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Threonine and Its Effect on Broiler Performance

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Abstract

The Indian poultry industry has shown rapid growth, with broiler production contributing substantially to the livestock sector. Feed cost, particularly crude protein, remains the major economic constraint. L-Threonine, the third limiting amino acid in broiler diets, plays a vital role in protein synthesis, gut integrity, and immunity. This review summarizes the effects of dietary L-Threonine supplementation on growth performance, nutrient utilization, gut morphology, immunity, and carcass traits in broilers. Experimental evidence indicates that threonine supplementation improves body weight gain, feed efficiency, intestinal villus development, and immune response, mainly through enhanced mucin production. Carcass traits, especially breast and drumstick yield, are also positively influenced without adverse effects on overall carcass yield. Overall, L-threonine is essential for formulating economically efficient and nutritionally balanced broiler diets, particularly under reduced crude protein systems. Further research is required to refine its optimal inclusion under varied production conditions.

KEY WORDS: Threonine, broiler, performance

INTRODUCTION

Poultry farming is one of the fastest growing sectors of Indian livestock production, contributing substantially to national income and rural employment. Feed accounts for more than 70% of total broiler production cost, with dietary protein being the most expensive component. Proteins are composed of amino acids, among which essential amino acids must be supplied through the diet to achieve optimal growth and performance.

In broiler nutrition, methionine and lysine are the first two limiting amino acids, followed by L-threonine. Threonine becomes more critical when crude protein levels are reduced in diets supplemented with synthetic amino acids. Although lowering dietary crude protein helps reduce feed cost and environmental nitrogen load, improper amino acid balance often leads to reduced bird performance. Therefore, precise threonine supplementation is essential to maintain growth, feed efficiency, and carcass yield in low-protein diets.

Threonine has a major role in intestinal development and well-functioning (Stoll, 2006), because intestinal mucin is mainly made of Thr (Faure *et al.*, 2005). Dietary total Thr level between 0.70 and 0.93% can support optimum gut morphology (Schaart *et al.*, 2005; Zaefarian *et al.*, 2008). Mucin is a glycoprotein in nature, which plays a vital role in protecting the intestine from acidic chyme, pathogens and digestive enzymes as well as maintains the intestinal integrity (Horn *et al.*, 2009). In gastrointestinal tract, mucin acts as a filtering agent for nutrients and affects their digestion and absorption (Smirnov *et al.*, 2006). Threonine is "furthermore" involved in different metabolic processes such as protein synthesis and uric acid formation (Eftekhari *et al.*, 2015). Diets deficient in Thr may compromise immunoglobulin production because Thr is an integral part of immunoglobulin in broilers (Azzam and El-Gogary, 2015). Threonine is considered as the second limiting amino acid for breast meat yield (Estalkhzir *et al.*, 2103) and, therefore, its supplementation is assumed to result in improved carcass characteristics. It is believed that Thr supplementation enhances feed intake, body weight gain and ultimately carcass weight (Estalkhzir *et al.*, 2103; Khan *et al.*, 2006). The present review describes the response of modern-day broilers to dietary Thr levels, and its effects on growth performance, gut morphology, immunity and carcass characteristics.

MODE OF ACTION

1. Role in Protein Synthesis and Growth

Threonine is a precursor for structural and functional proteins critical to broiler growth. It contributes directly to:

- **Muscle Development:** Threonine is incorporated into myofibrillar and sarcoplasmic proteins, which form the structural framework of muscle tissues.
- **Enzyme and Hormone Production:** It is essential for the biosynthesis of enzymes and hormones that regulate growth and metabolic pathways. Deficiency in threonine reduces protein deposition, leading to stunted growth and poor feed efficiency.

2. Maintenance of Gut Health

Threonine plays a pivotal role in maintaining intestinal integrity and functionality.

- **Mucin Production:** Threonine is a key component of mucins, glycoproteins secreted by goblet cells in the intestinal epithelium. Mucins form a protective mucus layer that:
  - Shields the gut lining from mechanical damage and pathogenic invasion.
  - Enhances nutrient absorption by supporting epithelial integrity.

- **Tight Junction Stability:** Adequate threonine levels ensure proper synthesis of tight junction proteins, reducing intestinal permeability and inflammation.

3. Enhancement of Immune Function

Threonine supports immune system development and responsiveness in broilers.

- **Immunoglobulin Synthesis:** It is a critical component of immunoglobulins, which are essential for humoral immune responses.
- **Increased Demand During Stress:** During periods of immune stress or disease challenges, threonine requirements increase to support the production of immune cells, repair damaged tissues, and sustain mucosal immunity.

4. Energy and Metabolic Functions

Threonine contributes to energy metabolism through its role in intermediary metabolic pathways:

- **Conversion to Glycine and Serine:** Threonine is metabolized into glycine and serine, amino acids involved in energy production and one-carbon metabolism.
- **Citric Acid Cycle Contribution:** It supports the synthesis of intermediates in the citric acid cycle, facilitating cellular energy generation.

5. Regulation of Amino Acid Balance

- **Synergy with Other Amino Acids:** Threonine interacts with lysine, methionine, and other essential amino acids to ensure optimal protein synthesis and growth. A balanced threonine-to-lysine ratio is critical for efficient nutrient utilization.
- **Nitrogen Retention:** Proper threonine supplementation minimizes excess nitrogen excretion by reducing the need for high crude protein diets, contributing to environmentally sustainable poultry production.

6. Antioxidant Support

Threonine indirectly supports antioxidant defense by influencing the availability of cysteine, a precursor for glutathione. This enhances the broilers' ability to combat oxidative stress, thereby improving overall health and productivity.

EFFECTS ON DIFFERENT PARAMETERS

Effect on Growth Performance

Recent findings by Ghanima *et al.* (2023) demonstrated that broilers fed diets supplemented with threonine at 130% of the basal requirement showed a significant improvement in final body weight and total weight gain compared to lower supplementation levels and the control group, under feed-restricted conditions. In contrast, Lin *et al.* (2023) evaluated graded dietary threonine levels ranging from 0.50 to 0.78% in yellow-feathered

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broilers and reported no significant effect on average daily gain, indicating that higher inclusion beyond the basal level did not further enhance growth. Earlier, Najafi *et al.* (2017) observed that increasing standardized digestible threonine from 0.65% to 0.89% significantly improved body weight gain during the starter phase, while further increases showed no additional benefit. Similarly, Chen *et al.* (2016) reported that supplementation of L-threonine at 1 and 3 g/kg feed did not significantly influence growth performance during the early growth period. Supporting these observations, Abbasi *et al.* (2013) reported that threonine supplementation at 110% of the recommended level significantly improved body weight gain over the entire rearing period. However, Waldroup *et al.* (2005) observed that threonine supplementation did not improve body weight when crude protein levels were below 20%, indicating that protein adequacy is essential for threonine effectiveness.

Effect on Feed Intake / Nutrient Intake

Under feed-restricted conditions, Ghanima *et al.* (2023) reported that increasing threonine levels up to 130% had no significant effect on feed intake. Similarly, Lin *et al.* (2023) observed that dietary threonine levels ranging from 0.50 to 0.78% did not significantly alter average daily feed intake in yellow-feathered broilers. Consistent with these findings, Najafi *et al.* (2017) also reported no significant change in feed intake with threonine supplementation up to 0.97% during the starter phase. Chen *et al.* (2016) further confirmed that L-threonine supplementation at 1 and 3 g/kg feed produced no significant variation in feed consumption. Likewise, Abbasi *et al.* (2013) found that dietary threonine levels from 100 to 120% of recommendations had no pronounced effect on average daily feed intake. These results collectively indicate that threonine primarily influences nutrient utilization efficiency rather than voluntary feed intake.

Effect on Feed Conversion Ratio (FCR)

According to Ghanima *et al.* (2023), broilers receiving 130% threonine supplementation exhibited the lowest FCR, indicating improved feed efficiency compared to lower levels. Lin *et al.* (2023) also reported a significant reduction in feed-to-gain ratio with increasing dietary threonine levels, and regression analysis suggested an optimal dietary threonine level of 0.68% for improved FCR. Earlier, Najafi *et al.* (2017) observed that increasing standardized digestible threonine from 0.65% to 0.89% significantly improved FCR, while further increases did not result in additional improvement. In contrast, Chen *et al.* (2016) reported no significant differences in FCR with L-threonine supplementation at 1 and 3 g/kg feed. Abbasi *et al.* (2013) reported that threonine supplementation at 110% of the recommended level significantly improved FCR during the grower phase. However,

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Waldroup *et al.* (2005) reported that reduction in dietary crude protein led to poor feed conversion irrespective of threonine supplementation.

Effect on Gut Morphology

Najafi *et al.* (2017) reported that threonine supplementation had no significant effect on the relative lengths of gut segments, crypt depth, or goblet cell numbers. However, villus height of the duodenum increased significantly at 0.89% threonine, and jejunal villus width increased at 0.93% threonine, indicating improved absorptive capacity. Similarly, Abbasi *et al.* (2013) observed that dietary threonine at 110% of the recommended level significantly improved the villus height to crypt depth ratio, mainly due to increased villus height and reduced crypt depth. These changes suggest enhanced intestinal maturation and nutrient absorption efficiency with optimal threonine supplementation.

Effect on Carcass Characteristics

In a recent study, Lin *et al.* (2023) reported that dietary threonine supplementation at 0.64%, 0.71%, and 0.78% significantly improved eviscerated yield percentage compared to lower levels. Additionally, higher threonine levels improved breast meat color by increasing redness while reducing brightness. Earlier, Abbasi *et al.* (2013) observed that dietary threonine supplementation up to 110% of the recommended level significantly increased the relative weights of breast and drumstick muscles, whereas overall carcass yield remained unaffected, indicating selective muscle deposition rather than total carcass enhancement.

SUMMARY AND CONCLUSION

Dietary threonine supplementation has a positive influence on growth performance, feed conversion efficiency, gut morphology, and carcass characteristics in broiler chickens, while feed intake generally remains unaffected. The improved intestinal structure supports better nutrient absorption and utilization, leading to enhanced body weight gain and muscle deposition. Overall, threonine can be considered an effective functional amino acid for improving broiler productivity and carcass quality when used appropriately.

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