

Role of Amino Acid Arginine for Broiler Production: A Review

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Abstract: Amino acids are known as anabolic factors that are essential for formation of muscle by stimulating protein synthesis while inhibiting proteolysis, and they are significant component for the synthesis of various nitrogenous compounds. There are 20 amino acids are essential to require in cell for formation of body protein of which about 10 amino acids, which cannot be synthesized by the birds are termed essential. Among the essential amino acid arginine one of the essential amino acids for chickens because, like other birds, they are unable to obtain Arginine from endogenous sources due to the absence of most of the enzymes involved in the urea cycle. This amino acid involved in synthesis of proline, hydroxyl proline and polyamines which are essential for connective tissue synthesis as well as increased growth of chicken. Moreover, L-arginine (L-Arg) is effective for reducing fat deposition in broiler. Moreover, it decrease heat stress increase meat quality and increase immune response of broiler. This re-view presents the recent advances in the relevance of the inclusion of excess L-Arginine in broiler ration to growth, fat deposition and immune response in broiler.

Key words: *L-Arginine, Broiler, Fat deposition, Growth, Immune Response*

INTRODUCTION

Amino acids (AA) are building blocks of protein and about 20 amino acids are essential to present in cell for formation of body protein [1]. In poultry, the essential amino acids are methionine, lysine, isoleucine, leucine, threonine, valine, tryptophan, arginine, histidine and phenylalanine. Optimum reproductive performance and growth are possible only if the diet contains the adequate amount of each of the 10 essential amino acids. If any one of the 10 essential amino acids is not supplied in adequate amount, performance will be impaired [2]. Arginine (Arg) is the nutritionally essential amino acid for poultry as they are unable to synthesize Arg, thus birds reliant on dietary supplementation. It is reported that the requirement of arginine in bird especially in

broiler is highest than the other species studied [3]. The higher requirement of Arg in commercial broilers may be due to the higher rate of protein deposition for quicker growth, less synthesis of endogenous Arg and antagonistic metabolic interaction between Arg and lysine [4]. Moreover, in the animal tissue Arg is one of the multipurpose amino acids which are essential for the synthesis of numerous compounds, such as creatine, protein, nitric oxide (NO) ornithine, polyamines, proline, and citruline [5], that are involved in multiple physiological and biological functions in birds [6]. Thus, with emphasis on broilers, this paper reviews amino acid arginine involvements in amino acid metabolism and their influences on growth performance, fat deposition, blood plasma profile and immune response.

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L-arginine and performance of broiler

Arg is a potent secretagogue, which stimulates the secretion of growth hormone, insulin and insulin-like growth factor-1 in the blood of animals. This takes place due to the increase in Arg catabolism in the body through renal arginase, which increased the requirement of arginine in the body [3]. Corzo et al. [7] observed that dietary supplementation of L-Arg over the recommendation dose of NRC (1994) [8] increased bird's performance, feed efficiency and carcass yield. Likewise, it was observed that broilers fed diet deficient in arginine had reduced carcass yield and lower weight of breast muscle [6]. It has been demonstrated that the requirement of Arg for breast muscle production was higher than maximizing body weight. Breast muscle weight increased when birds were fed diet containing higher level Arg [9]. The greater breast yield was attributed to the involvement of Arg in the synthesis of protein, proline and hydroxyproline, which are crucial for the formation of connective tissue [6]. In the same vein, Emadi et al. [10] observed that the supplementation of Arg improved feed intake, body weight gain and feed conversion ratio in broiler chickens in both starter and finisher phases.

Influence of L-arginine and fat deposition of broiler

Genetically selected modern broilers comprise about 15 to 29% fat of which 85% is not physiologically necessary for body function [11]. It is reported that excessive accumulation of fat especially in abdomen is undesirable which decreased carcass yield in birds and negatively affects customer perception owing to the health concern [12-13]. L-arginine is an essential amino acid in poultry, play a multiple roles for the biosynthesis of several molecules involved in metabolic pathways, as a precursor for nitric oxide (NO), L-Arg regulates energy expenditure and lipogenesis in the body (Fig 1). Generally L-Arg, via NO, stimulate lipolysis and reduced body fat deposition in rats which was demonstrated by down- regulating expression of key genes involved in lipogenesis such as acetyl-CoA carboxylase (ACC), stearoyl-CoA desaturase (SCD) and fatty acids synthase (FAS) [14]. Diet supplemented with 4% L-Arg decreased body fat in rat by increasing NO production, which decreased triacylglycerol synthesis and augmented lipolysis [15]. In the same vein, Fu et al. [16] and Nall et al. [17] demonstrated that addition of L-Arg in diet reduce adiposity and deposition of

abdominal fat in Zucker diabetic fat (ZDF) and Sprague-Dawley rats respectively. Moreover, Corzo et al. [7] and Tan et al. [18] observed that dietary supplementation of L-Arg was effective in increasing carcass yield and reducing fat accumulation in broilers and pigs respectively.

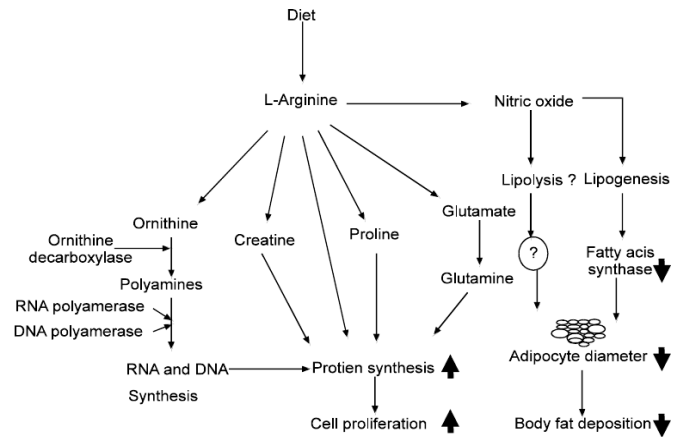


Figure 1. Effect of L-Arg on deposition of protein and fat (Fouad et al., [19])

↓ = Decrease; = ↑ Increase

Arginine and blood plasma metabolite

Arginine is required for the production of enzymes and hormones. The deficiency of arginine impaired insulin and glucose production and lipid metabolism in liver and Arginine augmented the glucose level and growth hormone [20]. Supplementation of arginine increased albumin, glucose, creatine kinase, uric acid and reduced aspartate amino transferase and cholesterol levels in broiler chickens [21]. Emadi et al. [10] reported that reduction in the TG level in serum at 49 days when broiler diet was supplemented L-Arg 2.5 times higher than the NRC recommendation. In chickens, the blood triglycerides concentration associated with fatty acid synthesis and Fouad et al. [19] demonstrated that dietary supplementation L-Arg (0.25% and 1%) is effective for reducing the triglycerides, total cholesterol in blood plasma in broiler chickens.

L-arginine and stress

Definitely chicken are always suffers from different kind of stress during rearing time including photoperiod time [22], stocking density [23], noise level (Campo et al. 2005) [24], cold stress [25] and during marketing

transport stress one of the major stress in broiler [26]. It is well known fact that different kind of stress associated with oxidative damage in poultry. Olanrewaju et al [27] reported that commercial broiler generally exposed to 24h to 23h lighting in the fattening period. It was observed that the lipid oxidation decreased in broiler exposed to 12h light regime compared to broiler exposed to 23h, 20h and 16h light regime [22]. In addition, stocking density is a crucial factor for broiler as high stocking density can cause stress in broiler as a consequence lowers performance and higher mortality observed in broiler [23]. Heat stress can cause higher level of lipid peroxidation in chicken than chicken subjected to normal temperature [28]. Moreover, the bad effect of cold stress same as heat stress in broiler, in cold stress broiler also suffers from oxidative stress [29]. Transport stress can increase the level of reactive oxygen species and level of lipid oxidation in thigh muscle in broiler. Thus, in commercial rearing condition broiler suffers different kind of stress which not only negatively affected the performance but also affect meat quality. However, supplementation L-arginine in broiler diet can overcome the different type of stress and increased the performance as well as meat quality of broiler [30].

Arginine and immune response in chickens

In mammals and birds, excess or deficiency of specific amino acids affects immune response [31]. Among amino acids, Arginine (Arg) play an important role in systematic immune response in chicken [32]. Firstly, by the action of arginase, arginine is converted to urea and ornithine then polyamines. In the polyamines synthesis pathway, arginine act as immunomodulator and may enhance mitogenesis. Secondly, arginine serves as a precursor in the synthesis of nitric oxide (NO) by the catalytic action of nitric oxide synthetases. Nitric oxide is formed in macrophage and different cells, which are associated with immune systems. Nitric oxide is an effective free radical and key signal molecule involved in multiple cell processes, thus modulating immune response and inflammation [14]. NO is effective for killing pathogens (bacteria, parasites, fungi), which enhance nonspecific immunity in body. In addition, NO regulates several cytokines such as tumor necrosis factor (TNF), and interferon (IFN), interleukin (IL) which influence the immune function. Thus, Arg is capable of modulating immune responses by the synthesis of nitric

oxide, polyamines and some important immune related hormones.

Studies on immunity in broiler chickens demonstrated that dietary inclusion of Arg increased nitric oxide secretion from macrophages, and improved lymphoid organ weight and heterophils and lymphocytes ratio [33]. Inadequate supply of Arg in animal diet impairs NO production and affects immune function. Supplementation of dietary Arg in diet increase lymphoid organ weight and improved antibody titer against NDV and cutaneous basophil hypersensitivity [34]. Bogdan [35] observed that blood T cells and B cells improved when dietary Arg above the NRC recommendation was supplemented in IBD vaccinated broiler. The addition of 2% dietary L-Arg significantly increases the antibody production against infectious bursal diseases virus [36]. Coccidiosis is a common and crucial infection in chicken production.

Coccidiosis is a common and crucial infection in chicken production [37]. About seven *Eimeria* responsible for coccidiosis have been identified [38]. Coccidiosis damages epithelial cell in the intestinal mucosa, which causes poor nutrient absorption, decreased performance and increased mortality in birds [39]. Allen and Fetterer [40] observed that plasma L-Arg in infected poultry reduced *Eimeria acervulina* and coccidian infectious. Similarly, significant improvement in IgG, IgM and antibody production has been observed in chicken infected with *Eimeria* when diet was supplemented with 0.3 to 0.6% L-Arg and vitamin E [41]. It has been demonstrated that both in diseases and normal condition, addition of L-Arg in diet improved the efficiency and immune response in broiler chickens [42-43]. L-Arg decrease environmental stress and increase immune response of chickens. In low environmental temperature, supplementation of L-Arg in diet reduced the occurrence and mortality of ascites [44-45].

Arginine and lipogenic gene expression

Liver is the key organ for fatty acid synthesis in chicken and about 85% fat is stored in liver. Thus, activities of lipogenic enzymes in the liver mirrored fatty acid synthesis [46]. Moreover, estimation of lipogenic enzyme in other tissues such as adipose tissue can also reveal the level of fatty acid synthesis and fat accumulation in the body. Jobgen et al. [47] demonstrated that dietary supplementation of L-Arg was effective in increasing muscle compare to fat in avian

species. L-Arg can be used as effective strategy for reducing fat in poultry products. Addition of excess L-Arg in diet increased fatty acid synthase mRNA expression in muscle and reduced lipoprotein lipase and Acetyl CoA carboxylase mRNA expression in abdominal fats in pigs [48] (Tan et al., 2011). The inclusion of medium and high level of L-Arg down-regulated lipogenic genes (acetyl-coenzyme A carboxylase, FAS, and malic enzyme) in liver and adipose tissue of broiler chickens [49]. This implies that down regulation of expression of FAS in hepatic tissue will decrease the accessibility of fatty acids for synthesis of triglycerides and storage in body.

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CONCLUSION

Arginine is involved for multiple functions in broiler production. Dietary supplementation arginine decreased abdominal fat increased carcass yield. Moreover, L-Arg plays an active role in reducing blood and meat cholesterol. This amino acid alleviates the adverse effect of different stress and reduces the immune immunosuppressive of vaccine, develop immune response and enhance immune system resistance to common diseases in broiler.

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