Original Article

Estimation and Study Effect of Some Trace Elements and Some Electrolytes in Hyperlipidemia Patients

Huda Ahmed Duhaib, Mufeed Jalil Ewadh, Tariq Hussein Mgheer

Department of Biochemistry, College of Medicine, University of Babylon,, Babylon,, Iraq

Abstract

Background: Measuring electrolytes in the blood is considered one of the most common diagnostic techniques. **Objectives:** To assess sodium, potassium, zinc, and copper levels and examine the correlation between parameters and study their probable relation with hyperlipidemia in Babylon province. **Materials and Methods:** Sodium, potassium, zinc, and copper were estimated in one hundred subjects; 50 patients with hyperlipidemia and 50 healthy subjects participated in this study. The age of the patients and control groups ranged between 19 and 75 years. Sodium and potassium levels were assessed by colorimetric enzymatic technique, whereas the level of zinc and copper was assessed in serum by the flameless atomic absorption spectrophotometer method. **Results:** Serum levels of sodium and zinc displayed a significant decrease, whereas serum copper significantly elevated ($P < 0.05$) in hyperlipidemia patients compared with the control group. Serum potassium observed nonsignificant change (P-value > 0.05) in hyperlipidemia patients. On the other hand, copper and zinc correlated significantly with cholesterol, triglyceride, and sodium. **Conclusion:** Among hyperlipidemia patients in Babylon province, the variability in some trace elements and some electrolytes concentration indicate a significant relationship with hyperlipidemia.

Keywords: Copper, hyperlipidemia, potassium, sodium, zinc

Introduction

The most affected public illness worldwide in industrialized and unindustrialized countries is hyperlipidemia; in this disease, blood lipids level is higher than average. Higher levels of lipids (triglyceride, fats, and cholesterol) dispose the patient to numerous grave and occasionally fatal complications such as cardiovascular disease, hepatic dysfunction, renal dysfunction, and cerebral strokes.[1]

Generally, the mortality by cardiovascular diseases in 1990 was about 14.4 million subjects, which elevated to 17.5 million in 2005, whereas in 2015, this number was probably 20 million. Thus, dyslipidemia represented the chief risk factor for cardiovascular diseases and mortality.[2]

In a medical context, measuring electrolytes in the blood is considered one of the most common diagnostic techniques.[3]

Sodium characterizes greater than 90% of cations in the extracellular fluid. That explains why sodium with corresponding anions regulates the osmotic pressure. As a consequence, sodium concentration is responsible for extracellular fluid volume. As a balance exists between intra and extracellular fluids, any variation of $Na+$ concentration causes the movement of water between cells and the extracellular environment. The critical role of sodium is maintaining acid-base balance and preserving standard membrane potentials and normal cardiac function.[4]

The principal intracellular cation is potassium. Virtually all processes in cells are based on gradients of potassium and atrium on both sides of the cell membrane.[5]

Several enzymes may have a fundamental role in preventing atherosclerosis, but copper and zinc are essential parts of the functional groups of these enzymes.[6]

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Address for correspondence: Mrs. Huda Ahmed Duhaib, Department of Biochemistry, College of Technology and Medicine, Baghdad, Iraq.
E-mail: hudatho1@gmail.com

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Copper deficiency may be attributable to the prevalence of inflammatory heart disease. A small amount of copper ingested has been on the decline, and it looks like that a large percentage of people do not eat the recommended dietary allowance (RDA) of copper.

Copper-dependent proteins are chaperones, transcriptional regulators, oxidoreductases, free radical scavenging, and mitochondrial electron transport. Copper has a crucial role in the immune system.[7]

Copper deficiency makes lipoproteins (low density lipoprotein [LDL], high density lipoprotein [HDL], very low density lipoprotein [VLDL]) more susceptible to oxidation. The enzymes that protect from oxidative modification contain copper and zinc, like superoxide dismutase; the deficiency of these enzymes catalyzes the oxidation of lipoproteins.[8]

Essential biological functions in organisms are conducted by zinc. First, a redox-neutral metal ion is zinc and can steadily bind to nearly 10% of the human proteome and maintain its structure. Second, more than 300 enzymes require zinc for catalysis and co-catalysis of various metabolic cell functions.[9] Third, zinc, representing "the calcium of the 21st century," is a signaling mediator and targets multiple enzymes in cellular signing, like kinases and phosphatases.

Zinc deficiency, even in a small amount, can cause a change in pathological conditions, especially age-related pathologies, such as atherosclerosis.[10]

In this study, we aimed to review the recent discoveries on the association between some trace elements and some electrolytes with hyperlipidemia.

Materials and Methods

Study design

A case–control study is the design of this revision.

Patients and control

This revision comprised 100 subjects. Fifty patients with hyperlipidemia participated in this study; the complete history of all patients was recorded, which included: age, body mass index, gender, family history, and smoking behaviors.

The second group comprises 50 healthy persons (control group).

Patients with pregnancy, concomitant acute or chronic inflammatory disorders, and malignancy patients were excluded from the revision—patients and control groups aged 19–75 years. For the statistical analysis, SPSS version 20.0 was used. All the results as mean ± standard deviation (SD), with significant results were recorded when P values are less than 0.05.

Chemicals and methods

1- Sodium concentration was measured by enzyme method via sodium-dependent Β-Galactosidase activity with O-nitrophenyl-8-galacto pyranoside (ONPG) as the substrate (Giesse Diagnostics, Italy).
2- Potassium concentration was determined enzymatically through a kinetic coupling assay system using potassium-dependent pyruvate kinase (Giesse Diagnostics).
3- The level of zinc and copper was assessed in serum by the flameless atomic absorption spectrophotometer method using graphite furnace (GFAAS) technique.

Ethical approval

This study was approved based on the ethical principles that originated in the Declaration of Helsinki. It was conducted with patients' verbal and analytical approval before taking the sample. The study protocol, subject information, and consent form were reviewed and approved by a local ethics committee according to document number 4 on July 6, 2022 to get this approval.

Results

The studied individuals consist of 100 adults designated into two groups:

1- Adults have hyperlipidemia (n = 50)
2- Adults as the control group (n = 50)

Age

The discrepancy in age (as mean) showed significant differences among control and hyperlipidemia groups, as demonstrated in Table 1.

Gender

The spreading of the hyperlipidemia group rendering to sexual characteristics is shown in Figure 1. The current review established that the prevalence of the hyperlipidemia group in female patients (54%) is more significant than in male patients (46%).

Body mass index

The mean ± SD of body mass index (BMI) for the control and hyperlipidemia groups were 23.2 ± 2.47 and 26.7 ± 2.0, respectively. The study result showed a significant difference in BMI in patients and the control group (P > 0.05), as shown in Table 1.

Table 1: Anthropometric measurement of studied groups

Study variables	Patients (N = 50) Mean ± SD	Controls (N = 50) Mean ± SD	P value
Age (years)	53.7 ± 16.0	33.8 ± 9.42	0.00
BMI (kg/m^2)	26.7 ± 2.0	23.2 ± 2.47	0.001

The biochemical parameters measured in hyperlipidemia patients and the control group

Table 2 shows a decreased concentration of sodium and zinc and an increased concentration of copper in hyperlipidemia patients compared with the control, with significant (p-value < 0.05) mean differences between them.

In contrast, the current study observed a nonsignificant change in serum potassium (P-value > 0.05) in hyperlipidemia patients.

Correlation of copper and zinc concentrations with the parameters measured in hyperlipidemia patients

A significant negative relationship was detected between zinc and copper ($r = -0.963$, $p = 0.00$) concentration in serum.

Also, zinc and copper were significantly correlated with serum cholesterol, serum triglyceride, and serum sodium concentration in hyperlipidemia patients.

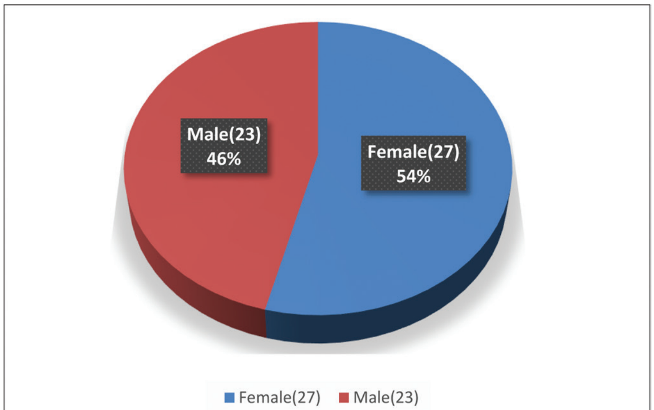

Figure 1: The ratio of males to females in hyperlipidemia patients

Whereas there were no relationships observed among zinc and copper concentrations and serum potassium in the patients' group ($P > 0.05$) [Table 3, Figure 2].

Table 4 reveals no relationship between zinc and copper concentration and age, whereas zinc concentration correlated significantly with BMI [Figure 3].

Receiver operating characteristic analysis of the zinc and copper

A receiver operating characteristic (ROC) curve [Figures 4 and 5] was used to determine the threshold serum zinc and copper level for diagnosing hyperlipidemia about the standard control.

Zinc and copper showed excellent sensitivity and specificity in discriminating hyperlipidemia from the normal state with an area under the curve of (94%, 91%) with sensitivity (92%, 90%) and specificity of (90%, 92%) at a cut-off value (71.5 ng/mL, 147 ng/mL) respectively.

Discussion

Several factors may contribute to the development of hyperlipidemia, including age or sex, family history, obesity, diabetes, lifestyle change, and some drugs.[11]

This fact was in harmony with the measurements of this revision; the mean age of subjects, who were established as hyperlipidemia patients and control, were 53.7 and 33.8 years, respectively.

Furthermore, this review found a slight female predominance of 54%, which contrasts with those of,[12] who found that women are more "protected" than men against hyperlipidemia.

Table 2: The mean differences in biochemical parameters rendering to study group

Parameter	Group	*N*	Mean ± SD	*t*-test	*P*-value
CHO (mg/dL)	Patient	50	252.2 ± 48.3	10.8	0.001
	Control	50	171.8 ± 20.0		
TG (mg/dL)	Patient	50	338.9 ± 102.27	15.4	0.002
	Control	50	101.4 ± 36.13		
HDL (mg/dL)	Patient	50	54.0 ± 12.0	–2.2	0.02
	Control	50	59.1 ± 10.4		
LDL (mg/dL)	Patient	50	123.1 ± 53.6	0.15	0.87
	Control	50	121.7 ± 28.69		
VLDL (mg/dL)	Patient	50	67.7 ± 20.9	13.9	0.00
	Control	50	24.6 ± 6.38		
Na (mmol/L)	Patient	50	136.9 ± 5.3	–5.3	0.00
	Control	50	141.3 ± 2.7		
K (mmol/L)	Patient	50	4.2 ± 0.39	–0.65	0.51
	Control	50	4.2 ± 0.33		
Cu (ng/mL)	Patient	50	202.5 ± 14.46	38.1	0.00
	Control	50	101.1 ± 11.99		
Zn (ng/mL)	Patient	50	39.3 ± 6.2	–36.2	0.001
	Control	50	95.4 ± 8.98		

HDL: high density lipoprotein, LDL: low density lipoprotein, SD: standard deviation, VLDL: very low density lipoprotein, $P < 0.05$: significant

Table 3: Correlation between parameters

		Cho	TG	Na	K	Cu	Zn
Cho	*r*	1	0.639**	–0.466**	–0.074	0.732**	–0.711**
	P		0.000	0.000	0.466	0.000	0.000
TG	*r*	0.639**	1	–0.448**	–0.066	0.813**	–0.815**
	P	0.000		0.000	0.512	0.000	0.000
Na	*r*	–0.466**	–0.448**	1	0.151	–0.402**	0.418**
	P	0.000	0.000		0.134	0.000	0.000
K	*r*	–0.074	–0.066	0.151	1	–0.092	0.044
	P	0.466	0.512	0.134		0.362	0.665
CU	*r*	0.732**	0.813**	–0.402**	–0.092	1	–0.963**
	P	0.000	0.000	0.000	0.362		0.000
Zn	*r*	–0.711**	–0.815**	0.418**	0.044	–0.963**	1
	P	0.000	0.000	0.000	0.665	0.000	

$P < 0.05$: significant, *r*: correlation

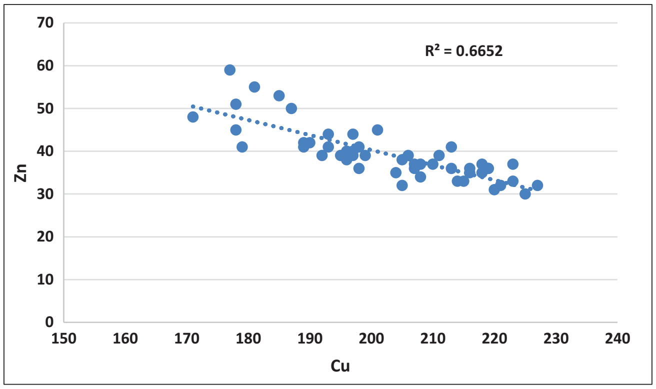

Figure 2: Correlation between Zn and Cu

Table 4: Correlation between copper and zinc with age and BMI in hyperlipidemia patients

		Age	BMI
Cu (ng/mL)	*r*	0.020	–0.266
	P	0.890	0.061
Zn (ng/mL)	*r*	0.033	0.309
	P	0.821	0.029

$P < 0.05$: significant, *r*: correlation

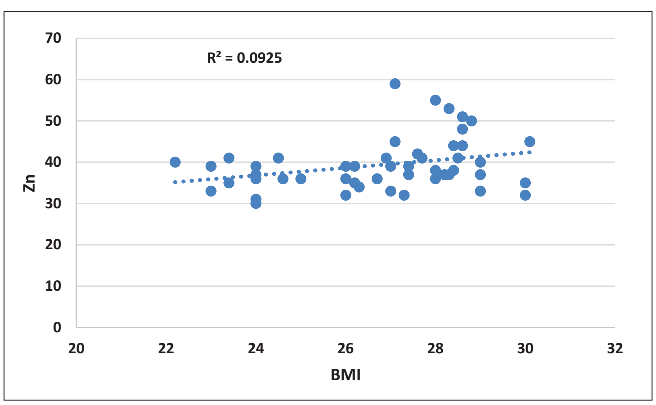

Figure 3: Correlation between BMI and Zn

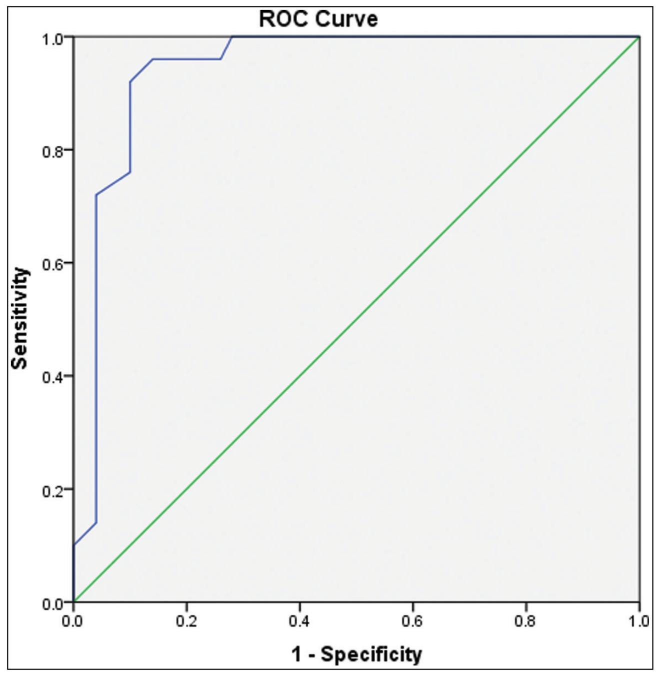

Figure 4: ROC curve for the sensitivity and specificity of zinc for diagnosis of hyperlipidemia

As shown in Table 2, there were significant differences in levels of lipid markers and hyperlipidemia prevalence between patients and control groups. The patients' group displayed unusual elevation of total cholesterol and very low-density lipoprotein, whereas low-density lipoprotein was nonsignificantly elevated.

There were numerous suggested causes for these alterations, that is, the elevation of lipids in aging people, with loss of hepatic LDL receptors according to age, obesity, higher waist circumference, and low level of sex hormone, among others.[13]

The association of triglycerides with central obesity is known. Consequently, hyperlipidemia is combined with

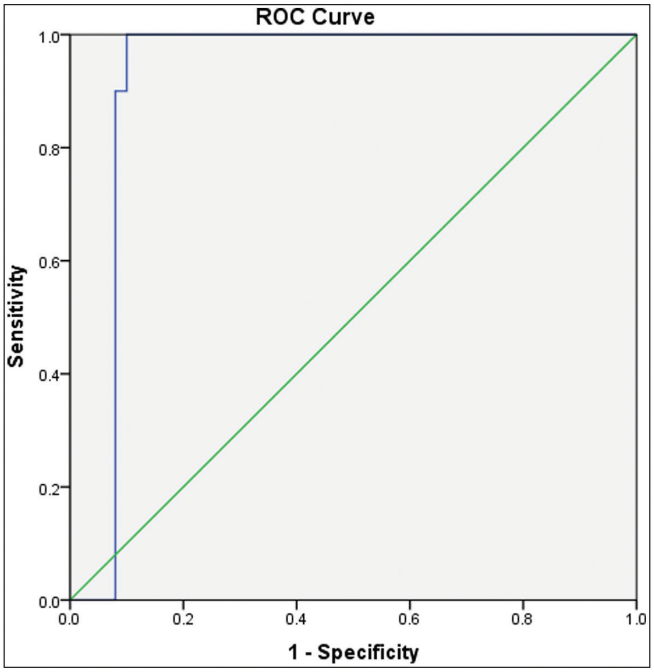

Figure 5: ROC curve for the sensitivity and specificity of copper for diagnosis of hyperlipidemia

this health condition, which clarifies why triglyceride levels are elevated significantly in hyperlipidemia patients.[14]

High-density lipoprotein decreased significantly in hyperlipidemia patients. This is consistent in previous studies: some assumed an adverse correlation between age and HDL cholesterol levels, whereas others instituted sex differences in altering HDL levels with age.[15]

Serum sodium concentration significantly decreased, and our findings, consistent with the results of Kim,[16] revealed that hyponatremia is an overestimation of the physiologic reduction of sodium in plasma by nonaqueous substantial. Elevated intravascular protein or lipid concentrations "dilute" the sodium concentration in plasma but do not change the solute concentrations in the intracellular or interstitial fluid compartments. So, a decrease in sodium is linked with a higher level of lipids or protein and can be reflected in artefactual, called pseudo hyponatremia.

As shown in Table 2, there was a nonsignificant change in plasma potassium concentration; our finding is inconstant with,[17] which shows that a decrease in the risk of lipid disturbance happens significantly with higher potassium levels in the plasma. Similarly, the systematic review and meta-analyses by Aburto *et al*.[18] demonstrated that increased potassium consumption had no adverse effect on lipid concentrations in the blood. The lipid-lowering influence linked with elevated potassium consumption was further established in reports by Bu *et al*.[19]

Trace elements may be considered markers for diagnosing the disease, and it is vital to understand if the balance is altered in free or bound elements.

Our results have shown a significant ($P < 0.05$) correlation between copper and zinc with cholesterol, triglyceride, and sodium in hyperlipidemia patients.

Copper is one of the chief micronutrients that is very important in human food and health. Numerous revisions stated a contrary relative between Cu and serum cholesterol in rats through deficiency in Cu,[20] whereas Koo and Williams[21] originated a nonsignificant association between the Cu and cholesterol levels in rats with non-Cu deficiency.

Engle *et al.*[22] recommended that insufficiencies of some trace elements, such as Zn, lead to alterations in lipid and lipoprotein metabolism; this explains the negative correlation of Zn with cholesterol and triglyceride. Our findings, consistent with El-Hendy *et al.*,[23] presented that Zn insufficiency increases serum cholesterol in a dose-dependent.

The detection rate for Hyperlipidemia was 94% and 91% using a threshold zinc value of 71.5 ng/mL and copper value of 147 ng/mL, but these results must be taken cautiously because of the small sample. The effect of hyperlipidemia on the zinc and copper level in patients must also be considered.

This inconsistency with preceding outcomes might result from diverse ethnicities, the sample size, and the study design.

Conclusion

Among hyperlipidemia patients in Babylon province, alteration in the level of sodium, zinc, and copper may indicate a significant link to hyperlipidemia diseases.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Naser IH, Abd Alkareem Z, Mosa AU. Hyperlipidemia: Pathophysiology, causes, complications, and treatment. A review. Kerbala J Pharm Sci 2021;1:1-15.
2. Bahmani M, Mirhoseini M, Shirzad H, Sedighi M, Shahinfard N, Rafieian Kopaei M. A review on promising natural agents effective on hyperlipidemia. J Evid Based Complementary Altern Med 2015;20:228-35.
3. Sen S, Ghosh P, Ghosh TK, Das M, Das S. A study on the effect of lipemia on electrolyte measurement by direct ion selective electrode method. J Biomol Res Ther 2016;5:142-54.
4. Burgunder L. Fluids and electrolytes.The Harriet Lane Handbook. Philadelphia, PA: Elsevier; 2020. p. 261.
5. Dimeski G, Mollee P, Carter A. Effects of hyperlipidemia on plasma sodium, potassium, and chloride measurements by an indirect ion-selective electrode measuring system. Clin Chem 2006;52:155-6.
6. Ward NC, Watts GF, Eckel RH. Statin toxicity: Mechanistic insights and clinical implications. Circ Res 2019;124:328-50.

7. DiNicolantonio JJ, Mangan D, O'Keefe JH. Copper deficiency may be a leading cause of ischaemic heart disease. Open Heart 2018;5:e000784.
8. Sharma GB, Nandavar A, Maben EVS, Kotian MS, Ganaraja B. Do cholesterol lowering drugs affect electrolyte balance, in-hypertensive patients? Res J Pharm Biol Chem Sci 2017;8:1-9.
9. Rafieian-Kopaei M, Setorki M, Doudi M, Baradaran A, Nasri H. Atherosclerosis: Process, indicators, risk factors, and new hopes. Int J Prev Med 2014;5:927-46.
10. Caballero B, Trugo LC, Finglas PM. Encyclopedia of Food Sciences and Nutrition. San Diego, CA: Academic; 2003.
11. Baiee HA, Makai MB. Medication adherence in hypertensive diabetic patients. Med J Babylon 2022;19:129-39.
12. Gao Z, Zengsheng C, Anqiang S. Gender differences in cardiovascular disease. Med Novel Technol Dev 2019;4:1-10.
13. Wang M, Hou X, Hu W, Chen L, Chen S. Serum lipid and lipoprotein levels of middle-aged and elderly Chinese men and women in Shandong Province. Lipids Health Dis 2019;18:58-65.
14. Al Obeidy BF, Al Zobair AA, Jawher NMT, Zheng F. Relationship between vitamin D_3 level and body mass index in postmenopausal breast cancer patients. Med J Babylon 2022;19:207-22.
15. Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, *et al*. ACC/AHA guideline on the primary prevention of cardiovascular disease: Executive summary: A report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. Circulation 2019;140:563-95.
16. Kim G-H. Pseudohyponatremia: Does it matter in current clinical practice? Electrolyte Blood Press 2006;4:77-82.
17. Avogbe PH, Sanni A. Elevated white blood cell count is associated with an increased risk of insulin resistance among non-diabetic taxi-motorbike drivers working in Cotonou, Benin. J Biosci Med 2022;12:159-75.
18. Aburto NJ, Hanson S, Gutierrez H, Hooper L, Elliott P, Cappuccio FP. Effect of increased potassium intake on cardiovascular risk factors and disease: Systematic review and meta-analyses. BMJ (Clin Res Ed) 2013;346:1378-88.
19. Bu SY, Kang MH, Kim EJ, Choi MK. Dietary intake ratios of calcium-to-phosphorus and sodium-to-potassium are associated with serum lipid levels in healthy Korean adults. Prev Nutr Food Sci 2012;17:93-100.
20. Cunnane SCJ. Role of zinc in lipid and fatty acid metabolism. Prog Food Nutr Sci 1988;12:151-88.
21. Koo I, Williams DAJ. Relationship between the nutritional status of zinc and cholesterol concentration of serum lipoprotein in adult male rats. Am J Clin Nutr 1981;34:2376-81.
22. Engle TE, Spears JW, Xi LJ. Concentration in fishing stress dietary copper effects on lipid metabolism and circulating catecholamine. J Am Sci 2000;78:2737-44.
23. El-Hendy HA, Yousef MI, Abo El-Naga NIJ. Effect of dietary zinc deficiency on hematological and biochemical parameters and zinc, copper and iron concentration in growing rats. Toxicology 2001;167:163-70.