Effect of Supplementary Dietary L-carnitine and Yeast Chromium on Lipid Metabolism of Laying Hens*

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ABSTRACT : Two hundred and eighty-eight 21-week-old Hyline Brown laying hens were randomly allotted to 9 treatments, 32 birds for each treatment. A 3×3 (chromium×L-carnitine) factorial experiment was designed to investigate the single and interactive effects of adding yeast chromium (0, 400 and 600 μg/kg) and L-carnitine (0, 50 and 100 mg/kg) to corn-soybean diets on lipid metabolism of laying hens for 7 weeks. The results showed that 600 μg/kg chromium or 100 mg/kg L-carnitine had significant effects on most indices of lipid metabolism ($p<0.05$ or 0.01). There were significant interactions on the concentration of liver triglycerides, egg yolk cholesterol, abdominal fat percentage between chromium and L-carnitine ($p=0.0003$-0.0500). Adding 400 μg/kg chromium and 100 mg/kg L-carnitine simultaneously was the best for reducing egg yolk cholesterol and adding 400 μg/kg chromium and 50 mg/kg L-carnitine at the same time was the best for reducing abdominal fat percentage. There was no side effect on production performance of laying hens while chromium or (and) L-carnitine reduced liver lipid, abdominal fat and egg yolk cholesterol. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 2 : 235-240)***

Key Words : Laying Hens, Yeast Chromium, L-carnitine, Lipid Metabolism, Synergic Effect

INTRODUCTION

The liver is an important organ of lipid metabolism for poultry. Fat Liver Syndrome (FLS) may result from abnormal lipid deposition in liver. The incidence of FLS, the key factor influencing production performance of laying hens, is related to high-production of laying hens (Zhou et al., 2002). The relationship between egg rich in cholesterol and cardiovascular system diseases of humans became a problem concerning by nutritionists and consumers. In America, it is one of the important preventive measures of coronary heart disease to reduce intake of cholesterol (Anonymous, 2001). Therefore, the study, which aimed at regulating lipid metabolism of high-production laying hens and reducing the content of cholesterol in eggs, had significance in theory and practice. It is possible for chromium (Cr) and L-carnitine to regulate cooperatively the metabolism of lipid, carbohydrate and protein. Han et al. (1999) showed that adding Cr and L-carnitine simultaneously to the diet of swine improved the growth performance better than adding either alone. Our research (Wang et al., 2004) showed that there were significant interactions on the lipid metabolism of broiler chickens between Cr and L-carnitine. The stage (transition to high-production) in which the lipid metabolism changes clearly was selected, and the experiment was conducted to investigate the single and interactive effects of Cr and L-carnitine on lipid metabolism of laying hens.

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MATERIALS AND METHODS

Animal raising and experimental design

Two hundreds and eighty-eight 21-week-old Hyline Brown laying hens were randomly allocated to 9 treatments, 32 birds for each treatment (4 replicates). A 3×3 (Cr×carnitine) factorial experiment was designed, in which Cr (0, 400 and 600 μg/kg) and L-carnitine (0, 50 and 100 mg/kg) were supplemented. Compositions and nutrient levels of the basal diet (according to the nutritional criteria for laying hens in P. R. China, 1986) were shown in Table 1. The experiment lasted for seven weeks. L-Carnitine and Cr were respectively derived from Carniking (Longsha Company in Hong Kong, 50% L-Carnitine in it) and Yeast Chromium (Alltech Biology Company in Beijing, 0.1% Cr in it).

Collection and biochemical analysis of samples

At the seventh weekend of the experiment, blood samples were obtained from the wings of 8 hens fasted for 12 h in each treatment. The serum centrifuged for 15 minutes and frozen (-30°C). The liver and abdominal fat were also taken, weighed and kept in -30°C refrigerator. Eight eggs from each treatment were kept in 4°C refrigerator.

The activity of serum insulin was determined by means

Table 1. Compositions and nutrient levels of the basal diet

Ingredients (%)		Nutrient levels	
Corn	60.00	Metabolic energy (MJ/kg) [3]	11.55
Soybean meal	22.50	Crude protein (%)	16.55
Wheat bran	2.50	Lysine (%)	0.84
Rapeseed meal	3.00	Methionine (%)	0.38
Fish meal	2.00	Methionine+cystine	0.64
$CaHPO_4$	1.70	Calcium (%)	3.77
Stone meal	7.00	Available phosphorus (%)	0.34
Salt	0.30	Chromium (μg/kg) [2]	300.00
Premix [1]	1.00	L-carnitine (mg/kg)[3]	5.00-11.00
Total	100.00		

[1] Every kg diet: Fe ($FeSO_4 \cdot H_2O$), 70 mg; Zn ($ZnSO_4 \cdot H_2O$), 50 mg; Mn ($MnSO_4 \cdot H_2O$), 60 mg; Cu ($CuSO_4 \cdot 5H_2O$), 6.0 mg; I (KI), 1.2 mg; Se ($NaSe_2O_3$), 0.20 mg. Vitamins premix: from Shanghai Tongren.

[2] Determined value, [3] Calculated value.

Table 2. Effect of dietary chromium and L-carnitine on the production performance of laying hens

Added levels			0 to 7 weeks during experiment				
CN (mg/kg)	Cr (μg/kg)	n	Daily percent lay (%)	Mean egg weight (g)	Egg mass /day (g)	Feed consumption /day (g)	Feed/egg (F/E)
0	0	8	89.55±2.11	57.29±1.16	51.30±3.01	143.79±7.84	2.78±0.17
	400	8	89.32±2.25	59.93±1.81	53.53±2.14	139.15±7.94	2.62±0.19
	600	8	89.55±2.56	59.90±2.55	53.64±2.78	137.89±6.51	2.58±0.16
50	0	8	88.69±3.69	58.66±1.70	52.03±2.45	137.67±8.94	2.69±0.12
	400	8	88.76±3.65	59.50±1.60	52.81±1.90	136.44±5.94	2.58±0.22
	600	8	88.97±2.39	59.67±1.88	53.08±1.91	137.92±8.18	2.62±0.15
100	0	8	87.86±3.83	59.63±2.63	52.39±1.97	133.15±6.33	2.53±0.16
	400	8	88.91±3.63	59.53±1.70	52.93±2.20	141.37±8.86	2.67±0.18
	600	8	87.52±4.13	58.64±1.77	51.32±2.56	134.55±5.66	2.57±0.16
0		24	89.47	59.04	52.82	140.27	2.66
50		24	88.81	59.27	52.64	137.34	2.63
100		24	88.09	59.27	52.21	136.36	2.59
	0	24	88.70	58.53	51.90	138.20	2.67
	400	24	90.00	59.65	53.09	138.98	2.62
	600	24	88.68	59.40	52.68	136.78	2.59
P value：	CN		0.7649	0.9175	0.9546	0.4196	0.5976
	Cr		0.9948	0.2014	0.6156	0.7664	0.5408
	CN×Cr		0.9986	0.2332	0.9152	0.4600	0.3913

CN: individual effect of L-carnitine; Cr: individual effect of Chromium; CN×Cr: interaction.

of radioimmunoassay (RIA) using a commercially available RIA kit (China Atomic Energy Science Institute). The content of serum free fatty acid (FFA) was measured by spectrophotometer, with reagents supplied by Nanjing Jiancheng Biotechnics Institution. The biochemical indices of serum, tissue and egg were measured by semiautomatic biochemistry analyst (Germany, PM5010), and the reagents were supplied by Beijing Zhongsheng High-tech Bioengineering Company. The ways of determination of total cholesterol (TC), triaclyglycerol (TG), High (Low) density lipoprotein cholesterol (HDL-C, LDL-C), Apolipoprotein AI or B (APOAI and APOB), Glucose (GLu) were respectively CHOD-PAP, GPO-PAP, PAT-Mg^{2+} (PVS), transmission turbidimetry and GOD-PAP. The TG and TC of liver and egg yolk in laying hens were extracted in methanol-chloroform before measurement.

Statistical analysis

Data were analyzed by F value using two factors, 3×3 levels procedures of SAS statistical software, and then Duncan's Multiple Range Test for Variable was carried out, with the standard probabilities of 0.01 and 0.05.

RESULTS

Effect of dietary chromium and L-carnitine on production performance of laying hens

At the end of experiment, adding Cr or (and) L-carnitine did not affect production performance of laying hens ($p>0.05$), but mean egg weight and egg mass tended to increase although daily percent lay tended to reduce (Table 2).

Table 3. Effect of dietary chromium and L-carnitine on AFW, AFP, Liver TG, TC and Yolk TC of laying Hens

Added levels		n	7th weekend during experiment				
CN (mg/kg)	Cr (μg/kg)		AFW (g)	AFP (%)	LiverTG (mg/g)	LiverTC (mg/g)	YolkTC (mg/g)
0	0	8	41.93±9.36^{a}	2.20±0.42^{a}	10.69±0.59^{a}	2.55±0.21^{a}	12.47±0.83^{a}
	400	8	41.05±4.96^{ab}	2.18±0.13^{a}	8.92±0.64^{c}	2.10±0.29^{bc}	10.89±0.81^{b}
	600	8	28.25±8.36^{bc}	1.58±0.61^{bc}	9.27±0.83^{bc}	2.24±0.43^{bc}	10.96±1.14^{b}
50	0	8	37.38±10.79^{ab}	2.04±0.54^{ab}	10.09±0.53^{abc}	2.64±0.21^{a}	10.94±0.72^{b}
	400	8	20.83±4.50^{c}	1.15±0.21^{c}	9.57±0.90^{abc}	2.40±0.41^{abc}	10.72±0.96^{b}
	600	8	35.73±9.77^{ab}	1.78±0.42^{abc}	9.72±1.05^{abc}	2.36±0.12^{abc}	10.04±1.19^{b}
100	0	8	27.00±7.25^{bc}	1.40±0.59^{bc}	9.31±0.34^{bc}	2.18±0.88^{bc}	10.47±0.86^{b}
	400	8	36.70±6.02^{ab}	1.87±0.23^{ab}	10.19±0.68^{ab}	2.01±0.27^{bc}	9.60±0.89^{b}
	600	8	34.83±3.90^{ab}	1.90±0.21^{ab}	9.56±0.64^{abc}	1.79±0.41^{c}	10.31±0.59^{b}
0		24	37.08	1.99	9.63	2.30^{ab}	11.44^{a}
50		24	31.31	1.65	9.79	2.47^{a}	10.57^{ab}
100		24	32.84	1.73	9.68	1.99^{b}	10.13^{b}
	0	24	35.43	1.88	10.03	2.45^{a}	11.29^{a}
	400	24	38.86	1.73	9.56	2.17^{b}	10.40^{b}
	600	24	32.93	1.75	9.52	2.13^{b}	10.44^{ab}
Pvalue:	CN		0.1864	0.1341	0.3985	0.0209	0.0100
	Cr		0.1381	0.6384	0.2377	0.0132	0.0395
	CN×Cr		0.0214	0.0053	0.0088	0.9068	0.0327

* CN: individual effect of L-carnitine; Cr: individual effect of Cr; CN×Cr: interaction.
* Values without same superscript letters within the same column differ significantly ($p<0.05$ or $p<0.01$).
* AFW=abdominal fat weight, AFP=abdominal fat percentage, TC= total cholesterol, TG=triaclyglycerol.

Effect of dietary chromium and L-carnitine on abdominal fat, liver lipid and yolk cholesterol of laying hens

Chromium or L-carnitine (*n=24*) : Cr or L-carnitine (n=24) had significant effects only on liver TC and Yolk TC of laying hens at the end of experiment ($0.0100\leq p\leq 0.0395$) (Table 3).

Adding chromium or L-carnitine singly (*n=8*) : Adding Cr or L-carnitine alone had significant effects on the contents of liver TG, liver TC, yolk TC and abdominal fat weight or percentage (AFW or AFP). Compared with the control group, the level of 400, 600 μg/kg Cr resulted in decrease of liver TG by 16.55% and 13.28% ($p<0.05$), decrease of liver TC by 17.65% and 12.16% ($p<0.05$), decrease of yolk TC by 12.67% and 12.11% ($p<0.05$), respectively. Only 600 μg/kg Cr significantly reduced AFP by 28.18% ($p<0.05$). The level of 50 and 100 mg/kg L-carnitine lead to decrease of yolk TC by 12.27% and 16.04% ($p<0.05$). Only 100 mg/kg L-carnitine reduced liver TG, liver TC and AFP by 12.91%, 14.51% and 36.36%, respectively ($p<0.05$) (Table 3).

Interaction between Chromium and L-carnitine (*n=8*) : Cr and L-carnitine presented significant interaction on AFW, AFP, liver TG and yolk TC ($0.0053\leq p\leq 0.0327$). Adding 400 μg/kg Cr and 50 mg/kg L-carnitine simultaneously was the best for reducing AFP, and the decreases of AFP were 17.86-47.72% compared with other 11 groups. While adding 400 μg/kg Cr and 100 mg/kg L-carnitine simultaneously was the best for reducing yolk TC, and decreased of yolk TC by 4.38-23.02% compared with other 11 groups. However, no better of Cr and L-carnitine was found for the decrease of liver TG (Table 3).

Effect of dietary chromium and L-carnitine on serum lipid and glucose of Laying Hens

Chromium or L-carnitine (*n=24*) : At the 7th weekend during experiment, serum FFA, LDL-C, APOAI, APOB and insulin had been significantly affected by supplementing dietary Cr ($0.0027\leq p\leq 0.0060$), but L-carnitine only had significant effects on serum FFA and APOAI ($0.0009\leq p\leq 0.0158$) (Tables 4 and 5).

Adding chromium or L-carnitine single (*n=8*) : Adding Cr alone had significant effects on the contents of serum FFA, HDL-C, APOAI and APOB. Compared with the control group, the level of 400, 600 μg/kg Cr resulted in increase of serum FFA by 23.35% ($p<0.01$) and 9.11% ($p<0.05$), increase of serum HDL-C by 51.81% and 22.89% ($p<0.05$), increase of serum APOAI by 47.11% ($p<0.01$) and 19.94% ($p<0.05$); decrease of serum APOB by 29.01% and 45.43% ($p<0.01$), respectively. Only 600 μg/kg Cr significantly reduced serum TG and LDL-C, respectively by 31.28% ($p<0.05$) and 54.85% ($p<0.01$). There were not significant effects on serum TC, glucose (GLu) and insulin (Tables 4 and 5).

Adding L-carnitine alone had significant effects on the contents of serum FFA, HDL-C and APOB. Compared with the control group, the level of 50 and 100 mg/kg L-carnitine increased serum FFA by 10.85% and 9.85% ($p<0.05$), increased serum HDL-C by 45.78% ($p<0.05$) and 110.8%

Table 4. Effect of dietary chromium and L-carnitine on serum TG, TC, FFA, HDL-C and LDL-C of Laying Hens

Added levels			7th weekend during experiment				
CN (mg/kg)	Cr (μg/kg)	n	Serum TG (mmol/L)	Serum TC (mmol/L)	Serum FFA (μmol/L)	Serum HDL-C (mmol/L)	Serum LDL-C (mmol/L)
0	0	8	18.54±3.67^{a}	3.79±0.24	469.22±23.96^{c}	0.83±0.30^{c}	2.06±0.52^{a}
	400	8	15.81±3.41^{ab}	3.82±0.56	578.80±33.19^{a}	1.26±0.31^{b}	1.46±0.53^{abc}
	600	8	12.74±3.90^{b}	3.26±0.33	511.98±48.98^{b}	1.02±0.39^{b}	0.93±0.39^{c}
50	0	8	14.53±4.36^{ab}	3.78±0.29	520.13±42.15^{ab}	1.21±0.27^{b}	1.54±0.50^{abc}
	400	8	11.70±3.50^{b}	3.69±0.53	438.15±34.17^{c}	1.01±0.31^{b}	1.30±0.49^{bc}
	600	8	14.01±3.27^{ab}	3.44±0.27	441.76±62.68^{c}	0.92±0.17^{bc}	1.24±0.36^{bc}
100	0	8	12.10±3.58^{b}	3.43±0.51	515.46±36.60^{b}	1.75±0.62^{a}	1.82±0.51^{ab}
	400	8	13.34±4.08^{ab}	3.38±0.19	527.91±30.48^{ab}	0.85±0.17^{bc}	1.27±0.38^{bc}
	600	8	13.57±3.89^{ab}	3.31±0.33	506.55±25.99^{b}	0.83±0.19^{bc}	1.38±0.32^{abc}
0		24	15.70	3.62	520.00^{a}	1.04	1.48
50		24	13.42	3.64	466.68^{b}	1.05	1.36
100		24	13.00	3.37	516.64^{a}	1.14	1.49
	0	24	15.06	3.67^{a}	501.60^{a}	1.26	1.81^{a}
	400	24	13.62	3.63^{ab}	514.95^{a}	1.04	1.34^{b}
	600	24	13.44	3.34^{b}	486.76^{b}	0.93	1.18^{b}
P value:	CN		0.1858	0.2477	0.0158	0.6870	0.7341
	Cr		0.5200	0.1553	0.0033	0.0564	0.0060
	CN×Cr		0.3057	0.7127	0.0003	0.0051	0.3642

* CN: individual effect of L-carnitine; Cr: individual effect of Cr; CN×Cr: interaction.
* Values without same superscript letters within the same column differ significantly ($p<0.05$ or $p<0.01$).
* TG=triaclyglycerol, TC=total cholesterol, FFA=free fatty acid, HDL-C=high density lipoprotein cholesterol, LDL-C=low density lipoprotein cholesterol.

Table 5. Effect of dietary chromium and L-carnitine on serum APOAI, APOB, GLU and insulin of laying hens

Added levels			7weekend during experiment			
CN (mg/kg)	Cr (μg/kg)	n	SerumAPOAI (mg/dl)	SerumAPOB (mg/dl)	Serum insulin (mIU/L)	SerumGLU (mmol/L)
0	0	8	16.60±0.63^{f}	67.38±4.49^{a}	3.78±1.61^{abc}	11.63±0.56^{ab}
	400	8	24.42±3.04^{b}	47.83±3.82^{c}	4.11±0.60^{ab}	12.10±0.32^{a}
	600	8	19.91±1.65^{c}	36.77±2.68^{d}	2.51±1.20^{c}	11.27±0.58^{ab}
50	0	8	17.73±0.73^{ef}	52.84±5.42^{bc}	3.90±0.22^{abc}	10.57±0.68^{b}
	400	8	19.35±0.96^{cd}	45.91±2.17^{c}	2.91±0.28^{bc}	12.13±0.53^{a}
	600	8	20.28±2.67^{c}	52.50±1.97^{bc}	3.14±0.29^{abc}	11.55±0.89^{ab}
100	0	8	28.62±1.26^{a}	56.78±3.92^{b}	4.63±0.66^{a}	11.80±0.60^{a}
	400	8	20.40±0.93^{c}	46.53±2.29^{c}	4.50±1.42^{a}	11.54±0.71^{ab}
	600	8	19.61±1.15^{c}	48.81±1.87^{c}	2.80±0.97^{bc}	11.66±0.64^{ab}
0		24	20.31^{b}	50.66	3.47	11.67
50		24	19.12^{b}	50.41	3.32	11.42
100		24	22.88^{a}	50.71	3.98	11.67
	0	24	20.99^{a}	59.00^{a}	4.10^{a}	11.34
	400	24	21.39^{a}	46.75^{b}	3.84^{a}	11.92
	600	24	19.93^{b}	46.03^{b}	2.82^{b}	11.49
P value:	CN		0.0009	0.1102	0.2175	0.5436
	Cr		0.0027	0.0047	0.0059	0.0785
	CN×Cr		0.0031	0.0061	0.2482	0.0511

* CN: individual effect of L-carnitine; Cr: individual effect of Cr; CN×Cr: interaction.
* Values without same superscript letters within the same column differ significantly ($p<0.05$ or $p<0.01$).
* APOAI=Apolipoprotein AI, APOB=Apolipoprotein B, GLU=Glucose.

($p<0.01$), decreased serum APOB by 21.58% and 15.73% ($p<0.05$). Only 100 mg/kg L-carnitine significantly reduced serum TG or increased APOAI, respectively by 37.74% ($p<0.05$) and 72.41% ($p<0.01$). There were not significant effects on serum TC, LDL-C, GLu and insulin (Tables 4 and 5).

Interaction between Chromium and L-carnitine (*n=8*) : Cr and L-carnitine presented significant interaction effect on serum FFA, HDL-C, APOAI and APOB ($0.0003 \leq p \leq 0.0061$). However, no obvious regularity was found (Tables 4 and 5).

DISCUSSION

Effect of dietary chromium and L-carnitine on lipid metabolism of Laying Hens

Our results showed that 600 μg/kg Cr had significant effects on abdominal fat, liver TG, serum TG, and serum FFA of laying hens at the end of experiment. The mechanism may be as follows: Cr, as a component of glucose tolerance factor (GTF), enhances the function of insulin, increasing intake of serum TG into tissue, promoting the transformation of energy, supplying more ATP to tissue, inhibiting decomposition of cAMP (Bian, 1997), promoting the phosphorylation of hormone sensitive lipase (HSL) (Ecan, 1992) and reducing the combination of insulin with adipocytes (Liu, 1990). Yu et al. (2001) and Gang et al. (2001) showed that Cr increased the activity of HSL and decreased the activity of fatty acid synthetase (FAS), malate dehydrogenate (MDH) and the content of insulin in pig. The increase of serum FFA in the study indicated Cr promoted the decomposition of fat tissue. But dietary Cr did not affect the serum Glu and insulin in our test, and this was similar to the result for pigs of Tang et al. (2001). Pigs fed Cr had lower carcass fat percentage and back-fat thickness (Wang et al., 2004). Lien et al. (1998) showed that Cr improved the activity of FAS and HSL at the same time, but reduced average back-fat thickness of pig at last. So many of the effects attributed to Cr cannot be explained only by insulin action because other metabolic or hormonal factors may be involved.

Suo et al. (2000) and Heo et al. (2000) showed that the carnitine concentration of liver in laying hens and pigs increased significantly with the addition of dietary carnitine. Carroll (2001) reviewed comprehensively the relationship between the scarcity of carnitine and fatty liver. The result of Lien (2001) indicated that Carnitine palmitoyltransferase activity of broilers in the carnitine supplemented group was significantly higher than in the control. Adding 100 mg/kg L-carnitine reduced abdominal fat, liver TG, serum TG, APOB and LDL-C concentrations and increased serum FFA concentrations in our experiment. The results showed that L-carnitine promoted decomposition of triglyceride in fatty tissue and inhibited synthesis of liver triglyceride by the feedback control of β-oxidation (of fatty acid) increasing.

Yolk TC was not highly related to serum TC according to the results in our test: yolk TC reduced significantly with the supplemention of 600 μg/kg Cr, but serum TC had only declining tendency. The reason may be that the content of egg TC depends on lipoprotein concentration in yolk but not serum TC concentration (Griffin, 1992). Liver is the key organ of cholesterol synthesis in laying hens. According to the effects of dietary chromium on liver TC, serum APOA (B) and serum HDL (LDL) in the study, the mechanism can be deduced as follows: chromium improved the conversion of acetyl CoA, decreasing the formation of cholesterol (Steel et al., 1981); chromium increased the activity of Lecithin Cholesterol Acyltransferase (LCAT), accelerating cholesterol esterification and excretion (Lien et al., 1998 and 2003).

L-carnitine decreased the content of acetyl CoA by combining with acetyl CoA and producing acetylcarnite (Ferrari, 1992). It may be the reason that liver TC declined with supplementation of L-carnitine in our experiment. Moreover, the declining of serum APOB and LDL-C indicated that L-carnitine decreased the synthesis of liver cholesterol in our experiment. In addition, the reduction of yolk TC can be partly attributed to the improving of serum APOAI and HDL-C with supplementary L-carnitine.

It was observed in our experiment that adding both L-carnitine and chromium tended to be better than adding L-carnitine or chromium alone for such indices as egg yolk cholesterol and abdominal fat percentage, but not all the indices had the tendency. It is obvious that lipid metabolism is affected by many factors so that it is difficult to establish one comprehensible measure controlling simultaneously every index of lipid metabolism.

The relationship between production performance and lipid metabolism of laying hens

The difference among some experimental results showed that the effects of Cr and L-carnitine on production performance of laying hens were related to the experimental conditions (Kang et al., 1996; Rabie et al., 1997; Richter et al., 1998; Li et al., 2001; Luo et al., 2002), no obvious effect in our experiment.

The lipid metabolism of laying hens is different from that of immature hens, stop-production hens and roosters. For example, the liver TG, plasma LDL and plasma total lipid of laying hens is higher, but plasma HDL is lower (Yin et al., 2000). The difference is attributed to the fact that lipid, one of the main precursors of yolk forming, stems from liver but not from ovary (Schneider et al., 1996). According to that fact, laying performance and embryo life can not keep normal unless the contents of liver and egg cholesterol reach a range (Hargis et al., 1988) and the laying performance decreased in some experiments aimed at reducing yolk TC. There was no side effect on production performance of laying hens while 600 μg/kg chromium or (and) 100 mg/kg L-carnitine reduced liver lipid, abdominal fat and egg yolk cholesterol in our test. Increased egg weight and egg mass were observed in our test. Bacon et al. (1985) thought that too much liver lipid accumulation of laying hens led to the vitellin formation decreasing in liver and affected the development and maturation of ovarian follicles. So reducing the lipid concentration to some degree assisted production performance of laying hens.

CONCLUSION

The effect of adding Cr (600 μg/kg) or L-carnitine (100 mg/kg) on the lipid metabolism of laying hens was greater at the end of experiment, and produced no side effect on production performance. There were significant interactions on serum FFA, APOAI, APOB, HDL-C and liver triaclyglycerol, liver cholesterol, yolk cholesterol and abdominal fat percentage between Cr and L-carnitine.

REFERENCES

Anonymous. 2001. Executive summary of the third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III). JAMA. Chicago. 285:2486-2498.

Bacon, W. L. 1986. Metabolism and ovarian follicular uptake of the major yolk precursor in laying turkey hens. Poult. Sci. 65:1184-1192.

Bian, J. C., Y. Z. Xiang, X. X. Yang, L. Wang, Y. Liu and J. B. Wang. 1997. Effect of chromium on thyroid hormone and cyclic nucleotide in rats with myocardial damage. Acta Nutrimenta Sinica. 19(4):465-467.

Carroll, M. C. 2001. Carnitine: a review. Compendium on continuing education for the practicing veterinarian. USA. 23(1):45-52.

Ecan, J. J. 1992. Metabolism of hormone-stimulated lipolysis in adipocytes: Translation of hormone sensitive lipase to the lipid storage droplet. Proc. Nati. Acad..Sci. USA. 89:8527.

Ferrari Red. 1992. L-carnitine and its role in medicine: From function to therapy. America: academic press. Chapt. 13.

Gang, X., Z. R. Xu, S. H. Wu and S. J. Chen. 2001. Effects of chromium picolinate on growth performance, carcass characteristics, serum metabolites and metabolism of lipid in pigs. Asian-Aust. J. Anim. Sci. 14(2):258-262.

Griffin, H. D. 1992. Manipulation of egg yolk cholesterol: a physiologist's view. World's Poult. Sci. 48(2):101-112.

Hargis, P. S. 1988. Modifying egg yolk cholesterol in the domestic fowl-a review. World's Poult. Sci. J. 44 (1):17-29.

Heo Kinam, Lin XI, J. Odle and I. K. Han. 2000. Kinetics of carnitine palmitoyltransferase-I are altered by dietary variables and suggest a metabolic need for supplemental carnitine in young pigs. J. Nutr. USA. 130(10):2467-2470.

Han, I. K. and J. H. Kim. 1998. The role of carnitine in early-weaned piglet. Proceedings of International conference on pig production. Beijing, 9-16.

Kang, C. W., H. Y. Lee and K. T. Nam. 1996. The effect of dietary inorganic and organic chromium on their transference rates to egg and accumulation in body tissues of laying hens. Proc World's Poult. Cong. New Delhi, India, 2-5:53-57.

Li, S. F., X. G. Luo, B. Liu, G. Z. Shao, X. Q. Guo and S. X. Yu. 2001. Effect of organic chromium on egg production and immune responses in heat stressed Layers. Acta Nutrimenta Sinica. 23(2):117-121.

Lien, T. F., C. P. Wu and P. H. Lin. 1998. Effect of different protein and limiting amino acid levels coupled with a supplement of chromium picolinate on lipid metabolism and carcass characteristics of pigs. Anim. Sci. 67:601-607.

Lien, T. F. and Y. M. Horng. 2001. The effect of supplementary dietary L-carnitine on the growth performance, serum components, carcass traits and enzyme activities in relation to fatty acid β-oxidation of broiler chickens. Br. Poult. Sci. 42(1):92-95.

Lien, T. F., C. P. Wu and J. J. Lu. 2003. Effect of cod liver oil and chromium picolinate supplementation on the serum traits, egg yolk fatty acids and cholesterol content in layer hens. Asian-Aust. J. Anim. Sci. 16:1177-1181.

Liu, C. Y. and S. E. Mills. 1990. Decreased insulin binding to porcine adipocytes *in vitro* beta-adrenergic agonists. J. Anim. Sic. 68:1603-1609.

Luo, X. G., S. F. Li, B. Liu, G. Z. Shao, X. Q. Guo and S. X. Yu. 2002. Effect of dietary chromium on egg production performance, egg quality, serum biochemical traits and immune responses of heat stressed Layers. Acta Veterinaria et Zootechnica Sinica. 33(4):313-320.

Rabie, M. H., M. Szilagyi and T. Gippert. 1997. Effects of dietary L-carnitine on the performance and egg quality of laying hens from 65-73 weeks of age. Br. J. Nutr. 78(4):615-623.

Richter, V. G., C. Schlumbohm and M. Baumgartner. 1998. Studies of L-carnitine effects in laying hens. Poult. Abstr. 24(9):353.

Schneider, W. J. 1996. Vitellogenin receptors: Oocyte-specific members of the low-density lipoprotein receptor supergene family. Int. Rev. Cytol. 166:103-137.

Suo, Y. F. and H. Y. Cai. 2000. Effect of dietary carnitine supplementation on the organs of laying hens. Chin. J. Anim. Sci. 36(2):18-20.

Tang, L., D. F. Li, F. L.Wang, J. J. Xing and L. M. Gong. 2001. Effects of different sources of organic chromium on immune function in weaned pigs. Asian-Aust. J. Anim. Sci. 14(8):1164-1169.

Wang, J. D., R. Du, J. Qin, S. L. Wang, W. K. Wang, H. Q. Li and Q. H. Pang. 2003. Effect of Yeast Chromium and L-carnitine on Lipid Metabolism of Broiler Chickens. Asian-Aust. J. Anim. Sci. 16(12):1809-1815.

Wang, M. Q. and Z. R. Xu. 2004. Effects of chromium nanoparticle on growth performance, carcass characteristics, pork quality and tissue chromium in finishing pigs. Asian-Aust. J. Anim. Sci. 17(8):1118-1122.

Yu, D. Y. and Z. R. Xu. 2001. Effects of chromium picolinate on carcass characteristics in finishing swine. Chin. J. Vet. Sci. 21(5):522-525.

Yin, J. D., G. H. Qi and Q. G. Huo. 2000. Advances in Modulation of Lipid Metabolism in Poultry. Acta Zoonutrimenta Sinica. 12(2):1-7.

Zhou, X. T. and J. J. Lu. 2002. Effect of Betaine on the Regulation of the Lipid Metabolism in Laying Hen. Scientia Agricultural Sinica 35(3):325-330.