Influence of feeding diets containing different levels of L-arginine on blood plasma characteristics of broilers

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Abstract

A total of 300 one-day old Ross 308 broiler chicks were used to examine the effect of supplementing of different levels of arginine to broiler diets on blood biochemistry. The chicks were allocated on 4 treatment groups each of five replicates and each replicate consisted of 15 chicks. The treatment groups were control (without arginine) and treatments T1, T2 and T3 having arginine in the diet at the levels of 0.02, 0.04 and 0.06 %, respectively. The blood plasma traits included in this study were protein, albumen, globulin, glucose, alkaline phosphatase, calcium, uric acid, cholesterol, aspartate aminotransferase (AST), and alanine aminotransferase (ALT). The results indicated that adding arginine to the diet of broilers (T1, T2 and T3) resulted in significant increases in blood plasma protein, albumen, globulin, glucose, ALP, and calcium and significant decreases in blood plasma cholesterol, uric acid, AST, and ALT during all periods of the experiment. In conclusion, supplementation of the broiler ration with L-arginine resulted in improvement with respect to blood plasma traits. Therefore, arginine can be used as effective feed additive for enhancing physiological status of broiler chickens.

Keywords: Arginine, blood plasma biochemical characteristics, broilers

Introduction

The amino acid arginine is essential for optimal growth and nitrogen balance in growing animals. Whereas most mature mammals can synthesize arginine to meet their requirements, chickens cannot synthesize arginine, therefore, they are completely dependent on the dietary arginine to meet their needs for protein synthesis and other functions (Tamir and Ratner, 1963). Moreover, arginine has more benefits and has vast effects when it is added as a supplementary diet. For instance, arginine increases the release of growth hormone (GH), facilitates muscle growth (by inhibiting muscle loss), improves muscle performance and improves glucose uptake into muscle cells and it is required for the transport of the nitrogen used in muscle metabolism (Stevens et al., 2000).

Moreover, arginine improves blood circulation, by stimulating the production of nitric oxide (NO), the endogenous neurotransmitter, which helps to prevent vasoconstriction by relaxing the smooth muscle cells of the blood vessels (Huk et al., 1997). Arginine also helps to prevent abnormal blood clotting by stimulating the production of plasmin, increasing vasodilation and inhibiting the adhesion of monocytes to the endothelium, besides, arginine reduces pulmonary blood pressure and improves blood circulation in pulmonary hypertension syndrome that is known as ascites (Nakaki, 1990; Nagaya, 2001).

Arginine lowers total serum cholesterol levels, and serum low-density lipoprotein (LDL) levels, reduces insulin resistance and improves blood sugar disposal in diabetes (Mohan and Cas, 1998). Furthermore, arginine helps to prevent bacterial and viral diseases and enhances immune system functions and increases the size of the thymus (Abdukalykova and Ruiz-Feria, 2006). Arginine also stimulates the production of helper T-cells by the thymus and restores the production of thymic hormones (Dean, 1999).

Deficiency of arginine impaired production of insulin and glucose and metabolism of liver lipids (Zaho et al., 2009), because it is involved in the production of variety of enzymes and hormones. Arginine facilitates the release of enzymes and stimulates the pancreas for
insulin production (Recabaren et al., 1996). It also increases the levels of glucose (Emadi et al., 2010). To the best of our knowledge, the role of arginine in poultry is poorly defined. Therefore this study was designed to investigate the effects of dietary supplementation of arginine on the physiological parameters of broilers.

**Materials and Methods**

A total of 300 one-day old Ross - 308 broiler chicks were housed in a well-ventilated room. Feed and water were provided ad libitum during the whole period of experiment which lasted for 6 weeks. Two types of diets were used in the experiment. Starter diet was used from one to 20 days of chicks age and then grower diet was used till the end of the experiment (Tables 1 and 2). The chicks were allocated for 4 treatment groups and each treatment was consisted of five replicates with 15 chicks each. The treatment groups were: C, the control group (without any addition of arginine), T1, T2 and T3 groups of arginine added to the diet at levels of 0.02, 0.04 and 0.06%, respectively.

Blood samples from 10 chicks per group were obtained (at week three and six of the experiment) by cervical dislocation. Serum was separated by centrifugation (1500 rpm for 10 minutes). The serum parameters include in this study were total protein, albumin, globulin, glucose, alkaline phosphatase (ALP), calcium, uric acid, cholesterol, aspartate aminotransferase (AST), and alanine aminotransferase (ALT). These traits were determined according to Al-Daraji et al. (2008).

Data of experiment were analyzed by one- analysis of variance using XLStat (version 7.5. The significance of differences between means of the treatments was tested by Duncan's multiple range test under the probability (P<0.05) (Duncan, 1955).

**Results**

Total protein, albumin, globulin, glucose, alkaline phosphatase and calcium concentrations at third and sixth weeks were significantly high in T3 group compared to the control (Tables 3 and 4). Uric acid, cholesterol, AST and ALT concentrations in all the treated groups were significantly lower compared to the control (Table 5 and 6).

**Discussion**

The significant increase in blood plasma protein, albumin and globulin concentrations in groups fed diet supplemented with arginine may be attributed to the increase in broilers' body weight (Al-Daraji and Salih, 2012).
Table 3: Effect of dietary arginine on total protein, albumin and globulin concentrations (Mean ± SE) of broilers at the tested weeks of age

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total protein (g/dl)</th>
<th>Albumin (g/dl)</th>
<th>Globulin (g/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weeks 3 6 average</td>
<td>Weeks 3 6 average</td>
<td>Weeks 3 6 average</td>
</tr>
<tr>
<td>C</td>
<td>2.25 ± 0.07d 3.00 ± 0.48g 2.63 ±0.27d</td>
<td>1.00 ±0.01b 1.00 ±0.10b 1.00 ±0.05b</td>
<td>1.24 ±0.04a 2.00 ±0.29g 1.62 ±0.16a</td>
</tr>
<tr>
<td>T1</td>
<td>2.64 ± 0.11c 3.26 ± 0.16c 3.08 ±0.13c</td>
<td>1.14 ±0.02b 1.16 ±0.02b 1.15 ±0.02b</td>
<td>1.50 ±0.06b 2.39 ±0.09c 1.94 ±0.07c</td>
</tr>
<tr>
<td>T2</td>
<td>3.00 ±0.10b 3.82 ± 0.14b 3.41 ±0.12b</td>
<td>1.17 ±0.04b 1.17 ±0.01a 1.17 ±0.02b</td>
<td>1.83 ±0.07b 2.64 ±0.07b 2.23 ±0.07b</td>
</tr>
<tr>
<td>T3</td>
<td>3.84 ± .03b 4.93 ± 0.08b 4.39±0.05b</td>
<td>1.18 ±0.03b 1.19 ±0.02a 1.18 ±0.02b</td>
<td>2.65 ±0.03b 3.74 ±0.05b 3.19 ±0.03b</td>
</tr>
</tbody>
</table>

C: control group; T1, T2 and T3: groups of arginine added to the diet at levels of 0.02, 0.04 and 0.06 %, respectively; a, b, c: Means on the same column having different superscript differ significantly (p<0.05).

Table 4: Effect of dietary arginine on glucose and calcium concentrations and alkaline phosphatase activity (Mean ± SE) of broilers at the tested weeks of age

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Glucose (mg/dl)</th>
<th>Alkaline phosphatase (King Armstrong unit)</th>
<th>Calcium (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weeks 3 6 average</td>
<td>Weeks 3 6 average</td>
<td>Weeks 3 6 average</td>
</tr>
<tr>
<td>C</td>
<td>135.04 ±5.64b 153.96 ± 9.69b 144.5 ± 7.66b</td>
<td>3382.60 ±80.49d 1283.55 ±24.87d 1433.07 ±32.95d</td>
<td>8.81 ±0.40c 9.40 ±0.27c 9.11 ±0.34c</td>
</tr>
<tr>
<td>T1</td>
<td>165.46 ±5.32a 184.24 ± 7.34a 174.85 ± 6.33a</td>
<td>3612.52 ±94.10c 1436.36 ±7.99c 2524.44 ±50.13c</td>
<td>10.62 ±0.57b 11.70 ±0.27b 11.16 ±0.36b</td>
</tr>
<tr>
<td>T2</td>
<td>166.8 ±6.93a 186.52 ± 8.02a 176.66 ± 7.47a</td>
<td>4663.88 ±50.01b 1838.07 ±18.90b 3250.97 ±30.32b</td>
<td>11.23 ±0.3a 12.56 ±0.21a 11.90 ±0.255a</td>
</tr>
<tr>
<td>T3</td>
<td>168.21 ±5.86a 187.56 ± 7.52a 177.88 ± 6.69a</td>
<td>5331.42 ±29.18a 2053.87 ±16.65a 3692.64 ±16.84a</td>
<td>11.68 ±0.45a 13.26 ±0.30a 12.47 ±0.376a</td>
</tr>
</tbody>
</table>

C: control group; T1, T2 and T3 groups: adding arginine to the diet of broilers at levels of 0.02, 0.04 and 0.06 %, respectively; a, b, c: Means on the same column having different superscript differ significantly (p<0.05).

Table 5: Effect of dietary arginine on uric acid and cholesterol concentrations (Mean ± SE) of broilers at the tested weeks of age

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Uric acid (mg/dl)</th>
<th>Cholesterol (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weeks 3 6 average</td>
<td>Weeks 3 6 average</td>
</tr>
<tr>
<td>C</td>
<td>5.02 ± 0.439a 4.98 ± 0.246a 5.0 ± 0.3425a</td>
<td>96.74 ± 6.85a 93.60 ± 6.45a 95.17 ± 6.65a</td>
</tr>
<tr>
<td>T1</td>
<td>4.83 ± 0.45b 4.80 ± 0.216b 4.91± 0.333b</td>
<td>85.00 ± 8.64b 79.92 ± 8.84b 82.46 ± 8.74b</td>
</tr>
<tr>
<td>T2</td>
<td>4.89 ± 0.548b 4.75 ± 0.181b 4.82 ± 0.3645b</td>
<td>92.78 ± 8.24b 79.5 ± 9.07b 86.14 ± 8.655b</td>
</tr>
<tr>
<td>T3</td>
<td>4.78 ± 0.353b 4.72 ± 0.244b 4.75 ± 0.2985b</td>
<td>91.78 ± 9.91b 77.32 ± 6.06b 84.55 ± 7.985b</td>
</tr>
</tbody>
</table>

C: control group; T1, T2 and T3: groups of arginine added to the diet of broilers at levels of 0.02, 0.04 and 0.06 %, respectively; a, b, c: Means on the same column having different superscript differ significantly (p<0.05).

Table 6: Effect of dietary arginine on AST and ALT activity (Mean ± SE) of broilers at the tested weeks of age

<table>
<thead>
<tr>
<th>Treatments</th>
<th>AST (U / L)</th>
<th>ALT (U / L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weeks 3 6 average</td>
<td>Weeks 3 6 average</td>
</tr>
</tbody>
</table>
| C         | 122.4 ± 4.34a 143.4 ± 3.53a 132.9 ± 3.93a 37.20 ± 4.8a 33.40 ± 3.5a 35.3 ± 1.15a | 2012a). Heavy body weight was observed to have a high concentration of blood plasma total protein (Corzo et al., 2005). Dietary arginine can contribute to a hormonal environment that increases protein synthesis and muscle growth (Leveilla et al., 1960).

Compounds including creatine, polyamines, praline, glutamate and arginine play a pivotal role in many bodily functions, including protein synthesis (Beaumier et al., 1996). L-arginine has anticatabolic properties because it improves nitrogen balance (Saito et al., 1987). In the current study, arginine decreased H/L ratio via decreasing the effects of glucocorticoids, since glucocorticoid hormone stimulates gluconeogenesis, particularly in the liver (Al-Daraji and Salih, 2012b). This pathway results in the synthesis of glucose from non-hexose substrates such as amino

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Acids (Wingfield et al., 1998). However, a major part of this increase in protein level in the blood plasma of the arginine supplemented group can be explained by the increase of albumin concentration. Blood plasma or serum electrophoresis showed that albumin is the major part of the total protein in the avian plasma or serum (Al-Daraji et al., 2008).

In the present study arginine supplementation to broilers' diet significantly increased the plasma concentration of glucose. The probable reason for this increase is that arginine stimulates the pancreas for insulin production (Balch et al., 1997). Arginine was reported also to increase the levels of glucose, GH, and glucagon (Braverman, 1997). However, glucagon responses to arginine present act via different mechanisms on the alpha cell (Reference???). Most obvious was the fact that arginine stimulated glucagon secretion. It is possible, that glucagon responses to arginine may be representative of pancreatic alpha cell responses to amino acids in general. The effects of arginine on glucagon secretion are employing the perfused pancreas technique which indicates that the pancreatic alpha cell is quite responsive to arginine (Pagliara et al., 1973). In this study, arginine supplementation also increased plasma ALP activity and calcium concentration. This may be account for that arginine is involved in remedy of osteoporosis and fractures or bone defects (Civitelli et al., 1992). Arginine is involved in the synthesis of polyamine and L-proline (that act as substrates for collagen synthesis) (Colao et al., 1999), of GH and IGF-I (Chevalley et al., 1998), and in NO (Trippel, 1998) production. NO has been shown to prevent the corticosteroid-induced loss of bone in mature rats (Wimalawansa et al., 1997) and arginine increases ALP activity in late period laying Japanese quail (Onderci et al., 2006). In general, high ALP activity is associated with early cell proliferation, followed by tissue-specific patterns of activity. The possibility that serum ALP activity might serve as a biochemical index of subsequent gain was based on the observation of Li et al. (1947). They reported that GH treatment increased the phosphatase level and that hypophysectomy was followed by a decline in phosphatase.

It was noticed in the present study that arginine lowered plasma cholesterol. This result is in agreement with that of Rossitch et al. (1991) who found arginine to lower serum cholesterol, LDL, and triglyceride levels. Arginine increases the secretion of GH and as a result thyroxine secretion increases; an inverse correlation between serum levels of cholesterol and thyroid hormone has been widely known (Kühn et al., 1993).

In the present study it was shown that adding arginine to broiler diet significantly decreased plasma AST and ALP activity as compared to control group. The decrease in the activity of these two enzymes in blood plasma may be attributed to that arginine helps in detoxification of liver and alleviates cirrhosis by neutralizing ammonia and may be beneficial in the treatment of liver disorders (Braverman, 1997; Balch et al., 1997). So liver malfunction can occur as a result of arginine deficiency (Moss, 1992).

**Conclusion**

In conclusion feeding diets containing L-arginine resulted in significant improvement in blood plasma parameters levels. Therefore, arginine could be used as an efficient feed additive for enhancing physiological performance of birds.

**References**


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