Effect of Yeast Chromium and L-carnitine on Lipid Metabolism of Broiler Chickens*

Jundong Wang, Rong Du, Jian Qin, Shaolin Wang[1], Wenkui Wang, Hongquan Li, Quanhai Pang**
College of Animal Science and Veterinary Medicine, Shanxi Agricultural University, Taigu, 030801 Shanxi, P. R. China

ABSTRACT : A 3×4 (chromium and L-carnitine) experiment was designed to investigate the single and interactive effects of adding yeast Cr and L-carnitine to corn-soybean meal diets on lipid metabolism of broiler chickens. Four hundred and eighty one-day-old avian chickens were randomly allocated to 12 treatments of 40 each for 7 weeks. Levels of adding Cr were 0, 400, 600 μg/kg and those of L-carnitine was 0, 30, 50, 100 mg/kg, respectively. The result showed that adding 600 μg/kg Cr or 100 mg/kg L-carnitine alone had better regulative effects on fat and cholesterol metabolism than lower adding levels. Effects were more significant at the end of the experiment. There were significantly interactive effects between Cr and L-carnitine on triaclyglycerol, whole cholesterol, HDL, dissociating FFA, and blood glucose, cholesterol and triaclyglycerol of liver, and cholesterol of chest muscle at the end of experiment ($p=0.0001$-0.0315). But Cr or L-carnitine had no significant effect on growth performance of broiler chickens ($p>0.05$). ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 12 : 1809-1815)***

Key Words : Broiler Chickens, Cooperative Effect, Lipid Metabolism, L-carnitine, Yeast Chromium

INTRODUCTION

Cr and L-carnitine are considered as human and animal's natural nutrients. Cr is generally believed to be an essential mineral component of GTF (glucose tolerance factor), which enhances the function of insulin to speed up the metabolism of glucose (Bunting, 1994; Amoikon, 1995). Cr also help to transform the rest glucose into tricylglycerol (Mertz, 1993), and meanwhile promote fat to be quickly hydrolysised and provide energy and carbon resource for amino acid and protein synthesis (Page, 1993). However L-carnitine is the only essential vector to incorporate FFA into mitochrondia for β-oxidization of FFA. Lien (2001) showed that diet L-carnitine could obviously improve the activity of carnitine acyltranferase, a key enzyme of combination of carnitine and FFA, so it is possible for Cr and L-carnitine to contribute to the metabolism of fat, protein and carbohydrate. There have been some researches about effect of Cr or L-carnitine on animal growth performance and lipid metabolism in recent years. Adding Cr can improve the performance of broiler chickens (Kim SW, 1995) and layers (Kim JD, 1997). In particular, Cr can decrease liver fat and abdominal fat percentage of the 8 weeks broiler chickens (Hossain, 1998; Wang, 1999), and is beneficial to the broilers (Lee, 2003) and laying hens (Lien, 2003). Rabie (1998) showed that adding L-carnitine from 18 d to 53 d obviously decreased broiler chicken's weight and percentage of abdominal fat. As far as interaction of Cr and L-carnitine is concerned, Smith (1997) showed that adding Cr and L-carnitine simultaneously in the diet of swine could obviously ameliorate the growth performance and muscle quality than adding lonely. But there are no systemic experiments about the effect of Cr and L-carnitine on broiler chickens simultaneously. Thus, the experiment was conducted to study the effect of both addition on growth performance and lipid metabolism, and to discuss the interactive effect of both.

MATERIALS AND METHODS

Experimental animals and animal management

Four hundred and eighty one-day-old avian chickens were randomly allocated to 12 treatments, 40 for each treatment (20 males, 20 females with 3 replicates). The chickens were fed the basal corn-soybean meal diet (see Table 1), and the experiment lasted for 7 weeks.

Experimental design and additives

The experiment applied the design of two factors (chromium×L-carnitine), 3×4 levels with repeats. Yeast Chromium (the actually content of Cr 1 g/kg, Beijing Alltech biology technique company) was supplied at the level of 0, 400, 600 μg/kg. L-carnitine (Carniking of Hongkong Company), which is composed of L-carnitine (50%), silicon dioxide (34%) and water (16%), and no D- and meso-carnitine, was provided by China Agriculture Academy, added level 0, 30, 50, 100 mg/kg.

* This work was financially supported by Shanxi National Natural Science Foundation (981083) and Shanxi Returning Student Foundation (99044).
** Corresponding Author: Jundong Wang. Tel: +86-354-6288206, Fax: +86-354-6222942, E-mail:wangjd@sxau.edu.cn
[1] College of Veterinary Medicine., Chinai Agricultural University, Beijing, 100094, People's Republic of China.
Received May 29, 2003; Accepted August 22, 2003

Table 1. Compositions and nutrient levels of the basal diet

Ingredients	0-3 week	4-7 week	Nutrient levels	0-3 week	4-7 week
Corn	52.00	57.00	ME (mcal/kg)	2.95	3.05
Soybean meal	33.00	25.61	CP (%)	21.00	18.99
Cottonseed meal	5.00	5.00	Lys (%)	1.04	0.95
Sunflower meal	2.50	3.00	Met (%)	0.50	0.43
Fish meal	0.50	2.00	Met+Cys (%)	0.85	0.74
$CaHPO_4$	1.90	1.70	Ca (%)	1.00	1.00
limestone	1.10	0.90	AP (%)[2)]	0.50	0.50
DL-Met	0.19	0.16	Cr (μg/kg)[3)]	330	320
L-Lys	0.00	0.00	L-CN (mg/kg)[4)]	5.0-11.05	8.07-13.01
Salt	0.27	0.24			
Soybean oil	3.10	4.00			
Micronutrients[1)]	0.44	0.44			
Total	100.00	100.00			

[1)] Composition of Microelements mix (mg/kg): Fe, 87; Zn, 182; Mn, 156; Cu, 22; I, 10; [2)] Available phosphorus. [3)] Determined value. [4)] Calculated value.

Table 2. Effect of dietary chromium and L-carnitine on the growth performance of broiler chickens

Added levels		n	Average daily gain (g)			Feed conversion rate (F/G)		
CN (mg/kg)	Cr (μg/kg)		0-3 week	4-7 week	0-7 week	0-3 week	4-7 week	0-7 week
0	0	6	26.5±2.54	66.5±6.16	49.4±4.42	1.4±0.25	2.0±0.38	1.86±0.09
	400	6	24.3±2.45	71.3±3.63	51.2±2.41	1.5±0.36	1.8±0.42	1.75±0.31
	600	6	23.9±0.99	66.2±9.02	48.1±5.45	1.6±0.24	2.1±0.17	1.98±0.32
30	0	6	23.8±1.98	73.1±7.88	52.0±5.29	1.7±0.10	1.8±0.05	1.73±0.39
	400	6	25.0±3.44	73.4±5.31	52.7±2.75	1.6±0.30	1.8±0.21	1.70±0.07
	600	6	24.9±0.63	67.1±9.27	49.0±7.03	1.6±0.27	1.8±0.34	1.74±0.27
50	0	6	25.6±4.13	68.9±4.74	50.3±2.05	1.5±0.31	1.9±0.30	1.80±0.18
	400	6	23.4±0.93	73.3±7.22	51.9±3.75	1.5±0.27	1.8±0.28	1.71±0.37
	600	6	24.5±2.07	69.4±9.75	50.2±5.09	1.7±0.21	2.1±0.36	1.99±0.06
100	0	6	26.5±1.59	63.1±7.90	47.4±4.53	1.5±0.41	2.1±0.38	1.96±0.19
	400	6	25.8±1.59	65.6±7.41	48.5±4.56	1.5±0.28	2.0±0.42	1.8±0.16
	600	6	25.0±1.62	68.9±9.61	50.1±4.96	1.5±0.12	1.8±0.05	1.7±0.24
0		18	24.9	68.0	49.5	1.5	2.0	1.9
30		18	24.6	71.2	51.2	1.6	1.8	1.7
50		18	24.5	70.5	50.8	1.6	1.9	1.8
100		18	25.8	65.8	48.7	1.5	2.0	1.8
	0	24	25.6	67.9	49.8	1.5	2.0	1.8
	400	24	24.6	70.9	51.1	1..5	1.8	1.8
	600	24	24.6	67.88	49.33	1.6	2.0	1.9
P	CN		0.5007	0.3402	0.5064	0.5882	0.4563	0.3785
	Cr		0.3565	0.4698	0.5399	0.4713	0.5368	0.5023
	CN×Cr		0.5949	0.8082	0.8958	0.5234	0.7823	0.4375

CN; individual effect of L-carintine, Cr; individual effect of Cr, CN×Cr interaction.

Sample of collection, preparation and analysis

At the end of the third and 7th wk, blood samples were taken from the heart of 6 chickens in every group, serum is collected by centrifuge and kept in a -30°C freezer. At the end of the 7th wk, liver and abdominal fat were taken, weighted, numbered and kept in a -30°C freezer. Samples of 100 g chest muscle and leg muscle were taken separately, numbered and kept in a -30°C freezer.

The content of FFA was measured by spectrophotometer, with reagent case supplied by Nanjing Jiancheng Biotechnics Institution. The biochemical indexes of serum and tissue were measured by semiautomatic biochemistry analyst, and the reagent was supplied by Beijing Zhongsheng Biotechnics Company, In the determination of triaclyglycerol (TG), total cholesterol (TC), HDL-C, and Glu are GPO-PAP, HOD-PAP, PAT-Mg^{2+}sedimentation, and GOD-PAP, respectively. The triaclyglycerol and total cholesterol of liver and tissue were extracted in methanol-chloroform.

Data analysis and management

All date were analysed by F value using two factors, 3×4 levels program of SAS statistical software, then the date showing significant differences were repeatedly compared by Duncan`s method, with the standard of 0.01 and 0.05.

Table 3. Effect of dietary chromium and L-carnitine on the body weight and abdominal fat (AF) of broiler chickens at the end of 7 weeks

Added levels		n	7week				
CN (mg/kg)	Cr (μg/kg)		Body weight (g)	DW (g)	DP (%)	AFW (g)	AFP (%)
0	0	6	2,475±216.1	2,200±190.7	88.9±1.79	42.9±2.01^{a}	1.7±0.18^{a}
	400	6	2,560±118.6	2,281±148.5	89.1±2.32	34.5±6.83^{bc}	1.3±0.23^{bc}
	600	6	2,410±267.7	2,118±303.7	88.2±2.54	34.0±3.17^{bc}	1.4±0.19^{bc}
30	0	6	2,603±261.1	2,306±257.0	88.5±1.22	30.7±9.78^{bc}	1.2±0.26^{c}
	400	6	26,343±135.1	2,334±130.8	88.6±1.84	39.2±6.85^{abc}	1.5±0.33^{abc}
	600	6	24,550±244.0	2,172±324.2	88.7±2.10	32.2±12.18^{bc}	1.3±0.37^{bc}
50	0	6	25,200±101.3	2,248±111.3	89.2±3.16	31.6±5.47^{bc}	1.3±0.19^{bc}
	400	6	2,597±182.6	2,292±145.5	88.3±0.94	38.3±6.81^{abc}	1.5±0.26^{abc}
	600	6	2,511±248.1	2,231±223.3	88.8±0.12	41.6±6.77^{ab}	1.7±0.40^{ab}
100	0	6	2,378±222.5	2,128±243.8	89.4±4.64	27.8±4.36^{c}	1.2±0.32^{bc}
	400	6	2,431±222.9	2,212±217.5	91.0±2.60	37.9±4.12^{abc}	1.6±0.14^{abc}
	600	6	2,507±242.2	2,191±226.7	87.9±0.98	32.4±9.73^{bc}	1.3±0.49^{bc}
0		18	2,482	2,200	88.7	37.1	1.5
30		18	2,564	2,271	88.5	34.0	1.3
50		18	2,543	2,257	88.8	37.2	1.5
100		18	2,439	2,177	89.4	32.7	1.4
	0	24	2,494	2,221	89.0	33.2	1.3
	400	24	2,556	2,280	89.2	37.5	1.5
	600	24	2,471	2,178	88.3	35.0	1.4
P	CN		0.5099	0.6825	0.8006	0.1596	0.1835
	Cr		0.5468	0.4309	0.5167	0.2362	0.3390
	CN×Cr		0.8978	0.9799	0.8160	0.1128	0.1140

CN; individual effect of L-carintine, Cr; individual effect of Cr, CN×Cr; interaction, Values without same superscript letters within the same column differ significantly ($p<0.05$ or $p<0.01$). * DW=Dressing weight, DP=Dressing percentageage, AFW=Abdominal fat weight, AFP=Abdominal fat percentage.

RESULTS

The effect of Cr and L-carnitine on growth performance

The effect of Cr and L-carnitine on the average daily gain and feed conversion is not statistically significant. But, it appears that growth performance was better with adding Cr (400 μg/kg) and L-carnitine (100 mg/kg) at the same time (Table 2).

The effect of L-carnitine and Cr on the abdominal fat

Adding Cr or L-carnitine alone decreases significantly the abdominal fat weight and Abdominal fat percentage at the end experiment. Compared with the control group, adding Cr (400; 600 μg/kg) alone decreases by 22.92% and 22.54% of abdomianl fat percentage ($p<0.05$). Adding L-carnitine (30; 50; 100 mg/kg) alone decreases by 33.33%, 28.16%, and 31.61% of abdominal fat percentage ($p<0.05$), and it appears that adding L-carnitine to decrease abdominal fat percentage is more obvious than adding Cr, but the statistical analysis did not show significant difference ($p<0.05$). The interactive effect of adding Cr and L-carnitine simultaneously on the abdominal fat percentage is statistical significant between Cr (n=24) or L-carnitine (n=18) and Cr (n=6) or L-carnitine (n=6) to some degree (Table 3).

The effect of Cr and L-carnitineon the blood lipid and sugar

Cr (n=24) or L-carnitine (n=18) : The effect of Cr on the serum TC and FFA is only significant at the end of the 3rd week ($p=0.0451$, $p=0.0006$); Its' effect on the serum TG, TC, HDL-C and FFA is significant at the end of the 7th weeks ($0.0001\leq p\leq 0.0133$); the effect of L-carnitine on the serum FFA is significant only at the end of the 3rd week ($p=0.0001$); but Its' effect on the serum TG, Glu, HDL-C and FFA is significant at the end of the 7th week ($0.0001\leq p\leq 0.0483$).

Adding Cr (n=6) or L-carnitine (n=6) : Adding Cr alone leads to effects on the serum TC only at the end of the 3rd week ($p<0.05$), compared with the control group at the end of the 7th week, The level of Cr (400; 600 μg/kg) leads to the content of serum TG declining by 24% and 31 % ($p<0.01$). In the same time, serum TC declined by 23% and 11% ($p<0.05$), respectively, serum HDL-C declining by 25% ($p<0.05$) and 38% ($p<0.01$), the serum FFA increasing by 34% ($p<0.01$) and 24% ($p<0.05$). Compared with the control group, the content of serum glucose declined significantly by 24% ($p<0.01$) at the level of Cr 600 μg/kg.

The effects of adding L-carnitine alone on the serum TC is significant only at the end of the 3rd week ($p<0.05$). In comparison with the control group at the end of the 7th week, the level of L-carnitine (0; 30; 50; 100 mg/kg)

Table 4. Effect of dietary chromium and L-carnitine on serum TG, TC and HDL-C of broiler chickens

Added levele		n	serumTG (mmol/L)		serumTC (mmol/L)		Serum HDL-C (mmol/L)	
CN (mg/kg)	Cr (μg/kg)		3 week	7 week	3 week	7 week	3 week	7 week
0	0	6	0.6±0.12^{abc}	0.67±0.05^{a}	3.49±0.37^{a}	4.4±0.42^{a}	1.3±0.08	1.3±0.15^{a}
	400	6	0.5±0.07^{c}	0.51±0.12^{b}	2.76±0.61^{cd}	3.4±0.13^{def}	1.0±0.09	1.0±0.22^{b}
	600	6	0.6±0.06^{bc}	0.46±0.08^{bc}	2.84±0.18^{cd}	3.9±0.15^{bc}	1.1±0.16	0.8±0.14^{b}
30	0	6	0.6±0.06^{abc}	0.47±0.11^{bc}	3.01±0.68^{bcd}	4.7±0.36^{a}	1.2±0.29	1.4±0.06^{a}
	400	6	0.6±0.04^{abc}	0.5±0.05^{bc}	2.9±0.07^{bcd}	4.0±0.60^{bc}	1.2±0.43	1.0±0.11^{b}
	600	6	0.6±0.14^{bc}	0.5±0.06^{bc}	2.6±0.33^{d}	2.9±0.03^{g}	1.2±0.29	0.9±0.22^{b}
50	0	6	0.7±0.06^{a}	0.4±0.02^{c}	2.9±0.07^{cd}	4.6±0.14^{a}	1.2±0.19	1.0±0.20^{b}
	400	6	0.7±0.08^{ab}	0.4±0.02^{bc}	2.9±0.35^{bcd}	3.2±0.45^{efg}	1.0±0.06	0.9±0.29^{b}
	600	6	0.6±0.09^{bc}	0.4±0.03^{bc}	3.0±0.37^{bcd}	3.1±0.11^{fg}	1.1±0.08	1.0±0.15^{b}
100	0	6	0.6±0.11^{bc}	0.5±0.13^{b}	3.2±0.17^{abc}	3.2±0.23^{ef}	1.1±0.03	1.0±0.05^{b}
	400	6	0.6±0.06^{abc}	0.4±0.05^{c}	3.5±0.03^{ab}	4.2±0.19^{b}	1.4±0.12	0.8±0.09^{b}
	600	6	0.6±0.07^{abc}	0.4±0.07^{c}	2.9±0.21^{cd}	3.8±0.33^{bcd}	1.1±0.23	0.8±0.04^{b}
0		18	0.56	0.54^{a}	3.03	3.90	1.14	1.02^{a}
30		18	0.59	0.47^{b}	2.84	3.84	1.21	1.06^{a}
50		18	0.64	0.39^{c}	2.92	3.63	1.10	0.97^{ab}
100		18	0.58	0.41^{bc}	3.19	3.72	1.20	0.86^{b}
	0	24	0.61	0.51^{a}	3.15^{a}	4.23^{a}	1.21	1.14^{a}
	400	24	0.61	0.44^{b}	3.01^{ab}	3.68^{b}	1.16	0.92^{b}
	600	24	0.56	0.42^{b}	2.82^{b}	3.41^{c}	1.12	0.88^{b}
P	CN		0.1100	0.0001	0.1038	0.3051	0.5037	0.0315
	Cr		0.1336	0.0133	0.0451	0.0001	0.4829	0.0001
	CN×Cr		0.3050	0.0315	0.0770	0.0001	0.2246	0.0208

CN; individual effect of L-carintine, Cr; individual effect of Cr, CN×Cr; interaction.

significantly declines the content of serum TG by 23%, 45% and 24% ($p<0.01$) and increases the content of serum FFA by 43%, 43% and 57% ($p<0.01$). The content of serum TC declines by 27% ($p<0.01$) significantly at the level L-carnitine (100 mg/kg), the content of serum HDL-C declines by 26% ($p<0.05$) and 27% ($p<0.01$) significantly at the level L-carnitine (50,100 mg/kg), and the content of serum glucose declines by 29% ($p<0.05$) and 29% ($p<0.01$) significantly at the level L-carnitine (30, 50 mg/kg), compared with the control group.

Interaction between Cr and L-carnitine : The effects of adding Cr and L-carnitine simultaneously on all indexes are presented in Table 4 and 5. Performance significantly differed at the end of the 7th week, but not after 3 weeks.

The interactive effect of L-carnitine and Cr on triaclyglycerol and cholesterol of the tissues

Cr (n=24) or L-carnitine(n=18) : The effect of Cr and L-carnitine on broiler chickens' muscle TC is not significant, but is significant on the liver TC and TG, and it declines by increasing the level of Cr and L-carnitine ($p=0.0001$, $p=0.0162$).

Adding Cr (n=6) or L-carnitine (n=6) alone : Adding L-carnitine declined all indexes of liver, chest muscle and leg muscle. Compared with the control group, the level of L-carntine (30; 50; 100 mg/kg) declines the content of liver TG by 41%, 22%, 41% ($p<0.01$); the content of TC of chest muscle declines by 23% ($p<0.05$), 39% ($p<0.01$), 30% ($p<0.05$). Three levels of L-carnitine have no significant effect on the content of TC of leg muscle; the effect on the liver TC is significant at the level of 100 mg/kg, declining by 40% ($p<0.01$) compared with the control group.

Compared with the control group, adding Cr along declines the content of TC of chest muscle and leg muscle. Compared with the control group, the level of Cr (400; 600 μg/kg) declines the content of liver TG by 7% ($p<0.05$), 39% ($p<0.01$); the content of liver TG declines by 19% ($p<0.05$), 39% ($p<0.01$); the content TC of chest muscle declines by 35%, 37% ($p<0.01$); the content of TC of leg muscle declines by 20%, 27%($p<0.05$), respectively.

The interaction of Cr and L-carnitine : Cr and L-carnitine presented significantly interactive effect ($0.0007\leq p\leq 0.004$) on the liver TG and TC and leg muscle TC (Table 6).

DISCUSSION

Effect of Cr and L-carnitine on the growth performance of broiler chickens

Many experimental results showed the effect of adding Cr and L-carnitine on the growth performance of animal, but related to the experimental condition, growth stage, added level, age and composition of basal diet level. Adding Cr in conditions of the high temperature stress obviously increased food intake, growth rate and food conversion (Nam, 1996), but it had no significant effect on growth

Table 5. Effect of dietary chromium and L-carnitine on serum FFA and Glu of broiler chickens

Added levels		n	Serum FFA (μmol/L)		Serum Glu (mmol/L)	
CN (mg/kg)	Cr (μg/kg)		3 week	7 week	3 week	7 week
0	0	6	1,430±153.1^{ab}	839.1±88.7^{c}	7.9±0.59^{ab}	1.0±1.28^{a}
	400	6	1,175±109.3^{bcd}	1,124.7±176.4^{a}	8.0±1.01^{ab}	9.5±1.01^{ab}
	600	6	1,436±75.3^{ab}	1,037.7±195.0^{ab}	8.7±0.72^{a}	7.6±1.07^{cd}
30	0	6	1,169±212.0^{bcd}	1,202.2±315.7^{a}	7.7±0.41^{ab}	7.1±1.57^{d}
	400	6	1,026±69.5^{d}	1,283.9±180.1^{a}	8.3±0.23^{a}	7.6±0.70^{cd}
	600	6	708±134.7^{e}	841.2±108.6^{c}	8.0±0.31^{ab}	8.2±0.38^{bcd}
50	0	6	1,270±271.0^{abcd}	1,202.2±72.6^{a}	6.8±1.91^{b}	7.1±0.40^{d}
	400	6	1,125±399.0^{cd}	945.5±97.3^{bc}	7.9±0.81^{ab}	8.2±2.11^{bcd}
	600	6	1,171±216.8^{bcd}	900.2±162.2^{bc}	7.6±0.46^{ab}	10.0±0.42^{a}
100	0	6	1,421±133.2^{abc}	1,317.4±93.4^{a}	8.3±1.07^{a}	9.1±1.85^{abc}
	400	6	1,138±19.2^{bcd}	1,272.2±234.9^{a}	7.8±0.14^{ab}	7.1±0.83^{d}
	600	6	1,106±61.2^{d}	1,168.0±257.4^{a}	7.8±0.20^{ab}	8.3±0.07^{bcd}
0		18	1,347^{a}	1,001^{b}	8.2	9.0^{a}
30		18	968^{c}	1,109^{b}	8.0	7.6^{b}
50		18	1,189^{b}	1,016^{b}	7.4	8.5^{ab}
100		18	1,222^{b}	1,253^{a}	8.0	8.2^{ab}
	0	24	1,323^{a}	1,140^{a}	7.7	8.3
	400	24	1,116^{b}	1,157^{a}	8.0	8.1
	600	24	1,105^{b}	987^{b}	8.0	8.5
P	CN		0.0001	0.0003	0.1342	0.0483
	Cr		0.0006	0.0056	0.4676	0.5603
	CN×Cr		0.0992	0.0001	0.3530	0.0009

CN; individual effect of L-carintine, Cr; individual effect of Cr, CN×Cr; interaction.

Table 6. Effect of dietary chromium and L-carnitine on liver TG and TC, muscle TC of broiler chickens at the end of 7 weeks

Added levels		n	7 week			
CN (mg/kg)	Cr (μg/kg)		Liver TG (mg/g)	Liver TC (mg/g)	Chest muscle TC (mg/g)	Leg muscle TC (mg/g)
0	0	6	11.2±1.66^{a}	3.6±0.35^{a}	1.2±0.29^{a}	1.1±0.17^{a}
	400	6	10.4±1.79^{ab}	2.9±0.53^{bc}	0.8±0.07^{cd}	0.9±0.13^{b}
	600	6	6.8±0.60^{cd}	2.2±0.41^{cd}	0.8±0.06^{cd}	0.8±0.15^{b}
30	0	6	6.6±0.49^{d}	3.5±0.36^{a}	0.9±0.12^{bcd}	1.1±0.39^{a}
	400	6	8.4±0.48^{cd}	3.2±0.20^{ab}	0.7±0.02^{d}	1.1±0.27^{ab}
	600	6	7.0±0.55^{cd}	3.6±0.25^{a}	0.6±0.05^{d}	1.1±0.30^{ab}
50	0	6	8.7±1.74^{bc}	3.6±0.39^{a}	0.7±0.14^{cd}	1.0±0.27^{ab}
	400	6	7.8±2.19^{cd}	2.2±0.68^{cd}	0.7±0.24^{d}	1.1±0.28^{ab}
	600	6	6.6±0.55^{d}	3.0±0.43^{ab}	1.1±0.26^{ab}	1.1±0.26^{a}
100	0	6	6.7±0.80^{d}	2.1±0.26^{d}	0.9±0.11^{bcd}	1.0±0.09^{ab}
	400	6	7.4±1.21^{cd}	2.6±0.60^{bcd}	1.0±0.26^{abc}	1.0±0.19^{ab}
	600	6	6.8±0.38^{cd}	2.6±0.68^{bcd}	0.9±0.25^{bcd}	0.8±0.22^{b}
0		18	9.5^{a}	2.9^{b}	0.93^{a}	0.9
30		18	7.3^{b}	3.4^{a}	0.74^{b}	1.1
50		18	7.7^{b}	3.0^{b}	0.84^{ab}	1.1
100		18	7.0^{b}	2.4^{c}	0.90^{ab}	0.9
	0	24	8.3^{a}	3.2^{a}	0.93^{a}	1.1
	400	24	8.5^{a}	2.7^{b}	0.78^{b}	1.0
	600	24	6.8^{b}	2.8^{b}	0.84^{ab}	1.0
P	CN		0.0001	0.0001	0.0892	0.2156
	Cr		0.0004	0.0162	0.0800	0.4689
	CN×Cr		0.004	0.0007	0.008	0.6599

CN; individual effect of L-carintine, Cr; individual effect of Cr, CN×Cr; interaction.

performance in normal feeding condition (Ward, 1994). Our result did not show obvious effects of Cr and L-carnitine on growth performance.

Effect of Cr and L-carnitine on the fat and cholesterol metabolism of broiler chickens

Fat deposition of avian species is determined by the

content of tricylglycerol in the blood (Yin 2000), and the content of blood tricylglycerol is determined by its synthesis in the liver. So, tricylglycerol levels in liver, fat and blood are related to each other. This experiment using 600 μg/kg yeast Cr obviously decreased the content of the serum and liver tricylglycerol and abdominal fat percentage at 7 weeks of age, but it was not significant at 3 weeks of age. This result indicated that the period of Cr supplementation was the major factor to influence the effect of Cr supplement. Guo (1999) reported Cr supplementation to 3-6 weeks broiler chickens only lead to decreasing trend in abdominal fat and serum tricylglycerol, and this result may be related to the short period of the Cr supplementation, besides the characteristic of broiler chickens, the content of Cr or the composition of the diet. In addition, the contents of lipid in liver and the weight of abdominal fat are greatly affected by fat metabolism. This experiment indicated Cr can increase the content of the serum FFA, which confirm Guyton's opinion (1991) that Cr can induce the fat catabolism. The mechanism may be that Cr, as a factor of GTP, enhances insulin effect promoting the transformation of energy, supplying more ATP to tissue, inhibiting the activity of cAMP diesterase and decreasing the decomposition of cAMP (Bian, 1997). According to the glucose-fat cycle suggested by Qi (1988), when the level of blood glucose decreases, the fat tissue will produce FFA, so the content of the blood FFA will increase. It can also partly explain that Cr regulates the metabolism of fat through the metabolism of glucose.

L-carnitine is the only vector that can transmit FFA into mitochondria for their oxidization, so it plays a key role in the metabolism of fat. L-carnitine in the chickens' diet obviously decreased the triclyglyerol content of serum and liver and abdominal fat percentage, which is related to L-carnitine promoting FFA β-oxidization. Zhou (1996) thought that β-oxidization being inhibited due to the decrease of the concentration of L-carnitine in vivo, could result in the rise of the level of serum FFA. In the present experiment, the levels of the serum FFA obviously rose with the content of supplement L-carnitine increasing at the end of the 7th week. Qi (1988) indicated that, at normal physical condition, the rise of the content of serum FFA is result from the increase of decomposition activity of fat tissue, not result from the decrease of usage of energy by other tissues. The increase of the assimilation of FFA by other tissues automatically speeds up the oxidization of FFA, and the rise of the oxidization of FFA promotes again the decomposition activity of fat tissue. Wang (2000) reported that betaine obviously increased the content of L-carnitine of liver and chest muscle of 7-weeks duck and the serum FFA. It indirectly indicated that L-carnitine could raise the level of the FFA at the later period of avian. Therefore, it is concluded that the reason L-carnitine leads to the decreasing of the abdominal fat is the rise of the oxidization of FFA, resulting in the low synthesis of triaclyglycerol in liver and the increases of the fat catabolism.

Liver is the key organ of synthesizing cholesterol, and the content of the cholesterol synthesized in liver is accountable for about three quarters of whole cholesterol synthesized in animal body. The cholesterol in blood mainly comes from the liver, and very little from feed, for the content of cholesterol in plant food is little. In the experiment adding L-carnitine (100 mg/kg) obviously decreased the content of cholesterol and HDL in serum and liver at the end of experiment. Adding Cr (400 μg/kg; 600 μg/kg) lonely obviously decreased the content of cholesterol in the serum, liver, leg muscle and chest muscle. In addition, Cr decreased the content of HDL cholesterol at the end of the 3rd and 7th week and especially obvious at the end of the 7th week. It is inferred that the synthesis of cholesterol in liver is inhibited, so decreasing the quantity of blood cholesterol released by LDL. In the same way, HDL transmitting cholesterol from blood to liver is at a relatively low level. But Liu (1991) showed that Cr could improve the activity of the Lipid Protein Lipase and Lecithin Cholesterol Acyltranferase, promoting the synthesis of HDL in the experiment of mice with high serum lipid syndrome. Hassain (1995) proved that 400 ppb Cr supplementation in diet of chicks from 1 day old could raise the concentration of serum HDL-C before slaughter. The reason causing this difference remains to be probed in future experiment.

CONCLUSION

The effect of adding Cr (600 μg/kg) or L-carnitine (100 mg/kg) on the metabolism of lipid is better in the later period of the broilers in normal feeding condition.

Cr and L-carnitine do have significant interactive effect on triaclyglycerol, whole cholesterol, HDL, FFA, glucose of serum, cholesterol and triaclyglycerol of liver, and cholesterol of chest muscle.

REFERENCES

Amoikon, E. K., J. M. Fernandez, L. L. Southern, D. L. Thompson, T. L. Ward and B. M. Olcott. 1995. Effect of chromium tripicolinate on growth, glucose to lerance, insulin .sensitivity, plasma metabolites, and growth hormone in pigs. J. Anim. Sci. 73:1123-1130.

Bian, J. C., Y. W. Xiang and X. X. Yang. 1997. Effect of Cr on thyroid hormone and cyclic nucliotide in rats with myocardial damage. Acta Nutrimenta Sinica, 19:465-467.

Bunting, L. D., J. M. Fernandez, D. L. Thompson and L. L. Southern. 1994. Influence of chromium picolinate on glucose usage and metabolic criteria in growing holstein calves. J. Anim. Sci. 72:1591-1599.

Guo, Y. L., X. G. Luo and Z. L. Hao. 1999. Effect of Cr on growth performance, serum biochemical traits, immune function and carcass quality of broiler chickens. Scientia Agricultura Sinica.

32:79-86.

Hossain, S. M., S. L. Barreto and C. G. Silva. 1998. Growth performance and carcass composition of broilers fed supplemental chromium from chromium yeast. Animal Feed Science and Technology, 71:217-228.

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

Kim, S. W., I. K. Han and Y. J. Choi. 1995. Effects of chromium picolinate on growth performance, carcass composition and serium traits and mortality rate of brow layers. Asian-Aust. J. Anim. Sci. 8:463-470.

Kim, J. D., I. K. Han and B. J. Chae. 1997. Effects of dietary chromium picolinate supplementation on performance of broilers fed different levels of crude protein. Asian-Aust. J. Anim. Sci. 10:1-7.

Lee, D. N., F. Y. Wu and Y. H. Cheng. 2003. Effects of dietary chromium picolinate supplementation on growth performance and immune responses of broilers. Asian-Aust. J. Anim. Sci. 16:227-233.

Lien, T. F., C. P. Wu and J. J. Lu. 2003. Effect of code 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.

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-oxidaxion of broiler chickens. Br. Poult. Sci. 42:92-95.

Mertz, W. 1993. Chromium in human nutrition. A review. J. Nutr. 123:626-627.

Nam, K. T., H. Y. Lee, C. W. Kang and I. J. Yoo. 1996. The effect of dietary chromium (Cr) on broiler chicks under heat stress. Proceedings World's Poultry Congress. New Delhi. India. 2:2-5.

Page, T. G., L. L. Southern, T. L. Ward and D. L. Thompson. 1993. Effect to chromium picolinate on growth and serum and carcass traits of growing finishing pigs. J. Anim. Sci. 71:656-662.

Qi, S. Z. 1988. Animal biochemistry, Second edition, China Agricultural Press, Beijing.

Rabie, M. H. and M. Szilagyi. 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. Br. J. Nutr. 80:391-400.

Wang, D. L., M. H. Zhang and R. Du. 1999. Effect of dietary Cr level on growth performance, immune function and carcass fat content of broilers. Acta Zoonutrimenta Sinica, 11:19-23.

Wang, Y. Z., Z. R. Xu and M. L. Chen. 2000. Effect of betaine on carcasss fat metabolism of meat duck. Chin. J. Vet. Sci. 20: 409-412.

Ward, T. L., L. L. Southern and S. L. Bolemon. 1994. Effect of dietary chromium picolonate on growing broiler chickens. Poult. Sci. 72 (suppl.1):37.

Yin, J. D., G. H. Qi and Q. G. Hu. 2000. Advances in modulation of lipid metabolism in poultry. Acta Zoonutrimenta Sinica, 12:1-7.

Zhou, J. H. and D. S. Liu. 1996. Effect of L-carnitine on the growth and fat metabolism in rats. Acta Nutrimenta Sinica, 18:209-212.