



## Biochemical Effect Of Chromium Element On Lipid Profile Of Broilers

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**Key words:**  
broilers;  
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### **ABSTRACT:**

This study was conducted to investigate the effect of water chromium chloride supplementation on lipid profile and some serum parameters of broilers. Eighty newly hatched cobb broiler chicks were equally distributed to four groups of 20 chicks each. The first group fed basal diet and normal water, the second group fed high fat diet and normal water, the third group fed a basal diet and water supplemented with chromium chloride (30 mg chromium chloride / liter water), the fourth group fed high fat diet and water supplemented with chromium chloride. Blood samples were collected for the determination of serum lipoproteins, glucose, total lipids, triglycerides, cholesterol, thyroid hormones and leptin hormone. Chromium decreased VLDL and LDL but increased HDL. A reduction in serum glucose was observed with watery chromium supplementation. Serum total lipids and triglycerides were non significantly decreased but serum cholesterol was significantly decreased with watery chromium supplementation. Serum thyroid hormones were non significantly increased but the serum leptin hormone was significantly increased with watery chromium supplementation.

## 1.INTRODUCTION

The fact that Cr is an essential mineral was first demonstrated by Schwarz and Mertz (1959) in rats. Chromium, which exists in nature mostly in the trivalent form is thought to be essential for activating certain enzymes and for stabilizing proteins and nucleic acids. its primary role in metabolism is to potentiate the action of insulin through its presence in the glucose tolerance factor (GTF). The GTF consists of one atom of trivalent chromium ( $\text{Cr}^{3+}$ ) bounded to several molecules of niacin and amino acids found in the glutathione (glutamic acid,

glycine and cystine). Without chromium at the center of the GTF molecule, it is inactive (Nielsen, 1994). The GTF potentiates the action of insulin, which functions in the animal to stimulate anabolism and inhibit catabolism.

Chromium occurs throughout the body with highest concentration in the liver, kidney, spleen and bone. It is present in nucleic acids in very high concentrations. It has a biological function in nucleic acid metabolism (Okada et al., 1984). Ribonucleic acid synthesis in mouse liver was significantly increased by trivalent

chromium, in the presence of DNA or chromatin (Okada et al., 1981). These effects were also present when the DNA or chromatin were first complexes with chromium prior to incubation.

Trivalent chromium supplementation decreases cholesterol, very low density lipoprotein and low density lipoprotein, but increases the high density lipoprotein, also chromium supplementation decreases total lipids and increases serum triglycerides (Ghorabaa. ,2005). Moreover, Chromium showed a non significant effect on thyroid hormones of broiler chicks. (Al-mashhadani et al.,2010).

Tallow has traditionally been used in poultry nutrition and its production is noticeable throughout the world and there has been a great use of tallow in blended oil for poultry (Balevi & Co\_kun,2000, Tabeidian *et al.*, 2005). Tallow has included about 42.5% saturated fatty acids (SFA) and only 1% unsaturated fatty acids (UFA) that all of them are n-6 fatty acids (Sadeghi & Tabeidian, 2005).

This study was designed to through light on the effect of water inorganic chromium supplementation on lipid profile and some blood serum parameters of broilers.

## 2.MATERIAL AND METHODS.

This experiment was conducted at Biochemical Department, Faculty of Vet. Med., Alex. University to investigate the effect of water chromium supplementation on lipid profile and some serum parameters of broilers.

**Table (1): Outline of the experimental design:**

Groups No.	Diet Type	Chromium supplementation (30 mg/Liter water)*
1	Normal Diet	--
2	High Fat Diet	--
3	Normal Diet	+
4	High Fat Diet	+

\*Chromium (chromium chloride) (CrCl<sub>3</sub>.6H<sub>2</sub>O).

### 2.1.Birds used.

A total of 80 one day old Cobb chicks were used in this experiment. They were randomly allocated into four groups(20 chicks per group) of mixed sex.

### 2.2.Accommodation and Management.

The chicks were housed in clean well ventilated room, previously disinfected with formalin and iodine. The room was provided with heaters to adjust the environmental temperature according to age of the chicks. The room floor was partitioned into four equal compartments of 1.5 x 2 m<sup>2</sup> for each compartment, bedded by fresh clean chopped wheat straw forming a deep litter of 5 cm depth which was turned over weekly and changed every two weeks. Each compartment was provided by suitable feeder and waterer.

### 2.3.The Experimental design and Feeding program:

The broiler chicks were randomly allotted into 4 groups; each group of (20 per group). The first group fed on the basal diet which formulated to meet nutrient requirements of broilers (normal diet), while the second one fed on the basal diet supplemented with beef tallow(5% of the diet) and consider as high fat diet, groups 3 and four fed as the first two groups respectively with water chromium supplementation(30 mg chromium chloride/ liter water) as shown in table 1.

#### 2.4. Sample collections and Analysis.

At the end of the experiment (60 days of age), blood samples (10 samples per group), were taken from wing vein by needle under aseptic precaution from chicks of different groups, and the blood was left to drop on the side of the tube to prevent destruction of the RBCs. Each blood sample was left to coagulate at room temperature. Separation of the serum was carried out by centrifugation of coagulated blood at 3000 rpm for 10 minutes. The clear serum was transferred carefully to clean and dry vials and kept in deep freezer until analysis for determination of serum glucose, total lipids, cholesterol, triglycerides, very low density lipoproteins (VLDL cholesterol), high density lipoproteins (HDL cholesterol), low density lipoproteins

(LDL cholesterol), T3 , T4 and leptin hormone.

Serum glucose was determined according to Kaplan (1984). Serum cholesterol was determined according to Thomas (1992). Serum triglycerides were determined according to Fossati and Prencipe (1982).

High density lipoproteins (HDL cholesterol) were determined according to Assman (1979). Low density lipoproteins were determined according to Fruchart (1982). Double antibody radioimmunoassays were used to determine plasma concentrations of T3, T4 and Leptin hormones.

Statistical analysis:

The analysis of variance for the obtained data was performed using Statistical Analysis System (SAS, 1996) to assess significant differences.

### 3. RESULTS and DISCUSSION

**Table (2): Effects of chromium supplementation on carbohydrates(mg/dl) metabolism.**

Items	Diet type	Chromium supplementation	
		0.0	30 mg/liter water
Glucose(mg/dl)	Normal	209.00±7.86 <sup>ax</sup>	159.25±12.28 <sup>by</sup>
	High fat	152.63±5.83 <sup>by</sup>	197.13±10.12 <sup>ax</sup>

Values are means ± Standard error .

Means within the same column carrying different superscripts (a, b) and within the same row carrying different superscripts (x, y) are significantly different at P≤0.05

**Table (3) : Effects of chromium supplementation on serum total lipids(mg/dl), triglycerides(mg/dl) and cholesterol(mg/dl).**

Items	Diet types	Chromium supplementation	
		0.0	30 mg/liter water
Total lipids(mg/dl)	Normal	429.88±8.21 <sup>bx</sup>	474.50±12.14 <sup>bx</sup>
	High fat	676.75±17.01 <sup>ax</sup>	526.63±22.35 <sup>ay</sup>
Cholesterol(mg/dl)	Normal	162.13±5.19 <sup>bx</sup>	142.63±4.87 <sup>ay</sup>
	High fat	185.50±7.15 <sup>ax</sup>	134.25±3.61 <sup>ay</sup>
Triglycerides(mg/dl)	Normal	81.38±5.03 <sup>bx</sup>	68.75±1.80 <sup>bx</sup>
	High fat	123.63±10.20 <sup>ax</sup>	89.13±2.41 <sup>ay</sup>

Values are means ± Standard error .

Means within the same column carrying different superscripts (a, b) and within the same row carrying different superscripts (x, y) are significantly different at P≤0.05

**Table (4): Effects of chromium supplementation on serum lipoproteins(mg/dl).**

Items	Diet types	Chromium supplementation	
		0.0	30 mg/liter water
VLDL(mg/dl)	Normal	16.28±1.01 <sup>bx</sup>	13.75±0.35 <sup>ax</sup>
	High fat	27.30±4.05 <sup>ax</sup>	17.83±0.48 <sup>ay</sup>
LDL(mg/dl)	Normal	90.98±6.27 <sup>ax</sup>	65.50±5.83 <sup>ay</sup>
	High fat	105.20±10.77 <sup>ax</sup>	63.43±4.51 <sup>ay</sup>
HDL(mg/dl)	Normal	54.88±1.37 <sup>ay</sup>	63.38±2.15 <sup>ax</sup>
	High fat	53.00±2.81 <sup>ax</sup>	53.00±2.51 <sup>bx</sup>

Values are means ± Standard error .

Means within the same column carrying different superscripts (a, b) and within the same raw carrying different superscripts (x, y) are significantly different at P≤0.05

**Table (5): Effects of chromium supplementation on serum T<sub>3</sub> (nmol/l), T<sub>4</sub>(nmol/l) and leptin hormones(nmol/l).**

Items	Diet types	Chromium supplementation	
		0.0	30 mg/liter water
T3(nmol/l)	Normal	0.18±0.02 <sup>ax</sup>	0.18±0.01 <sup>ax</sup>
	High fat	0.14±0.01 <sup>ay</sup>	0.19±0.01 <sup>ax</sup>
T4(nmol/l)	Normal	2.07±0.14 <sup>ax</sup>	2.28±0.06 <sup>ax</sup>
	High fat	1.78±0.09 <sup>by</sup>	2.20±0.04 <sup>ax</sup>
Leptin(nmol/l)	Normal	1.98±0.19 <sup>ay</sup>	4.59±0.38 <sup>ax</sup>
	High fat	2.33±0.14 <sup>ax</sup>	2.49±0.11 <sup>bx</sup>

Values are means ± Standard error .

Means within the same column carrying different superscripts (a, b) and within the same raw carrying different superscripts (x, y) are significantly different at P≤0.05

### **3.1.Effects of chromium supplementation on carbohydrates metabolism.**

Effects of chromium supplementation on carbohydrates metabolism was showed in table (2). Statistical analysis of the obtained data indicated that fat supplementation of broiler chicken feed significantly ( $P \leq 0.05$ ) reduced blood serum glucose concentration by about 27% when compared with broiler group fed on normal diet. The data are in agreement with those obtained by Monfaredi et al. (2011) who found that feeding broilers a diet containing beef tallow led to a decrease in serum glucose.

Chromium supplementation with normal fat diet significantly ( $P \leq 0.05$ ) reduced blood serum glucose supplementation of broilers by about 23.8% when compared with broiler fed on normal fat diet without water Cr supplementation. These results are in agreement with the results obtained by Rosebrough and Steele (1981), they stated chromium cofactor for insulin activity and necessary for normal glucose utilization and animal growth.

The results agree with (Ghoraba.,2005) who found that the serum glucose level of the Cr supplemented broilers were lower than the control group. Moreover, Sahin et al. (2001) reported that serum glucose of broilers supplemented with Cr was lowered, they mentioned that the decrease of serum glucose may be attributed to decreased glucocorticoid secretion, which increased glucogenesis. Similar to the results of the present study, Sahin et al. (2001) found that chromium supplementation markedly decreased blood glucose in Japanese quails. Also, Rosebrough and Steele (1981) reported that turkeys fed diet supplemented with Cr had greater liver glycogen levels as a result of increasing activity of the enzyme glycogen synthetase and chromium increased glucose transport by increasing insulin activity.

In contrast, Cr water supplementation with high fat diet feeding significantly ( $P \leq 0.05$ ) increased blood serum glucose concentration of broiler

chickens by about 29.2% when compared with broilers group fed on the same diet without water Cr supplementation. On the other hand, it was observed that Cr supplementation with hat fat diet significantly increased serum glucose concentration by about 23.8% when compared with normal fat diet feeding with Cr supplementation.

### **3.2.Effects of chromium on serum total lipids, triglycerides and cholesterol.**

Effects of chromium on total lipids, triglycerides and cholesterol was showed in table (3). Analysis of variance of the obtained data indicated that broiler feeding on high fat diet significantly ( $P \leq 0.05$ ) increased blood serum total lipids, cholesterol and triglycerides concentration by about 57.4%, 14.4% and 51.9% respectively when compared with broiler group fed on normal fat containing diet. The increase in total lipid in case of high fat diet were in agreement with Zaghloul.(2001) who reported a non significant increased in level of serum total lipids when fed beef tallow (4%). The increased TAG were agreed with Shoetan et al. (1984); sodimu et al.(1984); Sheela and Augusti.(1995) and Hussein et al. (2004) who found that, the feeding on hyperlipidemic diet leading to increasing of serum TAG in rats. The increased serum TAG can be attributed to the decreased lipoprotein lipase which is an insulin dependent enzyme involved TAG removal from circulation (Yost et al., 1995). Also , the increase serum TAG can be attributed also either to over production of VLDL by liver or defective in removal of TAG rich lipoproteins from the circulation or both (Hussein et al., 2004).

The increase in serum cholesterol in the present study is was in agreement with Zaghloul.(2001) who reported that the addition of hyperlipidemic diet (4%tallow) to the basal ration of hens for 2 weeks induced non significant increased in level of serum total cholesterol. The increased total cholesterol level in normal rats fed of the hyperlipidemic diet may be due to

the reduced catabolic rate of serum cholesterol or reduced activity of hepatic cholesterol 7 $\alpha$  hydroxylase (Szymanski et al.,1981). Moreover, Zhao et al.(1998) demonstrated that the intake of high cholesterol diet with the passage of time decreased the activity of LDL receptor of hepatocytes that resulted in reduced the synthesis of bile acid.

On the other hand, it was observed that water Cr supplementation with normal fat diet feeding had no significant effect on blood serum total lipid and triglycerides concentrations, while significantly ( $P \leq 0.05$ ) reduced blood serum cholesterol by about 12.03% when compared with broiler chicks group fed on the same diet without water Cr supplementation.

However, Cr supplementation with high fat diet feeding significantly ( $P \leq 0.05$ ) reduced blood serum total lipids, cholesterol and triglycerides concentrations by about 22.2%, 27.6% and 27.9% respectively, when compared with broiler chicks group fed on the same diet without water Cr supplementation. These results agree with Al-Mashhadani et al. (2010), who found that feeding broilers Cr-yeast led to non significant difference in plasma total lipids, but cholesterol and plasma triglycerides were decreased. Ali (2006) stated that organic chromium supplementation may increase glucose clearance rate which resulted in decrease in serum cholesterol in the broiler chickens. The present results agree with the results obtained by Sahin et al. (2001a) and Ghoraba (2005). They found that Cr supplementation decreased serum cholesterol. The decreased cholesterol concentrations may be attributed to decreased glucocorticoid secretion, which increases glucogenesis(Sahin et al., 2001b).

In non ruminants, reduced blood cholesterol due to chromium supplementation , may be caused by an augmented insulin action that reduces lipolysis and increases fatty acid incorporation in the adipocytes (Pechova A and Pavalatal., 2007).

It was observed that water Cr supplementation for broiler with high fat diet feeding significantly ( $P \leq 0.05$ ) increased blood serum total lipids and triglycerides concentrations by about 10.9% and 29.6% respectively, but had no significant effect on blood serum cholesterol concentration when compared with broiler group drank water with Cr supplementation and fed on normal fat diet.

### **3.3.Effects of chromium supplementation on serum lipoproteins.**

Effect of chromium supplementation on blood serum lipoproteins are presented in table 4. Analysis of variance of the obtained data indicated that significantly ( $P \leq 0.05$ ) blood serum VLDL concentration by about 67.7%, but had no significantly increased blood serum LDL by about 15.6% and non significantly decreased HDL concentration when compared with broiler group fed on normal fat containing diet. The results in case of high fat diet were in agreement with Bordia et al. (1979) who reported an increase in serum LDL and VLDL and a decrease in the level of HDL in birds kept on cholesterol enriched diet.

It was observed that chromium supplemented groups, VLDL was non significantly lowered than the control group, also LDL was decreased but HDL was increased. In case of high fat diet, VLDL and LDL increased , also HDL was non significantly changed. In case of Cr and high fat diet VLDL and HDL were non significantly changed but LDL was significantly decreased. These results agree with Lien et al. (1999) who found that chromium picolinate supplementation caused decrease in VLDL and LDL and increase in HDL of the broiler chickens.

Insulin can increase the lipoprotein lipase activity and eventually decreases the contents of T.G- rich lipoproteins (VLDL) (Garfinkel et al., 1976; Howard et al.,1993). A previous study indicated that insulin increases liver LDL receptors, thereby reducing the LDL content and concomitantly the HDL

proportion is increased (Brindley and Salter.,1991). Also these results agree with the results obtained by Mohamed and Afifi (2001) and Ghoraba (2005), they concluded that, chromium chloride supplementation caused decrease in VLDL and LDL but caused increase in HDL of the broiler chickens.

### 3.4.Effects of chromium on serum T<sub>3</sub>, T<sub>4</sub> and leptin hormones.

Effect of chromium supplementation on some blood serum hormones are presented in table 5. The obtained data revealed that high fat diet feeding had no significant effect on blood serum T<sub>3</sub> or leptin hormone concentration, while significantly ( $P \leq 0.05$ ) reduced blood serum T<sub>4</sub> concentration by about 4% when compared with broiler group fed on normal fat containing diet.

It was observed that water Cr supplementation with normal fat containing diet feeding non significantly increased blood serum T<sub>3</sub> and T<sub>4</sub> concentration while, significantly increased Leptin hormone when compared with broiler chick group fed on the same diet without water Cr supplementation. In contrast, Cr supplementation with high fat containing diet feeding significantly increased blood serum T<sub>3</sub> and T<sub>4</sub> concentration and non significantly increased leptin hormone when compared with broiler chick group fed on the same diet without water Cr supplementation.

These results are in agreement with the results obtained by Al-Mashhadani et al. (2010), who found that chromium yeast supplementation showed non significant effect on the levels of T<sub>3</sub> and T<sub>4</sub>.

On the other hand, supplemental Cr (Sahin et al.,2003) or Cr and vitamin C (Sahin et al.,2001b) caused increase in serum T<sub>3</sub> and T<sub>4</sub>. These results could have been the result of the positive effects of chromium (Sahin et al.,2003) or chromium and vitamin C (Sahin et al.,2001a), alleviating the negative effects of heat stress.

### 4- CONCLUSION:

From the results of this study, it could be concluded that watery supplementation of

chromium chloride at the level of 30 mg / l water reduced blood serum glucose, cholesterol and triglyceride concentrations but increased blood serum total lipids concentration. Watery supplementation of chromium chloride caused a decrease in VLDL-c and LDL-c but caused an increase in HDL-c. T<sub>3</sub> and T<sub>4</sub> hormones were non significantly increased due to watery chromium chloride supplementation. Also leptin hormone was increased by watery chromium chloride supplementation

### 5. REFERENCES

- Ali, E.A.G.2006. Effect of adding organic chromium in diet on performance, physiological and immunological parameters of three broiler strain. M.Sc. Thesis. College of Agric., University of Baghdad (in Arabic).
- Al-Mashhadani,H.E.,Ibrahim,K.D., Al-Bandr,K.L. 2010. Effect of supplementing different levels of chromium yeast to diet on broiler chickens on some physiological traits. Int. Poult. Sci. 9(4):376-381.
- Assman,G. 1979. Determination of high density lipoprotein cholesterol. Internist 20:559-565
- Balevi, T., Co-kun, B.2000. Effects of some oils used in broiler rations on performance and fatty acid compositions in abdominal fat.Rev.Med.Vet.151,937-944.
- Bauer, J.D. 1982. Clinical laboratory methods. 9th Ed, the C.V Company, Westline Industrial Missouri. 63116 chapter 33:555.
- Bordia, A., Bansal, H.C., Arora, S.,Singh, S.V.1979. Effect of essential oil of garlic and onion on alimentary hyperlipidemia. Atherosclerosis, 21(1):15-19.
- Brindley, D.N., Salter, A.M.1991. Hormonal regulation of the hepatic low density lipoproteinP: relationship with the secretion of very low density lipoprotein. J. lipid res. 30:349-360.
- Fossati,P., Precipe, L. 1982. Serum triacylglycerol determined colometrically with an enzyme that produces hydrogen peroxides. Clin. Chem. 28 (10):2077-2080.
- Fruchart,J.C. 1982. Separation of low density lipoproteins and determination of cholesterol and phospholipids bound to this fraction. Rev. Fr. Des. Lab. 103:7-17.
- Garfinkel, A.S., Nilsson-Ehle, P., Schotz, M.C.1976. Regulation of lipoprotein lipase induction by insulin. Bioch. Bioph.I Acta 424:264-269.
- Ghoraba,A.A.2005. Impact of dietary chromium supplementation on performance and immunological status of broilers. M.Sc.

- Thesis. College of Vet. Med., University of Alex.
- Howard, B.V., Schneiderman, N., Falkner, B., Haffner, S.M., Laws, A. 1993. Insulin, health behaviors, and lipid metabolism. *Metab.* 42 (9, 151): 25-35.
- Hussein, S.A., Azab, M.E., Abd El-Maksoud, H. 2004. Effect of garlic oil on certain physiological and biochemical aspects in normal and experimentally induced hyperlipidemia in male albino rats. *Egypt. Basic and Appl. Physiol.* 3 (2): 225-272.
- Kaplan, L.A.1984. Glucose. *Clin Chem. The C.V. Mosby co. st Louis. Toronto. Princeton.* Pp:1032-1036.
- Lien, T.F., Horng, Y.M., Yang, K.H. 1999. Performance, serum characteristics, carcass traits and lipid metabolism of broilers as affected by supplement of chromium picolinate. *Br. Poult. Sci* 40:357-363.
- Mohamed, F.F., Afifi, M. 2001. Role of inorganic chromium in modulating performance and immunity in broilers. *Vet. Med. J. Giza*, 49 (1):147-162.
- Monfaredi, A. Rzaei, M., Sayyazadeh, H.2011. Effect of supplemental fat in low energy diets on some blood parameters and carcass characteristics of broiler chicks. *S.Afri. J. Anim. Sci.* 41 :25-32.
- Nielsen, F.H.1994. Chromium. In: Shils, M.E., Olson, J.A. and Shike, M. (eds), *Modern nutrition in Health and Disease*. Lea and Febiger, Philadelphia, PP. 264-268.
- Okada, S., Ohba, H., Taniyama, M.1981. Alterations in ribonucleic acid synthesis by chromium. *J. Inorg. Biochem.* 15:223-231.
- Okada, S., Tsukada, H., Ohba, H. 1984. Enhancement of nucleolar RNA synthesis by chromium in regenerating rat liver. *J. Inorg. Biochem.* 21:113-124.
- Pechova, A., Pavalata, L. 2007. Chromium as an essential nutrient: a review. *Vet. Med.* 52:1-18.
- Rosebrough, R. W., Steele, N.C.1981. Effect of supplemental dietary chromium or nicotinic acid on carbohydrate metabolism during basal, starvation and refeeding periods in poultry. *J. Poul. Sci.* 60:407-417.
- Sadeghi, G.H., Tabeidian, S.A.2005. Effect of different energy to protein ratio and tallow supplementation on broiler performance. *Int. J. Poult. Sci.* 4: 976-981.
- Sahin, K., Sahin, N., Onderci, M., Gursu, F., Cikim, G. 2003. Optimal dietary concentration of chromium for alleviating the effect of heat stress on growth, carcass qualities and some serum metabolites of broiler chickens. *Biol. Trace Element Res.* 89(1):53-64.
- Sahin, K., Kucuk, O., Sahin, N., Ozbey, O. 2001a. Effect of dietary chromium picolinate supplementation on egg production, egg quality and serum concentrations of insulin, corticosterone and some metabolites of Japanese quails. *Nut. Res.* 21:1315-1321.
- Sahin, K., Sahin, N., Kucuk, O. 2001 b. Effects of dietary chromium and ascorbic acid supplementation on digestion of nutrients, serum antioxidant status, and mineral concentrations in laying hens reared at low ambient temperature. *Biol. Trace Element. Res.* 87:113-124.
- SAS (1996): *Statistical Analysis System. User's Guide: Statistics*. SAS Institute, Cary, North Carolina.
- Schwarz, K., Mertz, Z. 1959. Chromium and glucose tolerance factor. *Archives of Biochemistry and Biophysics*, 85, 292-295.
- Sheela, C.G., Augusti, K.T., 1995. Allyl cysteine sulphoxide isolated from *Allium sativum* lining cholesterol diet fed rats. *Indian J. Exp. Biol.*, 33(5):337-341.
- Shoetan, A., Augusti, K.T., Joseph, P.K.1984. Hypolipidemic effects of garlic oil in rats fed ethanol and high lipid diet. *Experientia*, 15:261-263.
- Sodimu, O.I., Joseph, P.K., Augusti, K.T. 1984. Certain biological effects of garlic oil on rats maintained on high fat-high cholesterol diet. *Experientia* 15; 40(1):78-80.
- Szymanski, E.S., Little, N.A., Kritchevsky, D. 1981. Phospholipid metabolism in livers of young and oil Fischer 344 and Sprague-Dawley rats. *Exp. Geront.* 163-169.
- Tabeidian, A., Sadeghi, G. H., Pourreza, J. 2005. Effect of dietary protein levels and soybean oil supplementation on broiler performance. *Int. J. Poult. Sci.* 4: 799-803.
- Thomas, L. 1992. *Enzymatic colometric determination of cholesterol*. Labor ND, Diagnose 4th Ed.
- Yost, T.J., Froyd, K.K., Jenson, D.R., Eckel, R.H. 1995. Changes in skeletal lipoprotein lipase activity in response to insulin/ glucose in non-insulin dependent circulatory regulation in conscious rats. *Hypertension.* 34:247-252.
- Zaghloul, N.F. 2001. Biochemical effect of dietary hypolipidemic agents on lipid metabolism in chickens. *Ph. D. Thesis, Fac. Vet. Med., Alex, Univ.*
- Zhao, J., Xiao, L., Su, Y., Cheng, N., Cheng, Z., Zhu, H. 1998. Effect of hypermagnesemia on the adenohipophyseal-gonadal function, parathyroid hormone secretion and some other hormonal indicators. *Horm. Metab. Res.* 25(1):29-33.