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INFLUENCE OF DIETARY LYSINE AND ARGININE INTERRELATIONSHIP ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS AND IMMUNE RESPONSE IN JAPANESE QUAIL*

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ABSTRACT

This study was designed to determine the effect of dietary supplementation of extra Lysine (LYS) and/or Arginine (ARG) than normal requirements of Japanese quail chicks and their interaction on growth performance, carcass quality, immune response and nutrient digestibility in Japanese quail.. A total of 672 one – day old Japanese quail chicks were used in this study and randomly allotted into equal 16 groups (42 per each) of mixed sex. Group 1 was fed basal diet without supplementation (control). Quail chicks of groups 2, 3 and 4 were fed on the basal diet supplemented with ARG at 110, 120 and 130% of the *NRC (1994)* requirement respectively. While quail chicks of groups 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 were fed basal diet supplemented with LYS/ARG at ratios of 110/100, 110/110, 110/120, 110/130, 120/100, 120/110, 120/120, 120/130, 130/100, 130/110, 130/120 and 130/130.

From the obtained data it was observed that ARG supplementation without LYS (groups 2, 3 and 4) showed non significant improvement in body weight, weight gain, RGR, FCR when compared with control and also supplementation of LYS alone (groups 5, 9 and 13) showed non significant improvement in the growth performance parameters. While, both ARG and LYS supplementation had no effect on growth rates as showed in quail chicks of groups 15 and 16.

There was an improvement of immune response with LYS and/or ARG supplementation as noticed in increased phagocytic activity and HI titer in quail chicks especially in the highest level of ARG supplementation (group, 4). Regarding serum parameters, there was an increase in serum total protein level in all groups fed on LYS and/or ARG supplemented diets when compared with the control and a significant increase in serum total cholesterol in the groups supplemented with higher levels of LYS alone (groups 5, 9 and 13). Both LYS and ARG supplemented groups had some variation in concentration of SGPT and SGOT and the highest level was observed in higher supplement level of ARG (group 4), while serum uric acid concentration increased with the level of LYS and/or ARG supplementation.

There was a significant increase lymphoid organ in quail chicks of group 4 which fed basal diet supplemented with LYS/ ARG at 100/130 when compared with the control and other supplemented groups. LYS or ARG supplementation had no effect on dressing and liver percent, while both of them improved thigh percent, reduced visible fat accumulation% and improved breast meat percent and LYS is more efficient for increasing breast meat when compared with control. LYS supplementation is more related to increase CP% in breast meat than ARG and higher supplementation of both of amino acids increase CP% in liver and generally that supplement had minor effect on the nutrient digestibility.

Key Words: Japanese quail, Lysine, Arginine, performance, Immune response, Serum parameters, Carcass quality, Liver and breast meat composition, Nutrient digestibility.

INTRODUCTION

Japanese quail (Coturnix Coturnix Japonica) are widely distributed allover the world. They were raised in Japan as pet and singing bird, and then had become widely used for meat production. Now, quail are raised for many reasons, it can be used as one of poultry species for meat and egg production to share in solving the lack of animal protein for human nutrition in several countries. For this, it is important to research for economically meat-producing quail. Japanese quail have become an important laboratory animal because of their small body size, sexual maturity in 6 – 7 weeks, high rate of reproduction and the ability to produce 3 – 4 generation in the year ***(Skim and Vohra, 1984).***

Japanese quail are fit for investment purpose for many advantage as compared to chicken, quick return of low investment, short generation interval, high rate of egg production, fast growth rate and they appear to be relatively more disease resistance without vaccination. So, the quail farming should be encouraged and promoted as available source of meat and egg production.

The amino acids are most important to achieve better growth, feed conversion and carcass quality potential. Most of the required amino acids are supplied from protein through feed ingredients. However, the relative levels of amino acids in feed ingredients are not the same as the relative levels needed by the bird, thus feed ingredients alone cannot efficiently supply the total amino acid requirements. Supplemental amino acids represent a way in which the amino acid ratios of a diet can be manipulated to match more closely the chick's ideal amino acids balance. The ratios of amino acids in diets are important simply because some amino acids are essential as they cannot be synthesized by the bird from other amino acids to meet its requirements.

Lysine is considered as the second limiting amino acid in practical poultry diets. Lysine has no precursor role in the body and its utilization is solely for protein accretion. Moreover, uricotelic species (as birds) can not synthesize arginine because they have an incomplete urea cycle. Past research has clearly demonstrated the importance of providing chickens adequate dietary arginine to support growth responses ***(Dean and Scott, 1965; Allen and Baker, 1972; Burton and Waldroup, 1979; Cuca and Jensen, 1990).*** The antagonism between lysine and arginine in poultry diets is well known ***(D'Mello and Lewis, 1970; Allen et al.,, 1972; Austic, 1986 and D'Mello, 1994).*** Recent research has focused on the relationship between these two amino acids in efforts to increase breast meat yield or to reduce the effects of heat stress with conflicting results among authors ***(Mahmoud et al., 1996; Mendes et al., 1997; Brake et al., 1998; Waldroup et al., 1998 and Veldkamp et al., 2000).*** Arginine has been reported to play an important role as a potent immunological modulator through production of nitric oxide ***(Collier and Vallance, 1989)*** and has been shown to directly influence the immune system of birds under several experimental models **(*Friedman et al., 1998; Kidd et al., 2001).*** Requirements for arginine have been determined in proportion to lysine after recognizing their relationship during absorption at the intestinal mucosa ***(Riley et al., 1989)***. An increase in the requirement for arginine has also been attributed to excess dietary lysine where an increase in kidney arginase activity has been shown to accentuate the degradation of arginine ***(Jones et al., 1967; Austic and Nesheim, 1970).*** On the other hand there are very rare studies concerning that relationship between amino acids in Japanese quail diets, so that the present study focused to investigate the influence of some dietary essential amino acids (lysine and arginine) interrelationships on growth performance, immune response, some blood parameters, nutrient digestibility, body composition and carcass characteristics of Japanese quail chicks.

MATERIALS AND METHODS

This work was carried out at Nutrition and Clinical Nutrition Department, Faculty of Veterinary Medicine, Alexandria University to investigate the possible effect of certain amino acids (Lysine and Arginine) interrelationship on growth, reproductive performance, carcass traits, some blood constituents and immune response of Japanese quail during the growing period.

Birds: A total of 672 one-day-old Japanese quail chicks were used in this study. They were obtained from a private quail farm at Motobis city (Kafer El-Sheikh govemorate), the quail chicks were randomly allotted into 16 equal groups (42 per each) of mixed sex.

Accommodation and management: The quail chicks were housed in a clean well ventilated room, previously disinfected with formalin. The room was provided with electric heaters to adjust the environmental temperature according to the age of the birds. The room floor was partitioned into 16 partitions 1 square meter, each compartment was bedded by fresh clean wheat straw forming a deep litter of four centimeters depth. The litter was turned over every ten days and removed every 20 days. Feeds and water were supplied ad-libitum. Prophylactic measures against the most common infectious diseases were carried out by using Colistine sulphate (1g/4 liter water) for Salmonellosis & E.coli infections at the first three days.. The chicks were vaccinated against Newcastle disease with different types of Newcastle disease vaccine as presented in table (1). After vaccination quail chicks received AD3E vitamins (1 ml/Liter water) to improve chick vitality.

Experimental design and feeding program: The Japanese quail chicks were randomly allotted into 16 groups; each group of quail (42 per each). The ingredient composition and chemical analysis of the basal diet (BD) are presented in table, 2. The applied experimental design is presented in table3.

Evaluation of growth performance: Body weight development (according to ***Vohra and Roudybush, 1971)*** and feed intake of quail in different groups were weekly recorded. The weight gain, feed conversion ratio and relative growth rate (RGR) according to ***Lambert et al., 1936 and Brody, 1968*** respectively were calculated.

Immune response measurements:

1- Haemagglutination Inhibition test: Four sets of blood samples were collected from the experimental birds of each group at 14, 24, 33 and 42 days of age. Blood samples was collected without anticoagulant for separation of sera to detect the titer of antibodies against Newcastle disease vaccine using haemaglutination inhibition test as an indicative of the bird's immune response in the different experimental groups. Micro technique of HI test was done according to ***Takatasy (1955)***. Geometric mean titre (GMT) was calculated according to ***Brugh (1978).***

2-Phagocytic activity (PA) and index (PI): phagocytic activity was determined according to ***Kawahara et al. (1991).*** Fifty micrograms of Candida albicans culture were added to 1 ml of citrated blood, collected at the end of experiment by slaughtering five birds from each group .Treated blood samples were put in shaker water bath at 23 – 25^{o} C for 3 – 5 hrs. Smears of blood were made and then stained with Geimsa stain. Phagocytosis was estimated by determining the proportion of macrophages which contain intracellular yeast cells in a random sample of 300 macrophages and expressed as percentage of phagocytic activity (PA). The number of phagocytized candida cells was counted in the phagocytic cells to calculate the phagocytic index according to the following equations:

$$PA = \frac{\text{Macrophages containing yeast}}{\text{Total number of macrophages}} \times 100$$

$$PI = \frac{\text{Number of cell phagocytized}}{\text{Number of phagocytic cell}} \times 100$$

3- Differential leucocytic count: This test was done at the end of growing period as blood film was prepared according to the method described by ***Lucky (1977).*** Ten drops from May-Grunwald stain stock solution were added to equal amount of distilled water on a dry unfixed smear then mixed and left for 1 minute for staining. The dye was decanted without rinsing. Diluted Geimsa stain was poured over the film as counter stain and left for 20 minutes then rinsed in water current and examined by oil emersion lens. The percentage and absolute value for each type of cells were calculated according to ***Maxine and Benjamin (1985).***

Table (1): Vaccination program against Newcastle disease of J. quail.

Age (days)	Vaccine	Route of administration
7	Hitchner B1	Eye Drops
18	Lasota	Eye Drops
28	Lasota	Eye Drops
36	Lasota	Eye Drops

- Vaccine produced by Intervet Co.

Table (2): Ingredient composition and chemical analysis of the basal diet

Physical Composition		calculated Analysis	
Ingredients	%	Items	%
Yellow Corn, ground	57.97	Moisture	10.76
Soybean (44%)	25.9	CP	24.39
Corn gluten meal	12.4	EE	3.85
MCP[1]	0.8	CF	3.87
Limestone	1.6	NFE	51.63
Common salt	0.4	Ash	5.5
Vitamin and mineral.Premix[2]	0.3	Ca	0.806
		Av. P	0.306
Lysine	0.33	Lysine	1.3
Methionine	0.05	Meth.	0.5
Anticoccidial[3]	0.1	Arginine	1.25
Anticlostridial[4]	0.15	ME(Kcal/ kg diet)	2980.8
		C/P ratio	122.21

1=(MCP) = monocalcium phosphate. 2= Vitamin and mineral premix (Heromix) produced by Heropharm and composed of (per 3 kg) vitamin A 12000000 IU, vitamin D3 2500000 IU, vitamin E 10000 mg, vitamin K3 2000 mg, vitamin B1 1000 mg, vitamin B2 5000 mg, vitamin B6 1500 mg, vitamin B12 10 mg, niacin 30000 mg, biotin 50 mg, folic acid 1000 mg, pantothenic acid 10000 mg, manganese 60000 mg, zinc 50000 mg, iron 30000 mg, copper 4000 mg, iodine 300 mg, selenium 100 mg and cobalt 100 mg. 3= Coxistac (produced by Pfizer Co.). 4= Zinc bacitracine. The basal diet was formulated according to ***NRC (1994).***

Table (3): Applied experimental design.

Group No.	Diet	Supplementation				Total Amino acid (calculated in the diet)		
		Lysine		Arginine				
		% NRC*	% of diet	% NRC*	% of diet	Lysine%	Arginine%	ARG/LYS ratio***
1	BD**	100	--	100	--	1.30	1.250	0.96
2	BD	100	--	110	0.125	1.30	1.375	1.06
3	BD	100	--	120	0.250	1.30	1.500	1.15
4	BD	100	--	130	0.375	1.30	1.625	1.25
5	BD	110	0.13	100	--	1.43	1.250	0.87
6	BD	110	0.13	110	0.125	1.43	1.375	0.96
7	BD	110	0.13	120	0.250	1.43	1.500	1.05
8	BD	110	0.13	130	0.375	1.43	1.625	1.14
9	BD	120	0.26	100	--	1.56	1.250	0.80
10	BD	120	0.26	110	0.125	1.56	1.375	0.88
11	BD	120	0.26	120	0.250	1.56	1.500	0.96
12	BD	120	0.26	130	0.375	1.56	1.625	1.04
13	BD	130	0.39	100	--	1.69	1.250	0.74
14	BD	130	0.39	110	0.125	1.69	1.375	0.81
15	BD	130	0.39	120	0.250	1.69	1.500	0.89
16	BD	130	0.39	130	0.375	1.69	1.625	0.96

* % from NRC requirement for J. quail chicks. ** BD (Basal diet). *** Arginine:Lysine ratio in the diet.

Blood parameters determination: At the end of the experimental period (6 weeks), blood samples were taken from quails (five birds from each group). Blood samples were left to drop on the side of the tube to prevent destruction of RBCs. Each blood sample was left to coagulate at room temp. Separation of serum was carried out by centrifugation of coagulated blood at 3000 rpm for 10 minutes. The clear serum was transferred carefully to clean and dry vials and kept in deep freezer until analysis for determination of total serum protein, albumin, SGPT and SGOT, alkaline phosphatase, total cholesterol, triglycerides, creatinine, creatine, urea and uric acid according to ***Doumas etal., (1981); Reinhold (1953); Reitman and Frankel (1957); Kind and king (1954); Zak et al., (1954); Sidney and Barnard (1973); Giorgio (1974); Henry (1978); Patton and Crouch (1977) and Fossatti and Prencipe (1980)*** respectively.

Digestibility Coefficient: At the end of the experimental period, 5 birds from each treatment were taken and each was put in separate cage which allowed a complete separation between each group and excreta collection was started after 5 days of the beginning to accustom the birds for the new battery conditions, the excreta were quantitatively collected for 4 days period during which feed consumption data were also recorded. The excreta then dried in hot air oven at 105°C for 3 hours, following this, excreta was allowed equilibrate in moisture with the air before being weighed, then finally ground and stored until chemical analysis for different nutrients according to ***AOAC (1985).*** Then **d**igestibility coefficients were calculated.

Carcass characteristic: At the end of the experimental period, 5 chicks from each group were randomly selected, fastened for 6 hours and then weighed and slaughtered to complete bleeding and weighed to determine the dressing percentage. Liver, spleen, thymus and bursa were weighed and their relative weights to body weight were calculated. Gizzard, heart, visible fat, breast meat muscles (boneless and skinless) from each quail chick were weighed, also the thigh muscle (with its bone and skin) from each chick was weighed ***(Kidd and Kerr, 1998).*** Pooled samples were taken from muscle and liver from each group at the end of the experimental period and the samples were dried in hot air oven at 105°C for 3 hours, finally ground and analyzed for dry matter, crude protein and ash according to ***AOAC (1985).***

Statistical analysis: The analysis of variance for the obtained data was performed using **Statistical Analysis System (SAS, 1987)** to assess significant differences.

Results & Discussion

Growth performance: The effects of dietary supplementation of lysine (LYS) and/or arginine (ARG) on body weight development of J. quail chicks are illustrated in table (4). The analysis of variance of the obtained data at the start of the experiment showed that there was no significant difference in body weight between different experimental groups, while there were differences in body weight development between the quail chicks fed different levels of LYS and/or ARG supplementation which began in the second week and more appeared at the end of the experiment.

From the obtained data, it was observed that quail chick groups which fed on the basal diet supplemented by LYS and/or ARG at level 100/110, 100/120 and 100/130 percent from NRC requirements which represent ratios, 105.77, 115.38 and 125.0 in the diet between ARG and LYS (groups 2, 3 and 4) respectively, showed non significant increase in body weight development by about 1.01%, 2.47% and 4.74% respectively when compared with the control group (No., 1). The data declared that J. quail chick body weight improved linearly with increasing the supplementation of ARG in the diet and these observations are in agreement with those obtained by ***Kidd et al (2001)*** who concluded that increasing dietary ARG but not lysine from 100 to 120% of NRC recommendation increased body weights at day 18. Also, the data are in agreement with ***Deng et al., (2005) and Waldroup et al. (1998)*** who indicated that the broiler chick body weight fed 1.25% ARG was significantly lower than that of birds fed higher levels of ARG. Moreover, the results disagree with that of **Chamruspollert et al. (2004)** who found that ARG supplementation (15.2 and 25.2 g/Kg diet) had no effect on body weight development in broiler chicks and that difference may be attributed to the higher supplementation level than other studies.

The obtained data revealed that LYS supplementation without ARG (Groups 5, 9 and 13) which fed on the basal diet supplemented with 110, 120 and 130% of the NRC lysine recommendation showed non significant improvement of the body weight by about 3.72%, 2.66% and 3.24% respectively when compared with the control one. These results are in harmony with those of ***Yakout et al. (2004)*** who concluded that LYS supplementation in quail chicks diets (1.13, 1.23, 1.33, 1.43 and 1.53%) improved body weight linearly with LYS level. Also, the results are in agreement with that of ***Bons et al. (2002), El-Banna et al. (2003; Jianlin et al. (2004)) and Rezaei et al. (2004***). On the other hand the analysis of variance of the obtained data showed that increasing the ARG supplementation with increasing LYS supplementation reduced the final body weight of quail chick when compared with group fed on the same of excess LYS without ARG supplementation except group 14 which were fed diet supplemented with LYS/ARG at 130/110 had significant ($p<0.05$) improvement in growth rates when compared with the control group. These results are in agreement with those of ***Austic and Scott (1975)*****.**

Table (5) shows the effect of dietary supplementation of different levels of LYS and/or ARG (100, 110, 120 and 130% of NRC recommendation of both amino acids) on body weight gain, relative growth rate, feed intake and feed conversion ratio (FCR).

From the obtained data, it was observed that ARG supplementation without lysine (Groups 2, 3 and 4) showed a non significant improvement in total body gain, relative growth rate when compared with the control group. These observations are in agreement with those obtained by ***Kidd et al. (2001) and Deng et al. (2005).***

The analysis of variance of the obtained data revealed that LYS supplementation alone at level 110%, 120% and 130% from the NRC recommendation (groups 5, 9 and 13) respectively, non significantly improved relative growth rate and body weight gain by about 3.84%, 2.89% and 3.39% for the three groups respectively when compared with the control. The results are in agreement with those of ***Bons et al., (2002); El-Banna et al. (2003); Jianlin et al. (2004) and Rezaei et al. (2004)***. On the other hand the statistical analysis of the obtained data showed that ARG supplementation with LYS (groups 6, 7, 8, 10, 11, 12, 15 and 16) non significantly lowered weight gain and relative growth rate when compared with the quail group fed on the same level of LYS without ARG supplementation and with the control group, while group 14 which fed on 130/110 (LYS/ARG) had significantly improved body weight gain and relative growth rate by about 8.4% and 0.61% respectively when compared with the control. The results are in harmony with ***Dale et al. (1983).***

There is no specific trend for increasing of feed intake but generally can be attributed that increasing LYS supplementation more than ARG in quail diet increase the feed intake and more ARG supplementation without or with LYS regulated that intake except in quail chick group's No. 10 and 11 which fed on LYS/ARG at level 120/110 and 120/120 from NRC recommendation respectively.

These results are in agreement with those of ***Tesseraud et al. (1999)***. The possible explanation for the higher feed consumption may be due to the LYS/ARG antagonism phenomenon. Limited increase of LYS level in the diet cause marked elevation of arginase activity; consequently increased ARG degradation which may necessitates the increase in ARG level in the diet ***(Scott et al., 1982 and Basiouni et al., 2006).*** Therefor, it could be possible that the birds had tried to eat more in an attempt to compensate for the differences in ARG level. From the obtained data it was observed that the final FCR was improved in quail chick groups which fed on the basal diet supplemented with 120 or 130% of ARG (groups 3 and 4) respectively by about 1.75% and 3.26% when compared with the control, while LYS supplementation alone at level 120% and 130% (groups 9 and 13) respectively, slightly improved FCR. On the other hand supplementation of both LYS and ARG at different levels in quail diet deteriorate the FCR and that may be due to the higher feed intake and lower body weight gain in that groups, except group 14 which fed on 130/110 (LYS/ARG) level which showed an improvement in FCR by about 6.27% when compared with the control. These data are in agreement with those obtained by ***Han and Bakr (1991); Mendes et al. (1997) and Kwak et al. (1999).***

Blood Picture: The effects of LYS and/or ARG supplementation on some blood picture of Japanese quail in different groups are shown in table (6). The results regarding RBCs showed that there was a significant increase in group 4 which fed the basal diet supplemented with the highest level of ARG (LYS/ARG, 100/130). Also, there was a significant increase in RBCs in groups 7, 9 and 10 which fed the basal diet supplemented with LYS/ARG at 110/120, 120/100 and 120/110 respectively, when compared with the control group. At the same time there was a significant increase in RBCs in groups supplemented with highest levels of either LYS and/or ARG (groups 12, 15 and 16 which fed basal diet supplemented with LYS/ARG at 120/130, 130/120 and 130/130, respectively) when compared with the control group and other supplemented groups, while group 16 is non-significantly higher in RBCs than groups 12 and 15. While WBCs, Hb and PCV had no specific trend and generally we can notice that increasing levels of both LYS and/or ARG had a negative effect on those parameters of J.quail chicks.

Hemagglutination Inhibition test (HI) to Newcastle disease vaccine: Table (7) illustrates effects of supplementation of LYS and/or ARG at 100, 110, 120 and 130% of the NRC (1994) recommendation of both essential amino acids on the results of HI titer to Newcastle disease vaccine. The analysis of variance of the obtained data showed different variations in HI titer at 14th, 24th, 33rd and 42nd days that there was a non significant increase in HI titer in quail chicks of group 4 and 11 at 42nd day which received LYS/ARG at 100/130 (highest level of ARG) and LYS/ARG at 120/120 respectively. This may indicate that ARG supplementation may have an effect on the immune response in quail chicks and these results are similar to that concluded by ***Chandrakant et al. (2006)*** who found that the antibody titers were significantly higher in ARG supplemented group when compared with unsupplemented group (control group).

<u>Phagocytosis and Differential Leukocytic count</u>: The effect of dietary LYS and/or ARG supplementation on phagocytosis and differential leukocytic count are presented in table (8). The analysis of variance of the obtained data showed that there was an increase in phagocytic activity in all supplemented LYS and/or ARG groups when compared with control. The highest phagocytic activity was observed in group 13 which fed basal diet supplemented with highest level of LYS (LYS/ARG at 130/100), followed by group 4 which fed on the higher level of ARG without LYS supplementation.. From this result, it was observed that the groups fed equal supplementation of LYS and ARG (groups 6, 11 and 16) which fed on the basal diet supplemented by 110/110, 120/120 and 130/130 of LYS/ARG respectively showed no effect on phagocytic activity when compared with the control. Regarding differential Leukocytic count, it was observed that there were some differences between supplemented LYS and/or ARG groups and the control one which fed the basal diet without supplementation as lymphocyte count was maximized in chicks of group 11 which fed the basal diet supplemented with LYS/ARG at 120/120, while basophilic cells was higher in LYS and/or ARG supplemented groups when compared with the control group. And the highest number was observed in quail chick groups fed on the basal diet supplemented with different ARG levels without LYS (groups 2, 3 and 4). On the other hand, the groups supplemented with higher levels of both LYS and ARG (groups 14, 15 and 16) had a non significant increase in basophilic cell number when compared with the control group. This means that ARG supplementation may have a higher effect in improving the immune response more than LYS supplementation for quail chicks. ARG has been reported to play an important role as a potent immunological modulator through production of nitric acid ***(Collier and Vallance, 1989)*** and has been shown to directly influence the immune system of chicken under several experimental models ***(Friedman et al., 1998 and Kidd et al., 2001).*** The outcome of this study is in accordance with the finding of ***Kidd et al. (2001) and Shang et al. (2003***) who found that ARG supplementation may enhance humoral immunity and attenuate the oxidative stress induced by burns in mice.

Effect of LYS and/or ARG on serum total protein, albumin and globulin levels: The effects of supplementation of LYS and/or ARG at 100, 110, 120 and 130% of the NRC (1994) recommendation of both essential amino acids on serum total protein, albumin, globulin and albumin/globulin (A/G) ratio of Japanese quail in different groups are illustrated in table (9). From the obtained data, an increase in serum total protein level was noticed in all supplemented LYS and /or ARG groups when compared with the control. The data revealed that ARG supplementation without LYS showed non significant increase in serum total protein (groups 2, 3 and 4) when compared with the control, while it was observed that the increase was significant ($p<0.05$) with higher levels of LYS supplementation with or without ARG supplementation (groups 13, 14, 15 and 16) and the highest total serum protein level was in group 16 which was fed basal diet supplemented with highest level of both LYS and ARG (LYS/ARG at 130/130). The data concerning albumin, globulin and A/G ratio showed different variations in which albumin was highest in group 16 and globulin was lowest in the control group and increased in all supplemented LYS and/or ARG group, while A/G ratio was also highest in the control group which fed the basal diet without any supplementation. This may indicate that globulin which is related to the immune response increased with increasing essential amino acid supplementation.

Some Blood Serum Parameters: Table (10) shows the effects of dietary supplementation of LYS and/or ARG at 100, 110, 120 and 130% NRC (1994) of both essential amino acids on SGPT, SGOT, alkaline phosphatase, cholesterol, triglycerides, creatinine, creatine, urea and uric acid of Japanese quail in different groups.

From the obtained results, it can be noticed that there was variations in the effect of supplementation on SGPT in which it was significantly higher in the group supplemented with highest level of ARG and normal requirement of LYS (LYS/ARG at 100/130) when compared with the control group. While, concerning SGOT and serum alkaline phosphatase, it can be observed that no significant difference between the supplemented LYS and /or ARG groups and control one, these findings are in agreement with those of ***Iordanova (1979).***

Regarding serum total cholesterol the data revealed that there was a significant ($p<0.05$) increase in the quail chick groups supplemented with higher levels of LYS with normal requirements of ARG (groups 5, 9 and 13) and the highest level was recorded in the group (13) which fed on highest level of LYS, that may be attributed to that excess LYS stimulated cholesterol biosynthesis and these results are in harmony with those of ***Dale et al. (1983)*** who fed a chick diets supplemented with three levels of L- LYS (0, 2, 4 and 6% of diet) and concluded that a marked hypercholesterolemia was observed in chicks fed the two higher levels of LYS. The obtained data showed a significant increase in serum triglycerides (Table 10) in the groups supplemented with higher levels of LYS with normal levels of ARG (groups 5, 9 and 13) although, there was no significant differences between these supplemented groups, the increase in triglycerides did not occur at higher levels of ARG and these results are in agreement with those of ***Dale et al. (1983) and Schmeisser et al. (1983)*** who investigated the effect of feeding broiler chicks a diet containing 4% L-LYS and observed an elevation of plasma lipids with this higher level.

The results regarding serum creatinine and creatine are illustrated in table (10) in which there was an elevation in creatinine levels in the chicks of group 11 which fed basal diet supplemented with LYS/ARG at 120/120 while the data regarding serum creatine showed that the level increased in quail chicks of groups 4, 8 and 12 which fed basal diet supplemented with LYS/ARG at 100/130, 110/130 and 120/130, respectively although there was no significant differences between all supplemented groups and control one. The analysis of variance of the obtained data in table (10) regarding serum urea and uric acid showed that there was a significant increase ($p<0.05$) in urea in quail chicks of group 16 which fed basal diet supplemented with highest levels of both LYS and ARG (130/130) when compared with the control group followed by group 12 which fed basal diet with LYS/ARG at

120/130 while the results concerning uric acid showed that there was a significant increase ($p<0.05$) in serum uric acid in quail chicks of group 16 when compared with the control group, and at the same time there was a non significant increase in the groups fed LYS levels at 120 or 130% NRC with or without ARG supplementation (groups 9-16). These results may be attributed that, increasing the dietary concentration of LYS stimulates the activity of ARG catabolizing enzyme (arginase enzyme) which leads to increase in the catabolism of arginine leading to formation of uric acid.

Carcass characteristics: The effects of dietary supplementation of LYS and/or ARG at 100, 110, 120 and 130% NRC (1994) for both essential amino acids on dressing percent, gizzard, heart, thigh, visible fat and breast meat percent of Japanese quail in different groups at the end of experimental period are summarized in table (11).

From the obtained data, it can be noticed that there was no significant difference in dressing percent and heart percent relative to the body weight between all experimental groups. While the results concerning gizzard % showed different data in which group 12 which fed the basal diet supplemented with LYS/ARG at 120/130 had the highest value (2.85%). The analysis of variance of the obtained data indicated that higher level of ARG or LYS supplementation (groups 4 and 13 respectively) significantly increased thigh percent by about 5.9% and 6.17% respectively, when compared with the control group, while thigh percent non significantly influenced by both LYS and ARG supplementation together. This may indicate that there is no interaction between LYS and ARG on thigh weight. These conclusions are in agreement with that conducted by ***Moran and Bilgili (1990).*** Concerning visible fat percent, it can be noticed that significantly decrease by about 46.3%, 50.5% and 78.2% for groups 5, 9 and 13 which fed the basal diet with 110%, 120% and 130% LYS supplementation when compared with the control, and ARG also had the same trend for decreasing the accumulation of abdominal fat (groups 2, 3 and 4), moreover the LYS and ARG synergistically interact to reduce the fat deposition as observed in gradually reduction with increasing the level of both amino acid supplementation. This may be attributed that LYS inter in the manufacturing of carnitine which have a role in fat catabolism. These findings are in harmony with those concluded by ***Leclercq (1998)*** who found that increasing dietary Lys decreased intramuscular fat. Also the obtained results are in agreement with those of ***Attia (2003)*** who found that Lys level at 0.95 and 1.01 % significantly decreased body fat deposition compared with the negative control and with those obtained by ***Hurwitz et al. (1998)*** who studied the effect of dietary arginine in diets containing 18, 20, 23 or 25%

dietary protein in broiler chickens. They observed that the amounts of extractable carcass fat or abdominal fat pad increased as dietary protein was lowered and were reduced by arginine supplementation.

Regarding the effect of LYS and/or ARG supplementation on breast meat % of Japanese quail, it can be observed that there was a significant increase (p<0.05) in breast meat % in quail chicks of groups 13 and 16 (fed LYS/ARG at 130/100 and 130/130, respectively) when compared with the control group. Also, the groups supplemented with higher LYS/ARG ratio (groups 9, 14 and 15) have a significant increase (p<0.05) in breast meat % when compared with the control group although there was a non significant differences between these groups. These findings are in agreement with those of ***Sibbald and Wolyntez (1986); Hickling et al. (1990; Bons et al. (2002)*** and ***Jianlin et al. (2004).*** While ARG supplementation (groups 2, 3 and 4) improved breast meat % by about 9.27%, 17.56% and 27.25% respectively, when compared with the control group. The results agree with those of ***Corzo et al. (2003)*** who concluded that additional total ARG up to 1.05% was needed to maximize weight recovery of fillets and total breast meat yield.

The effects of supplementation of LYS and/or ARG supplementation on Liver, spleen, thymus and bursa are summarized in table (12). The analysis of variance of the obtained data showed that there was a significant increase in liver % in quails of groups 3 and 4 which were fed basal diet supplemented with LYS/ARG at 100/120 and 100/130 when compared with those of the control group. However, there was no clear difference between other supplemented groups and the control one. The data concerning spleen % showed a significant increase (p<0.05) in quail chicks of group 4 which fed basal diet supplemented with LYS/ ARG at 100/130 when compared with the control and other supplemented groups. The results regarding thymus % showed no significant differences between all supplemented groups and control group, although the highest thymus % was noticed in group 4 (have a non significant increase when compared with the control group) which fed basal diet supplemented with LYS/ ARG at 100/130 followed by group 8 which fed basal diet supplemented with LYS/ ARG at 110/130. At the same table, the data regarding bursa % in which there were no significant differences between all supplemented groups and the controls

although the highest bursa % was noticed in group 8, which fed basal diet supplemented with LYS/ ARG at 110/130 followed by group 4 which fed basal diet supplemented with LYS/ ARG at 100/130 and this means that the highest thymus and bursa weight were obtained by highest level of ARG supplementation with or without low level of LYS supplementation. These results are in harmony with those obtained by ***Shelat et al. (1997);***

Efron and Brbul (1998); Kwak et al. (1999) and Basiouni et al (2006). The obtained data disagree with that of ***Kidd et al. (2001)***

Meat and liver chemical composition: The effect of dietary LYS and/or ARG supplementation on chemical composition (% on dry matter basis) of breast meat and liver of J. quail in different experimental groups are presented in table (13). From the obtained data, it can be observed that there was no great difference in moisture percent of breast meat between different experimental groups, while the highest value was obtained in group 5 (74.64%) which fed on the basal diet supplemented with 110% LYS from NRC requirement recommendation and the lowest values obtained in quail chick groups 12, 15 and 16, which fed on the basal diet supplemented with LYS/ARG at 120/130, 130/120 and 130/130, respectively and that moisture percent reflected consequently on the dry matter content. Moreover ash percent of breast meat showed no great difference between different experimental groups. From the obtained results, it can be noticed that the chemical analysis of CP in breast muscles showed an increase in % of CP in groups supplemented with higher levels of LYS alone (groups 9 and 13 which fed the basal diet supplemented with LYS/ARG at 120/100 and 130/100, respectively) or quail chicks of group supplemented with higher levels of both LYS and ARG (groups 11, 15 and 16 which fed the basal diet supplemented with LYS/ARG at 120/120, 130/120 and 130/130, respectively). These results may indicate that LYS is more related to increasing protein deposition in breast muscle than ARG supplementation singly. From the obtained data concerning chemical composition of liver it can be observed that there were no great differences in moisture content or DM content between supplemented and unsupplemented groups but DM of liver is highest in group 16 which fed the basal diet supplemented with higher levels of both LYS and ARG at 130/130. It can be observed that the CP % of liver was higher in groups supplemented with either LYS and /or ARG when compared with the control group and the increase in CP % of liver resulted with increasing LYS supplementation alone or with ARG supplementations (groups 9, 10, 12, 13, 14, 15 and 16) followed by the group supplemented with highest level of ARG alone (group 4). The obtained results agree with those of ***Lehman et al. (1996); Leclercq (1998) and Urdaneta and Leeson (2004)***

Nutrient digestibility: Effect of dietary LYS/ARG supplementation on nutrient digestibility is presented in table (14). From the obtained results it can be observed that the digestibility of DM and ash didn't had specific trend and generally not altered with different LYS and/or ARG supplementations in different groups but the digestibility of CP improved in quail chicks of group 9 which fed the basal diet supplemented with LYS at 120% NRC without ARG supplementation followed by the control group which were fed the basal diet without amino acids supplementation. These results agree with that of ***Abd-Elsamea (2001).***

Conclusion: From the obtained data, it can be concluded that ARG or LYS supplementation separately improve growth performance of quail chick, while supplementation of both amino acids together especially with the higher levels may negatively affect growth performance of J. quail. Supplementation of ARG and/or LYS improve thigh, breast meat percent and reduce the accumulation of visible fat, moreover improve immune response but increase the concentration of some blood parameters. From economical point of view, improvement of healthy condition and higher immune response of J. quail chick can be concluded that ARG supplementation at higher level (130% from the requirement) better than LYS and/or LYS with ARG supplementation.

Table (4): Effect of dietary lysine and/or arginine supplementation on body weight development (g) in different J. quail experimental groups.

Group No.	Age ((Weeks)						
	0	1	2	3	4	5	6
1	10.42 ±0.15^{a}	20.10 ±0.64^{ab}	39.20 ±2.04^{ab}	72.94 ±2.76^{ab}	107.84 ±3.34^{abc}	145.82 ±3.37^{bcd}	176.43 ±3.48^{bcde}
2	10.31± 0.18^{a}	20.55 ±0.58^{ab}	40.34 ±1.76^{a}	72.66 ±2.87^{ab}	112.84 ±3.69^{ab}	148.86 ±3.26^{abc}	178.22 ±2.98^{bcd}
3	10.65± 0.22^{a}	20.92 ±0.72^{ab}	40.83 ±1.95^{a}	72.78 ±3.24^{ab}	113.18 ±3.98^{ab}	150.94 ±3.67^{ab}	180.79 ±3.98^{abc}
4	10.51± 0.18^{a}	20.83 ±0.59^{ab}	40.49 ±1.77^{a}	67.62 ±2.61^{abc}	110.17 ±3.41^{abc}	147.47 ±3.54^{abcd}	184.45 ±3.44^{ab}
5	10.61± 0.16^{a}	20.14 ±0.66^{ab}	38.91 ±1.96^{ab}	73.45 ±3.24^{ab}	109.23 ±4.55^{abc}	145.02 ±3.89^{bcd}	183.00 ±3.41^{ab}
6	10.42± 0.20^{a}	21.69 ±0.64^{a}	35.10 ±1.83^{ab}	60.97 ±3.05^{c}	104.36 ±3.81^{bc}	144.99 ±3.53^{bcd}	175.23 ±3.40^{bcde}
7	10.67± 0.15^{a}	19.72 ±0.42^{ab}	33.75 ±1.41^{b}	61.62 ±2.55^{c}	105.38 ±3.22^{abc}	142.17 ±3.79^{bcde}	175.21 ±4.07^{bcde}
8	10.69± 0.16^{a}	19.91 ±0.51^{ab}	39.74 ±1.87^{ab}	64.78 ±2.59^{bc}	102.59 ±3.63^{bc}	134.91 ±4.48^{de}	167.21 ±4.18^{e}
9	10.32± 0.19^{a}	20.82 ±0.63^{ab}	37.18 ±1.90^{ab}	63.91 ±2.95^{bc}	106.21 ±2.96^{abc}	147.00 ±4.02^{bcd}	181.12 ±4.18^{abc}
10	10.43± 0.18^{a}	19.38 ±0.47^{b}	36.29 ±1.90^{ab}	63.88 ±3.21^{bc}	101.55 ±4.22^{bc}	136.90 ±4.45^{cde}	166.55 ±5.07^{e}
11	10.45± 0.15a	21.14 ±0.73^{ab}	35.79 ±1.97^{ab}	63.77 ±3.34^{bc}	105.60 ±4.42^{abc}	142.10 ±4.39^{bcde}	167.90 ±4.76^{de}
12	10.30± 0.17^{a}	19.78 ±0.75^{ab}	35.18 ±1.93^{ab}	64.40 ±3.47^{bc}	97.95 ±4.52^{c}	131.85 ±5.39^{e}	168.33 ±5.19^{cde}
13	10.51± 0.18^{a}	19.57 ±0.68^{b}	36.18 ±1.70^{ab}	68.00 ±2.48^{abc}	106.94 ±3.38^{abc}	151.35 ±2.40^{ab}	182.15 ±2.82^{ab}
14	10.68± 0.11^{a}	20.77 ±0.70^{ab}	40.81 ±1.98^{b}	74.87 ±3.19^{a}	117.33 ±3.59^{a}	159.26 ±3.88^{a}	190.63 ±4.09^{a}
15	10. 87± 0.19^{a}	19.90 ±0.54^{ab}	36.42 ±1.83^{ab}	64.47 ±2.82^{bc}	102.50 ±3.58^{bc}	145.32 ±3.42^{bcd}	180.20 ±3.40^{abcd}
16	10.61± 0.15^{a}	19.18 ±0.56^{b}	34.14 ±1.75^{b}	63.71 ±2.90^{bc}	105.10 ±3.57^{abc}	137.87 ±3.84^{cde}	169.12 ±3.35^{cde}

Values are means ± standard error. Means values with different letters at the same column differ significantly at $p = 0.05$

Table (5): Effect of dietary lysine and/or arginine supplementation on body weight gain (WG/g/chick), relative growth rate (RGR), feed intake (FI/g/Bird) and feed conversion ratio (FCR) in different J. quail experimental groups.

Group No.	Parameters						
	Total BG (g)	BG relative to control	RGR	Total FI (g)	FI relative to control	Average FCR	FCR relative to control
1	166.01±3.46^{bcde}	100.00	177.69±0.60^{abcd}	662.97	100.0	3.99	100.0
2	167.91±2.91^{bcd}	101.14	178.13±0.40^{abc}	678.09	102.28	4.04	101.25
3	170.14±3.92^{abcd}	102.49	177.75±0.55^{abcd}	667.13	100.63	3.92	98.25
4	173.94±3.40^{ab}	104.78	178.44±0.48^{ab}	672.14	101.38	3.86	96.74
5	172.39±3.40^{ab}	103.84	178.08±0.50^{abc}	690.1	104.09	4.10	102.76
6	164.81±3.40^{bcde}	99.28	177.55±0.62^{bcde}	671.33	101.26	4.07	102.0
7	164.54±4.04^{bcde}	99.11	177.04±0.48^{bcde}	671.0	101.21	4.08	102.26
8	156.53±4.15^{e}	94.29	175.96±0.61^{e}	680.45	102.64	4.43	111.03
9	170.81±4.11^{abc}	102.89	178.44±0.49^{ab}	674.6	101.75	3.95	99.0
10	156.12±4.98^{e}	94.04	176.43±0.64^{cde}	688.53	103.86	4.41	110.53
11	157.45±4.73^{de}	94.84	176.56±0.64^{bcde}	697.0	105.13	4.41	110.53
12	158.04±5.09^{de}	95.20	176.94±0.82^{de}	663.9	100.14	4.20	105.26
13	171.64±2.74^{ab}	103.39	178.18±0.35^{abc}	679.46	102.49	3.96	99.25
14	179.96±4.00^{a}	108.40	178.78±0.28^{a}	673.4	101.57	3.74	93.73
15	169.33±3.30^{abcd}	101.99	177.24±0.37^{abcde}	667.54	100.69	3.94	98.75
16	158.51±3.28^{cde}	95.48	176.39±0.46^{de}	680.11	102.59	4.29	107.52

Values are means ± standard error. Means values with different letters at the same column differ significantly at p = 0.05

Table (6): Effect of dietary lysine and/or arginine supplementation on blood picture {erythrocyte count (RBCs), leucocyte count (WBCs), hemoglobin (Hb) and packed cell volume (PCV) % of Japanese quail groups.

Group No.	Items			
	RBCs 10^6	WBCs 10^3	Hb%	PCV%
1	2.57±0.15^{ef}	21.30±0.47^{abc}	10.30±0.26^{ab}	30.10±0.90^{ab}
2	2.54±0.13^{ef}	21.10±0.50^{abc}	9.20±0.49^{bcd}	28.70±1.19^{abc}
3	2.38±0.06^{f}	22.50±0.50^{ab}	9.80±0.59^{abc}	26.50±1.45^{bc}
4	2.99±0.13^{bcd}	21.70±0.42^{abc}	8.60±0.50^{cd}	27.20±1.27^{abc}
5	2.72±0.14^{def}	21.40±0.56^{abc}	8.80±0.42^{bcd}	24.80±1.19^{c}
6	2.69±0.16^{def}	21.30±0.58^{abc}	10.00±0.47^{abc}	30.90±1.34^{a}
7	2.97±0.08^{bcd}	20.50±0.40^{bc}	8.20±0.42^{d}	26.50±1.28^{bc}
8	2.72±0.14^{def}	22.20±0.55^{abc}	9.80±0.36^{abc}	29.50±0.81^{ab}
9	2.98±0.10^{bcd}	21.50±0.60^{abc}	9.90±0.59^{abc}	28.30±1.04^{abc}
10	2.99±0.13^{bcd}	21.90±1.00^{abc}	9.50±0.37^{abcd}	28.40±1.39^{abc}
11	2.90±0.08^{cde}	22.70±0.92^{a}	9.60±0.60^{abcd}	28.80±1.55^{abc}
12	3.15±0.07^{abc}	20.20±0.65^{c}	9.80±0.49^{abc}	29.80±1.54^{ab}
13	2.68±0.14^{def}	20.80±0.51^{abc}	9.00±0.45^{bcd}	28.60±1.33^{abc}
14	2.69±0.16^{def}	22.40±0.83^{ab}	10.90±0.53^{a}	31.20±1.31^{a}
15	3.20±0.08^{abc}	22.50±0.50^{ab}	9.10±0.53^{bcd}	27.30±1.17^{abc}
16	3.36±0.15^{a}	21.00±0.61^{abc}	9.60±0.43^{abcd}	29.00±1.12^{abc}

Values are means ± standard error. Mean values with different letters at the same column differ significantly at p = 0.05

Table (7): Effect of dietary lysine and/or arginine supplementation on hemagglutination inhibition (HI), Geometric mean titer against ND virus vaccine of Japanese quail groups.

Group No.	Age (Days)			
	14	24	33	42
1	4.00±0.00^{abc}	3.67±0.33^{de}	4.00±0.00^{a}	4.67±0.33^{ab}
2	3.50±0.50^{abc}	4.00±0.00^{cde}	4.33±0.88^{a}	3.67±0.33^{b}
3	3.00±0.00^{bc}	4.67±0.33^{abcd}	4.67±0.33^{a}	4.77±0.33^{ab}
4	4.00±0.00^{abc}	4.00±0.58^{cde}	4.67±0.67^{a}	5.67±0.67^{a}
5	3.50±0.50^{abc}	4.00±0.58^{cdde}	5.67±0.67^{a}	4.67±0.67^{ab}
6	4.50±0.50^{ab}	4.00±0.58^{cde}	5.33±0.67^{a}	5.33±0.33^{ab}
7	2.50±0.50^{c}	3.67±0.33^{de}	5.00±1.00^{a}	3.67±0.33^{b}
8	3.50±0.50^{abc}	3.33±0.33^{e}	4.67±1.20^{a}	4.67±0.67^{ab}
9	4.00±0.00^{abc}	5.33±0.33^{ab}	4.33±0.33^{a}	4.00±0.58^{ab}
10	5.00±1.00^{a}	5.00±0.00^{abc}	6.00±0.00^{a}	4.67±0.33^{ab}
11	3.50±0.50^{abc}	4.33±0.33^{bcde}	5.00±0.58^{a}	5.67±0.33^{a}
12	3.50±0.50^{abc}	4.33±0.33^{bcde}	4.00±0.58^{a}	5.00±0.58^{ab}
13	4.00±1.00^{abc}	4.33±0.33^{bcde}	5.00±1.00^{a}	4.33±0.33^{ab}
14	4.50±0.50^{ab}	5.67±0.33^{a}	4.67±0.67^{a}	5.33±0.67^{ab}
15	3.50±0.50^{abc}	3.67±0.33^{de}	5.00±1.00^{a}	5.33±0.67^{ab}
16	3.50±0.50^{abc}	4.00±0.00^{cde}	4.67±0.33^{a}	4.67±0.33^{ab}

Values are means ± standard error. Means values with different letters at the same column differ significantly at p = 0.05

Table (8): Effect of dietary lysine and/or arginine supplementation on phagocytic activity, phagocytic index and differential leucocytes count (%) of Japanese quail groups.

Gr. No.	Items						
	Phagocytic activity	Phagocytic index	Lympho-Cyte.	Monocyte	Basophile	Eosinophile	Neutrophile
1	20.10± 0.43^{d}	2.27± 0.07^{def}	53.40± 0.65^{def}	1.70± 0.30^{ab}	6.50± 0.31^{e}	8.70± 0.42^{abcd}	29.70± 0.70^{abc}
2	22.80± 0.65^{abc}	2.55± 0.12^{bcde}	55.30± 0.76^{bcde}	1.70± 0.37^{ab}	8.40± 0.37^{abcd}	8.70± 0.37^{abcd}	25.90± 1.07^{cde}
3	21.80± 0.70^{abcd}	3.23± 0.11^{a}	53.10± 0.71^{def}	1.30± 0.21^{b}	8.90± 0.43^{abcd}	10.00± 0.39^{a}	26.70± 0.90^{bcde}
4	23.50± 0.80^{a}	2.59± 0.16^{bcd}	52.10± 0.77^{fg}	1.80± 0.39^{ab}	9.20± 0.42^{abc}	7.40± 0.52^{cd}	29.50± 1.15^{abc}
5	21.50± 0.52^{abcd}	2.09± 0.08^{ef}	55.70± 0.88^{bcd}	2.40± 0.34^{ab}	7.90± 0.43^{de}	9.00± 0.47^{abc}	25.00± 1.12^{de}
6	20.30± 0.47^{d}	2.85± 0.13^{ab}	54.60± 1.05^{cdef}	1.40± 0.40^{ab}	8.20± 0.49^{bcd}	9.20± 0.55^{ab}	26.60± 1.51^{bcde}
7	21.80± 0.55^{abcd}	2.12± 0.09^{ef}	54.00± 0.54^{cdef}	1.20± 0.29^{b}	8.70± 0.79^{abcd}	8.00± 0.60^{bcd}	28.10± 1.04^{abcd}
8	23.00± 0.71^{ab}	2.43± 0.22^{bcdef}	54.90± 1.20^{cdef}	1.70± 0.37^{ab}	9.40± 0.40^{ab}	7.30± 0.52^{d}	26.70± 1.49^{bcde}
9	21.20± 0.47^{bcd}	2.40± 0.22^{cdef}	56.60± 0.88^{abc}	1.80± 0.39^{ab}	7.80± 0.51^{de}	8.60± 0.60^{abcd}	25.20± 1.44^{de}
10	22.00± 0.39^{abcd}	2.44± 0.14^{bcdef}	53.10± 0.90^{def}	1.60± 0.40^{ab}	7.40± 0.54^{de}	8.90± 0.41^{abcd}	29.00± 1.01^{abcd}
11	20.60± 0.48^{d}	2.78± 0.16^{bc}	58.90± 1.19^{a}	2.10± 0.31^{ab}	9.90± 0.60^{a}	8.70± 0.45^{abcd}	20.40± 1.59^{f}
12	21.50± 0.64^{abcd}	2.29± 0.14^{def}	57.80± 1.07^{ab}	1.70± 0.45^{ab}	9.00± 0.37^{abc}	8.20± 0.55^{bcd}	23.30± 1.55^{ef}
13	23.60± 0.90^{a}	2.16± 0.11^{def}	53.10± 0.91^{def}	1.60± 0.31^{ab}	7.40± 0.48^{de}	8.70± 0.52^{bcd}	29.20± 1.42^{abc}
14	22.80± 0.88^{abc}	2.32± 0.09^{def}	50.10± 0.60^{g}	2.60± 0.60^{a}	7.60± 0.43^{de}	8.60± 0.37^{abcd}	31.10± 0.89^{a}
15	22.10± 0.67^{abcd}	2.07± 0.14^{f}	52.50± 0.76^{efg}	2.00± 0.39^{ab}	7.60± 0.45^{de}	8.00± 0.52^{bcd}	29.90± 0.77^{ab}
16	20.40± 0.47^{d}	2.37± 0.16^{cdef}	52.30± 0.72^{fg}	1.70± 0.37^{ab}	7.10± 0.31^{de}	9.20± 0.33^{ab}	29.70± 0.90^{abc}

Values are means ± standard error. Mean values with different letters at the same column differ significantly at $p = 0.05$

Table (9): Effect of dietary lysine and/or arginine supplementation on serum total protein, albumin, globulin and albumin/globulin (A/G) ratio of Japanese quail groups.

Group No.	Items			
	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	A/G ratio
1	3.97±0.41[d]	3.10±0.35[cd]	0.87±0.29[b]	3.56±1.47[a]
2	4.40±0.15[cd]	3.13±0.15[cd]	1.27±0.12[ab]	2.46±0.30[ab]
3	4.47±0.45[bcd]	2.90±0.25[cd]	1.57±0.35[ab]	1.85±0.51[b]
4	4.43±0.27[bcd]	3.03±0.18[cd]	1.40±0.15[ab]	2.16±0.21[b]
5	5.30±0.06[abc]	3.43±0.19[abcd]	1.87±0.24[a]	1.83±0.39[b]
6	4.86±0.18[abc]	3.63±0.26[abcd]	1.23±0.09[ab]	2.95±0.42[ab]
7	5.06±0.19[abc]	3.23±0.09[bcd]	1.83±0.15[a]	1.76±0.13[b]
8	4.47±0.03[abc]	3.50±0.21[abcd]	0.97±0.22[ab]	3.61±0.49[ab]
9	4.83±0.23[abcd]	3.27±0.07[bcd]	1.56±0.19[ab]	2.09±0.26[b]
10	4.47±0.45[bcd]	2.90±0.25[cd]	1.57±0.35[ab]	1.85±0.51[b]
11	4.66±0.37[bcd]	3.33±0.19[bcd]	1.33±0.49[ab]	2.50±1.14[ab]
12	4.73±0.32[abcd]	2.80±0.38[d]	1.93±0.09[a]	1.45±0.24[b]
13	5.07±0.20[abc]	3.57±0.20[abcd]	1.50±0.35[ab]	2.38±0.60[ab]
14	5.33±0.15[ab]	3.73±0.20[abc]	1.60±0.15[ab]	2.33±0.30[ab]
15	5.60±0.26[a]	4.00±0.36[ab]	1.60±0.17[ab]	2.50±0.44[ab]
16	5.63±0.28[a]	4.17±0.32[a]	1.46±0.39[ab]	2.86±1.54[ab]

Values are means ± standard error. Means values with different letters at the same column differ significantly at p = 0.05

Table (10): Effect of dietary lysine and/or arginine supplementation on some blood parameters of Japanese quail groups.

Groups	Parameters								
	SGPT (U/100ml)	SGOT (U/100ml)	Alkaline phosphatase (U/100ml)	Cholesterol (mg/dl)	Triglycerides (mg/dl)	Creatinine (mg/dl)	Creatine (mg/dl)	Urea (mg/dl)	Uric acid (mg/dl)
1	67.33± 1.33^{def}	71.67± 3.84^{a}	10.67± 0.33^{a}	197.67± 1.76^{bcd}	186.00± 2.52^{cd}	0.45± 0.05^{de}	0.60± 0.15^{a}	3.23± 0.24^{def}	8.33± 0.67^{b}
2	70.33± 2.03^{abcdef}	70.00± 3.46^{a}	11.67± 1.20^{a}	197.97± 5.21^{bcd}	188.00± 2.65^{bcd}	0.61± 0.03^{abc}	0.50± 0.15^{a}	3.47± 0.12^{cde}	9.67± 1.33^{b}
3	73.33± 1.76^{abc}	68.00± 2.08^{a}	12.00± 0.58^{a}	218.00± 6.66^{abc}	190.67± 0.88^{abc}	0.63± 0.02^{abc}	0.40± 0.06^{a}	2.77± 0.18^{fg}	8.33± 0.88^{b}
4	74.33± 2.33^{a}	69.33± 2.91^{a}	10.67± 0.88^{a}	190.67± 1.45^{d}	197.33± 2.96^{ab}	0.56± 0.06^{abcd}	0.82± 0.07^{a}	3.97± 0.22^{abc}	9.00± 1.15^{b}
5	73.67± 2.03^{ab}	72.00± 4.36^{a}	11.00± 1.15^{a}	218.00± 3.79^{abc}	199.00± 4.04^{a}	0.42± 0.06^{e}	0.53± 0.22^{a}	3.83± 0.15^{bcd}	8.33± 0.33^{b}
6	70.67± 1.20^{abcdef}	71.33± 3.84^{a}	10.33± 0.67^{a}	209.00± 5.29^{bcd}	193.00± 1.53^{abc}	0.60± 0.08^{abc}	0.73± 0.03^{a}	3.37± 0.15^{cdef}	9.67± 0.33^{b}
7	68.00± 1.15^{cdef}	68.67± 2.33^{a}	10.67± 0.33^{a}	204.00± 1.53^{bcd}	195.00± 8.50^{abc}	0.60± 0.03^{abc}	0.70± 0.12^{a}	3.43± 0.35^{cdef}	8.67± 0.88^{b}
8	66.33± 1.86^{ef}	71.00± 3.51^{a}	12.67± 0.88^{a}	201.67± 2.91^{bcd}	193.00± 1.15^{abc}	0.53± 0.04^{bcde}	0.81± 0.15^{a}	3.00± 0.38^{efg}	8.33± 0.67^{b}
9	65.67± 2.19^{f}	73.67± 5.04^{a}	11.33± 0.33^{a}	223.67± 4.81^{ab}	200.00± 3.51^{a}	0.54± 0.02^{bcde}	0.77± 0.09^{a}	2.40± 0.12^{g}	11.33± 2.33^{ab}
10	69.67± 2.03^{abcdef}	72.00± 4.62^{a}	11.33± 0.33^{a}	189.67± 6.33^{d}	186.67± 3.18^{bcd}	0.51± 0.03^{cde}	0.80± 0.06^{a}	3.13± 0.26^{def}	11.67± 2.67^{ab}
11	69.67± 0.88^{abcdef}	70.00± 4.58^{a}	10.67± 0.33^{a}	215.33± 3.48^{abcd}	171.67± 1.20^{f}	0.69± 0.02^{a}	0.67± 0.03^{a}	4.07± 0.18^{abc}	11.00± 1.15^{ab}
12	71.67± 1.67^{abcdef}	73.33± 4.70^{a}	10.33± 1.67^{a}	198.67± 4.98^{bcd}	179.00± 0.58^{def}	0.67± 0.03^{ab}	0.82± 0.24^{a}	4.40± 0.17^{ab}	11.00± 0.58^{ab}
13	72.33± 1.20^{abcd}	66.67± 1.45^{a}	12.00± 1.00^{a}	239.00± 27.01^{a}	198.33± 3.71^{a}	0.60± 0.02^{abc}	0.74± 0.06^{a}	4.03± 0.22^{abc}	11.67± 0.33^{ab}
14	68.67± 0.88^{bcdef}	67.00± 3.51^{a}	11.33± 0.88^{a}	192.33± 6.98^{cd}	185.00± 3.00^{cde}	0.64± 0.01^{ab}	0.70± 0.15^{a}	3.67± 0.23^{cdde}	11.88± 1.33^{ab}
15	68.00± 1.15^{cdef}	69.00± 2.52^{a}	11.33± 0.33^{a}	196.67± 1.86^{bcd}	191.33± 0.88^{abc}	0.65± 0.01^{ab}	0.77± 0.09^{a}	3.73± 0.09^{bcd}	12.00± 1.53^{ab}
16	70.33± 0.33^{abcde}	66.00± 2.00^{a}	11.67± 0.67^{a}	197.00± 1.73^{bcd}	175.33± 2.73^{ef}	0.51± 0.02^{cde}	0.60± 0.25^{a}	4.57± 0.09^{a}	15.33± 2.33^{a}

Values are means ± standard error. Means values with different letters at the same column differ significantly at $p = 0.05$

Table (11): Effect of dietary lysine and/or arginine supplementation on dressing percent, gizzard, heart, thigh, visible fat and breast meat percent (% relative to the live body weight) of Japanese quail groups.

Group No.	Items					
	Dressing%	Gizzard%	Heart%	Thigh%	Visible fat%	Breast meat%
1	65.82±1.20[a]	1.95±0.11[bcd]	0.98±0.05[a]	7.29±0.16[ab]	1.88±0.40[a]	14.35±1.56[c]
2	67.01±1.06[a]	2.17±0.13[bc]	0.91±0.07[a]	7.46±0.06[ab]	1.41±0.40[ab]	15.68±1.06[bc]
3	64.13±1.68[a]	2.25±0.30[bc]	0.90±0.01[a]	6.99±0.09[ab]	0.96±0.27[bc]	16.87±0.66[bc]
4	66.36±0.64[a]	2.06±0.29[bc]	0.89±0.08[a]	7.72±0.35[a]	0.69±0.29[bc]	18.26±0.77[ab]
5	65.80±1.08[a]	2.19±0.14[bc]	0.91±0.07[a]	7.31±0.29[ab]	1.01±0.45[abc]	16.93±0.20[bc]
6	66.18±1.15[a]	2.21±0.15[bc]	0.93±0.05[a]	6.96±0.31[ab]	0.88±0.29[bc]	16.28±1.16[bc]
7	66.09±1.59[a]	2.27±0.17[abc]	0.90±0.08[a]	6.89±0.23[ab]	0.81±0.08[bc]	18.26±0.77[eb]
8	67.70±1.28[a]	2.28±0.15[abc]	0.93±0.05[a]	7.58±0.17[ab]	0.74±0.20[bc]	17.23±1.32[bc]
9	65.91±0.65[a]	2.30±0.19[abc]	0.94±0.07[a]	7.19±0.25[ab]	0.93±0.22[bc]	18.57±1.24[ab]
10	66.55±1.49[a]	2.27±0.15[abc]	0.83±0.06[a]	6.51±0.65[b]	0.78±0.12[bc]	17.20±0.69[bc]
11	67.33±0.71[a]	1.86±0.15[cd]	0.97±0.06[a]	7.35±0.18[ab]	1.41±0.40[ab]	16.29±0.11[bc]
12	64.69±0.48[a]	2.85±0.28[a]	0.83±0.06[a]	7.05±0.41[ab]	1.14±0.19[abc]	16.65±0.99[bc]
13	66.68±0.61[a]	2.35±0.16[abc]	0.91±0.04[a]	7.74±0.26[a]	0.41±0.07[c]	20.62±1.662[a]
14	65.86±1.16[a]	1.46±0.06[d]	0.85±0.04[a]	7.35±0.32[ab]	1.27±0.61[abc]	18.26±0.22[ab]
15	66.04±1.30[a]	2.08±0.16[bc]	0.83±0.07[a]	7.12±0.14[ab]	0.45±0.14[bc]	18.16±0.77[eb]
16	65.43±0.58[a]	2.52±0.14[ab]	0.97±0.06[a]	7.58±0.17[ab]	0.33±0.07[c]	20.00±1.62[e]

Values are means ± standard error. Means values with different letters at the same column differ significantly at p = 0.05

Table (12): Effect of dietary lysine and/or arginine supplementation on liver, spleen, thymus and bursa (% relative to the live body weight) of Japanese quail groups.

Group No.	Organs			
	Liver	Spleen	Thymus	Bursa
1	2.29±0.13[b]	0.08±0.02[b]	0.30±0.03[abc]	0.09±0.02[ab]
2	2.56±0.11[ab]	0.07±0.01[b]	0.23±0.03[bc]	0.08±0.01[b]
3	3.23±0.39[a]	0.10±0.02[b]	0.32±0.09[abc]	0.12±0.03[ab]
4	3.21±0.39[a]	0.32±0.09[a]	0.46±0.03[a]	0.14±0.02[ab]
5	3.02±0.28[ab]	0.10±0.03[b]	0.32±0.03[bc]	0.13±0.01[ab]
6	2.46±0.30[ab]	0.10±0.03[b]	0.23±0.05[bc]	0.11±0.02[ab]
7	2.84±0.34[ab]	0.07±0.01[b]	0.32±0.04[abc]	0.13±0.04[ab]
8	2.46±0.30[ab]	0.06±0.00[b]	0.33±0.09[abc]	0.17±0.06[a]
9	2.29±0.13[b]	0.06±0.00[b]	0.17±0.04[c]	0.09±0.02[ab]
10	2.59±0.32[ab]	0.06±0.00[b]	0.27±0.05[abc]	0.10±0.02[ab]
11	2.68±0.14[ab]	0.06±0.00[b]	0.40±0.07[ab]	0.15±0.02[ab]
12	2.58±0.11[ab]	0.07±0.00[b]	0.24±0.05[bc]	0.08±0.01[b]
13	2.73±0.22[ab]	0.06±0.00[b]	0.24±0.07[bc]	0.07±0.01[b]
14	2.52±0.37[ab]	0.06±0.00[b]	0.36±0.06[abc]	0.08±0.01[b]
15	2.84±0.34[ab]	0.06±0.00[b]	0.34±0.07[abc]	0.08±0.02[b]
16	2.79±0.21[ab]	0.06±0.00[b]	0.26±0.07[bc]	0.08±0.01[b]

Values are means ± standard error. Means values with different letters at the same column differ significantly at p = 0.05

Table (13): Effect of dietary lysine and/or arginine supplementation on chemical composition (%, on dry matter basis) of breast meat and liver of Japanese quail groups.

GR. No.	Breast meat				Liver			
	Moisture	DM	CP	Ash	Moisture	DM	CP	Ash
1	70.18	29.82	71.22	3.82	68.21	31.79	44.89	4.90
2	70.81	29.19	70.89	4.45	69.04	30.96	45.90	4.98
3	71.77	28.23	73.25	4.12	63.41	36.59	44.60	4.99
4	70.29	29.71	74.54	4.45	68.20	31.80	47.73	5.12
5	74.64	25.36	71.62	3.40	68.48	31.52	46.25	5.32
6	72.85	27.15	73.56	3.30	71.26	28.74	46.26	4.87
7	71.64	28.36	72.23	3.50	68.33	31.67	45.30	5.20
8	72.30	27.70	71.89	3.75	66.32	33.68	46.20	5.00
9	70.65	29.35	75.56	3.30	66.89	33.11	49.81	4.90
10	73.39	26.61	72.36	3.80	65.02	34.98	47.78	4.90
11	72.76	27.24	75.62	4.18	69.44	30.56	45.23	4.89
12	69.23	30.77	70.35	4.10	69.05	30.95	48.62	5.30
13	72.01	27.99	75.65	4.00	65.26	34.74	48.23	4.30
14	70.97	29.03	74.21	4.10	65.99	34.01	47.20	5.23
15	69.30	30.70	75.21	3.50	68.48	31.52	48.20	5.40
16	69.59	30.41	75.62	4.10	63.98	36.02	51.71	4.75

Table (14): Effect of dietary lysine and/or arginine supplementation on nutrient digestibility of Japanese quail experimental groups.

Groups No.	Items		
	Dry matter	Crude protein	Ash
1	69.86	93.38	78.49
2	72.62	92.89	82.23
3	67.62	91.86	76.36
4	63.83	91.07	73.01
5	63.59	91.85	76.96
6	62.6	90.28	76.39
7	69.42	92.92	79.16
8	67.13	92.54	78.13
9	68.14	93.88	77.68
10	70.94	92.45	78.79
11	64.33	88.59	73.39
12	62.45	89.40	76.25
13	63.17	90.34	86.77
14	70.72	92.50	80.05
15	67.53	90.50	79.47
16	67.73	90.68	78.55

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