EFFICIENCY OF DIFFERENT LEVELS OF L-CARNITINE SUPPLEMENTATION ON GROWTH PERFORMANCE AND BLOOD PARAMETERS IN THREE LINES OF KURDISH QUAILS (*COTURNIX COTURNIX*)

Lina S. Mahdi Assist. Lecture
Lajan S. Ahmed* Assist. Prof.
Parizan W. Ibrahim Assist. Lecture
Gulstan H. Radha Assist. Lecture
Coll. Agric. Engin. Sci. - Salahaddin University
*lajan.ahmed@su.edu.krd

ABSTRACT

This study was aimed to assess the impact of genetic groups (comprising three distinct lines of Kurdish quails, which are desert, brown, and white), graded levels of L-carnitine and their interaction on the performance of growth traits and blood parameters. For this purpose, the same basic diet was given to 480 Kurdish quail chicks one day old, which was then supplemented for two to seven weeks of age with 0 (control), 150, 350, or 550 mg of L-carnitine per kg of diet. The statistical analysis showed that the lines, L-carnitine supplementation, and their interaction had a significant (p≤0.01) impact on the Kurdish quail's blood parameters, feed intake, feed conversion ratio, body weight, and body weight gain. The desert lines exhibited significantly higher growth performance values in all weeks. Furthermore, supplementation with 350 and 550 mg/kg L-carnitine throughout the experimental period significantly improved these characteristics compared to the control group, with the other experimental treatment (150 mg L-carnitine/kg diet) having the highest values. As well as for the interacted groups, the desert lines with diet of 350 mg/kg L-carnitine had significant influence on body weight, and weight gain. On the other hand, the white lines with a diet of 350 mg/kg L-carnitine showed significantly (P≤0.01) better feed intake and better feed conversion ratio than all other treatments in the same period. It was concluded that L-carnitine supplementation at 350 and 550 mg/kg was sufficient to improve growth characteristics and blood parameters in Kurdish quail lines.

Key words: quail, l- carnitine, diet, growth performance, blood estimations.

تأثيراضافة مستويات مختلفة من ل- كارنتين على أداء النمو وبعض المعايير الدمويةفي ثلاثة خطوط من طيور السمان الكردي(*COTURNIX COTURNIX*)

لينا صلاح مهدي مدرس مساعد
لاجان صلاح الدين احمد استاذ مساعد
بريزان هوشيار ابراهيم مدرس مساعد
كولستان حمدامين رضا مدرس مساعد
كلية علوم الهندسة الزراعية- جامعة صلاح الدين

المستخلص

هدفت الدراسة التقييم تأثير كل من المجموعات الوراثية (ثلاثة سلالات مختلفة من السمان الكردي وهي الصحراوي والبني والأبيض)، وإضافة المستويات مختلفة من ل- كارنتين والتفاعل بينها على أداء صفات النمو وتحليلات الدموية. من أجل تحقيق ذلك، تم تربية أربعمائة وثمانين الافراخ من السمان الكردي من عمر يوم واحد وغذيت على نفس النظام الغذائي الأساسي الذي تم استكماله بـ 0 (مجموعة السيطرة)، 150، 350، أو 550 ملغم/ كغم ل-كارنيتين من النظام الغذائي من العمر 2 إلى 7 اسبوع. اشارت نتائج التحليل الإحصائي الى وجود فرق معنوي (p≤0.01) لكل من خطوط، نتيجة اضافة ل- كارنتين والتداخل بينهما (العليقة × الخطوط) على كل من وزن الجسم، والزيادة الوزنية، واستهلاك العلف, وكفاءة تحويل العلف، وبعض الصفات الدموية في السمان الكردي. وكذلك تفوق خط صحراوي على الخطين ابيض والبني في أداء النمو بشكل ملحوظ في جميع الأسابيع التي تم الدرستها. كما أظهرت النتائج فرقاَ معنويًا في هذه الصفات عند إضافة 350 و550 ملغم / كغم من ل- كارنيتين طوال فترة التجربة مقارنة بمجموعة السيطرة والمعاملات التجريبية الأخرى (150 ملجم ل-كارنيتين / كغم من العلف). بالإضافة إلى التداخل بين (العليقة × الخطوط) ، هناك فرق معنوي للخطوط الصحراوية التي غذيت على 350 ملغم / كغم من ل- كارنيتين لها تأثير كبير على وزن الجسم وزيادة وزنيةللجسم. بينما الخطوط البيضاء التي غذيت على 350 ملغم / كغم ل- كارنيتين لها تاثيرمعنوي عالي (P≤0.01) على استهلاك العلف ونسبة تحويل العلف مقارنة بالمعاملات الاخرى. تستنتج أن إضافةل- كارنتين بمستويين 350 و 550 ملغم / كغم للعليقة ادى الى تحسين صفات النمو وبعض المقاييس الدموية في سلالات السمان الكردية.

الكلمات المفتاحية: السمان، ل-كارنتين، النظام الغذائي، اداء النمو، صفات الدموية

Received:12/2/2023 Accepted:31/5/2023

INTRODUCTION

The demand for animal-based protein, such as meat and eggs, for human consumption is on the rise. To improve the productivity indices of livestock production, farmers and scientists are looking into new approaches to animal production (17). Quail a small avian species, is widely used as a laboratory animal in research studies related to growth, selection and breeding. In the Kurdistan region of Iraq, various species of quail as supply the local markets for delicious meat and eggs, especially for the rural poor (2). Because of their small size, ease of handling, resistance to a number of common avian diseases and high egg production, quails are a popular bird model in many research fields. They are an excellent experimental birds that require little care, less feed and can be raised a large numbers of quails in a small area (6, 36). Ahmed and Al-Barzinji (1) investigate that the higher genetic distance among three different quail lines, these amounts of genetic variation required to made genetic improvement in this type of bird in growth and egg production performance. Poultry breeders are searching for methods to improve feed conversion, increase growth rate and decrease the deposition of abdominal and subcutaneous fat (37). L-carnitine (LC) has attracted attention recently as a potential supplement for increasing chicken meat production and physical performance (40). LC is a vitamin-like material that resembles amino acids in its structure. It can also be produced in vivo by combining two necessary amino acids, lysine and methionine, with ferrous ions and vitamins like ascorbate, niacin, and pyridoxine (12). During lipid catabolism, LC plays an important role in transporting long-chain fatty acids from the cytosol to the mitochondrial matrix across the inner mitochondrial membrane, thereby aiding in fat combustion and energy production. It also facilitates the elimination of short- and medium-chain fatty acids that accumulate through normal and abnormal metabolism, making it crucial in fat metabolism (22). Furthermore, through its antioxidant properties, LC increases the activity and levels of antioxidant enzymes such as superoxide dismutase and glutathione peroxidase in poultry plasma. Animal feeds high in LC may provide more protein energy for growth (16). Additionally, LC is applied in poultry for numerous purposes, including semen quality improvement, antioxidants, immune system increasing, and growth promotion (5). LC supplementation raises the -oxidation of fatty acids to produce adenosine triphosphate energy which enhances energy utilization. As a result, it is available for esterification to triacylglycerols and reduces the amount of long-chain fatty acids in adipose tissue (27). LC provides energy by stimulating the body to burn triglycerides as fuel to release glycogen stocked in the liver for more intense exertion. It facilitates fat burning and glycogen storage, which ultimately increases production and weight gain. LC helps muscles make more fat available. It is an alternative food additive in poultry diets because it plays an important role for increasing resistance to metabolic diseases, strengthens the immune system, improves poultry performance, and is beneficial in metabolic and physiological processes (11,18). Many studies conducted on quail birds have revealed that LC supplementation improves productive performance parameters (30, 31and 39). Therefore, the purpose of the current study was to evaluate the effects of lines and LC either by separately or in combination in Kurdish quail diets on growth characteristics, and blood measurements.

MATERIALS AND METHODS

This experiment was examined and approved at the quails Research Hall in Grdarasha Station, Dept. of Animal Resources, College of Agricultural Engineering Sciences, Salahaddin University-Erbil, from beginning of November 2022 until end of January 2023, this period included 7 weeks of rearing period field experiment. This experimental unit was supplied with all the necessary equipment to meet the specifications for every testing group such as light, water, and a good healthy environment.

Quails and dietary treatment

A total of 480 one days-old unsexed Kurdish quail lines of the desert, brown, and white lines were raised until 7 weeks old. After that, the quails were randomly separated into one control group and three treatment groups, each of which contained four replicate groups of 10 quails per replication whiten treatment. All offspring have been reared in hatchery batteries up to three weeks of age, and taken to growing cages until 7 weeks old. At 2-7 weeks of age, 4 experimental diets were formulated with an additional 3 doses of LC. The first group was fed a basal diet (control) and groups 2, 3 and 4 were fed a basal diet containing 150, 350 and 550 mg/kg LC, respectively. The LC used in this study was obtained from a pharmacy (Coventry, CV4 9UP. UK). The quails were placed in 40 cages for both male and female quails, and each cage held 12 quails. The cage dimensions were as follows: 45cm × 30cm × 25 cm (length, width, height). The management, hygienic, and environmental conditions were the same for all of the quail chicks until they were 7 weeks old. Throughout the duration of the experiment, feed and water were available for ad libitum consumption. The nutrient content of the diets were based on the recommended nutrient requirements of quails by the National Research Council in1994 (29) (Table 1).

Growth performance measurements

During the experimental period, the quails' performance was assessed by measuring their living body weight, weight gain, feed consumption and feed conversion ratio. Individual quail body weights were recorded weekly during the study. The food consumption of each treatment within each line of Kurdish quail was also recorded weekly. Amount of food consumed per unit of body weight gain was estimated weekly as the feed conversion r atio.

Serum biochemical analysis

Blood samples were taken from twelve birds per experimental group—three per replicate—were randomly selected of each line in the vena brachialis under the wing at the age of seven weeks then transferred to the sterile tubes without anticoagulants used to collect blood samples, which were left to clot for six hours at room temperature. Thereafter, the samples were centrifuged at 3000 rpm for 15 minutes to separate the clear serum and stored at –20 °C for various biochemistry traits, including total protein, cholesterol, glucose concentration, triglycerides (TG), low density lipoprotein (LDL), high density lipoprotein (HDL), and uric acid in blood serum samples,they were determined using a commercially available kit (Biolabosa As. Frances).

Table 1. Composition of Kurdish quail feeds during the experiment (%).

Ingredient (%)	Grower ration (0-35) days	Layer ration (after 35 days)
Yellow corn	30	40
wheat	30	26
Soybean meal	30	21
concentration protein *	5	5
Sunflower Oil	3	4
Limestone	1.1	1.0
Salt	0.3	0.3
Dicalcium phosphate	0.5	2.50
Vitamins- minerals	0.1	0.2
Calculated nutrient content (%)		
Crude protein	22.70	18.90
Metabolizable energy (kcal/kg)	2987.50	3149.90
Methionine %	0.47	0.42
Cystine %	0.33	0.29
Lysine%	1.17	0.90
Calsium %	0.9	0.77
Available phosphorous %	0.6	0.32
C/P	133.97	166.66

***Concentration protein (Wafi) contains 40% crude protein, 5% crude fat, 2.20% crude fiber, 4.20% calcium, 4.68% available phosphorus, 2.50% sodium, 3.70% methionine, 3.70% methionine + cysteine, and 4.12% lysine per 1 kg of vitamin and mineral premix (imported from Holland). metabolic energy of 2150 kcal/kg; 200000 IU of vitamin A, 80000 IU of vitamin D3, 600 mg of vitamin E, 50 mg of vitamin K3, 60 mg of vitamin B1 and 140 mg of vitamin B2, 80 mg of vitamin B6, 700 mg of vitamin B12, 20 mg of folic acid, 50 mg of biotin, 1.200 mg of zinc, 200 mg of copper, 20 mg of iodine, 1.000 mg of iron, 5 mg of selenium, 1.600 mg of manganese, *The NRC (1994) adopted the calculated Chemical composition analysis.**

Experimental Parameters

Statistical analysis: The collected data obtained from this study were analyzed statistically by SAS software (33) general linear model procedure (GLM) using two-way analysis of variance (ANOVA) as in the following model: Yijk = µ +Li + Tj + (L*T)ij + eijk Where: Yijk = the studied parameters in k quail bird of j line and i L-carnitine; µ = the overall mean; Li = the effect of lines; Tj = effect of LC treatments; (L*T)ij = the interaction between the line and L-carnitine and eijk = the experimental error. Duncan's Multiple Range test was utilized to statistically assess the significant differences among the treatments within lines. A significant value of $P < 0.05$ and $P < 0.01$ was used to express values as mean ± standard error (SE).

RESULTS AND DISCUSSION

Body weight: The results of Table (2) illustrated a significant ($p \leq 0.01$) influence on weekly body weight among different lines of Kurdish quail during 2 -7 weeks of age. The desert lines had the highest body weight, followed by the brown and white lines. Many researchers stated that there were significant variations among genotypes, and lines in body weight traits, according to (3) and (13) indicated that the higher significant effect of lines on body weight ($p \leq 0.01$) of Kurdish quail. Furthermore, the statistical analysis demonstrated a significant effect ($P \leq 0.05$) of adding LC to the live body weight of quail lines in various treatments from 2-7weeks of age. The treatment of birds fed on a diet supplemented with 350 mg/kg LC had a higher body weight compared to those fed with diets containing 0, 150 and 550 mg/kg LC. Meanwhile, control group had the lowest BW during the period of experiment. These results are in consistent with those of Mahmoud *et al.* (23) who discovered that quails fed with LC supplements at the levels of 200, 400, and 600 mg /kg were (183.85, 204.75, and 199.60) g respectively had a higher significantly influence on final live body weights (LBW) than quails fed with the control diet, which had the lowest LBW (163.05) at 5weeks of age. Additionally, Mosa *et al.* (25) found a significant ($P \leq 0.05$) effect of adding LC to quail diets, which resulted to increase body weight and growth rates. Abdel-Fattah *et al.* (4) also reported that LC had a positive impact on improving body weights. Therefore, LC dietary supplement promotes β-oxidation of long-chain fatty acids, produces adenosine triphosphate energy (ATP) and increases energy utilization (26). Furthermore, there was a significant ($P \leq 0.01$) interaction effect between lines and dietary supplementation of LC on quail bird's weight between the ages of 2 and 7 weeks. The desert lines fed with a diet containing 350 mg/kg LC had a significant impact on growth traits compared to the white lines fed with the control diet during the experimental period.

Table 2. Impact of dietary L-carnitine supplementation on body weight trait from three lines of Kurdish quail

Traits		N.	Body weight (g)					
			2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks
Overall		480	59.630±0.64	106.50± 1.11	154.55± 1.26	198.68± 1.58	235.87± 1.62	268.52± 2.05
Lines (L)								
Desert		160	61.300±1.13^{a}	109.450± 2.33^{a}	158.550±1.73^{a}	204.600±2.38^{a}	243.500±1.97^{a}	277.100±2.82^{a}
Brown		160	59.500±1.02^{a}	106.450±1.48^{ab}	154.700±2.52^{ab}	198.950±2.84^{a}	236.000±2.36^{b}	268.700±3.32^{b}
White		160	58.100±1.12^{a}	103.600±1.71^{b}	150.400±1.93^{b}	192.500±2.36^{b}	228.100±2.95^{c}	259.750±3.50^{c}
Treatments (T)								
T0= 0%		120	56.670±1.09^{b}	100.530±1.58^{b}	146.000±1.86^{c}	187.670±1.91^{c}	223.000±2.60^{c}	253.800±2.76^{d}
T1=150%		120	59.000±1.14^{ab}	105.730±2.23^{ab}	153.270±1.83^{b}	198.070±3.14^{b}	234.130±2.04^{b}	265.130±3.17^{c}
T2= 350%		120	62.270±1.11^{a}	111.070± 1.76^{a}	161.600±2.45a	206.800±3.37^{a}	245.800±2.95^{a}	281.530±3.87^{a}
T3= 550%		120	60.600±1.44^{a}	108.670± 2.39^{a}	157.330±2.13^{ab}	202.200±1.65^{ab}	240.530±1.99^{a}	273.600±2.80^{b}
Interaction(L×T)								
Desert	0%	40	58.200±1.36^{ab}	104.000±1.70^{abc}	151.200±2.48^{cde}	195.400±1.50^{bcd}	232.000±2.28^{cd}	264.800±3.40^{cd}
Desert	150%	40	61.200±2.08^{ab}	109.000±5.55^{ab}	157.200±1.32^{bcd}	203.600±2.79^{abc}	242.200±1.85^{abc}	274.200±7.43^{abc}
Desert	350%	40	63.800±1.39^{a}	113.600± 4.27^{a}	165.000±4.47^{a}	211.800±7.30^{a}	251.800±3.65^{a}	288.600±2.01^{a}
Desert	550%	40	62.000±3.48^{ab}	111.200±6.24^{ab}	160.800±1.83^{ab}	208.600±2.79^{ab}	247.000±1.92^{ab}	280.800±1.85^{ab}
Brown	0%	40	57.100±2.30^{ab}	100.600±3.11^{bc}	146.400±3.08de	187.800±1.56^{de}	222.400±1.50^{ef}	253.600±2.38^{de}
Brown	150%	40	58.800±1.74^{ab}	106.000±2.30^{abc}	152.600±4.06^{bcd}	199.000±8.34^{bcd}	234.200±2.08^{cd}	264.000±2.67^{cd}
Brown	350%	40	62.800±2.46^{ab}	110.600±2.58^{ab}	161.400±5.93^{ab}	207.000±5.22^{ab}	246.600±3.59^{ab}	282.400±6.07^{a}
Brown	550%	40	60.400±1.54^{ab}	108.600±2.38^{abc}	156.600±5.34^{bcd}	202.000±2.07^{abc}	240.800±2.31^{bc}	274.000±6.69^{abc}
White	0%	40	54.800±1.93^{b}	97.000± 2.74c	140.400± 2.48e	179.800±1.77^{e}	213.600±4.03^{f}	243.000±1.87^{e}
White	150%	40	56.000±2.00^{ab}	102.200±3.25^{abc}	149.000±2.92^{cde}	191.600±2.84^{cde}	226.000±1.73^{de}	256.400±1.81^{de}
White	350%	40	61.600±1.98^{ab}	109.400±2.17^{ab}	158.000±1.63^{abc}	201.800±5.09^{abc}	239.800±6.65^{bc}	273.600±9.37^{abc}
White	550%	40	59.400±2.54^{ab}	106.200±3.53^{abc}	153.800±3.07^{bcd}	197.000±1.58^{bcd}	233.800±3.31^{cd}	266.000±2.83^{bcd}

$^{a-d}$**:Statistically significant differences in both mean values with various superscripts in the same column ($P \leq 0.05$)**

Body weight gain

The impact of lines on Body weight gain (BWG) of three different Kurdish quails was present in Table (3). The study demonstrates a significant improvement in BWG among lines till the 4th week then the BWG decreased during the experimental period. Moreover, the desert lines surpassed the brown and white lines in body weight gain for 3 and 6 weeks, this provided evidence to support what Al-Neemy *et al.* (9) and Inci *et al.* (21) were detected. Also Dawood *et al.* (15) and Hamad and AL-Barzinji (20) revealed that the brown lines had the heaviest body weight at six weeks as compared with each white and black line. While, these results were disagreed with Hassan *et al.* (19) who found that the black variety had a significantly higher live body weight than the white and brown varieties at ages 1, 2 and 3 weeks. The study reveals a significant ($P \leq 0.01$) effect of adding LC to the diet on weight gain rates during the breeding period. The treatment of birds fed with the 350 mg/kg LC showed a significantly higher mean weight gain than those on other diets. These findings are consistent with those of Yalçin *et al.* (39) who found that adding 200 ppm LC to the diet of Japanese quail for one to four weeks significantly increased weight gain. Similarly, Mona (24) found that supplementing duck diets with 500 mg/kg LC positively increased weight gain during the first month of age. Abdel-Fattah *et al.*(4) also reported that supplementing Japanese quail diets with 200-400 mg/kg LC positively increased body weight gains. Parsaeimehr *et al.* (29) found that supplementing broiler chicken diets with 300 mg/kg LC significantly increased body weight gain. While, Taklimi *et al.* (35) detected that supplementing diets with 600-800 mg/kg LC significantly improved weight gain in broiler chickens. However, the results of Buyse *et al.* (10) and Xu *et al.* (38) suggest that supplementing diets with LC did not affect on body weight gain. As for the interaction, the study also shows a significant interaction ($P \leq 0.01$) between the addition of LC and lines on weight gain rates during the breeding period, T2 × desert lines provided higher significant value of weight gain, while with the T0 × white lines provided lowest weight gain.

Table 3. Impact of dietary L-carnitine supplementation on body weight gain trait from three lines of Kurdish quail

Traits	N.	Body weight gain (g)					
		2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks
Overall	480	30.30±0.26	46.95±0.34	48.05±0.38	43.60±0.38	37.10±0.34	32.73±0.37
Lines (L)							
Desert	160	30.65±0.43^{a}	48.15±0.45^{a}	49.10±0.63^{a}	46.05±0.52^{a}	38.65±0.47^{a}	33.60±0.67^{a}
Brown	160	30.30±0.41^{a}	46.95±0.60^{b}	48.25±0.61^{a}	42.65±0.51^{b}	37.05±0.61^{b}	32.95±0.63^{ab}
White	160	29.95±0.49^{a}	45.75±0.60^{c}	46.80±0.65^{b}	42.10±0.38^{b}	35.60±0.48^{c}	31.65±0.59^{b}
Treatments (T)							
T0= 0%	120	28.67±0.35^{b}	43.87±0.62^{c}	45.47±0.81^{c}	41.67±0.78^{b}	35.05±0.54^{b}	30.80±0.74^{c}
T1=150%	120	29.67±0.37^{b}	47.07±0.38^{b}	47.53±0.50^{b}	43.33±0.65^{ab}	36.07±0.57^{b}	31.33±0.43^{c}
T2= 350%	120	31.87±0.46^{a}	48.80±0.43^{a}	50.53±0.54^{a}	44.87±0.83^{a}	39.00±0.54^{a}	35.73±0.56^{a}
T3= 550%	120	31.00±0.45^{a}	48.07±0.46^{ab}	48.67±0.49^{b}	44.53±0.59^{a}	38.33±0.50^{a}	33.07±0.46^{b}
Interaction(L×T)							
Desert 0%	40	29.20±0.73^{cde}	45.80±0.86^{e}	47.20±0.85^{cd}	44.20±1.07^{abc}	36.60±1.03^{cd}	31.80±1.28^{cde}
Desert 150%	40	30.40±0.68^{cde}	47.80±0.37^{bcde}	48.20±0.86^{abc}	45.40±0.75^{b}	38.60±0.51^{abc}	32.32±0.71^{cde}
Desert 350%	40	32.60±1.08^{a}	49.80±0.58^{a}	51.40±0.60^{a}	46.80±1.24^{a}	40.00±1.00^{a}	36.80±1.39^{a}
Desert 550%	40	31.40±0.68^{ab}	49.20±0.58^{ab}	49.60±0.68^{abc}	46.20±0.80^{a}	39.40±0.51^{ab}	33.80±0.66^{bcd}
Brown 0%	40	28.60±0.51^{de}	43.60±0.93^{f}	45.80±0.86^{de}	41.40±1.08^{cde}	34.60±0.51^{efg}	31.20±1.56^{def}
Brown 150%	40	29.60±0.50^{de}	47.20±0.86^{cde}	47.60±0.93^{bcd}	40.60±0.45^{de}	35.20±0.66^{def}	31.60±0.51^{cde}
Brown 350%	40	32.00±0.71^{a}	48.80±0.58^{abc}	50.80±1.16^{ab}	44.60±0.68^{ab}	39.60±0.93^{ab}	35.80±0.66^{ab}
Brown 550%	40	31.00±0.69^{abc}	48.20±0.86^{bcd}	48.80±0.86^{abc}	44.00±0.51^{abc}	38.80±0.86^{abc}	33.20±0.86^{bcd}
White 0%	40	28.20±0.58^{e}	42.20±0.86^{f}	43.40±0.93^{e}	39.40±1.08^{e}	33.80±0.86^{g}	29.40±0.93^{f}
White 150%	40	29.00±0.71^{de}	46.20±0.58^{cde}	46.80±0.86^{cd}	42.60±1.36^{bcd}	34.40±0.51^{efg}	30.40±0.91^{ef}
White 350%	40	31.00±0.68^{abc}	47.80±0.83^{bcde}	49.40±0.93^{abc}	43.20±0.58^{bcd}	37.40±0.50^{bd}	34.60±0.51^{abc}
White 550%	40	30.60±1.03^{cde}	46.80±0.66^{de}	47.60±0.93^{bcd}	43.00±1.07^{bcd}	36.80±0.86^{cd}	32.20±0.85^{cde}

a-d : Statistically significant differences in both mean values with various superscripts in the same column ($P \leq 0.05$)

Feed consumption

As for the feed consumption, the genetic lines had a significant impact on this trait demonstrates in Table (4). Throughout the breeding period, the results indicate that desert quail consumed significantly higher quantities of feed than brown and white quails, moreover, the results showed that this superiority disappeared at 7 weeks of age. These findings consistent with the report of Hassan & Abd- Alsatter (20) and Dawood *et al.* (15) in quail chicken, where desert line had significantly (P ≤ 0.01) superseded the other two lines in feed consumption, Conversely, the white lines consumed the least amount of feed. Results in Table (4) studied the impact of different dietary treatments on feed consumption traits in various quail lines. The birds fed on diets supplemented with LC (350 mg/kg feed) consumed the least feed during the growth period of 2 - 7 weeks, compared to those on a basal diet. This finding agrees with Mosa *et al.* (25) observations, who noted a significant (P≤0.05) increase in feed consumption rates when adding carnitine (300 mg/kg) to local quail diets for periods of (1 - 2), (3 - 4), and (5 - 6) weeks. Additionally, AL-Jashami *et al.* (7) found that dietary supplementation of LC to quail birds at (0, 100, 200, 300 and 400) mg / kg feed had a significant (p≤ 0.01) effect on the average consumption of feed for weeks (2-6). However, Corduk *et al.* (13), Daskiran *et al.* (14), and Sarica *et al.* (32) indicated that different amounts of LC had no effect on quail feed intake. As well as for the interacted groups, T0 × desert lines interacted groups provided significantly higher feed consumption than T2× white line groups during the growth period of 2 - 7 weeks. White quail showed the highest food conversion efficiency which was significantly superior to both desert and brown quail lines.

Table 4. Impact of dietary L-carnitine supplementation on feed consumption trait from three lines of Kurdish quail

Traits		N.	Feed consumption (g) 2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks
Overall		480	80.83±0.95	122.04±1.37	168.50±1.18	188.42±1.24	200.88±1.51	208.96±1.18
Lines (L)								
Desert		160	83.195±1.81^{a}	127.503±2.49^{a}	172.898±1.78^{a}	194.863±1.25^{a}	210.815±2.17^{a}	214.765±1.45^{a}
Brown		160	80.900±1.69^{b}	121.903±2.17^{b}	169.028±1.59^{b}	189.485±2.05^{b}	196.073±2.38^{b}	207.410±2.11^{a}
White		160	78.385±1.30^{c}	116.720±1.86^{c}	163.585±2.24^{c}	180.910±1.82^{c}	195.748±1.78^{b}	204.700±1.91^{a}
Treatments (T)								
T0= 0%		120	90.867± 0.93^{a}	136.043± 1.36^{a}	176.767±0.95^{a}	198.807±1.31^{a}	213.417±0.63^{a}	217.817±1.02^{a}
T1=150%		120	82.700± 1.13^{b}	123.693± 2.29^{b}	175.240± 1.19^{a}	190.757±1.68^{b}	203.056±2.74^{b}	212.273±1.34^{b}
T2= 350%		120	74.340± 0.56^{c}	113.390±0.68^{c}	159.343± 0.83^{c}	180.873±1.92^{c}	189.400±1.59^{d}	197.183±1.80^{d}
T3= 550%		120	75.400± 0.52^{c}	115.040± 0.98^{c}	162.663±1.17^{b}	183.240±1.86^{d}	197.640±2.04^{c}	208.560±1.09^{c}
Interaction(L□T)								
Desert	**0%**	40	93.730±0.87^{a}	141.380±1.21^{a}	179.810±1.05^{a}	202.230±0.98^{a}	221.070±1.27^{a}	222.000±1.14^{a}
Desert	**150%**	40	87.500±0.49^{b}	133. 880±2.02^{b}	180.630±1.49^{a}	196.180±0.64^{b}	217.180±1.11^{b}	218.250±0.68^{b}
Desert	**350%**	40	75.130±0.91^{d}	115.250±0.66^{f}	167.080±1.06^{c}	189.570±1.18^{d}	197.140±1.12^{e}	206.210±0.92^{gh}
Desert	**550%**	40	76.420±0.64^{d}	119.500±0.6^{3e}	164.070±1.24^{c}	191.470±1.69^{cd}	207.870±0.61^{d}	212.60±1.30^{df}
Brown	**0%**	40	92.300±0.83^{a}	136.570±1.06^{b}	177.367±1.20^{a}	201.480±0.95^{a}	211.870±0.66^{c}	216.670±1.16^{cd}
Brown	**150%**	40	81.200±1.28^{c}	122. 920±1.14^{d}	172.560±0.88^{a}	193.780±0.81^{bc}	197.180±1.16^{e}	211.260±1.19^{ef}
Brown	**350%**	40	74.320±1.16^{d}	114.000±1.14^{fg}	159.810±1.06^{d}	179.930±1.44^{e}	184.560±1.08^{g}	192.870±1.42^{i}
Brown	**550%**	40	75.780±0.78^{d}	114.120± 0.84^{fg}	166.380±1.19^{b}	182.750±1.10^{e}	190.680±1.18^{f}	208.750±0.91^{fg}
White	**0%**	40	86.570±0.63^{b}	130.180± 0.98^{c}	173.130±1.06^{b}	192.710±1.46^{cd}	207.310± 1.14^{d}	214.690±1.11^{cd}
White	**150%**	40	79.400±1.60^{c}	114. 280± 1.12^{fg}	172.530±1.03^{b}	183.310±1.08^{e}	194.810± 0.89e	207.310±1.33^{gh}
White	**350%**	40	73.570±0.89^{d}	110.920±0.78^{g}	151.140±1.14^{e}	173.120±1.12^{f}	186.500±1.10^{g}	192.470±0.79^{i}
White	**550%**	40	74.000±0.99^{d}	111.500± 0.81^{g}	157.540±0.95^{d}	175.500±0.62^{f}	194.370±1.07^{e}	204.330±1.19^{h}

$^{a-d}$Statistically significant differences in both mean values with various superscripts in the same column (P≤0.05)

Feed conversion ratio

Table (5) indicated that the feed conversion ratio (FCR) during the 2-7 weeks of age was significantly affected (p≤0.05) by the genetic lines. White quail showed the highest food conversion efficiency which was significantly superior to both desert and brown quail lines. These findings are consistent with previous studies noticed by Inci *et al.* (21) and Hassan and Abd- ALsatter (20). However, as opposed to the current study results, Dawood *et al.* (15) and Hamad and AL-Barzinji (21) discovered that the brown quail had the highest rate of food conversion, which was much higher than that of the white quail lines and significantly better than that of the black quail during the whole breeding period. The results of this study demonstrated that LC supplementation during the growing period had a higher significant impact on feed efficiency. However, the feed conversion ratio was better in T2 followed by T3, which had better feed conversion ratio as compared with both T0 and T2 treatments. These findings are in line with those mentioned by Abdel-Fattah *et al.* (4) for quail chickens who used Lc supplementation at levels of (100, 200 and 400) ppm in Japanese quail diets at 2-6 weeks and found a significant improvement in feed conversion ratio, particularly with high level (400 ppm). Similarly, Al-Jashami *et al.* (7) observed that feed supplemented with (0, 100, 200, 300, and 400) mg/kg LC significantly (P≤0.01) improved the feed conversion ratio of quail chickens from age 8-42 days.

Table 5. Impact of dietary L-carnitine supplementation on feed conversation ratio trait from three lines of Kurdish quail

Traits		N.	Feed conversation ratio (g)					
			2weeks	3weeks	4 weeks	5 weeks	6 weeks	7weeks
Overall		480	1.66±0.02	1.74±0.03	2.53±0.04	3.84±0.04	5.10±0.06	6.17±0.08
Lines (L)								
Desert		160	$1.69±0.03^a$	$1.79±0.05^a$	$2.56±0.06^a$	$3.94±0.07^a$	$5.23±0.10^a$	$6.35±0.15^a$
Brown		160	$1.68±0.04^a$	$1.75±0.05^b$	$2.53±0.07^b$	$3.86±0.07^b$	$5.12±0.10^b$	$6.15±0.13^b$
White		160	$1.59±0.04^b$	$1.69±0.05^c$	$2.49±0.07^c$	$3.72±0.06^c$	$4.95±0.09^c$	$5.98±0.14^c$
Treatments (T)								
T 0%		120	$1.89±0.01^a$	$2.07±0.01^a$	$2.99±0.01^a$	$4.25±0.04^a$	$5.68±0.03^a$	$6.93±0.03^a$
T 150%		120	$1.70±0.01^b$	$1.81±0.02^b$	$2.52±0.02^b$	$3.95±0.02^b$	$5.29±0.05^b$	$6.48±0.06^b$
T 350%		120	$1.47±0.02^d$	$1.53±0.01^d$	$2.34±0.01^d$	$3.52±0.02^d$	$4.64±0.02^d$	$5.97±0.03^d$
T 550%		120	$1.56±0.02^c$	$1.57±0.01^c$	$2.36±0.01^c$	$3.63±0.03^c$	$4.76±0.03^c$	$5.31±0.05^c$
Interaction (L*T)								
Desert	0%	40	$1.92±0.01^a$	$2.12±0.01^a$	$2.99±0.01^a$	$4.39±0.03^a$	$5.82±0.03^a$	$7.05±0.02^a$
Desert	150%	40	$1.72±0.01^c$	$1.91±0.01^c$	$2.58±0.02^b$	$4.05±0.02^c$	$5.51±0.03^c$	$6.79±0.02^c$
Desert	350%	40	$1.53±0.01^e$	$1.54±0.01^h$	$2.25±0.02^e$	$3.57±0.01^g$	$4.74±0.02^g$	$5.42±0.03^i$
Desert	550%	40	$1.60±0.03^d$	$1.58±0.01^f$	$2.41±0.01^c$	$3.73±0.03^e$	$4.86±0.02^f$	$6.15±0.02^f$
Brown	0%	40	$1.92±0.01^a$	$2.05±0.01^b$	$2.99±0.01^a$	$4.28±0.04^b$	$5.71±0.03^b$	$6.95±0.03^b$
Brown	150%	40	$1.71±0.01^c$	$1.83±0.02^d$	$2.55±0.02^b$	$3.92±0.02^d$	$5.30±0.05^d$	$6.41±0.06^d$
Brown	350%	40	$1.49±0.02^f$	$1.53±0.01^{hi}$	$2.24±0.01^e$	$3.51±0.02^h$	$4.67±0.02^h$	$5.36±0.03^j$
Brown	550%	40	$1.59±0.02^d$	$1.57±0.01^{fg}$	$2.34±0.01^d$	$3.65±0.03^f$	$4.77±0.03^g$	$6.04±0.05^g$
White	0%	40	$1.83±0.01^b$	$2.05±0.01^b$	$2.98±0.01^a$	$4.07±0.02^c$	$5.52±0.03^c$	$6.79±0.01^c$
White	150%	40	$1.68±0.01^c$	$1.69±0.01^e$	$2.44±0.02^c$	$3.89±0.03^d$	$5.08±0.01^e$	$6.24±0.01^e$
White	350%	40	$1.38±0.02^g$	$1.51±0.02^i$	$2.25±0.01^e$	$3.48±0.04^h$	$4.54±0.02^i$	$5.16±0.02^k$
White	550%	40	$1.50±0.01^{ef}$	$1.55±0.01^{fg}$	$2.33±0.01^d$	$3.50±0.03^h$	$4.66±0.02^h$	$5.73±0.01^h$

$^{a-d}$Statistically significant differences in both mean values with various superscripts in the same column (P≤0.05)

The influence of interaction between the addition of LC and the lines on feed conversion ratio was significantly (P≤0.05) differed among all treatments at whole periods. Whereat, a decreased feed conversion ratio was shown in T0 × desert line, when compared to the other treatments. While, the T2× white line of all treatments had the greater significant (P≤0.05) feed conversion ratio, during the all periods.

Hematological parameters

Table6 illustrates the impact of lines, LC supplementation, and their interaction on biochemical analyses. The lines had a highly significant effect (p≤0.05) on blood serum parameters, including glucose, cholesterol, triglycerides, HDL, LDL, total protein, and uric acid. These findings disagree with Al-Kafajy *et al.* (8) who reported that a non-significantly(P>0.05) different among all study lines of quail in blood glucose, triglyceride, cholesterol, protein, uric acid, and ALP values.Supplementation with various dietary amounts of LC significantly affected on blood serum, as presented in Table-6. Birds fed on diets containing 550 mg/kg of LC had the lowest level (181.470, 114.900, and 11.930 mg/dl) of cholesterol, triglycerides, and LDL, respectively, as contrasted with the control group. Similar outcomes were demonstrated by Abdel-Fattah *et al.* (4) and Mahmoud *et al.*, (23), who demonstrated that adding LC to diets containing 200 and 400 mg/kg LC significantly (P≤ 0.05) decreased the serum concentrations of total lipid, cholesterol, triglycerides, and LDL in quails. While, supplementation with 600 mg/kg LC significantly (P ≤ 0.01) increased serum HDL levels and decreased each of triglyceride and VLDL levels in all LC-supplemented treatments compared to birds given the basal diet without (LC) containment. The reduction in serum cholesterol levels in birds fed LC supplements can be refer to the importance of carnitine in fatty acid oxidation and energy metabolism (36). In addition, dietary supplementation with LC increases pituitary secretion of growth hormone and thyroid hormone (thyroxine) T4 (10). Furthermore, this table illustrated a significant ($P\leq0.05$) impact of carnitine addition on quail line's blood serum concentrations of total protein, glucose, and HDL, with the highest values (3.790, 266.60 and 95.69 g/100 ml) respectively were recorded in quail serum after treatment with the addition of 550 mg/kg LC, while the lowest total protein, glucose and HDL rates 2.53, 238.60 and 80.66g/ 100 ml serum, respectively in a non-additive treatment. The results of Mahmoud *et al.* (23) showed that serum concentrations of total protein ($P\leq0.05$) were significantly more effective in the quail group fed 600 mg LC/kg than in the control group. The statistical analysis provided higher significantly effect of the interaction between different lines of quail bird and the addition of LC on various blood serum parameters, such as Glucose, cholesterol, triglycerides, HDL, LDL, total protein, and uric acid. Among the interacting groups, the brown lines ×550 mg/kg LC concentration exhibited higher levels of glucose (271.60 g/100 ml) and lower levels of triglycerides (108.90 g/100 ml) as compared to other groups. The T0 × White lines displayed the highest significant value for both Triglycerides (176.80 g/100 ml) and LDL (30.80 g/100 ml) among the interacting groups, whereas T3 × Brown and T3 × desert groups showed the lowest values. The T3 × desert group recorded the highest levels of HLD (106.20 g/100 ml) and total protein (3.95 g/100 ml) among all groups, while T0 × White exhibited the lowest levels. Moreover, the T2 × desert group demonstrated the highest concentration of blood uric Acid (12.00 g/100 ml), whereas T0 × White had the lowest concentration (4.90 g/100 ml). Finally, the T3 × desert group showed the lowest levels of cholesterol (174.10 g/100 ml) and LDL (7.90 g/100 ml) compared to the T3 × Brown group, which exhibited higher cholesterol levels (280.80 g/100 ml).

CONCLUSIONS

According to the results of current investigation, the findings indicated that lines, food additives of LC and their interaction lead to an improvement in the productive performance of quails represented by increasing body weights, weight gains feed consumption and feed conversion ratio. On the other hand administration of dietary supplements with high LC content of 350 and 550 mg/kg in three different Kurdish lines of quail throughout all periods (2-7) weeks of growth had positive influence on growth achievement and biochemical blood parameters.

Table 6. Impact of dietary L-carnitine supplementation on blood parameters trait from three lines of Kurdish quail

Traits		N.	blood parameters (mg/dl)						
			Glucose	cholesterol	Triglycerides	HDL	LDL	Total protein	Uric Acid
Overall		480	253.800±1.46	218.030±4.61	142.02 ±0.94	88.67± 0.99	18.67± 0.88	3.15±0.07	8.69± 0.33
Lines (L)									
Desert		160	251.91± 1.63^{b}	215.28±7.72^{c}	144.0± 5.69^{b}	94.68±1.97^{a}	14.87±1.38^{c}	3.40±0.11^{b}	8.88±0.68^{a}
Brown		160	252.28± 3.12^{b}	217.78±8.69^{b}	136.15± 4.44^{c}	86.58±0.91^{b}	18.80±1.37^{b}	3.13±0.12^{a}	9.43±0.53^{a}
White		160	257.20± 2.58^{a}	221.03±7.87^{a}	145.90± 5.06^{a}	84.75±1.16^{c}	22.35±1.42^{a}	2.93±0.13^{c}	7.78±0.43^{b}
Treatments (T)									
T0= 0%		120	238.60±1.04^{d}	274.93±1.79^{a}	172.50±1.92^{a}	80.66±0.66^{d}	27.50±0.91^{a}	2.53±0.10^{c}	6.03±0.33^{d}
T1=150%		120	251.70±1.21^{c}	215.63±1.22^{b}	149.27±2.40^{b}	87.12±1.33^{c}	19.83±1.02^{b}	3.06±0.07^{b}	7.57±0.16^{c}
T2= 350%		120	258.28±1.51^{b}	200.07±0.80^{c}	131.40±1.27^{c}	91.19±1.19^{b}	15.43±0.94^{c}	3.24±0.10^{b}	11.23±0.64^{a}
T3= 550%		120	266.60±1.14^{a}	181.47±1.61^{d}	114.90±1.94^{d}	95.69±2.06^{a}	11.93±0.86^{d}	3.79±0.07^{a}	9.93±0.34^{b}
Interactin(L□T)									
Desert	0%	40	242.50±1.06^{h}	265.80±0.52^{c}	177.70±0.86^{a}	82.80±1.10^{e}	23.30±0.84^{c}	2.79±0.16^{e}	5.60±0.26^{gh}
Desert	150%	40	250.20±1.12^{f}	221.30±0.40^{d}	154.20±0.78^{c}	93.00±0.95^{c}	16.80±0.88^{ef}	3.25±0.02^{bc}	6.90±0.18^{fg}
Desert	350%	40	253.35±0.78^{e}	199.90±0.88^{h}	132.60±1.59^{e}	96.70±0.79^{b}	11.50±0.73^{h}	3.60±0.09^{b}	12.00±1.00^{b}
Desert	550%	40	261.60±0.72^{c}	174.10±0.70^{l}	111.40±1.20^{g}	106.20±0.8^{a}	7.90±0.53^{i}	3.95±0.10^{a}	11.00±0.71^{bc}
Brown	0%	40	234.40±1.00^{j}	280.80±0.77^{a}	162.90±1.28^{b}	80.66±0.83^{fg}	28.40±0.43^{b}	2.55±0.15^{ef}	7.60±0.19^{ef}
Brown	150%	40	247.40±0.72^{g}	211.30±0.73^{f}	137.20±2.05^{d}	86.10±0.94^{e}	18.20±0.78^{e}	3.07±0.13^{d}	8.20±0.10^{ef}
Brown	350%	40	255.70±1.03^{de}	197.30±1.00^{i}	135.60±1.08^{de}	90.10±0.94^{cd}	15.50±0.76^{f}	3.14±0.18^{d}	13.00±0.84^{a}
Brown	550%	40	271.60±0.62^{a}	181.80±0.65^{k}	108.90±1.42^{g}	89.90±0.65^{d}	13.10±0.59^{h}	3.77±0.12^{a}	8.90±0.14^{de}
White	0%	40	238.90±0.98^{i}	278.20±0.91^{b}	176.80±1.34^{a}	78.98±0.90^{g}	30.80±0.71^{a}	2.24±0.15^{f}	4.90±0.17^{h}
White	150%	40	257.50±0.36^{d}	214.40±1.17^{e}	156.20±0.70^{c}	82.27±1.38^{f}	24.50±1.02^{c}	2.86±0.12^{cde}	7.60±0.08^{ef}
White	350%	40	265.80±0.59^{b}	203.00±0.92^{g}	126.00±1.10^{f}	86.78±0.83^{e}	19.30±0.77^{d}	2.97±0.11^{cd}	8.70±0.11^{de}
White	550%	40	266.60±0.56^{b}	188.50±0.63^{j}	124.40±1.20^{f}	90.98±1.29^{cd}	14.80±0.78^{f}	3.64±0.13^{a}	9.90±0.33^{cd}

$^{a-d}$Statistically significant differences in both mean values with various superscripts in the same column ($P\leq0.05$).

REFERENCES

1. Ahmed, L.S. and Y.M.S. Al-Barzinji, 2019. Genetic diversity among local quail using RAPD-DNA marker. Revista Cientifica-Facultad de Ciencias Veterinarias. *29*(3): 178-185

2. Ahmed, L.S. and Y.M.S. Al-Barzinji, 2020. Three candidate genes and its association with quantitative variation of egg production traites of local quail by using pcr-rflp. Iraqi Journal of Agricultural Sciences. 51:124-131. 51(Special Issue):124-131
https://doi.org/10.36103/ijas.v51iSpecial.889

3. Ahmed, L.S. and Y.M.S. Al-Barzinji, 2022. Detection of quantitative loci correlation with growth traites in local quail using PCR-RFLP technique. Iraqi Journal of Agricultural Sciences. 53(1): 16-26. https://doi.org/10.36103/ijas.v53i1.1501

4. Abdel-Fattah, S.A. and M.I. Shourrap, 2012. March. Physiological effects of in ovo L carnitine and embryonic thermal conditioning on pre and posthatch development of broiler chicks. In 3rd Mediterranean Poultry Summit and 6th International Poultry Conference. 26-29.

5. Adabi, S.G., R.G. Cooper, N. Ceylan, and M. Corduk, 2011. L-carnitine and its functional effects in poultry nutrition. World's Poultry Science Journal. 67 (2): 277-296

6. Akpa, G.N., J. Kaye, I.A. Adeyinka, and M., Kabir, 2008. The relationships between laying age and repeatability of egg quality traits in Japanese quails (*Coturnix coturnix* japonica). International Journal of Poultry Science. 7 (6): 555-559

7. Al-Jashami, S.M., F.R. Al-Khafaji, and R.M. Hamza, 2015. Effect of different levels addition of L-Carnitine to the diet on some productive characteristics of Japanese quail bird exposed to heat stress. Euphrates Journal of Agriculture Science.7 (4): 88-98

8. Al-Kafajy, F.R., M.B.S. Al-Shuhaib, G.S. Al-Jashami, and T.M. Al-Thuwaini, 2018. Comparison of three lines of Japanese quails revealed a remarkable role of plumage color in the productivity performance determination. Journal of World's Poultry Research. 8(4): 111-119

9. Al-Neemy, M.A.S., T.M. Abd Al-Bake, and F.T. Ahmed, 2014. Effect of genetic group and added fat source in grower ration on some reproductive traits quail. Tikrit Journal for Agricultural Sciences. 14(2): 283- 294

10. Buyse, J., G.P.J. Janssens, and E. Decuypere, 2001. The effects of dietary L-carnitine supplementation on the performance, organ weights and circulating hormone and metabolite concentrations of broiler chickens reared under a normal or low temperature schedule. British Poultry Science. 42(2): 230-241

11. Carroll, M. C., and E. Cote, 2001. Carnitine: a review. Compendium on Continuing Education for the Practicing Veterinarian. 23(1): 45-52

12. Cave, M.C., R.T. Hurt, T.H. Frazier, P.J. Matheson,R.N. Garrison,C.J. McClain, and S.A. McClave, 2008. Obesity, inflammation, and the potential application of pharmaconutrition. Nutrition in Clinical Practice. 23(1): 16-34

13. Chatoo, K.B. and Y.M.S. Al-Barzinji, 2022. Comparative Study of Production Performance among Local Quails. Iraqi Journal of Agricultural Sciences, 53(6):1298-1304. https://doi.org/10.36103/ijas.v53i6.1644

14. Corduk, M., N. Ceylan, and F. Ildiz, 2007. Effects of dietary energy density and L-carnitine supplementation on growth performance, carcass traits and blood parameters of broiler chickens. South African Journal of Animal Science. 37(2): 65-73

15. Daşkıran, M., A.G. Önol, Ö. Cengiz, O. Tatlı, and M., Sarı, 2009. Effects of dietary methionine levels and L-carnitine supplementation on performance and egg quality parameters of layers. Journal of Animal and Feed Sciences. 18(4): 650-661.

16. Dawood, I.R., M.A. Alneemy, and S.M. Hameed, 2021. Study of the effect of the genetic group, egg weight, and their interaction on the productive performance of quail birds during the growth stage. Plant Archives. 21(1): 98-103

17. Dikel, S., B., Ünalan, O.T. Eroldoğan, and A.Ö. Hunt, 2010. Effects of dietary L-carnitine supplementation on growth, muscle fatty acid composition and economic profit of rainbow trout (*Oncorhynchus mykiss*). Turkish Journal of Fisheries and Aquatic Sciences. 10(2): 173–180

18. Faitarone, A.B.G., A.C. Pavan, C. Mori, L.S. Batista,R.P. Oliveira, E.A. Garcia, C.C. Pizzolante, A.A. Mendes, and M.R.Sherer, 2005. Economic traits and performance of Italian quails reared at different cage stocking densities. Brazilian Journal of Poultry Science. 7 (1):19-22.

19. Gropp, J.M., A.Schumacher, and F.J. Schweigert, 1994. Recent research in vitamin nutrition with special emphasis to vitamin A, β-carotene and L-carnitine. In proceedings of the Arkansas Nutrition Conference, AR: Arkansas Poultry Federation. 124-134
20. Hamad, K. and Y.M.S. AL-Barzinji, 2022. Evaluation of meat and egg production characteristics 0f crossbred local quail. Euphrtes Journal of Agriculture Sciences, 14(3):187- 194
21. Hamad, K. and Y.M.S. AL-Barzinji, 2023. Polymorphism of three loci influence on growth traits in local quail. Iraqi Journal of Agricultural Sciences, 54(2):455-463. https://doi.org/10.36103/ijas.v54i2.1720
22. Hassan, A.M., D.A. Mohammed, K.N. Hussein, and S.H. Hussen, 2017. Comparison among three lines of quail for egg quality characters. Science Journal of University of Zakho. 5(4): 296-300
23. Hassan, K.H., and A.R. Abd-Alsattar, 2017. Study of productive performance of three varieties of Japanese quail in meat production. Diyala Agricultural Sciences Journal. 9(1): 39-47
24. Inci, H., B. Sogut, T. Sengul, A.Y. Sengul, and M.R. Taysi, 2015. Comparison of fattening performance, carcass characteristics, and egg quality characteristics of Japanese quails with different feather colors. Revista Brasileira de Zootecnia. 44(11): 390–396
25. Jalali Haji-abadi, S.M.A., N. Mahboobi Soofiani, A.A. Sadeghi, M. Chamani, and G.H. Riazi, 2010. Effects of supplemental dietary l-carnitine and ractopamine on the performance of juvenile rainbow trout (Oncorhynchus mykiss). Aquaculture Research. 41(11): 1582-1591
26. Mahmoud, R.E., Elshopakey, G.E., and W.F., Awadin, 2020. Effects of feeding diets supplemented with different levels of L-carnitine on growth performance, serum metabolites, histopathological changes in growing Japanese quails. International Journal of Veterinary Science. 9(1): 16-23
27. Mona, E.M., 2015. Influence of dietary L-carnitine on productive performance, internal organs and carcass characters of two duck breeds reared for foie gras production. Alexandria. Journal for Veterinary Sciences. 44:159-168
28. Mosa, R.K., J.M. Jassim, and B.A.H. Al-Sereah, 2018. Effect of individual and combination addition of l–carnitine and dl–methionine to diet on productive performance for quail (coturnix). International Journal of Innovations in Agricultural Sciences. 2(2): 146 – 154.
29. Neuman, S.L., T.L. Lin, and P.Y. Heste, 2002. The effect of dietary carnitine on semen traits of White Leghorn roosters. Poultry Science. 81(4): 495-503
30. Nouboukpo, K.E., K. Tona, B.Kamers, N.Everaert, H.Willemsen, O.M. Onagbesan, M.Gbeassor, and E. Decuypere, 2010. Effects of in ovo administration of L-carnitine on hatching events and juvenile performance of layer-type chick. International Journal of Poultry Sciences. 9(10):980-983
31. NRC, 1994. Nutrient Requirements of Domestic Animals. Nutrient Requirements of Poultry (9th ed). National Academy Press, Washington, D.C., USA
32. Parsaeimehr, K., M. Afrouziyeh, and S. Hoseinzadeh, 2014. The effects of L-Carnitine and different levels of animal fat on performance, carcass characteristics, some blood parameters and immune response in broiler chicks. Iranian Journal of Applied Animal Science. 4(3): 561-566
33. Rabie, M.H., and M. Szilágyi, 1998. Effects of L-carnitine supplementation of diets differing in energy levels on performance, abdominal fat content, and yield and composition of edible meat of broilers. British Journal of Nutrition. 80(4): 391-400
34. Rabie, M.H., M. szilágyi, and T. Gippert, 1997a. Effects of dietary L-carnitine supplementation and protein level on performance and degree of meatness and fatness of broilers. Acta Biologica Hungarica.48: 221-239
35. Sarica, S., M. Corduk, U. Ensoy, H. Basmacioglu, and U. Karatas, 2007. Effects of dietary supplementation of L-carnitine on performance, carcass and meat characteristics of quails. South African Journal of Animal Science. 37(3): 189-201
36. SAS: SAS user's guide. Statistical Version, 2004, SASInstitute Inc., Cary, North Carolina, USA.
37. Sigma – Tau Health Science. 2004. Virmani A and Binienda Z (Sigma – tau

Health Science, Italy), carnitine esters' role in brain neuropathology. Molecular Aspects of Medicine. 25 (5 to 6): 533 – 549

38. Taklimi, S.M.M.,K. Ghazvinian, and M.R.A. Kasgari, 2015. Effect of L-carnitine on performance and carcass quality of broiler chickens. Academia Journal of Scientific Research. 3(3): 50-54.

39. Vali, N., M.A. Edriss, and H. Moshtaghi, 2006. Comparison of egg weight between two quail strains. International Journal of Poultry Science.5 (4): 398-400

40. Waller, A., 2007. Take a fresh look at broiler nutrition-Feed accounts for most of the cost of broiler production but the most economic option is not always to reduce feed cost. The impact of the current rise in. Poultry International. 46(9): 12-15

41. Xu, Z.R., M.Q. Wang, H.X.Mao,X.A. Zhan, and C.H. Hu, 2003. Effects of L-carnitine on growth performance, carcass composition, and metabolism of lipids in male broilers. Poultry Science. 82(3): 408-413

42. Yalcin, S., B. Özsoy, O. Cengiz, and T. Bülbül, 2008. Effects of dietary L-carnitine supplementation on growth performance and some biochemical parameters in Japanese quails (*Coturnix coturnix* japonica). Revue De Medecine Veterinaire. 159: 502-507

43. Zeyner, A., and J. Harmeyer, 1999. Metabolic functions of L-Carnitine and its effects as feed additive in horses. A review. Archives of Animal Nutrition. 52(2):115-138.