ASPI | Afarand Scholarly Publishing Institute; Iran
ISSN: 2008-2630 Iranian Journal of War & Public Health 2022;14(3):317-321 DOI: 10.29252/ijwph.14.3.317

A Comparative Study of Lead and Cadmium Concentrations in Serum Samples of Diabetic Patients in Al-Najaf Governorate

ARTICLE INFO

Article Type
Original Research

Authors
Mohammad A.R.[1] *MSc,*
Hussein H.A.[2] *BSc,*
Kadhim S.A.[3] *PhD,*
Hashoosh M.H.[4] *BSc,*
Hassan E.S.*[1] *MSc*

How to cite this article
Mohammad A R, Hussein H A, Kadhim S A, Hashoosh M H, Hassan E S. A Comparative Study of Lead and Cadmium Concentrations in Serum Samples of Diabetic Patients in Al-Najaf Governorate. Iranian Journal of War & Public Health. 2022;14(3):317-321.

ABSTRACT

Aims This study aimed to investigate the concentration of Cadmium (Cd) and lead (Pb) in different serum samples of diabetic patients and compared them with healthy subjects.

Materials & Methods This pilot study was conducted in the Al-Hira area, Najaf governorate, Iraq from June 2021 to January 2022. It included 25 diabetic patients (12 males and 13 females) and 15 healthy non-diabetic subjects (7 males and 8 females) whose ages ranged between 30-80 years. The diabetic patients with an average age of 52.52 years, have type 1 or type 2 diabetes. Healthy people have an average age of 53 years. The blood samples were taken after fasting one night and centrifuged after acid digestion to obtain serum which was stored for later use. Lead and Cadmium measurements were done using an atomic absorption spectrophotometer, SHIMADZU model AA-7000 atomic absorption spectrophotometer (Japan), which was calibrated. By SPSS 20, data were analyzed using the independent t-test and Pearson Correlation.

Findings The Cd concentration in diabetic patients was higher than the control group with a high statistical significance ($p<0.0001$), this was true for the concentration of Cd in diabetic male and female patients which was significantly higher ($p<0.001$) than in male and female of the control group. While the Pb concentration is significantly lower in the diabetic group as compared to the healthy group but it was insignificantly ($p>0.05$) change in diabetic males and females as compared to healthy male and female persons. The Cd concentration was significantly higher in both type1 and type2 diabetic patients while the concentration of Pb insignificantly changed in those patients.

Conclusion The Cd concentration is low in type1 and type2 diabetic patients of both gender, while the concentration of Pb is lower in diabetic patients than in healthy individuals.

Keywords Diabetes; Lead; Cadmium; Analytical Chemistry Technique

[1]Department of Pharmacology & Therapeutics, Faculty of Medicine, University of Kufa, Najaf, Iraq
[2]Physical Planning Unit, Middle Euphrates Oncology Center, Najaf, Iraq
[3]Department of Physics, Faculty of Sciences, University of Kufa, Najaf, Iraq
[4]The Ministry of Education, Baghdad, Iraq

***Correspondence**
Address: Department of Pharmacology & Therapeutics, Faculty of Medicine, University of Kufa, Najaf, Iraq
Phone: +96 (47) 803012849
Fax: -
ekhlass.khazaal@uokufa.edu.iq

Article History
Received: May 18, 2022
Accepted: August 1, 2022
ePublished: August 15, 2022

CITATION LINKS

[1] Comparing the levels of trace elements in patients with ... [2] Variation in macro and trace elements ... [3] Cytomegalovirus infection and glutamic ... [4] Diagnosis and classification of diabetes ... [5] Role of minerals and trace elements in diabetes ... [6] Copper, zinc, and magnesium levels in non-insulin dependent ... [7] A review on role of essential trace ... [8] Evaluation of some trace elements in type 2 diabetes ... [9] Copper, chromium, manganese, iron, nickel, and zinc levels ... [10] Cellular transport and homeostasis of essential and nonessential ... [11] EST derived SSR markers for comparative ... [12] Technical efficiency analysis of rice production ... [13] Carcinogenic metal compounds: recent ... [14] Child welfare programs and child nutrition ... [15] Assessment of water quality of polluted lake using multivariate ... [16] The role of cadmium in obesity and ... [17] Cadmium, lead, arsenic and selenium ... [18] Relationship between the level of zinc, lead ... [19] Assessment of heavy metals by ICP-OES ... [20] Blood cadmium in Chinese adults and its ... [21] Cadmium exposure, fasting blood glucose ... [22] A review of diabetes mellitus and exposure ... [23] Cadmium impairs p53 activity in ... [24] Assessment of concentration of lead, cadmium, chromium and ... [25] Status of toxic metals in biological samples of diabetic mothers ... [26] Association between serum heavy metals ... [27] Multivariate investigation of toxic and essential metals ... [28] Assessment of metals induced histopathological and gene ... [29] Cadmium exposure decreases fasting blood ... [30] Effects of selenium, zinc, insulin and ...

Introduction

Diabetes mellitus (DM) is a group of metabolic disorders characterized by high blood sugar [1]. It is a chronic disease that occurs when the body is not able to use insulin effectively or when the pancreas does not excrete enough insulin [2]. DM is a global disease that spreads all over the world at a rate that differs from country to country [3]. This disease is usually divided into two types, are the most common, type1 (destruction of β cells with an absolute lack of insulin), and the percentage of people with this type is 5-10%, while the second type is the most prevalent 90-95% of cases, the subjects suffer from a relative lack of insulin secretion [4]. Minerals and trace elements are essential micronutrients required for the normal functioning body. These elements are particularly beneficial for physiological functions [5]. A relationship has been reported between trace elements and diabetes mellitus [6]. Minerals and trace elements are essential for many biochemical reactions, and present as stabilizing components of enzymes and proteins in addition they function as cofactors for many enzymes. Certain trace elements regulate crucial biological processes by binding to the receptor site of the cell membrane or by changing the shape of the receptor to prevent the entry of particular molecules into the cell [7]. Some essential trace metals including copper (Cu), zinc (Zn), magnesium (Mg), iron (Fe), and calcium (ca) are associated with diabetes mellitus type 2 [8]. There are many trace elements altered in diabetes mellitus and might have specific roles in the pathogenesis and progress of this disease, they reported higher levels in the blood, urine, and scalp hair of diabetics than nondiabetics [9]. Lead (Pb) is harmful to most of the human body organs and obstructs metabolism and cellular activities [10]. A linear relationship is reported between blood Pb level and renal dysfunction in age-related diseases after recurrent exposures to Pb [11]. It badly affects the antioxidant pathways [12]. The metal-induced toxicity may cause derangement of antioxidant mechanisms in living tissues; as a result, highly reactive oxygen species (ROS) are produced. This antioxidant discrepancy might lead to the degradation of proteins, nucleic acids, and lipid peroxidation. An oxidative attack of cellular components by ROS is concerned with the pathogenesis of numerous human diseases including diabetes [13].

Cadmium (Cd) is a heavy metal that is broadly detected in air, water, and soil. Increased Cd level in water is absorbed by plants, animals, and humans [14]. Frequent exposure to Cd supplied to its excess addition in the kidney causes renal damage and nephropathy [15]. The high level of Cd reduces calcium absorption, which becomes an approaching cause of bone and kidney losses, called Itai-Itai disease. The Cd might down-regulate glucose transporter-4 (GLUT4) translocation by insulin [16].

A previous study proved that blood Cd and Pb levels were higher in diabetics with reduced antioxidant concentration, and it suggested that the elevation of toxic metals may be a contributing factor to the pathogenesis of diabetes mellitus [17].

These studies have been done in some areas of the world, but these studies in Iraq are very few and this is the first study in the Al-Hira area. Therefore, this study aimed to investigate the concentration of these two elements in different serum samples for diabetic patients and compared them with healthy persons.

Materials and Methods

This pilot study was conducted in the Al-Hira area, Najaf governorate, Iraq from June 2021 to January 2022. It included 25 diabetic patients (12 males and 13 females) and 15 healthy non- diabetic subjects (7 males and 8 females) whose ages ranged between 30-80 years. The diabetic patients with an average age of 52.52 years, have type 1 or type 2 diabetes. Healthy people have an average age of 53 years.

The blood samples were taken after fasting one night and centrifuged after acid digestion to obtain serum which was stored for later use. Lead and Cadmium measurements were done by using an atomic absorption spectrophotometer, SHIMADZU model AA-7000 atomic absorption spectrophotometer (AAS) made in Japan which was calibrated to cadmium and lead elements to obtain values controlled for the groups under study as in Diagrams 1 & 2.

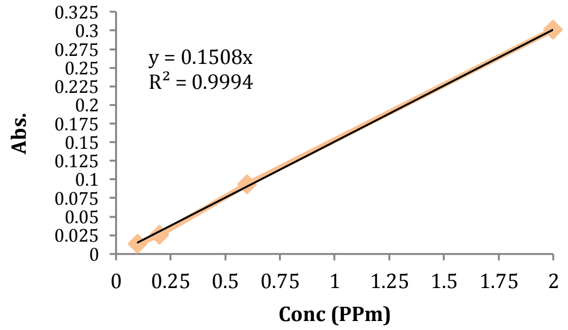

Diagram 1) Calibration of the atomic absorption system for cadmium

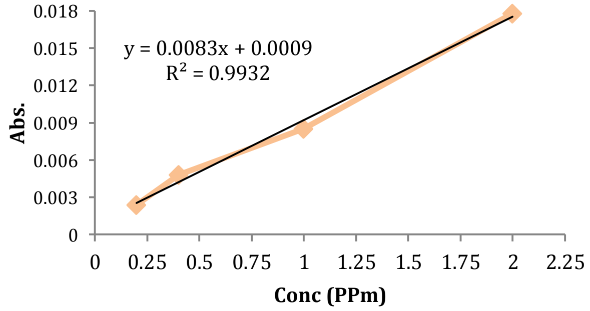

Diagram 2) Calibration of the atomic absorption system for lead

Microsoft Excel 2019 was used for spreadsheets, SPSS software version 20 was used to analyze the data, and used the independent t-test and Pearson Correlation to find the statistical significance between the different samples which depend on $p<0.05$.

Findings

The study population included 25 diabetic patients (12 males and 13 females) and 15 healthy non-diabetic subjects (7 males and 8 females) so the gender is comparable in number between case and control groups. Age ranged between 30-80 years. The diabetic patients had an average age of 52.52 years and the healthy people had 53 years' average age with a non-significant difference between the two groups. All the participants were living in the Al-Hira area, Najaf governorate in Iraq, and this was the first study for these heavy elements in that area.

This study demonstrated that the cadmium concentration in diabetic patients was higher than in the control group with a high statistical significance ($p<0.0001$), while the lead concentration is significantly lower in the diabetic group as compared to the healthy group (Table 1). According to our results, the cadmium concentration in diabetic male patients was significantly higher ($p<0.001$) than in the male of the control group, meanwhile lead concentration in the serum of diabetics was insignificantly ($p>0.05$) lower than in healthy male persons (Table 1; Diagram 4). The same results were found when comparing concentrations of Cd and Pb in the serum of the female diabetic and control group (Table 1).

Table 1) Concentrations of Cd and Pb elements in the serum of healthy and diabetic patients

Gender	Element	Groups	Lower limit	Upper limit	Mean±SD	p-value
Male	Cd	Healthy	0.0114	0.0318	0.022±0.007	0.0001
		Diabetics	0.0321	0.0765	0.051±0.014	
	Pb	Healthy	0.1053	0.2211	0.165±0.044	0.174
		Diabetics	0.0842	0.2684	0.134±0.046	
Female	Cd	Healthy	0.0101	0.0259	0.017±0.006	0.0001
		Diabetics	0.0561	0.0725	0.062±0.005	
	Pb	Healthy	0.1105	0.2368	0.178±0.047	0.073
		Diabetics	0.0947	0.1842	0.134±0.032	
Total	Cd	Healthy	0.0101	0.0318	0.0201±0.007	0.0001
		Diabetic	0.0321	0.0765	0.0568±0.012	
	Pb	Healthy	0.1053	0.2368	0.168±0.044	0.026
		Diabetic	0.0842	0.2684	0.134±0.039	

Pearson correlation analysis was carried out to determine the relationship between variables (Table 2). There was a strong inverse relationship between cadmium and lead in healthy people, with a statistically significant correlation. There was also a strong inverse and statistically significant association between cadmium in healthy subjects with cadmium in people with diabetes, and a moderate positive correlation between cadmium in healthy people and lead in diabetic patients without statistical significance, and finally, the correlation was negative and not statistically significant between lead in healthy people and cadmium in diabetic patients with the negligible correlation between cadmium among sick and healthy subjects.

Table 2) Comparative study for Pearson correlation r between (Cd and Pb)

Correlations (ppm)	**4**	**3**	**2**	**1**
1- Cd healthy	0.540	-0.782**	-0.848**	1
2-Pb healthy	-0.499	0.864**	1	
3-Cd diabetes	-0.185	1		
4- Pb diabetes	1			

** Correlation was significant at the 0.01 level (2-tailed)

In Table 3, there was no statistically significant between the different groups of the studied serum samples for the lead trace. There was statistically significant between healthy versus type 1 and healthy versus type 2 Groups using the independent test as well as for the triple groups (control, type 1, type 2) using the ANOVA test ($p<0.05$).

Table 3) Comparison of serum samples between healthy and types 1 and 2 diabetes groups

Element	**Group**	**Lower**	**Upper limit**	**Mean±SD**	**p-value**
Cd	Healthy	0.0101	0.0318	0.020±0.007	-
	Type1	0.0321	0.0765	0.057±0.014	0.0001*
	Type 2	0.0331	0.0686	0.056±0.011	0.0001**
Pb	Healthy	0.1053	0.2368	0.171±0.044	-
	Type1	0.0947	0.1737	0.130±0.024	0.076*
	Type 2	0.0842	0.2684	0.136±0.046	0.081**

* Healthy and type 1; ** Healthy and type 2

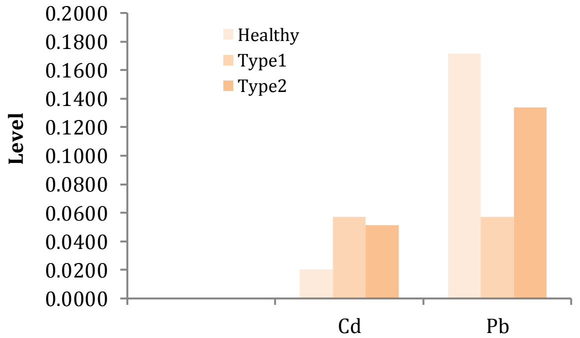

Diagram 3) Illustration of Cadmium and lead serum levels in healthy, type1, and type 2 subjects

Discussion

According to the studied samples that we have in our study, cadmium concentration (for both males and females) in diabetic patients is higher than the healthy ones These results were in agreement with other clinical research which found that Cd level is increased in diabetic and prediabetes patients [17-20].

A cohort study in China suggested that high chronic Cd exposure for general population adults might contribute to elevated fasting blood glucose and result in type 2 diabetes mellitus development [21].

Both experimental and epidemiological studies showed that exposure to the environmental pollutant cadmium is associated with hyperglycemia, type 2 diabetes, and reduced serum insulin. Individual cellular effects of cadmium are reviewed, it is likely that no single mechanism is involved, somewhat multiple mechanisms exist, and work synergistically ensuing in islet dysfunction and finally dysglycemia [22].

it was found that Cadmium, a non-essential heavy metal, presents potential environmental and human risks, is a toxic and carcinogenic metal, and can lead to elevated ROS formation, which in turn leads to DNA damage, as well as its ability to interfere with cell signaling [23].

We noted that the lead concentration in diabetic patients was lower than the healthy persons. This result disagreed with other studies like Akinloye *et al.* who found that the mean value of Pb was significantly higher in the serum of diabetic patients when compared with the control [21] and Salman *et al.* found that Cd and Pb were relatively high in patients with type 1 diabetes [24].

Serum level of lead for males in diabetic patients was insignificantly different from healthy subjects and this was true for females in our study. These results were consistent with Tadayon *et al.*, who estimated hair lead levels and found that there was a nonsignificant change between type 2 diabetic patients and the control group [18]. Kolachi *et al.* studied the level of Pb in biological samples (whole blood, scalp hair, and urine) which was found to be increased significantly in diabetic mothers while in our study, the level of Pb was non significantly lower in diabetic females [25].

Excessive exposure to lead has many negative effects on human health. Evidence indicates that exposure to lead increases susceptibility to cancer and may affect human health by interfering with the DNA repair machinery after genetic insults, impairing the ability of cells to develop appropriate and accurate responses to environmental endotoxins [26]. The behavior of lead in our study was the opposite of some international studies [27] might be due to the small sample size or due to biological factors, human nature, and their relationship to geographical distribution. This can be considered the first study of diabetic patients in Iraq (Al-Najaf Governorate, Al-Hira region) for the elements cadmium and lead so no other local study for results comparison.

The serum concentration of cadmium, in our research, was significantly higher in Healthy Type1 and Type 2 versus the healthy group, this agreed with many international studies as Salman *et al.* found that Cd was relatively high in patients with Type 1 diabetes [24] and Kolachi *et al.* who found that Cd in biological samples (whole blood, scalp hair, and urine) of insulin-dependent diabetic mothers were significantly higher as compared to mothers in the control group [25].

Cadmium as a heavy metal had an important role in the pathogenesis of both types of diabetes. The pancreatic tissue of diabetic rats exposed to Cd for 30 days revealed severe degeneration, necrosis, degranulation, shrinkage, and depression in the islets of Langerhans [28].

Li *et al.* investigate the effects of long-term exposure to Cd in a type-2 diabetes mellitus mouse model and the underlying mechanism, he concluded that Cd exposure disturbed glucose metabolism and exacerbated diabetes [29].

Another explanation is that Cd exposure in type I diabetic rats causes an increment in oxidative stress and Metallothionine gene expression levels [30].

Our research was the first in terms of measuring these two dangerous heavy metals (Cd and Pb) in the serum of diabetic patients who lived in (Al-Najaf Governorate, Al-Hira region) in Iraq, we recommend other studies for measuring them in other governorates and other biological samples as hair and urine for comparison.

Conclusion

The Cd concentration is low in type1 and types 2 diabetic patients of both genders while the concentration of Pb is lower in diabetic patients than in healthy subjects.

Acknowledgments: The researchers would like to extend their thanks and appreciation to all the workers in the Department of Physics, Faculty of Science, University of Kufa, and all faculty staff for their continuous support in completing the research requirements.

Ethical Permissions: The current study has been approved by the ethics committee of the Faculty of Sciences, University of Kufa.

Conflicts of Interests: All authors declare that there is no conflict of interest in the study.

Authors' Contributions: Mohammad AR (First Author), Introduction Writer/Main Researcher (30%); Hussein HA (Second Author), Assistant Researcher/Statistical Analyst (20%); Kadhim SA (Third Author), Assistant Researcher (20%); Hashoosh MH (Forth Author), Assistant Researcher/Statistical Analyst (10%); Hassan ES (Fifth Author), Assistant Researcher/Discussion Writer (20%)

Funding/Sources: This is a self-funded study. All authors participated in the costs.

References

1- Makhlough A, Makhlough M, Shokrzadeh M, Mohammadian M, Sedighi O, Faghihan M. Comparing the levels of trace elements in patients with diabetic nephropathy and healthy individuals. Nephrourol Mon. 2015;7(4):e28576.

2- Siddiqui K, Bawazeer N, Scaria Joy S. Variation in macro and trace elements in progression of type 2 diabetes. Sci World J. 2014;2014:461591.

3- AI-Nafakh RT, Yasir SJ, AL-Fadhul SAL, Hassan ES. Cytomegalovirus infection and glutamic acid decarboxylase antibodies in type 2 diabetic patients. Pak J Medd Health Sci. 2020;14;450-4.

4- American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2010;33(Suppl 1):S62-9.

5- Dubey P, Thakur V, Chattopadhyay M. Role of minerals and trace elements in diabetes and insulin resistance.

Nutrients. 2020;12(6):1864.
6- Zargar AH, Shah NA, Masoodi SR, Laway BA, Dar FA, Khan AR, et al. Copper, zinc, and magnesium levels in non-insulin dependent diabetes mellitus. Postgrad Med J. 1998;74(877):665-8.
7- Prashanth L, Kattapagari KK, Chitturi RT, Baddam VR, Prasad LK. A review on role of essential trace elements in health and disease. J NTR Univ Health Sci. 2015;4(2):75-85.
8- Abduallateef N, Khalied S. Evaluation of some trace elements in type 2 diabetes mellitus patients. AL-Yarmouk J. 2012;1.
9- Kazi TG, Afridi HI, Kazi N, Jamali MK, Arain MB, Jalbani N, et al. Copper, chromium, manganese, iron, nickel, and zinc levels in biological samples of diabetes mellitus patients. Biol Trace Elem Res. 2008;122:1-8.
10- Martinez-Finley EJ, Chakraborty S, Fretham SJ, Aschner M. Cellular transport and homeostasis of essential and nonessential metals. Metallomics. 2012;4(7):593-605.
11- Yu JK, La Rota M, Kantety RV, Sorrells ME. EST derived SSR markers for comparative mapping in wheat and rice. Mol Genet Genom. 2004;271(6):742-51.
12- Khai HV, Yabe M. Technical efficiency analysis of rice production in Vietnam. J ISSAAS. 2011;17(1):135-46.
13- Beyersmann D, Hartwig A. Carcinogenic metal compounds: recent insight into molecular and cellular mechanisms. Arch Toxicol. 2008;82:493.
14- Afridi F. Child welfare programs and child nutrition: evidence from a mandated school meal program in India. J Dev Econ. 2010;92(2):152-65.
15- Kazi TG, Arain MB, Jamali MK, Jalbani N, Afridi HI, Sarfraz RA, et al. Assessment of water quality of polluted lake using multivariate statistical techniques: a case study. Ecotoxicol Environ Saf. 2009;72(2):301-9.
16- Tinkov AA, Filippini T, Ajsuvakova OP, Aaseth J, Gluhcheva YG, Ivanova JM, et al. The role of cadmium in obesity and diabetes. Sci Total Environ. 2017;601:741-55.
17- Akinloye O, Ogunleye K, Oguntibeju OO. Cadmium, lead, arsenic and selenium levels in patients with type 2 diabetes mellitus. Afr J Biotechnol. 2010;9(32):5189-95.
18- Tadayon F, Abdollahi A, Nia SR, Ostovar R. Relationship between the level of zinc, lead, cadmium, nickel and chromium in hair of people with diabetes. E3S Web Conf. 2014;1:41012.
19- Saba S, Akash MS, Rehman K, Saleem U, Fiayyaz F, Ahmad T. Assessment of heavy metals by ICP-OES and their impact on insulin stimulating hormone and carbohydrate metabolizing enzymes. Clin Exp Pharmacol Physiol. 2020;47(10):1682-91.
20- Nie X, Wang N, Chen Y, Chen C, Han B, Zhu C, et al. Blood cadmium in Chinese adults and its relationships with diabetes and obesity. Environ Sci Pollut Res. 2016;23(18):18714-23.
21- Xiao L, Li W, Zhu C, Yang S, Zhou M, Wang B, et al. Cadmium exposure, fasting blood glucose changes, and type 2 diabetes mellitus: a longitudinal prospective study in China. Environ Res. 2021;192:110259.
22- Edwards J, Ackerman C. A review of diabetes mellitus and exposure to the environmental toxicant cadmium with an emphasis on likely mechanisms of action. Curr Diabetes Rev. 2016;12(3):252-8.
23- Urani C, Melchioretto P, Fabbri M, Bowe G, Maserati E, Gribaldo L. Cadmium impairs p53 activity in HepG2 cells. Int Sch Res Not. 2014;2014.
24- Salman M, Rehman R, Mahmud T, Shafique U, Anwar J, Sana A, et al. Assessment of concentration of lead, cadmium, chromium and selenium in blood serum of cancer and diabetic patients of Pakistan. J Chem Soc Pak. 2011;33(6):869-73.
25- Kolachi NF, Kazi TG, Afridi HI, Kazi N, Khan S, Kandhro GA, et al. Status of toxic metals in biological samples of diabetic mothers and their neonates. Biol Trace Elem Res. 2011;143(1):196-212.
26- Marouf B. Association between serum heavy metals level and cancer incidence in darbandikhan and Kalar area, Kurdistan region, Iraq. Niger J Clini Pract. 2018;21(6):766-71.
27- Mahmood MH, Qayyum MA, Yaseen F, Farooq T, Farooq Z, Yaseen M, et al. Multivariate investigation of toxic and essential metals in the serum from various types and stages of colorectal cancer patients. Biol Trace Elem Res. 2022;200:31-48.
28- Riaz MA, Nisa ZU, Anjum MS, Butt H, Mehmood A, Riaz A, et al. Assessment of metals induced histopathological and gene expression changes in different organs of non-diabetic and diabetic rats. Sci Rep. 2020;10:5897.
29- Li M, Wang S, Liu X, Sheng Z, Li B, Li J, et al. Cadmium exposure decreases fasting blood glucose levels and exacerbates type-2 diabetes in a mouse model. Endocrine. 2022;76:53-61.
30- Gungor H, Kara H. Effects of selenium, zinc, insulin and metallothionein on cadmium-induced oxidative stress and metallothionein gene expression levels in diabetic rats. J Basic Clin Physiol Pharmacol, 2020;31(2).