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Effect of Dietary L-Arginine on Productive Performance of Broiler Chickens

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Abstract: A total of 300 one day old Ross 308 broiler chicks were used in this study to determine the effect of supplementing ration with different levels of arginine on productive performance of broiler chickens. The chicks were allocated for 4 treatment groups (75 chicks for each group) and each treatment was consisted of five replicates with 15 chicks each. Treatment groups were: C: control group (without any addition of arginine); T1, T2 and T3: adding arginine to the diet of broiler chickens at levels of 0.02, 0.04 and 0.06%, respectively. Two types of diets were used over the period of 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 (46 days of age). Productive traits included in this study were live body weight, weight gain, feed intake, feed conversion ratio, production index, economic figure and livability. Results revealed that feeding diets containing arginine (T1, T2 and T3) resulted in significant increase (p<0.05) in live body weight, weight gain, feed intake and feed conversion ratio during the most period of experiment and with relation to accumulative weight gain, accumulative feed intake and accumulative feed conversion ratio as compared with control group (C). However, adding arginine to the diet of broiler chickens resulted in significant increase (p<0.05) in production index, economic figure and livability in comparison with control group. In conclusion, dietary arginine supplementation resulted in significant improvement in productive traits included in this study. So arginine can be used as effective feed additive for improve productive performance of broiler chickens.

Key words: Arginine, productive performance, broiler chickens

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, chicks are completely dependent on dietary arginine to meet their needs for protein synthesis and other functions (Tamir and Ratner, 1963). Lewis (1996) reported that birds appear unable to synthesize any arginine via the urea cycle, which may be due of lack of carbamoyl phosphate synthetase I in mitochondria and as a result, the dietary requirement for arginine is higher than in growing mammals. Moreover arginine has more benefits and has vast effects when it is added as supplementary diet, for instance arginine increases the release of growth hormone and arginine facilitates muscle growth (by inhibiting muscle loss) and it is required for the transport of the nitrogen used in muscle metabolism and arginine improves muscle performance, also improves glucose uptake into muscle cells (Stevens et al., 2000). Studies showed that arginine improves functions of digestive system in both mammals and birds when arginine reduces intestinal permeability due to its role in the production of nitric oxide and promotes the healing of the ulcers that occur in the digestive tract, arginine also increases the jejunal

activities for carbohydrate and protein digestion (Uni and Ferket, 2003). Corzo and Kidd (2003) indicated that the chick has considerably acute need for dietary arginine at an earlier age possibly associated with immune system development and early microbial challenges. Furthermore, arginine affects immune status of chicken. Diet supplemented with arginine at levels above the ones recommended for the starter phase may be necessary for improved muscle development in broilers (Fernandes et al., 2009). Arginine is a protein constituent that is involved in the secretion of insulin by pancreas β cells (Bolea et al., 1997) and it is suggested that L-arginine is a potentiation of glucose-induced insulin secretion occurs independently of nitric oxide (Thams and Capito, 1999) and it's also involved in the secretion of growth hormone (Merimee et al., 1969). Since arginine is involved in the secretion of growth hormone and chickens rely totally on a dietary supply of arginine; uricotelic species (i.e., birds) cannot synthesize arginine because they have an incomplete urea cycle. Past researches have clearly demonstrated the importance of providing chickens adequate dietary arginine to support growth responses (Cuca and Jensen, 1990). Therefore, this study was conducted to determine the effect of dietary supplementation with different levels of arginine on productive performance of broiler chickens.

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Table 1: Ingredient of the starter diet used in the experiment

	Treatments			
Ingredients	Control	Trt. 1	Trt. 2	Trt. 3
Yellow corn	58.00	58.00	58.00	58.00
Soya bean meal	27.00	27.00	27.00	27.00
Protein conc.*	9.00	9.00	9.00	9.00
Wheat	4.00	3.98	3.96	3.94
Sunflower oil	1.50	1.50	1.50	1.50
DCP**	0.30	0.30	0.30	0.30
Salt	0.20	0.20	0.20	0.20
Arginine	0.00	0.02	0.04	0.06
Total	100.00	100.00	100.00	100.00
Calculated composition***				
Protein	22.01	22.00	22.00	22.00
ME kcal/kg	3045.00	3040.00	3040.00	3040.00
Calcium	0.74	0.74	0.74	0.74
Phosphorus	0.41	0.41	0.41	0.41
Lys.	1.30	1.30	1.30	1.30
Meth.	0.62	0.62	0.62	0.62
Meth. to Cyst.	0.96	0.96	0.96	0.96
Arginine	1.55	1.57	1.59	1.61
Arg:Lys	1.19:1	1.20:1	1.22:1	1.23:1

*Protein concentrate used in the diets was produced in Holland (WAFI) which contains: 40% crude protein, 2100 kcal ME/kg, 5% crude fat, 2% crude fiber, 6.5% calcium, 2.50% phosphorus, 3.85% lysine, 3.70% methionine and 4% cystine.
**DCP: Dicalcium Phosphate.
***The calculated composition of the diets was determined according to NRC (1994). Trt. = Treatment

Table 2: Ingredient of the grower diet used in the experiment

	Treatments			
Ingredients	Control	Trt. 1	Trt. 2	Trt. 3
Yellow corn	61.00	61.00	61.00	61.00
Soya bean meal	24.00	24.00	24.00	24.00
Protein conc.*	7.00	7.00	7.00	7.00
Wheat	5.00	4.98	4.96	4.94
Sunflower oil	2.50	2.50	2.50	2.50
DCP**	0.30	0.30	0.30	0.30
Salt	0.20	0.20	0.20	0.20
Arginine	0.00	0.02	0.04	0.06
Total	100.00	100.00	100.00	100.00
Calculated composition***				
Protein	20.15	20.13	20.13	20.13
ME kcal/kg	3150.00	3145.00	3145.00	3145.00
Calcium	0.60	0.60	0.60	0.60
Phosphorus	0.35	0.35	0.35	0.35
Lys.	1.16	1.16	1.16	1.16
Me.	0.54	0.54	0.54	0.54
Meth. to Cyst.	0.85	0.85	0.85	0.85
Arginine	1.387	1.407	1.427	1.447
Arg:Lys	1.19:1	1.21:1	1.23:1	1.24:1

*Protein concentrate used in the diets was produced in Holland (WAFI) which contains: 40% crude protein, 2100 kcal ME/kg, 5% crude fat, 2% crude fiber, 6.5% calcium, 2.50% phosphorus, 3.85% lysine, 3.70% methionine and 4% cystine.
**DCP: Dicalcium Phosphate.
***The calculated composition of the diets was determined according to NRC (1994). Trt. = Treatment

MATERIALS AND METHODS
A total of 300 one day old Ross 308 broiler chicks were housed at clean well - ventilate room previously disinfected and the management of the four treatment groups were identically carried out, where the new hatched chicks have been raised at poultry experimental fields, which consisted of several separate rooms from each other and the area of each room were (5.75 x 3.75 m) and the chicks have been randomly distributed into 3 rooms and chicks were raised on floor cages (140 x 120 x 90 cm). Feed and water were provided *ad libitum* during the whole period of experiment which lasted 6 weeks. Two types of diets were used over the period of 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 (Table 1 and 2).The chicks were allocated for 4 treatment groups (75 chicks for each group) and each treatment was consisted of five replicates with 15 chicks each. Treatment groups were: C: control group (without any addition of arginine); T1, T2 and T3: adding arginine to the diet of broiler chicken at levels of 0.02, 0.04 and 0.06%, respectively. Productive traits included in this study were live body weight, weight gain, feed intake, feed conversion ratio, production index, economic figure and livability. Data of experiment were analyzed using XLStat, version 7.5, 2004. The significant differences between means of traits included in this study were determined using Duncan's multiple range test under the probability (p<0.05) (Duncan, 1955).

RESULTS AND DISCUSSION
Compared to control group, the values of Body Weight (BW) during most periods of experiments have gradually increased (p<0.05) due to increased level of dietary arginine (Table 3), BW was enhanced with increased dietary arginine. This linear enhancement was continuous up to T3 group. It was noticed from Table 3 that T3 and T2 in the 1st week tended to have higher BW than control group, in spite of there were no significant differences between these treatments (C, T1, T2 and T3), whereas, the lowest level of supplemented arginine recorded the lowest (p<0.05) value of BW in the first week. On the other hand, T3 recorded significantly (p<0.05) higher BW in the 2nd week compared to all other groups, while there was no significant differences among T2, T1 and control groups. Nonetheless, there was clear tendency for BW to be higher in T1 and T2 groups than C groups during this week of the experiment. In the 3rd, 4th, 5th and 6th weeks of experiment all arginine supplemented groups (T1, T2 and T3) recorded high values of BW (p<0.05) as compared to control group. The means values for BW during the 6th week were 2007.33, 2063.33, 2203.33 and 2345.00 g for C, T1, T2 and T3, respectively. Dietary arginine supplementation also increased (p<0.05) Weight Gain (WG) during most periods of experiment in the arginine supplemented groups (T1, T2 and T3) in comparison with control group (Table 4). In the 1st week, T2 and T3 had a slightly tendency to have higher BWG

Table 3: Effect of dietary supplementation of arginine on live body weight (g) (Mean±SE) of broiler chicken at different weeks of age

Trt.	Weeks					
	1	2	3	4	5	6
C	116.520±2.21[a]	319.760±3.19[b]	718.40±06.41[c]	980.72±34.61[c]	1527.50±40.46[c]	2007.33±64.33[d]
T1	110.720±2.59[b]	321.960±3.91[b]	721.00±12.65[b]	1011.99±33.89[b]	1540.00±26.49[b]	2063.33±43.26[c]
T2	117.080±2.60[a]	322.320±3.41[b]	723.00±11.40[a]	1071.55±40.53[b]	1660.00±36.52[b]	2203.33±51.74[b]
T3	119.640±2.92[a]	328.680±4.83[a]	730.00±13.17[a]	1168.00±42.76[a]	1702.50±43.84[a]	2345.00±47.40[a]

C: Control group; T1, T2 and T3: adding arginine to the diet of broiler chicken at levels of 0.02, 0.04 and 0.06%, respectively.
[a,b,c]Mean values having different superscript in column differ significantly (p<0.05). Trt. = Treatment

Table 4: Effect of dietary supplementation of arginine on weight gain (g) (Mean±SE) of broiler chickens at different weeks of age

Trt.	Weeks						
	1	2	3	4	5	6	Accum. BWG
C	69.520±2.04[ab]	203.240±43.92[c]	398.640±09.40[a]	262.322±37.07[d]	546.778±20.18[d]	479.833±40.85[d]	1960.33±60.50[d]
T1	64.720±2.58[b]	211.240±04.68[b]	399.040±14.62[a]	291.990±37.42[c]	528.002±43.21[c]	523.333±56.42[c]	2017.37±43.50[c]
T2	69.080±1.99[a]	205.240±04.46[b]	400.680±12.36[a]	348.550±33.23[b]	588.446±12.34[b]	543.333±53.69[b]	2155.23±51.00[b]
T3	72.140±2.37[ab]	212.040±05.46[a]	401.320±14.29[a]	444.000±38.64[a]	534.500±31.48[a]	642.500±60.01[a]	2297.00±57.00[a]

C: Control group; T1, T2 and T3: adding arginine to the diet of broiler chicken at levels of 0.02, 0.04 and 0.06%, respectively.
[a,b,c]Mean values having different superscript in column differ significantly (p<0.05). Trt. = Treatment; Accum. = Accumulative

Table 5: Effect of dietary supplementation of arginine on feed intake (g) (Mean±SE) of broiler chickens at different weeks of age

Trt.	Weeks						
	1	2	3	4	5	6	Accum. FI
C	75.49±0.657[a]	279.57±6.06[ab]	657.79±16.83[a]	528.96±50.54[a]	1140.03±98.78[a]	1027.64±42.05[a]	3709.48±36.15[c]
T1	70.15±1.283[b]	292.00±8.89[a]	656.44±20.84[a]	580.20±66.56[a]	1083.39±79.04[a]	1088.00±83.19[a]	3770.18±51.09[b]
T2	72.67±1.189[a]	274.34±9.41[c]	660.28±25.19[a]	651.75±40.44[a]	1171.70±76.89[a]	1070.82±99.56[a]	3901.56±91.44[a]
T3	75.81±1.189[ab]	272.89±9.56[bc]	668.09±09.16[a]	781.22±45.68[a]	1047.15±80.95[a]	1195.59±91.88[a]	4040.75±19.23[a]

C: Control group; T1, T2 and T3: adding arginine to the diet of broiler chicken at levels of 0.02, 0.04 and 0.06%, respectively.
[a,b,c]Mean values having different superscript in column differ significantly (p<0.05). Trt. = Treatment; Accum. FI = Accumulative Feed Intake

as compared to the control group in spite of there were no significant differences between C, T2 and T3 groups regarding this traits, whereas, T1 was the lowest (p<0.05) in relation to WG in spite of there were no significant differences between C, T1 and T3 groups with respect to this characteristics. However, in the 3rd week all supplemented arginine groups (T1, T2 and T3) have an obvious trend to have an increase in WG compared to control group, in spite of that there were no significant differences among all experimental groups concerning this traits. All supplemented birds grew faster and had a higher (p<0.05) means of WG in 2nd, 4th, 5th and 6th weeks of experiment. The means value of WG in the 6th week of age were 479.833, 523.333, 543.333 and 642.500 g for C, T1, T2 and T3, respectively. The highest value of WG was in T3 group, increasing WG due to increased level of dietary arginine during these subsequent periods was consistent. It's worth mentioning that the accumulative weight gain was increased significantly (p<0.05) by arginine supplementation to the diet. The mean values of this trait were 1960.33, 2017.37, 2155.23 and 2297 gm for C, T1, T2 and T3, respectively. However the highest mean of the accumulative WG belongs to the high level of arginine supplementation and so on concerning the other arginine treatment groups. The effect of

supplemental arginine on feed intake (FI) is shown in Table 5. FI slightly fluctuated in the 1st and 2nd weeks, which in the 1st week T1 had lowest mean than the other groups; meanwhile, there was no significant (p>0.05) differences between T2, C and T3 and between T1 and T3. Then again in the 2nd week T1 surpasses all groups in FI, while T2 was the lowest group among all groups in relation to FI. However, there were no significant differences between C and T1 and between C and T3 as regard this trait. In the 3rd, 4th, 5th and 6th weeks of age, FI tended to increase linearly with increased dietary arginine despite that the differences among experimental groups were not significant. The mean values of this trait in the 6th week of age were 1027.64, 1088, 1070.82 and 1195.59 g for C, T1, T2 and T3, respectively. However, for accumulative FI, the differences were significant (p<0.05), all supplemented groups had higher means of accumulative FI than control group. The means value of accumulative feed intake were 3709.48, 3770.18, 3901.56 and 4040.75 g for C, T1, T2 and T3, respectively. Data of the feed conversion ratio is noticed in Table 6. In the 1st week, T3 and T2 groups significantly excel (p<0.05) T1 and control groups; meanwhile T1 clearly tented to have numerically higher FCR than C group in spite of there were no significant differences between these two groups (C and

Table 6: Effect of dietary supplementation of arginine on feed conversion ratio (Mean±SE) of broiler chicken at different weeks of age

Trt.	Weeks 1	2	3	4	5	6	Accum. FCR
C	1.085±0.034[a]	1.351±0.032[a]	1.635±0.034[a]	1.940±0.037[a]	2.084±0.040[a]	2.100±0.016[a]	1.864±0.32[a]
T1	1.084±0.058[a]	1.335±0.028[b]	1.620±0.076[b]	1.918±0.026[b]	2.014±0.014[b]	2.079±0.110[b]	1.839±0.35[b]
T2	1.052±0.034[b]	1.288±0.045[c]	1.598±0.161[c]	1.869±0.028[b]	1.940±0.020[c]	1.970±0.012[c]	1.782±0.50[c]
T3	1.051±0.044[b]	1.287±0.060[c]	1.590±0.170[c]	1.759±0.090[c]	1.903±0.031[d]	1.860±0.010[d]	1.733±0.67[d]

C: Control group; T1, T2 and T3: adding arginine to the diet of broiler chicken at levels of 0.02, 0.04 and 0.06%, respectively.
[a,b,c]Mean values having different superscript in column differ significantly (p<0.05). Trt. = Treatment; Accum. = Accumulative

T1) with relation to this traits. All arginine treatments (T1, T2 and T3) were significantly (p<0.05) superior to C group in the 2nd, 3rd, 4th, 5th and 6th weeks of age as regards this trait. Dietary arginine also significantly increased (p<0.05) accumulative FCR in T3, T2 and T1 compared to C groups. The mean values of accumulative FCR were 1.864, 1.839, 1.782 and 1.733 for C, T1, T2 and T3, respectively. However, T3 group recorded the best results with respect to FCR as compared with other experimental groups (C, T1 and T2) during all periods of experiment and with relation to accumulative FCR.

In the present study, increasing the dietary arginine levels above the NRC-recommended requirements significantly increased body weight, weight gain, accumulative feed intake and feed conversion ratio (Table 3, 4, 5 and 6). It is obvious that arginine has important role in supporting chickens for maximum growth and several possible mechanisms may account for the enhanced growth of chickens in response to additional dietary arginine. These include increase availability of arginine for protein synthesis, stimulated secretion of hormones such as glucagon, insulin and Growth Hormone (GH) which may consequently increase protein synthesis and feed intake and enhanced production of ornithine which may increase DNA synthesis and cell proliferation (Kwak *et al.*, 1999). All above hormones have major effects on productive performance in chicks; growth hormone is one of the most important hormones that regulate the metabolism of glucose and amino acids in major tissues including skeletal muscle, adipose tissues, liver and heart (Meijer and Dubbelhis, 2004). Alba-Roth *et al.* (1988) reported that arginine stimulates growth hormone secretion by suppressing endogenous somatostatin secretion that means it should set in motion a rapid and significant release of GH. GH is required for normal post hatching growth. GH is thought to exert its effect on somatic growth by increasing circulating concentrations of Insulinlike Growth Factor-I (IGF-I) via stimulation of IGF-I production from the liver. Plasma concentrations of IGF-I in chicks are reduced following hypophysectomy (Huybrechts *et al.*, 1985) but increased by chronic GH treatment in either hypophysectomized chicks (Scanes *et al.*, 1986) or in young pullets receiving pulsatile GH administrations and in which growth is enhanced (Vasilatos-Younken *et al.*, 1988). Consequently in broiler

chickens, an arginine-deficient diet reduced growth, weight gain and feed intake (Carew *et al.*, 1997). Apart from growth hormone, another important hormone that assists the endocrine system's role in growth and development is thyroxine. This hormone is produced in the thyroid gland and is responsible for the regulation of metabolism in virtually all the cells of the body. Thyroxine is responsible for increasing the rate of carbohydrate metabolism and also that of protein synthesis and breakdown. Thus the endocrine system is able to play a vital role in growth and development through the actions of thyroxine and growth hormone. Growth hormones have important interactions with thyroxine, primarily in growth and development of birds. Thyroid hormones are required for body growth, but it appears that they act in a permissive or indirect way, in conjunction with GH which influences growth factors that directly stimulate cell proliferation.

Thyroid hormones also modulate GH production and release by the pituitary gland, by direct inhibition of pituitary somatotropes and by feedback effects on TRH which stimulates somatotropes (Harvey, 1993). GH also influences thyroid physiology by its effects on extra thyroidal deiodination pathways (Darras *et al.*, 1993). Increased plasma GH toward the end of incubation is one of the factors that contribute to the increase in plasma T3 during the perinatal period. Glucocorticoids, which also rise at this time, may increase iodothyronine monodeiodinase (59D-I) activity (Decuypere *et al.*, 1991) and also have important effects on organ differentiation in lung and gut. These hormonal interactions are conspicuous during the perihatch period (Decuypere *et al.*, 1991) and continue to be important in a variety of metabolic and developmental events at other ages. Rorsman *et al.* (1991) reported that arginine strongly stimulate glucagon secretion. Peter and Kirsten (1999) reported that L-arginine, independent of NO, potentiates glucose induced insulin secretion through stimulation of membrane depolarization and that glucose may sensitize L-arginine stimulation by three mechanisms (i.e. by potentiation β-cell membrane depolarization, by activation of protein kinase A and by activation of protein kinase C in the membrane of β-cell of the islets of Langerhans). Consequently the increase of insulin concentration in blood plasma will increase both the feed consumption and weight gain of the birds (Shanawany *et al.*, 1979).

Table 7: Effect of dietary supplementation of arginine on production index, economic figure and livability (Mean±SE) of broiler chickens

Trt.	Production index	Economic figure	Livability (%)
C	274.9±08.39[d]	275.0±07.53[d]	83.3±6.21[c]
T1	282.9±11.05[c]	283.0±11.82[c]	85.3±5.82[b]
T2	317.5±09.65[b]	317.5±09.94[b]	88.0±6.51[b]
T3	355.7±12.34[a]	355.9±08.87[a]	90.6±3.99[a]

C: Control group; T1, T2 and T3: adding arginine to the diet of broiler chicken at levels of 0.02, 0.04 and 0.06%, respectively.
[a,b,c]Mean values having different superscript in column differ significantly (p<0.05). Trt. = Treatment

As shown from Table 7 adding arginine to the diet of broiler chickens resulted in significant (p<0.05) increase in Production Index (PI), Economic Figure (EF) and livability as compared with control group. However, T3 recorded the highest values as regards these three traits. The improvement in PI and EF traits in arginine treatment groups may be due to the significant improvement in BW, FC and livability in these groups as determination of PI and EF traits mainly depended on the traits mentioned above (Naji and Hanna, 1999).

Conclusion: In conclusion adding argininine to the diet of broiler chickens resulted in significant improvement as regards live body weight, weight gain, feed intake, feed conversion ratio, production index, economic figure and livability, therefore could be used as an efficient additive for improving productive performance of broiler chickens.

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