

## BODY COMPOSITION AND SEXUAL MATURITY IN FEMALE QUAIL FED DIETS CONTAINING L-CARNITINE

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### Abstract

Female quail were fed the diets containing various amounts of L-carnitine from 21 days of age to sexual maturity, and the effects of dietary L-carnitine on body growth and composition and sexual maturity in female Japanese quail were investigated. Body growth did not vary with the amounts of dietary L-carnitine. At sexual maturity, carcass protein and fat contents were not different due to dietary L-carnitine level, and no differences were also found in serum cholesterol, triglyceride and free fatty acid concentrations among the treatment groups. Age and ovary weight at sexual maturity did not vary with dietary L-carnitine level. The growth of ovarian follicles at sexual maturity was not changed by dietary L-carnitine. The results suggested that dietary L-carnitine supplementation did not influence body growth and composition and ovary growth in female quail.

**Key Words:** carnitine, body composition, sexual maturity, quail

### Introduction

L-carnitine is biosynthesized *de novo* from lysine and methionine. It acts as transporter of long-chain fatty acids from the cytosol to the mitochondrial matrix, thereby playing an important role in the use of fatty acids as energy substrate by the tissues<sup>(1)</sup>. In instances of carnitine insufficiency, movement of long-chain fatty acids into mitochondria and their subsequent oxidation could be impaired. Added carnitine to diets could augment carnitine supply, thereby facilitating the oxidation of fatty acids and consequently improving performance of domestic animal.

There are reports on the effects of dietary L-carnitine on the lipid metabolism and performance. Coffey *et al.* showed that a low L-carnitine diet depressed the lipid oxidation of liver in piglets<sup>(2)</sup>. In contrast, it was reported that dietary L-carnitine increased fatty acid oxidation in piglets<sup>(3)</sup>. Added L-carnitine to diet improved growth rate and feed efficiency<sup>(4, 5)</sup> and decreased body lipid content in weaning pigs<sup>(4, 6)</sup>. In broiler, dietary L-carnitine did not change body weight gain, feed conversion<sup>(7)</sup> and carcass composition<sup>(7, 8)</sup>. On the other hand, Rabie and Szilagyí showed that supplemental L-carnitine increased body weight gain, improved feed conversion and reduced the quantity of abdominal fat in broiler<sup>(9)</sup>. Dietary L-carnitine improved body weight gain and feed intake<sup>(10)</sup>, but did not influence abdominal fat in broiler<sup>(11)</sup>. Thus, the effect of dietary L-carnitine supplementation is conflicting.

Several studies have been done to determine whether dietary L-carnitine influences reproductive performance. Soufir *et al.* showed that infertile men had lower seminal carnitine concentrations than fertile men<sup>(12)</sup>. Baumgartner reported that boars had a significant increase in semen volume due to dietary carnitine<sup>(13)</sup>. Neuman *et al.* indicated that dietary carnitine did not affect testes weight, semen volume or sperm viability, but that rooster fed carnitine had greater sperm concentrations than control-fed birds<sup>(14)</sup>. Dietary L-carnitine did not influence egg production rate in laying hens<sup>(15)</sup>. Although the effects of dietary carnitine on sperm and egg production have been assessed in poultry, the effects of supplemental L-carnitine on the sexual maturity of female domestic fowl are not well known. The present study was performed to investigate the effect of additional L-carnitine to diet on body growth and composition and sexual maturity of female quail.

### Materials and Methods

#### *Birds and Management*

Eighty female Japanese quail (*Coturnix coturnix japonica*) were used in this study. The birds were raised in electrically heated, thermostatically controlled battery brooder equipped with wire floors from hatch to 19 days of age. At 19 days of age they were divided into 4 groups with each group having 4 sub-groups, and then were maintained in individual cages until sexual maturity (lay of first egg) under the light regime of

16 hr light and 8 hr dark. The brooder temperature was maintained at 33 C for the first week, and was gradually reduced by 4 C every week until room temperature. All experiments were carried out according to the guideline for the care and use of laboratory animals established by Kagawa University.

#### Diets

A corn-soybean basal feed (CP 24% and ME 2900 kcal/kg) was formulated to meet or exceed nutrient requirements of Japanese quail<sup>(16)</sup>. The basal feed was prepared to contain 58.77% corn, 31.03% soybean, 8.00% fish meal, 0.36% corn oil, 0.13% dicalcium phosphate, 1.14% limestone, 0.15% salt, 0.80% DL-methionine, 0.09% threonine and 0.30% vitamin-mineral premix. The experimental diets were prepared to contain 0, 125, 250 or 500 mg L-carnitine/kg in the basal feed. The birds of each group were fed the experimental diets from 21 days of age to sexual maturity with free access to food and water.

#### Measurements of Responses

Feed intake was measured from 21 to 35 days, and body weight was measured at 21 and 35 days of age and sexual maturity. At sexual maturity, blood samples were drawn under ether anesthesia and then the birds were sacrificed. Thereafter, ovary and oviduct were excised from abdominal cavity and immediately weighed. The largest 6 follicles were also removed from the ovary and the follicles were weighted. During the process of evisceration abdominal fat was designated as the depot of fat surrounding the Bursa of Fabricius, cloaca and adjacent muscle and adhering to the gizzard, and its weight was measured. Carcasses were kept at -29 C in freezer until determining protein, fat and ash. Sera were separated from the blood samples and kept at -29 C in freezer for determining serum composition.

#### Body and serum composition

Six carcasses from each category were selected for the composition analysis. The carcass was thawed overnight at 4 C in a refrigerator, and then breast muscle and tibia were separated from carcass. Breast muscle weight and tibia length were measured as an indicator of lean body growth and an estimate of skeletal development, respectively. Each carcass was minced and homogenized thoroughly in a blender. Replicate samples were randomly taken from the homogenized carcass and analyzed for carcass protein, fat and ash contents. Protein was determined with Kjeldahl method<sup>(17)</sup> and fat was extracted with the method of Folch *et al.*<sup>(18)</sup> and measured by drying the lipid extract and weighing residual fat. Ash was determined with AOAC method<sup>(17)</sup>. Serum cholesterol, triglyceride and

free fatty acid were determined spectrophotometrically using commercial kits (Wako Pure Chemicals Co. Ltd., Osaka).

#### Statistical analysis

Statistical analysis for data was carried out by one-way ANOVA followed by multiple range test<sup>(19)</sup>. Statistical significance was accepted when  $P < 0.05$ .

## Results and Discussion

In weanling pigs, feed efficiency was improved with increasing dietary L-carnitine; however, body weight gain and feed intake were not affected<sup>(4, 5)</sup>. In broiler chicken, Rabie and Szilagyi<sup>(9)</sup> and Celik and Ozturkan<sup>(11)</sup> showed that supplemental L-carnitine increased body weight gain and improved feed conversion in broiler. On the other hand, dietary L-carnitine did not affect body weight gain and feed efficiency in broiler<sup>(7, 8, 20)</sup> and laying hen<sup>(15)</sup>. In current study, there were no significant differences in body weight gain and feed requirement during the raising period due to the amounts of dietary L-carnitine (Table 1), indicating that dietary L-carnitine did not influence body growth and feed efficiency in female Japanese quail.

Data on physical attributes and carcass composition at sexual maturity are shown in Table 2 and 3. The weights of breast muscle and abdominal fat did not vary with dietary L-carnitine supplementation, and tibia length was not significantly different between the treatment groups (Table 2). No significant differences were observed in the content and percentage of carcass protein, fat and ash due to the amounts of added L-carnitine to diets (Table 3). These results indicated that dietary L-carnitine did not influence body protein and fat deposition and skeletal size at sexual maturity in female quail. Lien and Horng<sup>(8)</sup> also demonstrated that supplemental L-carnitine facilitated fatty acid transportation and did not influence the carcass characteristics of broiler. On the other hand, it is reported that the weight of breast muscle was increased<sup>(9, 20)</sup>, whereas the quantity of abdominal fat was reduced<sup>(9, 20, 21)</sup> by

Table 1 Body gain and feed intakes during a raising period in female quail fed diets containing L-carnitine

Item	Dietary L-carnitine (mg/kg)			
	0	125	250	500
Body wt. (g)				
21 days of age	71.6 ± 0.7*	71.7 ± 0.8	71.8 ± 0.8	71.6 ± 0.7
35 days of age	114.9 ± 1.9	114.5 ± 1.5	114.7 ± 1.1	113.8 ± 2.0
Body gain (g)	43.1 ± 1.6	42.8 ± 0.8	42.9 ± 1.3	42.2 ± 1.3
Feed intakes (g)	221.1 ± 0.7	226.9 ± 2.9	224.4 ± 2.2	223.0 ± 2.7
Feed requirement	5.19 ± 0.15	5.24 ± 0.06	5.29 ± 0.10	5.26 ± 0.14

\*Mean ± SE (n = 4)

Table 2 Physical attributes at sexual maturity of female quail fed diets containing L-carnitine

Item	Dietary L-carnitine (mg/kg)			
	0	125	250	500
Breast muscle				
g	21.59 ± 0.28*	20.74 ± 0.51	21.45 ± 0.46	21.21 ± 0.45
% per body wt.	15.61 ± 0.16	14.93 ± 0.26	15.05 ± 0.19	15.42 ± 0.28
Abdominal fat				
g	1.66 ± 0.22	1.55 ± 0.13	1.56 ± 0.14	1.56 ± 0.11
% per body wt.	1.20 ± 0.15	1.12 ± 0.10	1.09 ± 0.09	1.13 ± 0.08
Tibia length				
cm	4.55 ± 0.02	4.56 ± 0.04	4.58 ± 0.04	4.57 ± 0.03

\*Mean ± SE (n = 20)

Table 3 Carcass composition at sexual maturity of female quail fed diets containing L-carnitine

Item	Dietary L-carnitine (mg/kg)			
	0	125	250	500
Protein				
g/carcass	24.48 ± 0.15*	24.38 ± 0.23	25.20 ± 0.25	24.54 ± 0.52
%	19.37 ± 0.09	19.01 ± 0.19	19.24 ± 0.17	19.20 ± 0.31
Fat				
g/carcass	12.69 ± 0.74	14.48 ± 0.51	14.41 ± 0.58	13.66 ± 0.83
%	10.02 ± 0.70	11.29 ± 0.47	11.04 ± 0.77	10.71 ± 1.01
Ash				
g/carcass	4.91 ± 0.16	4.83 ± 0.14	5.33 ± 0.15	5.30 ± 0.13
%	3.89 ± 0.16	3.77 ± 0.15	4.06 ± 0.16	4.15 ± 0.11

\*Mean ± SE (n = 6)

Table 4 Serum composition at sexual maturity of female quail fed diets containing L-carnitine

Item	Dietary L-carnitine (mg/kg)			
	0	125	250	500
Cholesterol (mg/dl)	206 ± 19*	216 ± 19	232 ± 20	244 ± 18
Triglyceride (mg/dl)	1980 ± 308	2253 ± 325	3058 ± 390	2389 ± 436
Free fatty acid (mg/dl)	0.37 ± 0.02	0.45 ± 0.03	0.45 ± 0.03	0.44 ± 0.03

\*Mean ± SE (n = 13)

supplemental L-carnitine in broiler. Such conflicting results on L-carnitine may be partially due to variation in bird age, dietary ingredient and diet composition.

Serum composition at sexual maturity is shown in Table 4. Serum cholesterol and free fatty acid concentrations at sexual maturity did not vary with increasing the amounts of dietary L-carnitine. Triglyceride concentration was slightly higher 250 mg group compared with other groups, but the difference was not statistically significant. Lien and Horng showed that dietary L-carnitine did not change serum cholesterol concentration in broiler<sup>(8)</sup>, supporting our results. Dietary L-carnitine is reported to lower serum triglyceride<sup>(8, 20)</sup> and free fatty acid<sup>(8)</sup> concentrations in broiler. In contrast, Buyse *et al.* indicated that plasma triglyceride concentration was not influence by dietary L-carnitine supplementation in broiler<sup>(21)</sup>, being similar to result in this study. Chapa *et al.* demonstrated

Table 5 Age and body and reproductive organ weights at sexual maturity of female quail fed diets containing L-carnitine

Item	Dietary L-carnitine (mg/kg)			
	0	125	250	500
Age at sexual maturity (days)	42.2 ± 0.6*	41.7 ± 0.6	42.1 ± 0.6	42.9 ± 0.8
Body wt. (g)	138.4 ± 1.6	138.8 ± 2.0	142.6 ± 2.7	137.6 ± 2.0
Ovary wt.				
g	6.01 ± 0.28	6.36 ± 0.22	6.70 ± 0.28	6.05 ± 0.28
% per body wt.	4.34 ± 0.30	4.59 ± 0.16	4.70 ± 0.18	4.41 ± 0.29
Oviduct wt.				
g	5.83 ± 0.13	5.70 ± 0.18	5.80 ± 0.19	5.80 ± 0.22
% per body wt.	4.21 ± 0.09	4.10 ± 0.10	4.06 ± 0.09	4.23 ± 0.16

\*Mean ± SE (n = 20)

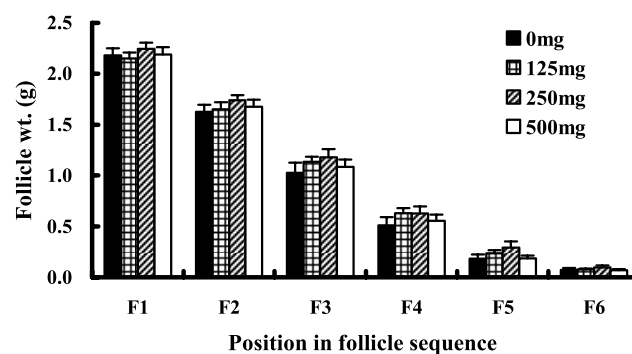


Figure 1 Follicle weights in the ovary of female quail fed diets containing L-carnitine

that plasma free fatty acid was elevated with intravenous L-carnitine administration in sheep<sup>(22)</sup>.

Data on age and ovary and oviduct weights at sexual maturity is summarized in Table 5. Age at sexual maturity did not vary with increased amounts of dietary L-carnitine. Body weight at sexual maturity was not significantly different among the treatment groups. The ovary and oviduct weights had almost the same values among the treatment groups. There were no significant differences in each follicle in sequence of follicle size among the treatment groups (Figure 1). Although dietary L-carnitine supplementation increased semen volume in boars<sup>(13)</sup> and elevated the sperm concentration of rooster<sup>(14)</sup>, the present results indicated that L-carnitine supplementation had no effect on reproductive function, particularly the growth of ovarian follicles in female quail. Rabie *et al.* also suggested that dietary L-carnitine may not influence the growth of ovarian follicles in laying hens<sup>(15)</sup>.

These facts suggested that dietary L-carnitine supplementation did not influence body growth and composition and ovary growth in female Japanese quail.

## References

- (1) BORUM, P. R.: Carnitine. *Ann. Rev. Nutr.*, **3**, 233 – 259 (1983) .
- (2) COFFEY, M. T., SHIREMAN, R. B., HERMAN, D. L. and JONES E. E.: Carnitine status and lipid utilization in neonatal piglets fed diets low in carnitine. *J. Nutr.*, **121**, 1047 – 1053 (1991) .
- (3) KEMPEN, T. A., VAN, T. G. and ODLE, J.: Medium-chain fatty acid oxidation in colostrums-derived newborn piglets: Stimulative effect of carnitine supplementation. *J. Nutr.*, **123**, 1531 – 1537 (1993) .
- (4) OWEN, K. Q., NELSSSEN, J. L., GOODBAND, R. D., WEEDEN, T. L. and Blum S. A.: Effect of L-carnitine and soybean oil on growth performance and body composition of early-weaned pigs. *J. Anim. Sci.*, **74**, 1612 – 1619 (1996) .
- (5) RINCKER, M. J., CARTER, S. D., REAL, D. E., NELSSSEN, J. L., TOKACH, M. D., GOODBAND, R. D., DRITZ, S. S., SENNE, B. W., FENT, R. W., PETTEY, L. A. and OWEN, K. Q.: Effects of increasing dietary L-carnitine on growth performance of weanling pigs. *J. Anim. Sci.*, **81**, 2259 – 2269 (2003) .
- (6) WEEDEN, T. L., NELSSSEN, J. L., HANSEN, J. A., FITZNER, G. E. and GOODBAND, R. D.: The effect of L-carnitine on starter pig performance and carcass composition. *J. Anim., Sci.* **69**, Supplement 1, 105 (1991) .
- (7) BAKER, D. L. and SELL, J. L.: Dietary carnitine did not influence performance and carcass composition of broiler chicken and young turkeys fed low or high fat diets. *Poultry Sci.*, **73**, 281 – 287 (1994) .
- (8) LIEN, T-F. and HORNG, Y-M.: The effects of supplementary dietary L-carnitine on the growth performance, serum components, carcass traits and enzyme activities in relation to fatty acid oxidation of broiler chickens. *Br. Poult. Sci.*, **42**, 92 – 95 (2001) .
- (9) RABIE, H. M and SZILAGYI, M.: 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. *Br. J. Nutr.*, **80**, 391 – 400 (1998) .
- (10) KITA, K., KATO, S., AMAN YAMAN, M., OKUMURA, J. and YOKOTA, H.: Dietary L-carnitine increases plasma insulin-like growth factor-I concentration in chicks fed a diet with adequate dietary protein level. *Br. Poult. Sci.*, **43**, 117 – 121 (2002) .
- (11) CELIK, L. and OZTURKCAN, O.: Effects of dietary supplemental L-carnitine and ascorbic acid on performance, carcass composition and plasma L-carnitine concentration of broiler chicks reared under different temperature. *Arch. Tierernahr*, **57**, 27 – 38 (2003) .
- (12) SOUFIR, J. C., DUCOT, B., MARSON, J., JOUANNET, P., FENEUX, D., SOUMAH, A. and SPIRA, A.: Levels of seminal free L-carnitine in fertile and infertile men. *Int. J. Androl.* **7**, 188 – 197 (1984) .
- (13) BAUMGARTNER, M.: Boars react positively to L-carnitine supplements. *Int. Pig Topics*, **13**, 32 (1998) .
- (14) NEUMAN, S. L., LIN, T. L. and HESTER, P. Y.: The effect of dietary carnitine on semen traits of White Leghorn roosters. *Poultry Sci.*, **81**, 495 – 503 (2002) .
- (15) RABIE, M. H., SZILAGYI, M. and GIPPERT, T.: Effects of dietary L-carnitine on the performance and egg quality of laying hens from 65-73 weeks of age. *Br. J. Nutr.*, **78**, 615 – 623 (1997) .
- (16) NRC: Nutrient Requirements of Poultry, Ninth revised edition, National Academy Press, Washington, D.C. (1994) .
- (17) AOAC : Official Methods of Analysis (15<sup>th</sup> Ed.) Association of Official Analytical Chemists, Arlington, VA. (1990) .
- (18) FOLCH, J., LEES, M. and SLOANE-STANLEY, G. H.: A simple method for the isolation and purification of total lipids from animal tissue. *J. Biol. Chem.*, **226**, 497 – 509 (1957) .
- (19) DUNCAN, D. B.: Multiple range and multiple F test. *Biometrics*, **11**, 1 – 42 (1955) .
- (20) XU, Z. R., WANG, M. Q., MAO, H. X., ZHAN, X. A. and HU, C. H.: Effects of L-carnitine on growth performance, carcass composition, and metabolism of lipids in male broilers. *Poultry Sci.*, **82**, 408 – 413 (2003) .
- (21) BUYSE, J., JANSSENS, G. P. and DECUYPERE, E.: 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. *Br. Poult. Sci.*, **42**, 230 – 241 (2001) .
- (22) CHAPA, A. M., FERNANDEZ, J. M., WHITE, T. W., BUNTING, L. D., GENTRY, L. R., WARD, T. L. and BLUM, S. A.: Influence of intravenous L-carnitine administration in sheep preceding an oral urea drench. *J. Anim. Sci.*, **76**, 2930 – 2937 (1998) .

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## L-カルニチン添加飼料を給与したメスウズラの体成分と性成熟

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メスウズラに種々の量のL-カルニチンを含む飼料を21日齢から性成熟（産卵開始）まで給与し、L-カルニチンが体成長、体成分量および性成熟に及ぼす影響を調べた。体成長は添加したL-カルニチン量によって差異がなかった。性成熟時においてと体の蛋白質と脂肪量は飼料のL-カルニチン量によって違いが認められず、また血清コレステロール、トリグリセライドおよび遊離脂肪酸濃度も変化を示さなかった。また、性成熟日齢はL-カルニチン添加飼料を給与しても各処理間でほぼ同じであり、また性成熟時の卵巢重と卵巢中の卵胞の発育もL-カルニチン添加飼料の給与によって違いがみられなかった。この結果から、L-カルニチン添加飼料の給与はメスウズラの体成長、体成分量および卵巢発達に対して影響しないことが示唆された。