acids and Their Importance

Norlysine is a derivative of lysine, an essential amino acid that plays a critical role in protein synthesis, hormone production, and enzyme function in both plants and animals. Amino acids, including norlysine and lysine, are organic compounds containing amine ( $\text{-NH}_2$ ) and carboxyl ( $\text{C(=O)OH}$ ) functional groups along with a side chain (R group)[\[24\]](#). While the human body can synthesize 11 out of the 20 amino acids, lysine is classified as an essential amino acid that must be obtained through diet, emphasizing its nutritional significance[\[25\]](#).

Lysine, in particular, is known to be limiting in major cereal grains, making its bioavailability a target for agricultural enhancement and herbicide development[\[24\]](#). Additionally, lysine is involved in various metabolic pathways and epigenetic modifi-



cations, influencing stress biology in plants[24]. The synthesis of lysine is regulated at multiple levels, including feedback mechanisms that involve enzymes such as diaminopimelate decarboxylase (DAPDC)[3].

## Biostimulants and Nutritional Enhancement

The application of biostimulants containing amino acids like norlysine, aspartic acid, and glycine has been shown to improve plant growth and nutritional quality. Studies have indicated that these biostimulants positively affect fresh and dry weight, leaf area, and photosynthetic activity in crops[26]. For instance, amino acids play a crucial role as precursors for phytohormones and contribute to the biosynthesis of proteins and phenolic compounds, thereby enhancing the overall nutritional value of plants[26].

Furthermore, the inclusion of amino acids in biostimulant formulations has been associated with improved phenolic content and protein levels in various vegetable crops, such as radishes and turnips[26]. These findings suggest that norlysine and other amino acids can enhance the biochemical pathways that lead to better crop yield and quality.

## Connections with Other Metabolic Pathways

Norlysine, as a variant of lysine, participates in various metabolic pathways, linking it to other amino acids and their biosynthetic routes. For instance, methionine and tyrosine biosynthesis are closely interconnected with lysine metabolism, highlighting the complex relationships between different amino acids in plant physiology[27][26]. The interplay between these compounds underscores the potential of genetic and agronomic strategies to optimize amino acid profiles in crops, ultimately contributing to improved nutritional quality and crop resilience under stress conditions.

Understanding the metabolic networks that involve norlysine and related compounds can pave the way for innovative agricultural practices aimed at enhancing food security and nutritional value in crops.

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