Nangarhar University
International Journal of Biosciences
Received: 15 July 2023
Accepted after revision: 25 Sep 2023
Published Online: 30 Sep 2023
ORIGINAL ARTICLE
Vol 2, Issue 3 (2023)
e-ISSN: 2957-9988

Dietary Arginine as a Growth Promoter for Broiler Chickens

Faisal Danish[1], Rahimullah Amarkhil[2], Adil Naeem Jan[3], Mohammad Naeem Azizi[4], Hematzai Nasratullah[5]

[*1]Department of Clinic, Faculty of Veterinary Science, Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan.
[2]Department of Para-Clinic, Faculty of Veterinary Science, Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan.
[3]Department of Animal Science, Faculty of Animal Science, Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan.
[4]Department of Pre-Clinic, Faculty of Veterinary Science, Afghanistan National Agricultural Sciences and Technology University, ANASTU, Kandahar, Afghanistan.
[5]Department of Para-Clinic, Faculty of Agriculture, Bamyan University, Bamyan, Afghanistan

[*]Corresponding author email: Faisaldanish443@gmail.com

ABSTRACT

Background: Animals require amino acid (arginine) to maintain optimal body growth and nitrogen balance. The intent of the present study was to understand the impact of arginine on broiler chick productivity.

Materials and Methods: A 35-days study was conducted at the Veterinary Science Faculty's research farm in Nangarhar, Afghanistan. 60 chicks of one-day-old were purchased from a local hatchery and were divided into four equal groups: control, treatment 1 (T1), treatment 2 (T2), and treatment 3 (T3). The arginine supplementation provided to these groups was 0% (control), 0.1% (T1), 0.2% (T2), and 0.3% (T3), respectively.

Findings: The treatment groups had better weight gain and feed efficiency in the third, fourth and fifth weeks compared to the control group ($p<0.05$). Dietary arginine supplementation also contributed to an increase in body weight gain (BWG) during the majority of the experiment's period. All arginine-supplemented groups had significantly ($p<0.05$) better FCR in the 1st, 2nd, 3rd, 4th, and 5th weeks of age compared to the control group.

Conclusion: Supplementation of arginine to the diet of broiler chickens significantly increased their live body weight, weight gain, feed intake, and feed conversion ratio. These results indicate that arginine might be used as a useful supplementation to increase their productivity.

Keywords: Arginine, Broilers chicks, Diets, Productive performance

INTRODUCTION

Animals' regular body growth and nitrogen balance require the amino acid arginine. The majority of adult mammals can make enough arginine on their own body to meet their needs, but since poultry cannot, they must obtain their arginine from their diet (Hazim and Salih, 2012). As mitochondria lack carbamoyl phosphatase synthetase I, chickens cannot synthesize any arginine via the urea cycle; hence, they require more arginine in their diets than growing animals (Tan et al., 2009).

Many studies in various species have demonstrated that arginine can positively affect such desirable parameters as body weight, carcass yield, and reduced fat deposition (Nabi et al., 2022). Arginine promotes bone growth through its role in the synthesis of collagen and connective tissue, as well as through growth hormone (GH) (Hassan et al., 2021). GH stimulates chondrocyte proliferation and differentiation, which in turn has an impact on the development of the epiphyseal growth plate both directly and indirectly through insulin-like growth factor-l (IGF-1) (Wu et al., 2011). In addition, arginine can influence nutritional partitioning, favorably reduce whole-body fat accumulation in mammals, and decrease the activity of hepatic lipogenic enzymes in ducks by boosting the generation of nitric oxide (NO). Thus, arginine is crucial for multiple physiological functions in chickens (Castro et al., 2019).

Muscle protein synthesis is controlled by a key signaling mechanism called the mechanistic target of rapamycin (mTOR), and arginine may increase protein synthesis by stimulating the mTOR signaling pathway's initial effectors (Yu et al., 2018). Additionally, arginine boosts the release of gut and pituitary hormones such as glucagon, insulin, ghrelin, and GH through a secretagogue effect. This induced hormone production might increase feed consumption and protein synthesis (Uni and Ferket, 2003). According to studies, dietary arginine levels above the NRC's suggested limits can help in the secretion of certain hormones (insulin, glucagon, gherlin, and GH) and the development of the digestive system, which can improve the growth of chicks (Jun Yu et al., 2018).

Studies have shown that chicks at an earlier age have an acute need for dietary arginine, which may be related to early microbial threats and immune system growth (Corzo and Kidd, 2003). Supplementation of more than the recommended level of arginine in the diet for the starter phase is essential for boosting muscle development in broilers (Bolea et al., 1997). Decrease in arginine in broiler diets reduced body fat and breast meat yields (Khajali et al., 2011). According to studies, upsurge in the arginine amount of the diet after 21 days is most important for muscle growth in broiler chickens (Jun Yu et al., 2017). It is also found that adding 0.1, 0.2, and 0.3% L-arginine from one to twenty-one days of age played a significant role in increasing breast weight, thickness, and myofibril diameter (Tan et al., 2009).

In chickens, Arginine is involved in wound healing and enhances immune function during metabolic stress (Jianzhuang et al., 2014). Chicken breast muscle mass was high ($p<0.05$) in groups fed different doses of dietary L-arginine in comparison to the control group (Sathyappriya et al., 2018). The amount of raw protein and fat in the breast muscle increases once arginine is added to the diet (Stamler and Messner, 2001). According to a study, dietary arginine had a considerable impact on body weight and serum IGF-l ($p<0.05$) (Fernandes et al., 2009). High concentrations of arginine in the diet have been reported to improve weight gain, dietary efficiency, meat production, breast fat, and raw protein intake (Xu et al., 2018). A rise in dietary arginine led to an increase in body weight at 21 and 42 days of age ($p<0.01$) (Ebrahimi et al., 2014). Past researches have clearly demonstrated the importance of providing chickens adequate dietary arginine to support growth responses (Hazim and Salih, 2012). Therefore, this study was conducted to determine the effect of dietary supplementation with different levels of arginine on productive performance of broiler chicks.

MATERIALS AND METHODS

Study Area

The study was carried out at the Faculty of Veterinary Sciences' research farm at Nangarhar University (Nangarhar, Afghanistan).

Animals, Housing, and Experimental Design

A total of 60 Ross 308 one-day-old broiler chicks were placed in the sanitized and well-ventilated chamber. The management of the four treatment groups was done appropriately; the one-day-old chicks were raised in chicks' experimental chambers, and the area of each experimental chamber was 50 x 40 cm. During the whole 5-week experiment, ad libitum access to food and drink were provided. The chicks were divided into one control and three treatment groups of 15 chicks each, and each group included three replicates, each with five chicks. Treatment groups included T1, T2, and T3, with supplementation of arginine to the chickens' diets at levels of 0.1%, 0.2%, and 0.3%, respectively. The control group (C) with no supplementation of arginine to the diet.

Growth Performance measurements

On a replicate basis, the number and body weight (BW) of birds were recorded at placement (D0), feeding phase switches (D7/14/21/28, and 35), and feed intake (FI) was measured for each feeding phase. Daily weight gain, daily feed intake, and feed conversion ratio (FCR) were calculated for the abovementioned feeding phases separately. Additionally, cumulative growth performance was calculated for the entire rearing period (0–35 d).

Statistical Analysis

All the experimental data are shown as the mean ± SEM and analyzed by One-way ANOVA followed by a Post Hoc test. Statistical level of significance was considered at $p<0.05$ level. The data were analyzed using SPSS version 21.

RESULTS

Body weight (BW) values have steadily grown throughout the vast majority of experimental periods as compared to the C group ($p<0.05$) as an outcome of higher dietary arginine levels (Table 1). This linear progress persisted up to the T3 group. Table 1 indicates that T1, T2, and T3 tended to have higher BW in the first week compared to the C group ($p<0.05$). As opposed to all other experimental groups, T3 had a considerably ($p<0.05$) higher BW between the third and fifth weeks of age. Nevertheless, there was a clear trend for BW to be higher in the T1 and T2 groups than in the C groups across this week of experiments. In the 3rd, 4th, and 5th weeks of the experiment, all groups that were supplemented with arginine (T1, T2, and T3) indicated high values of BW ($p<0.05$) in contrast to the C group. The mean values for BW during the 5th week were 2174.50, 2286.66, 2295.00 and 2490.16 g for control, T1, T2, and T3, respectively.

Table 1. Shows the effects of dietary arginine supplementation on broiler chicks body weight (g).

Groups	Weeks				
	1	2	3	4	5
Control	130.23 ± 2.43^{a}	435.70 ± 7.38	964.03 ± 28.73^{a}	1625.83 ± 27.07^{a}	2174.50 ± 28.20^{a}
T1	136.66 ± 1.20^{b}	446.33 ± 1.76	1013.0 ± 09.07^{ab}	1739.00 ± 23.11^{b}	2286.66 ± 18.55^{b}
T2	137.33 ± 1.20^{b}	445.00 ± 1.52	1035.0 ± 11.54^{b}	1733.66 ± 16.14^{b}	2295.00 ± 16.07^{b}
T3	137.66 ± 1.33^{b}	445.66 ± 1.76	1051.6 ± 14.81^{b}	1724.00 ± 14.00^{b}	2490.16 ± 24.68

Data presented as Mean ± SE over different weeks of age. Different superscripts letters in the column differed significantly ($p<0.05$).

Dietary arginine supplementation also contributed to an increase in body weight gain (BWG) during the majority of the experiment's period (Table 2). However, there was no discernible distinction between the groups (p>0.05). There were no significant differences between control (C), T1, T2, and T3 groups. In the third week, the T1, T2, and T3 groups tended to have higher BWG compared to the C group. However, in the 5th week of experiments, the T3 group has a trend toward an increase in BWG (p<0.05) in contrast to other experimental groups. The mean values of BWG in the 5th week of the experiment were 548.66, 547.66, 561.33, and 766.16 g for C, T1, T2, and T3, respectively. The highest value of BWG was in the T3 group. It is important to state that adding arginine to the diet considerably increases the accumulative BWG (p<0.05). The mean values of this experiment were 2138.83, 2247.33, 2255.66, and 2445.50 g for C, T1, T2, and T3, respectively. However, the highest mean of cumulative BWG belongs to the high level of arginine supplementation and soon concerns the other arginine supplemented groups.

Table 2. Effects of dietary arginine supplementation on broiler chicks body weight gain (g).

	Weeks					
Groups	1	2	3	4	5	**Accum. BWG**
Control	94.56±4.06	305.46±6.03	528.33±28.93	661.80±46.89	548.66±45.83	2138.83±30.75^{a}
T1	97.33±0.33	309.66±2.18	566.66±08.37	726.00±22.06	547.66±39.60	2247.33±18.67^{a}
T2	98.00±1.52	307.66±2.72	590.00±11.35	698.66±25.96	561.33±29.16	2255.66±17.89^{a}
T3	96.00±2.08	308.00±1.15	606.00±14.73	672.33±26.81	766.16±28.41	2445.50±26.12^{b}

Accum = Accumulative. Data presented as Mean ± SE over different weeks of age. Different superscripts letters in the column differed significantly (p<0.05).

Table 3 demonstrates the impact of arginine supplementation on feed intake (FI). In the first week, T1 had the lowest mean compared to the other groups; meanwhile, there were no significant (p>0.05) differences between the treatment groups. Additionally, compared to the other experimental groups in the second week, T1 had the lower mean and the C group had the greatest mean (p<0.05). FI tended to increase linearly with increased dietary arginine, and differences between the groups were significant (p<0.05). The mean values of these traits in the 5th week were 1120, 1138.67, 1160.33, and 1240.00 g for C, T1, T2, and T3, respectively.

Table 3. Effects of dietary arginine supplementation on broiler chicks feed intake (g).

	Weeks					
Groups	1	2	3	4	5	**Accum. FI**
Control	129.53±2.0	434.47±06.6	925.00±18.19^{b}	1231.00±23.09	1120.00±34.64^{b}	3790.00±26.45
T1	123.66±0.8	386.00±10^{a}	918.00±09.06^{a}	1122.67±18.55^{b}	1138.67±12.42^{a}	3689.00±12.42
T2	124.66±1.2	420.00±03^{b}	878.00±12.01^{a}	1123.67±29.32^{b}	1160.33±17.63^{a}	3706.66±17.63
T3	125.33±2.0	415.33±03^{b}	846.67±17.45^{a}	1009.33±31.79^{a}	1240.00±23,33^{a}	3636.66±23.33

Accum = Accumulative. Data presented as Mean ± SE over different weeks of age. Different superscripts letters in the column differed significantly (p<0.05).

Data on the feed conversion ratio (FCR) are shown in Table 4. In the 2nd week T1 significantly excels (p<0.05) in other groups. All arginine-supplemented groups had significantly (p<0.05) better FCR in the 1st, 2nd, 3rd, 4th, and 5th weeks of age compared to the control group. The mean values of the FCR in the 5th week of the experiment were 1.76, 1.61, 1.61, and 1.46 for C, T1, T2, and T3, respectively. However, the T3 group recorded the best result for FCR according to other experimental groups (C, T1, and T2) during all periods of experiments.

Table 4. Effects of dietary arginine supplementation on broiler chicks feed conversion ratio (g).

	Weeks				
Groups	1	2	3	4	5
Control	1.37±0.702	1.29±0.012	1.54±0.055[b]	1.67±0.022	1.76±0.038
T1	1.27±0.009	1.14±0.022[a]	1.40±0.015[a]	1.46±0.012[b]	1.61±0.008[b]
T2	1.27±0.027	1.22±0.107[b]	1.37±0.021[a]	1.46±0.018[b]	1.61±0.019[b]
T3	1.30±0.043	1.21±0.007[b]	1.31±0.010[a]	1.39±0.021[a]	1.46±0.019[a]

Data presented as Mean ± SE over different weeks of age. Different superscripts letters in the column differed significantly (p<0.05).

DISCUSSION

The main factor influencing growth performance and BWG is dietary amino acid supplementation, which are the structural blocks of proteins (Ball et al., 2007). Maintaining the broiler's growth performance requires feeding it a balanced diet containing ample amino acids. Our results demonstrated that feeding arginine above the recommended specifications promotes broiler growth performance. In the present study, higher dietary arginine levels have led to continuously increasing BWG values throughout the majority of trial periods as compared to the C group (p<0.05; Table 2). Many studies conducted with broilers (Hazim and Salih, 2012; Hassan et al., 2021; Khajali et al., 2011) indicated that arginine supplementation improved BWG while it was decreased by arginine deficiency. Also, it has been reported that increasing arginine levels from 1.10 to 1.34% increased BWG (Atencio et al., 2004). Contrary to our findings, Fouad et al. (2013) reported that BW gain was not influenced as the arginine supplementation was increased from 0.1 to 1%. The contradictory results of arginine supplementation above the recommended level and its varying impact on broiler body weight may be due to some other factors such as the birds' age, sex, strain, and the region where the birds are reared.

The dietary, management, and genetic conditions of broilers each have an impact on their FCR. The results we found reveal that groups receiving arginine supplementation achieved lower FCR throughout the majority of the experiment period. The impact of arginine supplementation on FCR in broilers was further supported by Castro et al. (2019), who reported that increasing the arginine level from 70 to 110% of the broilers' suggested requirement reduced feed intake and FCR. Similar to the aforementioned, another study indicates that FCR was significantly lower in the arginine-supplemented group compared to the C group (Zampiga et al., 2018). In another study, Ebrahimi et al. (2014) supported the previous findings and demonstrated that when the broiler diet's arginine supplementation was raised from 100% of the required amount to 183%, the FCR considerably improved.

Feed intake tended to increase linearly with increased dietary arginine, and differences between the groups were significant (p<0.05). Our findings were further supported by Emadi et al. (2010), who reported that an increase in dietary arginine increases FI. In another study, it was reported that arginine supplementation has favorable effects on FI (Ruan et al., 2020). However, other studies (Corzo et al., 2003; Ebrahimi et al., 2014) failed to demonstrate that the various levels of arginine supplementation had any effect on FI in broilers chicks. Jahanian and Khalifeh-Gholi, (2018) showed that high concentrations of arginine did not affect FI in Ross 308 broiler chicks. These results indicate that arginine supplementation above the recommended level and its variable effects on broiler FI may be attributed to a variety of factors, like age, sex, strain, and the geographic location where the chickens were reared.

CONCLUSION

In conclusion, adding arginine to the diet of broiler chickens significantly improved their live body weight, weight gain, feed intake, and feed conversion ratio. This indicates that arginine could be utilized as an efficient additive for improving the productive performance of broiler chicks.

Conflict of Interest: No conflict of interest was declared by authors.

Funding: This research received no external funding.

REFERENCES

Al-Daraji, H. J., & Salih, A. M. (2012). Effect of dietary L-arginine on carcass traits of broilers. *Research Opinions in Animal and Veterinary Sciences*, *2*-(1), 40-43.

Atencio, A., Albino, L. F. T., Rostagno, H. S., Carvalho, D. C. D. O., Vieites, F. M., & Pupa, J. M. R. (2004). Arginine requirement of male broiler chicks in different phases of development. *Revista Brasileira de Zootecnia*, *33*, 1456-1466.

Ball, R. O., Urschel, K. L., & Pencharz, P. B. (2007). Nutritional consequences of interspecies differences in arginine and lysine metabolism. *The Journal of Nutrition*, *137*-(6), 1626S-1641S.

Bhogoju, S., & Nahashon, S. (2022). Recent advances in probiotic application in animal health and nutrition: A review. *Agriculture*, *12*-(2), 304.

Bolea, S., Pertusa, J. A., Martín, F., Sanchez-Andrés, J. V., & Soria, B. (1997). Regulation of pancreatic β-cell electrical activity and insulin release by physiological amino acid concentrations. *Pflügers Archiv*, *433*, 699-704.

Brugaletta, G., Zampiga, M., Laghi, L., Indio, V., Oliveri, C., De Cesare, A., & Sirri, F. (2023). Feeding broiler chickens with arginine above recommended levels: effects on growth performance, metabolism, and intestinal microbiota. *Journal of Animal Science and Biotechnology*, *14*-(1), 33.

Castro, F. L. S., Su, S., Choi, H., Koo, E., & Kim, W. K. (2019). L-Arginine supplementation enhances growth performance, lean muscle, and bone density but not fat in broiler chickens. *Poultry science*, *98*-(4), 1716-1722.

Cuca, G. M., & Jensen, L. S. (1990). Arginine requirement of starting broiler chicks. *Poultry Science*, *69*-(8), 1377-1382.

Ebrahimi, M., Zare Shahneh, A., Shivazad, M., Ansari Pirsaraei, Z., Tebianian, M., Ruiz-Feria, C. A., ... & Mohamadnejad, F. (2014). The effect of feeding excess arginine on lipogenic gene expression and growth performance in broilers. *British Poultry Science*, *55*-(1), 81-88.

Emadi, M., Kaveh, K., Bejo, M. H., Ideris, A., Jahanshiri, F., Ivan, M., & Alimon, R. A. (2010). Growth performance and blood parameters as influenced by different levels of dietary arginine in broiler chickens. *Journal of Animal and Veterinary Advances*, *9*-(1), 70-74.

Fernandes, J. I. M., Murakami, A. E., Martins, E. N., Sakamoto, M. I., & Garcia, E. R. M. (2009). Effect of arginine on the development of the pectoralis muscle and the diameter and the protein: deoxyribonucleic acid rate of its skeletal myofibers in broilers. *Poultry Science*, *88*-(7), 1399-1406.

Fernandez, X., Monin, G., Talmant, A., Mourot, J., & Lebret, B. (1999). Influence of intramuscular fat content on the quality of pig meat—1. Composition of the lipid fraction and sensory characteristics of m. longissimus lumborum. *Meat Science*, *53*-(1), 59-65.

Fouad, A. M., El-Senousey, H. K., Yang, X. J., & Yao, J. H. (2013). Dietary L-arginine supplementation reduces abdominal fat content by modulating lipid metabolism in broiler chickens. *Animal*, *7*-(8), 1239-1245.

Foye, O. T., Ferket, P. R., & Uni, Z. (2007). The effects of in ovo feeding arginine, β-hydroxy-β-methyl-butyrate, and protein on jejunal digestive and absorptive activity in embryonic and neonatal turkey poults. *Poultry Science*, *86*-(11), 2343-2349.

Hassan, F., Arshad, M. A., Hassan, S., Bilal, R. M., Saeed, M., & Rehman, M. S. (2021). Physiological role of arginine in growth performance, gut health and immune response in broilers: a review. *World's Poultry Science Journal*, *77*-(3), 517-537.

Jiao, P., Guo, Y., Yang, X., & Long, F. (2010). Effects of dietary arginine and methionine levels on broiler carcass traits and meat quality. *Journal of Animal and Veterinary Advances*, *9*-(11), 1546-1551.

Khajali, F., & Wideman, R. F. (2010). Dietary arginine: metabolic, environmental, immunological and physiological interrelationships. *World's Poultry Science Journal*, *66*-(4), 751-766.

Khajali, F., Tahmasebi, M., Hassanpour, H., Akbari, M. R., Qujeq, D., & Wideman, R. F. (2011). Effects of supplementation of canola meal-based diets with arginine on performance, plasma nitric oxide, and carcass characteristics of broiler chickens grown at high altitude. *Poultry Science*, *90*-(10), 2287-2294.

Kidd, M. T., Peebles, E. D., Whitmarsh, S. K., Yeatman, J. B., & Wideman Jr, R. F. (2001). Growth and immunity of broiler chicks as affected by dietary arginine. *Poultry Science*, *80*-(11), 1535-1542.

Liu, S., Tan, J., Hu, Y., Jia, X., Kogut, M. H., Yuan, J., & Zhang, H. (2019). Dietary l-arginine supplementation influences growth performance and B-cell secretion of immunoglobulin in broiler chickens. *Journal of animal physiology and animal nutrition*, *103*-(4), 1125-1134.

Nabi, F., Arain, M. A., Bhutto, Z. A., Shah, Q. A., Bangulzai, N., Ujjan, N. A., & Fazlani, S. A. (2022). Effect of early feeding of L-arginine and L-threonine on hatchability and post-hatch performance of broiler chicken. *Tropical Animal Health and Production*, *54*-(6), 380.

Ruan, D., Fouad, A. M., Fan, Q. L., Huo, X. H., Kuang, Z. X., Wang, H., ... & Jiang, S. Q. (2020). Dietary L-arginine supplementation enhances growth performance, intestinal antioxidative capacity, immunity and modulates gut microbiota in yellow-feathered chickens. *Poultry science*, *99*-(12), 6935-6945.

Stamler, J. S., & Meissner, G. (2001). Physiology of nitric oxide in skeletal muscle. *Physiological reviews*, *81*-(1), 209-237.

Tan, B., Yin, Y., Liu, Z., Li, X., Xu, H., Kong, X., ... & Wu, G. (2009). Dietary L-arginine supplementation increases muscle gain and reduces body fat mass in growing-finishing pigs. *Amino acids*, *37*, 169-175.

Wu, G., Bazer, F. W., Davis, T. A., Kim, S. W., Li, P., Marc Rhoads, J., ... & Yin, Y. (2009). Arginine metabolism and nutrition in growth, health and disease. *Amino acids*, *37*, 153-168.

Xu, Y. Q., Guo, Y. W., Shi, B. L., Yan, S. M., & Guo, X. Y. (2018). Dietary arginine supplementation enhances the growth performance and immune status of broiler chickens. *Livestock Science*, *209*, 8-13.

Yu, J., Yang, H., Wang, Z., Dai, H., Xu, L., & Ling, C. (2018). Effects of arginine on the growth performance, hormones, digestive organ development and intestinal morphology in the early growth stage of layer chickens. *Italian Journal of Animal Science*, *17*-(4), 1077-1082.

Yu, L. L., Gao, T., Zhao, M. M., Lv, P. A., Zhang, L., Li, J. L., ... & Zhou, G. H. (2018). Effects of in ovo feeding of l-arginine on breast muscle growth and protein deposition in post-hatch broilers. *animal*, *12*-(11), 2256-2263.

Zampiga, M., Laghi, L., Petracci, M., Zhu, C., Meluzzi, A., Dridi, S., & Sirri, F. (2018). Effect of dietary arginine to lysine ratios on productive performance, meat quality, plasma and muscle metabolomics profile in fast-growing broiler chickens. *Journal of animal science and biotechnology*, *9*, 1-14.