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THE ROLE OF L-HISTIDINE IN BROILER PRODUCTIVE PERFORMANCE, IMMUNITY, AND MEAT QUALITY

Daniel PALCU[1], Minodora TUDORACHE[1], Tatiana PANAITE[2], Monica Paula MARIN[1]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Marasti Blvd, District 1, Bucharest, Romania
[2]National Research-Development Institute for Animal Biology and Nutrition (INCDBNA-IBNA),
1 Calea Bucuresti, 077015, Balotesti, Romania

Corresponding author email: danielpalcu@gmail.com

Abstract

L-histidine is an essential amino acid involved in protein synthesis, acid-base regulation, antioxidant protection, immune function and skeletal muscle metabolism in broiler chickens. Interest in histidine has increased because modern broiler genotypes have high breast muscle accretion, while reduced-protein feeding programs require precise amino acid supply. This article evaluates current scientific evidence on dietary L-histidine and related carnosine precursors in broilers, with an emphasis on productive performance, immune and antioxidant status, carcass traits, breast meat quality, and practical feed formulation. The literature indicates that histidine supply influences muscle dipeptide deposition and may support growth, feed conversion, breast yield, oxidative stability of meat, and tolerance to metabolic stress. However, responses depend on genotype, age, sex, dietary protein level, amino acid balance, beta-alanine availability and environmental conditions. Therefore, histidine should be considered both an indispensable amino acid and a functional nutrient in precision broiler nutrition.

Key words*: amino acid metabolism, antioxidant capacity, broiler chickens, carnosine, L-histidine.*

INTRODUCTION

Broiler production has become one of the most efficient systems for converting plant-based feed ingredients into animal protein. This efficiency is strongly dependent on accurate amino acid nutrition, because modern broilers have high rates of lean tissue deposition and relatively low tolerance to amino acid imbalances. Among the indispensable amino acids, L-histidine has received less attention than lysine, methionine, threonine and valine, although it participates in several physiological processes that are directly linked to performance and meat quality. Histidine is required for protein synthesis, haemoglobin formation, tissue growth, regulation of acid-base balance, synthesis of histamine and formation of histidine-containing dipeptides such as carnosine and anserine (Moro et al., 2020).

The practical importance of histidine in poultry nutrition is increasing for three main reasons. First, reductions in dietary crude protein are widely promoted to decrease feed costs, nitrogen excretion and environmental impact. These programs are successful only when limiting amino acids are supplied with sufficient precision, and recent work has emphasised that the energetic cost of amino acid catabolism and the balance among individual amino acids must be considered carefully in broilers (Woyengo et al., 2023; Cho et al., 2024; Macelline et al., 2025). Second, high breast yield genotypes may have increased sensitivity to changes in amino acid supply, especially when amino acids affect muscle metabolism and postmortem quality. Third, histidine is the precursor of carnosine, a dipeptide with antioxidant and buffering properties that can improve muscle oxidative stability and meat shelf life (Hu et al., 2009; Cong et al., 2017a; Baldi et al., 2021).

In poultry muscle, carnosine and anserine are relevant because they can buffer hydrogen ions during anaerobic metabolism, chelate transition metals and reduce lipid oxidation. Therefore, nutritional strategies that increase muscle carnosine content may improve meat quality, particularly in breast muscle, where high metabolic activity and rapid postmortem pH decline can contribute to quality defects. Studies with histidine, beta-alanine and carnosine have demonstrated that muscle dipeptide

concentration can be modified by diet, but the magnitude and biological relevance of this modification vary among experiments (Haug et al., 2008; Kai et al., 2015; Kralik et al., 2015a; Lackner et al., 2021; Qi et al., 2021).

The objective of this paper is to review and synthesise the available evidence regarding the role of L-histidine in broiler chickens, focusing on growth performance, immune regulation, antioxidant status, carcass characteristics and meat quality. Special attention is given to histidine-to-lysine ratios, histidine and beta-alanine as carnosine precursors, in ovo amino acid strategies, reduced-protein feeding and the practical implications of histidine in modern broiler feed formulation.

MATERIALS AND METHODS

This paper was prepared as a narrative literature review of peer-reviewed studies related to histidine, carnosine, beta-alanine, amino acid balance and reduced-protein nutrition in broiler chickens. The literature was selected to cover the following topics: histidine metabolism, histidine-containing dipeptides, growth performance, carcass and breast yield, meat oxidative stability, breast muscle quality, immune and antioxidant responses, ingredient amino acid digestibility and low-protein feeding programs. The main databases consulted were ScienceDirect, PubMed, Google Scholar and Web of Science. Search terms included L-histidine, broiler, chicken, carnosine, anserine, beta-alanine, histidine-to-lysine ratio, meat quality, oxidative stability, immune response, reduced-protein diet, standardised ileal amino acid digestibility and nitrogen excretion.

Studies were considered relevant when they addressed broiler chickens directly or provided mechanistic information applicable to poultry nutrition and muscle biology. Direct broiler experiments were prioritised for practical conclusions. Studies in other species were used only when they provided useful information on histidine metabolism, carnosine functions or antioxidant mechanisms and were interpreted cautiously. Particular emphasis was placed on research published during the last decade because of changes in broiler genetics, carcass yield, feed ingredient use and the expanding interest in low-protein diets supplemented with crystalline amino acids. The final reference list includes 30 sources that together support the major areas of the paper: histidine metabolism, broiler performance, meat quality, immunity, ingredient digestibility and sustainable feed formulation.

The literature search covered publications from 2008 to 2025, with the main emphasis on studies from 2015 onwards. An initial screening of titles and abstracts was performed across the four databases using the search terms listed above. Records were excluded if they: (i) did not involve poultry or did not provide mechanistic information relevant to poultry; (ii) focused exclusively on laying hens or turkeys without applicable data for broilers; (iii) were conference abstracts, letters or non-peer-reviewed sources; or (iv) were not available in full text. From an initial pool of approximately 120 records identified by the search strategy, 60 were screened at the full-text level, and 30 were selected for inclusion in the final reference list based on direct relevance to the topics covered in this review.

RESULTS AND DISCUSSIONS

HISTIDINE METABOLISM AND NUTRITIONAL SIGNIFICANCE IN BROILERS

Histidine metabolism and physiological functions

Histidine is an indispensable amino acid for poultry because broilers cannot synthesise it in sufficient quantities to meet the requirements of rapid growth. In addition to its structural role in body proteins, histidine is involved in several metabolic pathways. It contributes to haemoglobin synthesis, tissue repair, acid-base regulation and methyl group metabolism. Histidine can be decarboxylated to histamine, a compound involved in immune responses, vascular function and gastric secretion. The imidazole ring of histidine gives it specific buffering properties, which are important in tissues where rapid changes in pH occur. These biochemical functions explain why histidine deficiency may affect not only body weight gain, but also blood physiology, immunity and muscle quality (Moro et al., 2020).

One of the most important routes of histidine utilisation in broilers is the synthesis of histidine-containing dipeptides. Carnosine is formed from beta-alanine and histidine, while anserine is produced through methylation of carnosine. These dipeptides are particularly abundant in skeletal muscle. The limiting substrate for carnosine synthesis may vary with species, tissue and diet. In poultry, both histidine and beta-alanine availability can influence carnosine and anserine concentrations, although some studies suggest that beta-alanine may be especially important when histidine is adequate (Haug et al., 2008; Kai et al., 2015; Qi et al., 2021).

Carnosine is relevant to broiler nutrition because it performs several functions in muscle. It can buffer hydrogen ions, reduce oxidative damage, inhibit lipid peroxidation and react with reactive carbonyl compounds. These properties are valuable because the broiler breast muscle has high economic importance and is vulnerable to quality deterioration during storage. Research on poultry and other animals confirms that increased carnosine deposition can be associated with improved oxidative stability and better meat quality traits (Hu et al., 2009; Cong et al., 2017a; Kralik et al., 2018; Li et al., 2024). Therefore, histidine should be evaluated not only as a growth-limiting amino acid, but also as a nutrient that can influence postmortem muscle metabolism.

Dietary histidine requirements and histidine-to lysine ratio

Amino acid requirements in broilers are commonly expressed relative to digestible lysine because lysine is closely related to lean tissue deposition and is often used as the reference amino acid in ideal protein systems. Histidine has historically been considered less limiting than methionine, lysine, threonine or valine in corn-soybean meal diets. However, the relative importance of histidine increases when diets contain alternative ingredients, low levels of crude protein or high additions of crystalline amino acids. Franco et al. (2017) estimated optimal ratios of digestible histidine to digestible lysine for broilers and showed that histidine can influence both performance and breast yield when other amino acids are adequately supplied.

More recent work directly evaluated dietary histidine titration in female Cobb 500 broilers. Nelson et al. (2024) reported that histidine-to-lysine ratios in the range of approximately 33% to 38% supported desirable responses in feed conversion and breast yield. These results are important because they provide practical ratio targets for modern broiler genetics. They also indicate that histidine may become a limiting amino acid in high-performance feeding systems, particularly when crude protein is reduced and the diet is formulated close to minimum amino acid specifications.

The optimum histidine level is unlikely to be universal. Differences in strain, sex, age, growth rate, environmental temperature, health status and ingredient composition can change the response. Lackner et al. (2022a) demonstrated that different histidine-to-lysine ratios affected performance, meat quality and the occurrence of breast myopathies. This finding is particularly relevant for modern broilers because breast myopathies are linked to rapid growth, high breast muscle accretion and altered muscle metabolism. Although histidine cannot be considered a single solution for such problems, an adequate histidine supply may support metabolic stability in breast muscle.

Histidine, beta-alanine and carnosine deposition in muscle

Several studies have examined whether dietary histidine, beta-alanine or carnosine can increase carnosine concentration in broiler meat. Haug et al. (2008) showed that histidine supplementation increased carnosine and anserine concentrations in broiler muscle, confirming that diet can alter the pool of bioactive dipeptides in poultry meat. Kai et al. (2015) also reported that dietary histidine influenced carnosine and anserine levels in broiler muscles. These early results created interest in using histidine as a nutritional strategy to produce meat with improved functional and antioxidant properties.

The role of beta-alanine must also be considered because carnosine synthesis requires both beta-alanine and histidine. Qi et al. (2021) reported that beta-alanine and L-histidine supplementation affected growth performance, meat quality, carnosine content and the expression of enzymes related to carnosine metabolism. Lackner et al. (2021) similarly

evaluated histidine and beta-alanine supplementation and found effects on carnosine concentration, growth performance and meat quality. These studies indicate that combined supplementation may be more effective than histidine alone in some feeding conditions, especially when the other precursor becomes limiting.

Research in slow-growing chickens has provided additional evidence that carnosine precursor supplementation can modify meat biochemical composition. Suwanvichanee et al. (2022) showed that beta-alanine and L-histidine supplementation affected carnosine synthesis, meat quality and protein structure in Korat chickens. Promkhun et al. (2023) further demonstrated that dietary carnosine precursors changed biochemical compounds and metabolomic profiles in the same type of slow-growing chicken. Although slow-growing genotypes differ from commercial broilers, these studies support the broader concept that histidine-related metabolism can modify muscle composition and meat quality.

Dietary carnosine supplementation has also been tested directly. Hu et al. (2009) observed effects of carnosine on growth performance, carcass characteristics, meat quality and oxidative stability in broiler chickens. Cong et al. (2017a) reported that carnosine supplementation improved aspects of meat quality and antioxidant capacity, while Cong et al. (2017b) associated carnosine supplementation with changes in growth performance, meat quality, antioxidant capacity and muscle fibre characteristics. These findings are consistent with the biochemical role of carnosine as an antioxidant and pH-buffering compound.

Effects on growth performance and feed efficiency

Growth performance responses to histidine depend on whether the basal diet is deficient, marginal or adequate in histidine. When histidine is clearly deficient, supplementation can improve body weight gain, feed intake and feed conversion because histidine becomes limiting for protein synthesis. When histidine is adequate, further supplementation may have smaller or inconsistent effects on performance but can still influence muscle dipeptide concentrations and meat quality. This explains why different experiments report variable responses to histidine or carnosine supplementation.

Nelson et al. (2024) provided direct evidence that titrating histidine in modern broilers can improve economically important performance traits. Franco et al. (2017) also demonstrated that the histidine ratio affects performance and breast yield when evaluated within an ideal protein framework. These results support the inclusion of histidine in least-cost formulation matrices, especially when formulating diets with reduced crude protein or alternative feed ingredients.

Carnosine and its precursors may also affect performance indirectly by improving oxidative status, metabolic efficiency or muscle integrity. Hu et al. (2009), Cong et al. (2017b) and Kralik et al. (2018) reported beneficial or potentially beneficial responses in growth performance and carcass traits after supplementation with carnosine, histidine or related amino acids. However, the performance response is not always proportional to the increase in muscle carnosine. Therefore, the most reliable justification for histidine supplementation remains meeting the amino acid requirement, while additional functional benefits should be considered as complementary advantages.

Immune response and antioxidant status

Histidine and histidine-containing dipeptides are linked to immune function and antioxidant defence. Histidine can influence histamine synthesis and immune signalling, while carnosine can reduce oxidative stress through radical scavenging, metal chelation and protection against lipid peroxidation. In rapidly growing broilers, oxidative stress may arise from high metabolic activity, heat stress, inflammation or tissue damage. Nutritional strategies that strengthen antioxidant defences can therefore contribute to health and performance stability.

In ovo amino acid nutrition is an emerging strategy for supporting early development. Keshtkaran et al. (2024) reported that in ovo injection of L-carnosine affected physiological indexes in neonatal broiler chickens. Yehia et al. (2025) showed that in ovo-fed amino acids influenced muscle and liver metabolome in

broiler chickens, with implications for early metabolic programming. These findings suggest that histidine-related pathways may be relevant not only during the feeding period but also during embryonic and neonatal development.

The antioxidant effects of histidine-related compounds are also supported by work on muscle oxidative stability. Baldi et al. (2021) examined the role of histidine dipeptides in postmortem acidification of broiler muscles, showing the relevance of these compounds to muscle metabolism after slaughter. Cong et al. (2017a), Hu et al. (2009) and Kopec et al. (2020) reported that dietary carnosine, L-histidine or β-alanine can influence antioxidant capacity, histidine-dipeptide deposition and oxidative stability in chicken tissues. Immune and antioxidant responses should be interpreted with caution because they are influenced by stress level and experimental conditions. In healthy broilers raised under low challenge, the measurable effect of histidine supplementation on immune markers may be limited. Under heat stress, disease challenge, high stocking density or oxidised feed conditions, histidine and carnosine may become more important. Future studies should evaluate immune outcomes together with oxidative biomarkers, growth performance and meat quality to identify the conditions under which histidine has the greatest functional value.

Carcass characteristics, breast yield and breast muscle quality

Breast yield is one of the most important economic traits in broiler production. Because breast muscle is rich in protein and represents a major sink for amino acids, even small changes in amino acid balance may influence carcass value. Histidine has been associated with breast yield responses in ideal amino acid ratio studies. Franco et al. (2017) and Nelson et al. (2024) demonstrated that histidine-to-lysine ratio can affect breast yield, indicating that histidine should not be ignored when optimising diets for high breast meat production.

Breast muscle quality is also an important issue in modern broilers. Rapid growth and high breast yield have been associated with myopathies such as wooden breast and white striping, as well as changes in pH, water-holding capacity and texture. Lackner et al. (2022a) specifically evaluated histidine-to-lysine ratios in relation to performance, meat quality and breast myopathies. Although breast myopathies have multifactorial causes, amino acid nutrition can influence muscle metabolism, antioxidant status and tissue repair, and histidine may contribute through carnosine synthesis and acid-base regulation.

The quality of broiler meat is determined by pre-slaughter muscle metabolism and postmortem biochemical changes. Histidine-containing dipeptides may affect both. Baldi et al. (2021) showed that these dipeptides are involved in postmortem acidification, a process closely related to ultimate pH and meat quality. Kralik et al. (2015a) reported that dietary histidine, hybrid line and gender influenced meat quality and carnosine concentration. These results show that histidine effects interact with genetic and biological factors, and that recommendations should consider the production system and target market.

Meat oxidative stability and shelf-life

Oxidative stability is a key component of meat quality because lipid and protein oxidation reduce colour stability, flavour, nutritive value and consumer acceptance. Poultry meat contains unsaturated fatty acids and can be sensitive to oxidative deterioration during processing and storage. Carnosine and anserine are valuable because they can inhibit oxidation reactions and may contribute to shelf-life extension. Studies by Hu et al. (2009), Cong et al. (2017a) and Kralik et al. (2015b) demonstrated that carnosine or its precursors can improve oxidative stability in chicken meat.

Kralik et al. (2015b) reported that beta-alanine and L-histidine affected carnosine concentration and oxidative stability of chicken meat. Kralik et al. (2018) further evaluated amino acids in relation to growth performance, carcass characteristics, meat quality and carnosine concentration. These results confirm that nutritional manipulation of carnosine precursors can be a practical strategy to improve the value of poultry meat, especially where oxidative stability is important for fresh meat display, processed products or extended storage.

Recent alternative feeding strategies may also influence meat bioactive compounds. Grassi et al. (2025) examined bioactive compounds in the

breast meat of broilers fed black soldier fly wholemeal. Insect meals may contribute nutrients and bioactive compounds, but their amino acid composition and digestibility must be carefully evaluated. Such studies are relevant because future poultry feeding systems may use more alternative protein sources, making it necessary to monitor histidine supply, carnosine deposition and meat quality at the same time.

Histidine in reduced-protein and sustainable broiler diets

As described above, reduced-protein diets are widely adopted, and histidine can become deficient or imbalanced in such programs. Histidine becomes important in this context because feed formulation may rely more heavily on crystalline amino acids and alternative ingredients. Woyengo et al. (2023) reviewed strategies for low-protein broiler diets and emphasised the need to balance essential and nonessential amino acids while maintaining performance. Cho et al. (2024) also reported that low-protein diets supplemented with amino acids can influence growth performance and nitrogen excretion.

The economic and metabolic cost of amino acid catabolism is another important factor. Excess amino acids are deaminated and used for energy, producing nitrogen waste and increasing metabolic heat. Macelline et al. (2025) highlighted the cost of amino acid catabolism for energy utilisation in broiler chickens. From this perspective, the goal is not simply to add more amino acids but to provide the correct amount and ratio. Histidine supplementation should therefore be integrated into an ideal protein approach that considers lysine, sulfur amino acids, threonine, valine, isoleucine, arginine, phenylalanine plus tyrosine and other potentially limiting amino acids.

Reduced-protein diets may also alter immune and oxidative status because they change nitrogen metabolism, gut fermentation and ingredient composition. Kareem et al. (2025) evaluated reduced-protein diets with varying ingredient combinations, while Kandel et al. (2025) examined the impact of soybean meal and field pea inclusion on growth performance. These studies illustrate that ingredient choices affect more than crude protein concentration. They also modify amino acid profiles, digestibility, fibre level and antinutritional factors. Therefore, a reduced-protein diet can be successful only if digestible histidine and other amino acids are accurately supplied.

Ingredient digestibility and feed formulation implications

Accurate formulation requires reliable values for standardised ileal amino acid digestibility. Histidine content and digestibility differ among feed ingredients, and this variation becomes more important when alternative protein sources are used. De Almeida et al. (2025) reported values for nitrogen-corrected apparent metabolizable energy and standardised ileal amino acid digestibility of distillers dried grains with solubles. Iqbal et al. (2025) investigated the standardised ileal amino acid digestibility of rice protein meal. Such studies are important because ingredients like DDGS, rice protein meal, field peas, insect meals and other plant proteins may change the supply of digestible histidine relative to lysine.

Feed additives may also influence nutrient utilisation. Kumar et al. (2025) evaluated nutrient density diets with emulsifier supplementation and showed that formulation strategies can interact with nutrient availability and energy utilisation. Although emulsifiers do not directly supply histidine, improved fat digestion and energy use can alter the balance between energy intake and amino acid deposition. In precision feeding, histidine recommendations should be interpreted together with metabolizable energy, digestible amino acid values, feed intake and the expected growth curve.

Practical least-cost formulation should include digestible histidine as an active nutrient constraint, especially in low-protein diets or diets containing nontraditional protein sources. If histidine is not constrained, the diet may meet crude protein and lysine specifications but remain marginal in histidine. This risk is higher when soybean meal is reduced and replaced with cereals, DDGS, rice protein meal, field peas or insect-derived ingredients. Therefore, the formulation matrix should include analysed or reliable tabular values for total histidine, standardised ileal digestible histidine and the ideal histidine-to-lysine ratio.

In ovo supplementation and early metabolic programming

The embryonic and neonatal periods are critical for broiler development because digestive capacity, immune function and muscle satellite cell activity are being established. In ovo nutrition aims to provide nutrients directly to the embryo before hatch, supporting early development and post-hatch adaptation. Keshtkaran et al. (2024) showed that in ovo injection of L-carnosine affected physiological indexes of neonatal broiler chickens, suggesting that histidine-related compounds can influence early metabolic status.

Yehia et al. (2025) reported that in ovo-fed amino acids changed the muscle and liver metabolome of broiler chickens. This is relevant because the liver is central to amino acid metabolism, antioxidant defence, and energy regulation, while muscle is the main target tissue for meat production. If histidine-related pathways are modified early in life, they may influence later growth and resilience. However, in ovo supplementation requires careful control of dose, injection site, timing and solution osmolarity. More research is needed before practical recommendations can be made for commercial hatcheries.

Summary of main literature sources

Table 1 below provides a brief summary of key references identified in this research, including the main outcomes reported for specific dietary interventions.

Table 1. Summary of key studies on L-histidine, beta-alanine and carnosine in broiler chickens and related species

Reference	Species/ Genotype	Dietary Intervention	Main outcomes reported
Haug et al. (2008)	Broiler	L-histidine supplementation of commercial feed	Increased carnosine and anserine in muscle
Hu et al. (2009)	Broiler	Dietary carnosine supplementation	Improved growth, carcass traits, meat quality, oxidative stability
Kai et al. (2015)	Broiler	Dietary L-histidine levels	L-histidine influenced carnosine and anserine in muscle
Kralik et al. (2015a)	Broiler (hybrid, sex)	Dietary L-histidine, hybrid line, gender	Meat quality and carnosine concentration are affected by all three factors
Kralik et al. (2015b)	Broiler	β-Alanine + L-histidine supplementation	Increased muscle carnosine; improved oxidative stability
Franco et al. (2017)	Broiler	L-histidine: Lysine ratio titration (ideal protein)	Optimal L-histidine: Lysine ratio estimated; breast yield and performance affected
Cong et al. (2017a, b)	Broiler	Dietary carnosine supplementation	Improved meat quality, antioxidant capacity, and muscle fibre characteristics
Kralik et al. (2018)	Broiler	Amino acid (L-histidine) supplementation	Growth, carcass, meat quality and carnosine all positively influenced
Kopec et al. (2020)	Broiler	Carnosine, L-histidine, β-Alanine supplementation	Antioxidant characteristics of breast meat and blood improved
Baldi et al. (2021)	Broiler	Histidine-dipeptide role in postmortem metabolism	Histidine-dipeptides regulate postmortem acidification and ultimate pH
Lackner et al. (2021)	Broiler	L-histidine + β-Alanine supplementation	Carnosine deposition, growth performance and meat quality were affected
Qi et al. (2021)	Broiler	β-Alanine + L-histidine supplementation	Growth, meat quality, carnosine and carnosine-related enzyme mRNA changed
Lackner et al. (2022a)	Broiler	L-histidine: Lysine ratio (multiple levels)	Performance, meat quality and breast myopathy incidence influenced
Lackner et al. (2022b)	Broiler	L-histidine + β-Alanine at multiple ages	Blood plasma metabolome altered; age-dependent responses identified
Suwanvichanee et al. (2022)	Korat chicken (slow-growing)	β-Alanine + L-histidine supplementation	Carnosine content, meat quality and protein secondary structure modified
Promkhun et al. (2023)	Korat chicken (slow-growing)	Carnosine precursors in the diet	Jejunal metabolomic profile and biochemical compounds changed
Keshtkaran et al. (2024)	Neonatal broiler	In ovo L-carnosine injection	Physiological indices of neonatal chicks were affected
Nelson et al. (2024)	Cobb 500 female broiler	L-histidine titration (22-42 d phase)	L-histidine: Lysine ~33-38% optimal for feed conversion ratio and breast yield
Yehia et al. (2025)	Broiler	In ovo amino acid feeding	Muscle and liver metabolome altered; early metabolic programming demonstrated

Knowledge gaps and future research

Despite growing interest, several knowledge gaps remain. First, the histidine requirement for modern broilers should be refined by age, sex, genotype and production objective. Studies such as those by Nelson et al. (2024), Franco et al. (2017) and Lackner et al. (2022a) provide important ratio estimates, but more work is needed under different dietary protein levels, environmental temperatures and health conditions. Second, the interaction between histidine and beta-alanine requires further clarification. Research by Qi et al. (2021), Lackner et al. (2021), Suwanvichanee et al. (2022) and Promkhun et al. (2023) indicates that both precursors influence carnosine synthesis, but the most cost-effective supplementation strategy is still uncertain.

Third, the relationship between histidine supply, breast myopathies and meat quality deserves more attention. Carnosine may improve buffering capacity and oxidative stability, but breast myopathies are complex conditions involving vascular, metabolic, oxidative and structural changes. Histidine should therefore be studied together with antioxidants, sulfur amino acids, arginine, glycine, creatine precursors and management factors. Fourth, more research is needed on histidine in low-protein diets because the benefits of reducing crude protein depend on complete amino acid balance and accurate digestibility values (Woyengo et al., 2023; Cho et al., 2024; Macelline et al., 2025).

Finally, future studies should combine performance measurements with metabolomics, transcriptomics and meat quality evaluation. Lackner et al. (2022b) demonstrated that histidine and beta-alanine supplementation changed the blood plasma metabolome of broiler chickens at different ages. Such approaches can help identify biomarkers of histidine adequacy and explain why some birds respond more strongly than others. Better understanding of these mechanisms will allow nutritionists to use histidine more precisely in sustainable broiler production systems.

Practical recommendations

Based on the current literature, broiler diets should be formulated using digestible histidine values rather than total histidine or crude protein alone. Histidine should be included as a nutrient constraint when crude protein is reduced, when soybean meal is partially replaced, or when alternative protein ingredients are used. A digestible histidine-to-lysine ratio close to the range reported in recent broiler studies may be used as a practical starting point, but the exact target should be adjusted according to genotype, age, sex, feed intake and expected breast yield (Franco et al., 2017; Lackner et al., 2022a; Nelson et al., 2024).

Supplementation with histidine, beta-alanine or carnosine may be considered when the goal is to increase muscle carnosine concentration or improve oxidative stability of meat. However, the economic value of this strategy depends on ingredient prices, product positioning and measurable improvements in shelf life or quality. In standard broiler production, the first priority should remain meeting the digestible histidine requirement. In premium meat programs or systems with high oxidative challenge, additional carnosine precursor supplementation may provide added value.

Feed manufacturers should also update ingredient matrices with recent digestibility data for DDGS, rice protein meal, insect meals, field peas and other alternative ingredients. Without accurate digestibility values, histidine supply can be overestimated or underestimated. Routine formulation should evaluate histidine together with lysine, methionine plus cysteine, threonine, valine, isoleucine and arginine, particularly in reduced-protein diets. This approach supports productive performance while reducing nitrogen excretion and improving sustainability.

CONCLUSIONS

L-histidine is an essential amino acid with important nutritional and functional roles in broiler chickens. Beyond its contribution to protein synthesis, histidine is involved in acid-base balance, immune regulation, antioxidant protection and the synthesis of carnosine and anserine in skeletal muscle. The reviewed literature shows that adequate histidine supply can support growth performance, feed efficiency, breast yield, meat oxidative stability and postmortem muscle metabolism. Histidine becomes especially important in modern feeding programs based on reduced crude protein,

alternative ingredients and precision amino acid formulation.

The most consistent practical message is that histidine should be considered within the ideal protein concept and formulated on a digestible basis. Dietary histidine-to-lysine ratio, beta-alanine availability, genetic line, sex, age and dietary protein concentration all influence the response. Histidine and its related dipeptides also have potential as nutritional tools for improving meat quality and oxidative stability, but more research is needed to define cost-effective supplementation strategies. Future studies should integrate performance, immune markers, antioxidant status, metabolomic responses, breast myopathy evaluation and meat quality traits to establish precise recommendations for sustainable broiler production.

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