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≪**Research Note**≫

Dietary L-Carnitine Supplementation Improves Albumen Quality of Laying Hens

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The effect of L-carnitine supplemented into a commercial diet on egg weight, albumen height, Haugh unit, yolk weight and albumen weight of eggs from laying hens was examined. The levels of dietary L-carnitine supplementation were 0, 25, 50 and 200 mg/kg. Laying hens were given the diets for 8 weeks. Albumen height and Haugh unit were the highest in the 25 mg/kg L-carnitine group. When L-carnitine was added at the levels of more than 50 mg/kg, yolk weight was significantly increased. In conclusion, dietary L-carnitine supplementation had a beneficial effect on albumen quality and could modify the components of the edible part of the egg.

Key words : L-carnitine, albumen height, haugh unit, laying hens

Introduction

L-Carnitine (β-OH-(γ-N-trimethylamino)-butyrate) is a small-molecular-weight water-soluble amine which occurs naturally in microorganisms, plants and animals (Bremer, 1983). L-Carnitine is synthesized from lysine and methionine and is well recognized as playing an important role for the mitochondrial oxidation of long-chain fatty acids to produce energy via β-oxidation and oxidative phosphorylation (Borum, 1983). Several studies in avian species demonstrated a growth improvement by feeding dietary L-carnitine (Rabie *et al.,* 1997 b, c ; Rabie and Szilagyi, 1998). In these reports, the authors speculated that the improvements in body weight gain in response to an improved utilization of dietary N, achieved through more efficient fat oxidation by L-carnitine. We also investigated the effect of dietary L-carnitine supplementation on body weight gain and muscle weight of layer (Single Comb White Leghorn) chicks. In this study, body weight gain was improved by dietary L-carnitine supplementation at the level of more than 500 mg/kg, and breast muscle weight also increased significantly with rising dietary L-carnitine levels from 200 to 500 mg/kg (Kita *et al.,* 2002). Furthermore, we demonstrated that the improvement of body weight gain caused by dietary L-carnitine supplementation seemed to be partially explained by an increase in plasma IGF-I concentration, which is a 70 amino acid peptide having the potency to

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stimulate body weight gain (Kita *et al.,* 1996, 1999).

It was well known that egg quality can be modified by various nutritional factors. Haugh unit, which was suggested by Haugh (1937 a, b) and has been used as a unit for albumen quality and egg freshness, showed higher score when pullets were given a low protein diet during growing period (Christmas *et al.*, 1982). Biotin deficiency decreased albumen height and it was improved by biotin supplementation (Whitehead, 1980). Although the influence of supplemental dietary L-carnitine on laying-hen performance and egg quality was investigated during late laying period (Rabie *et al.*, 1997 a), its effect on egg quality of laying hens during mid laying period has not been clarified. The objective of the present study was to investigate the influence of dietary L-carnitine supplementation on egg quality of laying hens during mid laying stage.

Materials and Methods

Three hundreds twenty single-comb White Leghorn laying hens (36 weeks of age) were used and were divided evenly into 4 experimental groups of 80 birds each. The birds were fed on a commercial corn-soy diet (Toyohashi Feed Mills Co. Ltd., Shinshiro, Japan) supplemented with 4 levels of L-carnitine (0, 25, 50 or 200 mg/kg). Light condition was 16L8D. Egg weight, yolk weight, albumen weight, albumen height and Haugh unit score were measured on 3, 5 and 8 weeks of experimental periods. Collected eggs were weighed individually. Then, they were broken onto a smooth level surface and the height of albumen was determined at the two highest points on opposite sides of the yolk, using a standard tripod micrometer. The average of the two measurements of thick albumen height together with egg weight were used to compute the Haugh unit score for each individual egg according to the calculation of Haugh (1937 a, b). The yolk was separated from the albumen and then weighed. Albumen weight was calculated by subtracting the yolk plus shell weight from the total egg weight.

Statistical analysis of data was performed by two-way ANOVA followed by Duncan's multiple range test (Duncan, 1955) using the General Linear Model Procedures (GLM ; SAS/STAT Version 6, Statistical Analysis Systems Institute Inc., Cary, NC, USA). Differences between means were considered to be significant at $P < 0.05$.

Results

Egg weight, yolk weight, albumen weight, albumen height and Haugh unit score of eggs on each group are shown in Table 1. There were no interactions between L-carnitine level and experimental period in all parameters. Egg weight was not affected by dietary L-carnitine supplementation. Albumen height and Haugh unit score were the highest in the 25 mg/kg L-carnitine group. The highest value for yolk weight was achieved by the group of birds fed on the higher levels of L-carnitine more than 50 mg/kg. There was no influence of dietary L-carnitine supplementation on albumen weight.

Discussion

Recently the influence of dietary L-carnitine supplementation on the performance

Table 1. Egg weight, albumen weight, Haugh unit score, yolk weight and albumen weight of laying hens fed diets with various L-carnitine levels

Carnitine (mg/kg)	Experimental period (weeks)	Egg weight (g)	Yolk weight (g)	Albumen weight (g)	Albumen height (mm)	Haugh unit score
0	0	60.3[2]	16.6[2]	35.0[2]	7.02[2]	83.3[2]
	3	61.8[2]	17.4[2]	35.4[2]	7.00[2]	82.6[2]
	5	61.1[2]	16.9[2]	35.4[2]	6.85[2]	81.9[2]
	8	60.2[1]	16.9[2]	34.4[2]	6.65[1]	81.9[1]
	Mean	60.7	16.9[b]	35.0	6.97[b]	82.7[b]
25	0	59.8[3]	16.4[4]	34.8[4]	6.96[3]	83.0[3]
	3	60.0[2]	16.6[2]	34.8[2]	7.29[2]	85.0[2]
	5	60.1[3]	16.5[4]	35.0[4]	6.99[4]	83.1[4]
	8	60.2[3]	17.1[4]	34.6[4]	7.18[3]	84.4[3]
	Mean	60.2	16.5[c]	35.0	7.19[a]	84.4[a]
50	0	59.9[2]	17.2[2]	34.2[2]	6.67[2]	81.1[2]
	3	61.6	17.7	35.1	6.81	81.4
	5	59.3[1]	16.8[2]	34.5[2]	6.71[2]	81.4[2]
	8	61.3[1]	17.6[2]	34.8[2]	6.52[1]	79.7[1]
	Mean	60.5	17.1[ab]	34.6	6.66[c]	80.9[c]
200	0	59.6	16.6	34.5	6.67	80.7
	3	61.1[1]	17.4[2]	34.9[2]	6.71[1]	80.9[1]
	5	60.6	16.9	34.8	6.72	81.0
	8	61.1[2]	17.2[2]	35.0[2]	6.48[2]	79.2[2]
	Mean	60.7	17.2[a]	34.8	6.67[c]	80.6[c]
Pooled SEM		0.31	0.11	0.22	0.05	0.32
Analysis of variance				Probability		
L-Carnitine		0.292	0.001	0.583	0.001	0.001
Experimental period		0.044	0.001	0.533	0.031	0.066
L-Carnitine×Period		0.410	0.454	0.854	0.268	0.186

[a, b, c] Means in the same column with unlike superscript letters were significantly different ($P < 0.05$).
The number of chicks used in each treatment was eighty. [1] One missing value. [2] Two missing values. [3] Three missing values. [4] Four missing values.

of young chickens was systematically investigated by Rabie *et al.* (1997 b, c, 1998) and our research group (Kita *et al.,* 2002). In these reports, it can be led that dietary L-carnitine supplementation has potency to improve body weight gain of chickens during early stages of growth. On the other hand, the research investigating the

influence of dietary L-carnitine supplementation on the performance of laying hens has been limited. Rabie *et al.* (1997 a) reported that dietary L-carnitine supplementation resulted in an improvement in albumen quality (albumen height and Haugh unit score) during the late laying period from 65–73 weeks of age. As shown in Table 1, it was obvious that supplemental dietary L-carnitine had the potency to improve albumen quality even during the mid laying period (36–44 weeks of age) as well as the late laying period. Dietary L-carnitine treatment within 8 weeks significantly affected on egg weight, yolk weight and albumen height in the present study, though Rabie et al. (1997 a) reported that the effect of L-carnitine on egg quality was observed after 8 weeks of treatments. Although the positive effect of dietary L-carnitine supplementation on albumen quality was observed above 50 mg/kg of carnitine level during the late laying period, albumen quality was improved by supplemental dietary L-carnitine at the level of 25 mg/kg during the mid laying period (Table 1). In the present study, L-carnitine was given to laying hens for 8 weeks. As Rabie *et al.* (1997 a) mentioned, the mechanism by which the improvement in albumen quality occurred by supplemental dietary L-carnitine has not been clear yet. Based on the results reported here, however, the difference in the effect of dietary L-carnitine supplementation on albumen quality may be modified by the difference in laying stages as well as layer strain, dietary sources and environment. Furthermore, it has been reported that ovomucin content of eggs is mainly responsible for the gelatinous properties of the thick albumen (Robinson, 1987), and dietary L-carnitine might be stimulus to enhance obomucin secretion resulting in the improvement of albumen height and Haugh unit score. This issue should be elucidated in the future.

In conclusion, dietary L-carnitine supplementation was effective to improve albumen quality especially as an index of egg freshness during the mid laying period.

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