The Effect of Dietary L-Carnitine Supplementation on Growth Performance, Carcass Traits, and Composition of Edible Meat in Japanese Quail (*Coturnix coturnix japonica*)

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Primary Audience: Animal Nutritionists, Animal Feeding Supervisors, Growers

SUMMARY

The present study was conducted to determine the effects of supplemental dietary L-carnitine at different levels on growth performance, carcass traits, and composition of edible meat in Japanese quail. One hundred sixty-eight 1-d-old Japanese quail chicks were fed the same basal diet that was supplemented with 0 (control), 30, 40, or 50 mg L-carnitine/kg of diet. The effects of dietary L-carnitine supplementation at different levels on body weight gain, cumulative feed intake, and feed conversion ratio of Japanese quail did not differ. Supplementation of L-carnitine to Japanese quail diets from 0 to 35 d of age did not affect the hot and cold carcass yields and the relative values of heart, liver, gizzard, and abdominal fat. Levels of supplemental dietary L-carnitine did not affect the dry matter, moisture, CP, or ether extract content of the total edible meat in Japanese quail chicks.

Key words: L-carnitine, growth, carcass trait, Japanese quail

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DESCRIPTION OF PROBLEM

L-Carnitine (β-hydroxy γ-trimethylamino-butyrate) is a water-soluble quaternary amine that occurs naturally in microorganisms, plants, and animals [1]. Plants and plant-based feedstuffs generally contain very little carnitine compared with animals [2]. The concentration of carnitine in animals varies widely across species, tissue type, and nutritional status of the animal [3, 4]. L-Carnitine is biosynthesized in vivo from lysine and methionine [5] in the presence of ferrous ions and 3 vitamins, ascorbate, niacin, and pyridoxine that are required as cofactors for the enzymes involved in the metabolic pathway of L-carnitine [6, 7, 8]. It is reported that L-carnitine has 2 major functions: facilitating the transport of long-chain fatty acids across the

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mitochondrial membrane and facilitating the removal from mitochondria of short- and medium-chain fatty acids that accumulate as a results of normal and abnormal metabolism [3, 9, 10, 11, 12]. Thus, dietary L-carnitine supplementation promotes the β-oxidation of these fatty acids to generate adenosine triphosphate (ATP) and improves energy use [4, 13]. Consequently, L-carnitine supplementation to diets reduces long-chain fatty acid availability for esterification to triacylglycerols and storage in the adipose tissue [12, 14]. In addition, L-carnitine has secondary functions such as buffering and removing potentially toxic acyl groups from cells, equilibrating ratios of free coenzyme A and acetyl-CoA between mitochondria and cytoplasm. It also participates in biological processes, for example, regulation of gluconeogenesis, stimulation of fatty acid synthesis and ketone, branched-chain amino acid, triglyceride, and cholesterol metabolism [15].

Studies on the effect of L-carnitine supplementation to quail diets are sparse. In different studies, the effects of dietary L-carnitine supplementation on the performance and body composition of broiler chickens have been reported [3, 4, 9, 12, 14, 16]. The effects of L-carnitine supplementation to the broiler diets are less clear. Studies with broiler chickens have shown that supplemental dietary L-carnitine increases body weight gain, improves feed conversion ratio, and reduces abdominal fat content [3, 4, 9]. However, there are contradictory studies in which dietary L-carnitine supplementation did not affect growth performance, abdominal fat content, and some internal organ weights [14, 17, 18].

The aim of the present study was to determine the effects of supplemental dietary L-carnitine at different levels on growth performance, carcass traits, and composition of edible meat in Japanese quail (*Coturnix coturnix japonica*).

MATERIALS AND METHODS

Experimental Design

One hundred sixty-eight 1-d-old Japanese quail chicks (*Coturnix coturnix japonica*) obtained from a commercial hatchery were wing-banded, weighed, and randomly assigned to 4 groups of similar mean weight, each of which included 3 replicates of 14 chicks. The chicks were kept on wire cages equipped with nipple drinkers under uniform environmental conditions from hatch until 5 wk of age. Temperature was kept 32°C for the first week, 28°C for the second week, and 21°C thereafter. A continous lighting program was provided during the experiment. Japanese quail chicks were given a basal diet supplemented with 0 (control), 30, 40, or 50 mg L-carnitine/kg of diet in the form of Carniking [19]. L-Carnitine was incorporated into diets in the place of corn. The composition and the calculated nutrient content of the basal diet are presented in Table 1. Prior to experimental diet formulation, feed ingredients were analyzed for their CP, crude fat, starch, and total sugar according to the methods of the Association of Official Analytical Chemists [20]. Metabolizable energy of feed ingredients was calculated based on analyzed values of feedstuffs [21]. The

TABLE 1. Composition (%) and analyzed nutrient content of basal diet

Item	Starter-grower (0–35 d)
Ingredient	
Corn	56.68
Soybean meal	34.50
Fish meal	5.54
Vegetable oil	0.62
Salt	0.25
Limestone	0.71
Dicalcium phosphate	1.28
DL-Methionine	0.07
Vitamin premix[1]	0.25
Trace mineral premix[2]	0.10
Calculated composition	
Metabolizable energy (kcal/kg)	2,901
CP (%)	24
Calcium (%)	0.80
Available phosphorus (%)	0.30
Methionine (%)	0.50
Methionine + cystine (%)	0.80
Lysine (%)	1.39
Arginine (%)	1.27
Tryptophan (%)	0.34

[1]Vitamin premix provided per kilogram of diet: vitamin A, 12,000 IU; vitamin D_3, 1,500 IU; vitamin E, 50 mg; vitamin K_3, 5 mg; vitamin B_1, 3 mg; vitamin B_2, 6 mg; vitamin B_6, 5 mg; vitamin B_{12}, 0.03 mg; niacin, 25 mg; Ca-D-pantothenate, 12 mg; folic acid, 1 mg; D-biotin, 0.05 mg; apocarotenoic acid ester, 2.5 mg; choline chloride, 400 mg.
[2]Trace mineral premix provided per kg of diet: Mn, 80 mg; Fe, 60 mg; Zn, 60 mg; Cu, 5 mg; Co, 0.20 mg; I, 1 mg; Se, 0.15 mg.

experimental diets were formulated to meet minimum nutrient requirements of Japanese quail, as established by the National Research Council [22]. They were fed a starter-grower diet (24% CP and 2,900 kcal of ME/kg) from hatch to 5 wk of age. The experimental diets in mash form and drinking water were provided ad libitum.

Data Collection

The growth performance of Japanese quail was evaluated by recording body weight gain, feed intake, and feed conversion ratio. Individual live body weights of quails were recorded at the beginning of the experiment and on a weekly basis thereafter. Feed intake for each cage was recorded weekly. Feed conversion ratio was calculated weekly as the amount of feed consumed per unit of body weight gain. At the end of the experiment, 6 Japanese quail chicks (3 male and 3 female quails) whose body weights were similar to the group average were selected from each cage and were euthanized by exsanguination via the branchial vein to determine measurements of carcass yield and quality. These measurements included hot and cold carcass yields, carcass components (weights of eviscerated carcass and some internal organs), abdominal fat content (as a percentage of body weight), and chemical composition of edible meat of Japanese quail (in terms of dry matter, CP, and ether extract contents of breast plus thigh meat). The carcasses were immediately plucked, processed (removal of head and feet), eviscerated (removal of gastrointestinal tract), weighed, and then chilled overnight in a refrigerator (+4°C) to scale for cold carcass weight. The weights of heart, liver, and gizzard were individually measured. The weights of these internal organs were expressed as a percentage of live body weight. The hot and cold carcass yields were calculated as a percentage of the preslaughter body weight of Japanese quail chicks.

Edible parts of carcasses selected for analyses of nutrients composition were homogenized using a blender with horizontal blades, and samples were frozen and stored at −20°C until further analyses. The carcasses were analyzed for dry matter, CP (N × 6.25) and crude fat according to the Association of Official Analytical Chemists [20]. Fat was extracted with ethyl ether using a Soxhelet apparatus.

Statistical Analysis

The data obtained from the experiment were analyzed by using SPSSWIN [23] statistical programs with the ANOVA. Significant differences among treatment means were separated using Duncan's multiple range test with a 5% probability [24].

RESULTS AND DISCUSSION

The effects of dietary L-carnitine supplementation at different levels on body weight gain, cumulative feed intake, and feed conversion ratio of Japanese quail are summarized in Table 2. The results showed that there were no significant differences in body weight gain, cumulative feed intake, and feed conversion ratio between dietary treatments during the whole experiment. These results are in agreement with those reported by other authors for broiler chickens [11, 12, 14, 17, 18, 25]. Cartwright [17] reported that growth performance of broilers, in terms of body weight and feed intake, was not affected by feeding diet supplemented with 0.05% L-carnitine of the diet from 5 to 7 wk of age. Barker and Sell [14] also reported that the supplementation of dietary L-carnitine at 0, 50, or 100 mg/kg diet did not affect body weight gain, feed intake, or feed efficiency of broiler chickens and young turkeys fed low- or high-fat diets. Likewise, Leibetseder [18] pointed out that body weight gain and feed conversion ratio of broiler chickens were not influenced by dietary carnitine (L or DL form) at 200 mg/kg. The dietary addition of 100 mg/kg L-carnitine did not affect body weight gain, feed intake, or feed efficiency of broilers [11]. Lien and Horng [25] noticed that feeding diets supplemented with 0 and 160 mg of L-carnitine/kg did not significantly affect the performance of broiler chickens. Xu et al. [12] observed no differences in body weight gain, feed intake, or feed conversion of male broilers fed diet supplemented with 0, 25, 50, 75, or 100 mg/kg L-carnitine.

However, Lettner et al. [26] showed that dietary supplementation with L-carnitine from 20 to 60 mg/kg tended to improve growth performance of broiler chickens. Rabie et al. [4] indicated that the supplementation of dietary L-carnitine at 3 levels (50, 100, or 150 mg/kg) to a basal diet significantly increased body weight

TABLE 2. Effects of dietary L-carnitine supplementation at different levels on body weight gain, cumulative feed intake and feed conversion ratio of Japanese quail during the experimental period from 0 to 35 d of age

Performance parameters and age	Levels of L-carnitine added (mg/kg)					
	0	30	40	50	SEM	*P*
Live body weight, g						
0 d	7.81	7.86	7.76	7.81	0.065	0.972
7 d	33.30	33.78	32.71	33.08	0.489	0.920
14 d	73.69	74.34	71.76	72.85	0.811	0.759
21 d	115.23	118.53	116.88	119.61	1.359	0.744
28 d	158.81	161.74	160.59	160.18	1.681	0.959
35 d	186.77	187.67	190.00	186.91	2.326	0.971
Body weight gain, g						
0 to 7 d	25.49	25.92	24.95	25.27	0.445	0.920
7 to 14 d	40.39	40.56	39.05	39.77	0.451	0.690
14 to 21 d	41.54	44.19	45.12	46.76	0.921	0.252
21 to 28 d	43.58	43.21	43.71	40.57	0.733	0.432
28 to 35 d	27.96	25.93	29.41	26.73	1.397	0.871
0 to 35 d	178.96	179.81	182.24	179.10	2.277	0.967
Cumulative feed intake, g						
0 to 7 d	37.52	38.87	39.54	36.42	0.940	0.711
7 to 14 d	84.33	85.64	87.34	84.38	0.703	0.435
14 to 21 d	118.91	127.47	123.89	128.70	2.191	0.438
21 to 28 d	157.34	159.43	159.86	156.25	1.673	0.889
28 to 35 d	188.56	185.57	188.30	184.29	2.584	0.943
0 to 35 d	586.66	596.98	598.93	590.04	6.092	0.911
Feed conversion ratio, g/g						
0 to 7 d	1.47	1.50	1.59	1.44	0.026	0.192
7 to 14 d	2.09	2.11	2.24	2.12	0.026	0.117
14 to 21 d	2.87	2.89	2.74	2.76	0.032	0.269
21 to 28 d	3.62	3.69	3.66	3.86	0.048	0.353
28 to 35 d	7.08	7.52	6.41	6.90	0.354	0.792
0 to 35 d	3.28	3.32	3.29	3.30	0.020	0.916

gain of broiler chickens compared with those of broilers fed the basal diet. The discrepancies between studies may result from different levels of L-carnitine supplementation, ingredients and metabolizable energy, methionine and lysine levels of diets, sex, and physiological status of the animals. The calculated methionine and lysine (the precursors of L-carnitine) levels in the present experimental diets were sufficient for Japanese quail according to the nutrient requirements established by the National Research Council [22]. It is possible that if the potential contents of lysine and methionine in the experimental diets were deficient or insufficient, supplementation with L-carnitine could improve the use of dietary nitrogen, either directly through sparing its precursors for protein biosynthesis and other cellular functions or indirectly by optimizing the balance between essential and nonessential amino acids within the cell. No mortalities were recorded during the whole experiment.

Carcass yields and components of 35-d-old Japanese quail fed diets supplemented with L-carnitine at different levels during the experimental period from 0 up to 35 d of age are shown in Table 3. Supplementation of L-carnitine to Japanese quail diets from 0 to 35 d of age did not significantly affect the hot and cold carcass yields and the relative values of heart, liver, gizzard, and abdominal fat. Limited comparative information could be found in the literature on the influence of dietary carnitine on carcass yield or components for poultry and other species. The calculated metabolizable energy levels of the experimental diets in the present study were adequate for Japanese quail. The role of dietary L-carnitine supplementation in energy metabolism, especially in the effects on the abdominal

TABLE 3. Carcass yields and components of 35-d-old Japanese quail fed diets supplemented with L-carnitine at different levels during the experimental period from 0 to 35 d of age

Parameter	Levels of L-carnitine added (mg/kg) 0	30	40	50	SEM	*P*
Preslaughter live body weight, g	196.94	185.83	189.17	194.44	2.80	0.497
Hot carcass weight, g	124.33	120.03	118.94	122.50	1.48	0.577
Hot carcass yield, %	63.45	64.70	63.14	63.26	0.43	0.554
Cold carcass weight, g	124.26	119.32	118.66	121.92	1.48	0.529
Cold carcass yield, %	63.41	64.32	62.98	62.96	0.42	0.647
Liver, g (100 g/BW)	2.56	2.40	2.62	2.65	0.10	0.829
Heart, g (100 g/BW)	0.87	0.95	0.91	0.88	0.01	0.128
Gizzard, g (100 g/BW)	1.92	1.98	2.02	1.99	0.04	0.816
Abdominal fat, g (100 g/BW)	1.38	1.46	1.57	1.53	0.11	0.940

fat content and ether extract contents of the total edible meat of Japanese quail chicks, would be better identified if the metabolizable energy levels and fat sources in the present experimental diets were different. Theoretically, dietary L-carnitine could play a role in reducing the undesirable carcass fat of poultry. The abdominal fat content and ether extract contents of the total edible meat of Japanese quail chicks might have been influenced by differences in the fatty acid composition of dietary fat because L-carnitine has an important role in facilitating the transport of long-chain fatty acids across the inner mitochondrial membrane for β-oxidation to generate ATP, thereby decreasing their availability for esterification to triacylglycerols and storage in the adipose tissues.

Findings in the present study concur with those of other researchers [3, 4, 14, 16, 17, 18, 25, 27]. Cartwright [17] observed no significant effect on abdominal fat when L-carnitine was fed at 0.05% of the diet from 5 to 7 wk of age. Barker and Sell [14] reported that addition of L-carnitine to the diet (50 or 100 mg/kg) did not influence abdominal fat weight of broiler chickens fed low- or high-fat diets. Leibetseder [18] also reported that abdominal fat content of broilers was not affected by dietary carnitine (L or DL form) at 200 mg/kg of diet. Rabie et al. [3, 4] pointed out that supplementary carnitine did not significantly affect live body weight or the relative weights of liver, heart, and gizzard, except abdominal fat pad weights. Daskiran and Teeter [16] observed no significant effect in dressing percentage and abdominal fat pad contents of broilers in response to dietary L-carnitine supplementation. Lien and Horng [25] pointed out that abdominal fat pad weight of broilers was not significantly affected by diet supplementation with carnitine. Likewise, Celik et al. [27] indicated that supplementary carnitine did not influence carcass weight, carcass yield, or relative weight of abdominal fat in broiler chickens. However, Lettner et al. [26] found that the composition of the abdominal fat was significantly affected by addition of L-carnitine to the diet. Rabie and Szilagyi [9] and Xu et al. [12] reported that the abdominal fat percentage of body weight was significantly reduced by adding L-carnitine to diets.

The dry matter, moisture, CP, and ether extract contents of the total edible meat (breast plus thigh meat) of 35-d-old Japanese quail fed diets supplemented with L-carnitine at different levels during the experimental period are summarized in Table 4. Levels of supplemental dietary L-carnitine did not significantly affect the dry matter or moisture, CP, and ether extract contents of the total edible meat (breast plus thigh meat) of 35-d-old Japanese quail.

The results of the present study are in agreement with those reported by other authors [4, 9, 14, 16, 28]. Barker and Sell [14], Rabie et al. [4], and Rabie and Szilagyi [9] pointed out that the supplementation of L-carnitine to the broiler diet did not significantly affect the dry matter, CP, and ether extract components of breast or thigh meat. Daskiran and Teeter [16] observed no significant effect of dietary L-carnitine supplementation on carcass fat percentage of 7-wk-old broilers. Celik and Ozturkcan [28] reported that carcass dry matter, crude fat, and

TABLE 4. Compositions of the total edible meat (breast plus thigh meat) of 35-d-old Japanese quail fed diets supplemented with L-carnitine at different levels during the experimental period

	Levels of dietary supplemental L-carnitine (mg/kg)					
Components and analyses[1]	0	30	40	50	SEM	*P*
Total edible meat						
Dry matter, %	37.53	35.37	36.69	36.04	0.45	0.374
Moisture, %	62.47	64.63	63.31	63.96	0.45	0.374
CP, %	19.54	20.11	20.12	20.01	0.13	0.355
Ether extract, %	15.35	13.25	14.62	13.86	0.52	0.515

[1]Means of 18 quail per treatment group (% of fresh weight).

CP contents in broiler chickens were not significantly affected by dietary L-carnitine supplementation. In contrast, Xu et al. [12] showed that crude fat content in breast muscle of male broilers is significantly increased by supplementing with 50 or 75 mg of L-carnitine/kg of diet.

CONCLUSIONS AND APPLICATIONS

1. The dietary L-carnitine supplementation at 0, 30, 40, or 50 mg/kg did not have any effect on the performance, carcass yields and components, or the nutrient composition of the total edible meat of Japanese quail.
2. The diets used in this study contained fishmeal, which would probably include some carnitine. L-Carnitine may be more effective when added to an all-vegetable diet or diets with a deficiency of lysine and methionine.
3. To identify the key role of L-carnitine in energy metabolism, especially in the effects on the abdominal fat content and ether extract contents of the total edible meat of Japanese quail chicks, the reponses to supplemental dietary L-carnitine of Japanese quail fed diets with different levels of metabolizable energy and different dietary fat source could be further investigated. Additional studies are required to explore the specific role that L-carnitine has in Japanese quail.

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