

Evaluation of the toxicity of heavy metal salts when adding selenium and zinc in the liver and kidneys and their effect on health

Lashkr Hameed Hamzah¹, Hozan Jalil Hamasalim², Dilsher M R Palani³, Hemin Nuradden Mohammed², Zirak M R Palani⁴

¹Sulaymaniyah Health Directorate, Sulaimanyah, Kurdistan Region, Iraq.

²Department of Animal sciences/college of Agricultural Engineering Science/ University of Sulaimani, Iraq.

³Animal production department, College of Agricultural Engineering Sciences, University of Garmian, Kalar, Sulaimanyah, Kurdistan Region, Iraq

⁴PhD in Animal Physiology, Kurdistan Region, Iraq.

*Corresponding author: Dr. Zirak M R Palani. Email: zirak_axa@yahoo.com

Abstract

Acquisition of knowledge about toxic elements and their distribution in the liver and kidneys and their effect on health after doses of selenium and zinc for lambs of the Kurdi sheep breed, as well as using the assessment as an indicator of toxic elements in the liver and kidneys. In this study lambs were divided into four groups, the first groups without any addition, the second group, a dose of selenium at a concentration of 0.5 mg / kg fed, and the third group a dose of zinc 100 mg / kg fed. and the Fourth group, their mixture of Se +Zn (0.5 + 100) mg / kg fed for a period of 90 days. The results were the following elements were determined in the tissues of the liver and kidneys: Selenium, zinc, Iron, Cobalt, Copper, Molybdenum, Tin, arsenic, Lead, Chromium and Nickel, their levels were within the permissible limits. The elements Chromium, Rhenium, mercury, Vanadium, Manganese, indium, Cadmium, Niobium, Silver, Bismuth and Iridium were free of these elements. While the elements Strontium, Tantalum, argon, Palladium, Bromine, thallium, Antimony, Zirconium and Tungsten were, their levels were not known to the permissible limits or their toxic levels due to the absence of any data for them or previous studies, we conclude from this study the addition of selenium and zinc may be Enhances health Kurdi sheep and needs to know the mechanism of action and the toxic level of the mentioned mineral elements.

Keywords: Selenium, Zinc, heavy metal, liver, kidney, Kurdi sheep.

1. Introduction

Knowledge of toxic concentrations in animal tissues is necessary to assess the potential impact on humans of pollutant consumption in these animals. Furthermore, there has been a growing awareness among consumers regarding food safety, environmental toxicology issues and the health field over the past 20 years, Because of the high concentrations reported in the liver and kidneys, it is important to monitor levels of toxic metals. Animal tissues such as the liver and kidneys are important to the human diet, providing essential nutrients for the body (Khalafalla et al.;2015). In many Middle Eastern countries, the internal organs (such as the liver and kidneys) are consumed as a valuable and acceptable food for consumers (Falandysz,1993) and in most countries these products are served as popular foods in many restaurants (El-Salam.,2013). Unfortunately, visceral organs sometimes contain certain toxic compounds such as heavy metals. Herds of cattle, goats and sheep are usually grazing on contaminated land, where soil, grass, air and water can contaminate heavy metals that enter the tissues of different livestock (Ihedioha and Okoye 2012). At present increasing population growth (Yabe., 2011).

Liver and kidneys of cattle are responsible for removing toxins from the toxic substances that enter the body. Thus, higher concentrations of these substances appear than in other organs (Khalafalla et al.;2015). Heavy metals can accumulate in the body and become toxic or carcinogenic Cow and sheep manure contains large amounts of heavy metals, especially selenium (Se), nickel (Ni), cobalt (Co), tin (Sn), lead (Pb) and cadmium (Cd) in Sulaymaniyah Governorate in the Kurdistan region of Iraq. And plants and reduces environmental pollution as it is useful for recycling waste and reduces risks to human health (Palani et al.,2022a). Unfortunately, in many countries, local standards for levels of heavy metals in products such as meat and the internal organs of animals are missing. Liver has been reported to contain higher concentrations of toxic elements than meat and is a good indicator of these elements in the animal body (Falandysz,1993), (El-Salam.,2013). Therefore, liver is used in food safety control procedures as an indicator of toxic elements in meat. Toxic elements are persistent chemicals and are not metabolized, although their chemical forms may change as they pass through the intestine or during storage in animal tissues (Biehl and Buck, 1987). It is considered toxic to living organisms because it tends

to accumulate in target tissues of humans and animals with the potential to cause renal, carcinogenic and immune disorders (McDowell, 2003) (Zukowska and Biziuk, 2008). The long-range transport of toxic elements through the atmosphere depends mainly on the size and composition of the particles to which the toxic elements bind as well as their solubility (AMAP, 2002). The Permissible Toxicological Terminology (PTWI/PTMI) developed by the Joint Food and Agriculture Organization (FAO)/WHO Expert Committee on Food Additives (JECFA), as well as Maximum Levels (ML) for some contaminants defined by the European Commission (EC), are relevant as it relates to the concentrations of toxic elements in both the human body and food, respectively (WHO, 2010) (IPCS, 2011). PTWI/PTMI limits are the tolerable points for pollutants such as toxic elements with cumulative properties, which represent the permissible weekly/monthly human exposure to those pollutants inevitably associated with the consumption of contaminated food. The maximum concentration of contaminants in foodstuffs that have no risks to human health represents the maximum concentration, i.e., acceptable concentrations in or on foodstuffs (IPCS, 2011). Selenium supplementation with a concentration of 0.5 mg/kg of feed in Kurdi sheep resulted in improvement of some important elements and no adverse effects on the environment and its levels within the permissible limits of ANZFA, World Health Organization and Institute of Medicine (USA). Moreover, there are no negative effects from the mineral elements in the muscles and liver which is important for animal health as well as for human consumption (Palani et al., 2019). shown the beneficial effect of supplementation of selenium and zinc on Glutathione activity in Liver and kidney tissues which may provide better protection to from oxidative damage, Which may play a role in good on efficiency of Kurdi lambs (Palani et al., 2020). Our main purpose was to study to level of toxic elements in the liver and kidneys of sheep when adding selenium or zinc or their mixture to lambs of the Kurdi sheep breed.

2. Materials and Methods

his experiment was conducted in the Bakrajo district of Sulaymani city, Sulaymaniyah governorate in the Kurdistan Region of Iraq, during the summer. 16 lambs aged between 4-5 months. Lambs were divided into four groups for each experiment, where each group had 4 lambs in each group, where the first group was fed without any addition, the second group added Sodium Selenite Na_2SeO_3 at a dose of 0.5 mg / kg of feed, the third group added Zinc (zinc sulfate) ZnSO_4 at a dose of 100 mg / kg feed. The fourth group added a mixture (selenium with zinc) at a dose of 0.5 + 100 mg / kg feed. After that lambs were randomly distributed and each of them was placed in a cage with an area of 1 * 1.5 m² for a 90-day experiment. The fodder consisted of 60% barley and 12% soybeans and did not contain any amount

of selenium. The feed also contained 26% wheat bran, 1% salt, 0.5% limestone, 0.5% a mixture of vitamins and minerals. Use empty gelatin capsules to get selenium and zinc for animals, where the amount of selenium and zinc determined for each animal is taken and weighed with a sensitive scale, and this amount is calculated on the basis of the daily amount of feed consumed for each animal. Mix selenium or zinc with cornmeal to dilute them and put them in an empty gelatin capsule. The capsule was administered to sheep daily for 90 days in the morning before feeding. After that the lambs of the Kurdi sheep were slaughtered, samples of the liver and kidneys were taken, and they were placed in topped bags and frozen until the analyzes were performed, then dried in the oven at a temperature of 105 degrees Celsius and crushed. Mineral content in liver and kidneys was assessed using ICPE-9000 from Shimadzu Japan. 200 mg after dilution with 1-4 sulfuric acid (H_2SO_4), and HClO_4 perchloric acid for 16 hours, and added to 50 ml deionized water. The design of the experiment was a complete factorial randomization design (CRD) to determine the effects of selenium and zinc on lambs and rams. . The analysis is performed with XLstat (2016) according to this equation: $Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk}$ where Y_{ijk} = dependent variable, μ = general mean, A_i = effect of Se application and Zn factor B_j : effect Age factor, AB_{ij} = effect of interactions between two factors, e_{ijk} = standard error, mean comparison according to Duncan (1955) within the programme.

3. Results and Discussion

The results of Table (1) showed the level of selenium (Se) in the liver and kidneys, and the results were significant, as the level of selenium increased in the addition of selenium with the second treatment and the fourth treatment compared to the third treatment and the control group. There were no significant differences when adding zinc (Zn) in the third and fourth treatment compared to the second treatment and the control group. The level of iron (Fe), cobalt (Co), copper (Cu), arsenic (As), and lead (Pb) decreased when adding selenium and zinc compared to the control group in the liver and kidney tissues of Kurdi sheep. While the level of molybdenum (Mo), nickel (Ni), antimony (Sb) and thallium (Tl) increased in the liver and kidneys, and Strontium in the liver when adding selenium and zinc compared to the control group. Tin (Sn) was increased when zinc was added in the third and fourth treatment in the liver, while it increased when selenium was added in the second and fourth treatment in the kidneys. Tantalum (Ta) was determined when selenium was added in the second and fourth treatments in the liver and kidneys. And argon (Ar) was determined in the liver when selenium was added in the second and fourth treatments. Palladium (Pd) is also found in the liver and kidneys. Bromine (Br) was determined in kidneys and increased in all addition treatments compared to the control group. Zirconium (Zr) was detected in the

liver and kidneys when a mixture of selenium and zinc was added. Tungsten (W) component was identified in the liver and kidneys. No level of bromine (Br) was found in the liver. The results of the analysis for the elements Chromium (Cr), Rhenium (Re), mercury

(Hg), Vanadium (V), Manganese (Mn), indium (In), Cadmium (Cd), Niobium (Nb), Silver (Ag), Bismuth (Bi) and Iridium (Ir) were free and did not show any determination of the levels of elements in the liver and kidneys of male Kurdi sheep.

Table (1): Determination of the levels of mineral elements in Liver and Kidney tissues after adding Selenium and Zinc in Kurdi sheep.

Metals	Liver (ppb)				Kidney (ppb)			
	Treatment (Control)	Treatment (Se)	Treatment (Zn)	Treatment (Se+Zn)	Treatment (Control)	Treatment (Se)	Treatment (Zn)	Treatment (Se+Zn)
Selenium (Se)	47.667 e ± 15.07	121.000 b ± 6.66	26.000 ef ± 8.33	157.000 a ± 8.39	15.333 f ± 2.85	74.333 d ± 15.19	19.000 f ± 2.31	97.000 bcd ± 9.54
zinc (Zn)	23.517 ef ± 0.21	24.833 e ± 0.11	31.017 d ± 2.08	33.793 c ± 1.23	18.527 g ± 0.22	17.777 g ± 1.47	21.623 f ± 0.25	25.103 e ± 0
Iron (Fe)	19.960 b ± 0.23	17.717 c ± 0.19	13.633 e ± 0.09	13.227 e ± 0.24	19.253 b ± 0.11	12.100 f ± 0.13	16.530 d ± 0.74	10.823 g ± 0.3
Cobalt (Co)	1.053 b ± 0.07	0.340 d ± 0.02	0.767 bcd ± 0.22	0.727 bcd ± 0.22	1.617 a ± 0.34	0.497 cd ± 0.02	0.970 bc ± 0.06	0.567 bcd ± 0.2
Copper (Cu)	26.247 a ± 0.14	22.517 c ± 0.08	24.543 b ± 0.53	21.247 d ± 0.67	19.010 e ± 0.08	4.097 fg ± 0.05	3.547 g ± 0.12	4.350 f ± 0.18
Molybdenum (Mo)	0.340 d ± 0.1	1.367 d ± 0.22	1.050 d ± 0.02	1.353 d ± 0.08	0.343 d ± 0.07	0.513 d ± 0.08	1.477 d ± 0.06	2.367 d ± 0.29
Tin (Sn)	1.680 hi ± 0.08	1.167 j ± 0.15	2.057 fg ± 0.03	2.133 fg ± 0.04	2.640 e ± 0.09	4.263 d ± 0.13	2.573 e ± 0.17	4.293 d ± 0.12
Strontium (Sr)	0.090 ef ± 0.04	0.247 cd ± 0.04	0.177 de ± 0.03	0.287 cd ± 0.02	0.777 a ± 0.09	0.433 b ± 0.03	0.477 b ± 0.1	0.250 cd ± 0.02
arsenic (As)	3.233 a ± 0.55	0.230 c ± 0.01	0.970 bc ± 0.07	0.160 c ± 0.02	3.100 a ± 1.14	0.350 c ± 0.03	1.800 b ± 0.32	0.227 c ± 0.01
Lead (Pb)	1.833 cd ± 0.49	1.467 cdef ± 0.15	1.067 defg ± 0.09	0.733 fg ± 0.12	4.200 a ± 0.21	2.267 bc ± 0.34	1.600 cde ± 0.32	1.933 c ± 0.09
Chromium (Cr)	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0
Tantalum (Ta)	0.000 e ± 0	0.580 bc ± 0.11	0.000 e ± 0	0.477 c ± 0.13	0.000 e ± 0	0.730 b ± 0.09	0.000 e ± 0	1.180 a ± 0.04
Rhenium (Re)	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0
argon (Ar)	0.000 b ± 0	0.373 a ± 0.08	0.000 b ± 0	0.493 a ± 0.13	0.000 b ± 0	0.000 b ± 0	0.000 b ± 0	0.000 b ± 0
Palladium (Pd)	10.747 jk ± 0.1	13.390 g ± 0.25	11.660 i ± 0.15	10.537 k ± 0.11	11.263 ij ± 0.13	15.620 f ± 0.12	12.543 h ± 0.17	16.583 e ± 0.13
Nickel (Ni)	0.733 efg ± 0.29	1.500 cde ± 0.38	1.600 bcde ± 0.21	2.567 a ± 0.41	0.150 g ± 0.04	0.883 defg ± 0.06	1.163 cdef ± 0.04	1.087 cdef ± 0.05
mercury (Hg)	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0
Vanadium (V)	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0
Manganese (Mn)	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0
indium (In)	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0
Bromine (Br)	0.000 k ± 0	0.000 k ± 0	0.000 k ± 0	0.000 k ± 0	1.133 g ± 0.01	2.350 b ± 0.02	2.587 a ± 0.02	0.250 j ± 0.01
thallium (Tl)	4.097 h ± 0.05	4.500 fgh ± 0.55	4.357 gh ± 0.25	4.213 h ± 0.12	5.197 fgh ± 0.08	7.600 e ± 0.44	6.353 ef ± 0.2	9.967 d ± 1.28
Antimony (Sb)	2.537 h ± 0.15	3.210 g ± 0.16	3.630 f ± 0.12	4.383 e ± 0.1	5.053 d ± 0.02	8.017 a ± 0.01	4.590 e ± 0.09	6.533 c ± 0.15
Zirconium (Zr)	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.073 c ± 0.01	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.533 a ± 0
Cadmium (Cd)	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0
Niobium (Nb)	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0
Silver (Ag)	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0	0.000 a ± 0
Bismuth (Bi)	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0	0.000 d ± 0
Tungsten (W)	0.203 fg ± 0.05	0.503 de ± 0.1	0.287 efg ± 0.04	0.140 g ± 0.02	0.537 de ± 0.11	1.023 ab ± 0	1.053 ab ± 0.02	0.440 def ± 0.13
Iridium (Ir)	0.000 c ± 0	0.000 c ± 0	0.000 c ± 0	0.000 c ± 0	0.000 c ± 0	0.000 c ± 0	0.000 c ± 0	0.000 c ± 0

Means with different letters within each column differ significantly ($P \leq 0.05$) according to Duncan's test.

This study was recent as it was conducted to determine the effect of adding selenium and zinc, each separately or their combination, and on the other hand to find rare and new mineral elements in the liver and kidneys of Kurdi sheep, so there were no existing studies in the previous studies to compare with the current study. Selenium and zinc greatly improve some important elements of minerals, there are no harmful effects of mineral elements, which is important for animal health (Palani et al, 2022b). Heavy metals, such as cadmium (Cd), chromium (Cr), arsenic (As), nickel (Ni), mercury (Hg), lead (Pb), Tin (Sn), thallium (Ti), tungsten (W), and bromine (Br), are a group of toxic metallic compounds that are which raises concern when dealing with the quality of animal feed. Providing the safest feed products for animals is critical not only to protect animal health and production but also to reduce human exposure to toxic heavy metals and organic pollutants. Accumulation of heavy metals in soil can lead to agricultural land degradation. It acts on eutrophication and uptake of toxic substances. This leads to long-term effects on agricultural soil quality, including phytotoxicity in high concentrations and transport of zoonotic toxic elements into the human diet due to increased uptake of crops or soil by uptake by grazing cattle (Nicholson et al., 2003).

Trace minerals in animal feeds are the most diverse nutrients due to factors of soil maturity stage, plant species and climatic conditions (Underwood, 1981; Berger, 1996). Minerals such as zinc (Zn), copper (Cu), cadmium (Mo), selenium (Se), iron and magnesium are essential for animal health, production and survival as they are part of the organism's structural, physiological, catalytic and regulatory roles (Ries et al., 2010). In addition, farm animals rely heavily on their nutritional status for their performance and intracellular detoxification of free radicals (Smith and Akinbamijo, 2000). Liver cells contain thousands of different enzymes, including zinc-containing carbonic anhydrase, various oxidases, and other enzymes dependent on Zn^{2+} , which are responsible for the metabolism of components harmful to humans. However, zinc ions and zinc-dependent enzymes are transported from the liver through the blood to all other organs. Taking into account the range of values. (Kato et al., 2002). Liver cells contain thousands of different enzymes, including zinc-containing carbonic anhydrase, various oxidases, and other enzymes dependent on Zn^{2+} , which are responsible for the metabolism of components harmful to humans. However, zinc ions and zinc-dependent enzymes are transported from the liver through the blood to all other organs. Taking into account the range of values (Kato et al., 2002). Thus, it seems that the biological role and possible reasons for the increase in their concentration in some organs of the body for some trace elements are not entirely clear. In the

results, mineral elements whose levels were determined for the first time appeared attributable to the reason Addition of selenium or zinc and their interactions. In this study, we estimated for the first time the identification of thirty metallic elements in the liver and kidneys of Kurdi sheep in Sulaymaniyah Governorate, Kurdistan Region of Iraq. The content of mineral elements in the organs of the liver and kidneys is determined in part by their content (ppb), In addition, mineral ions are components of many hormones and vitamins where some of the detected mineral ions play very different biological functions in the organs used in the study. Moreover, the concentrations of some mineral elements (Selenium, zinc, Iron, Cobalt, Copper, Molybdenum, Tin, arsenic, Lead, Chromium and Nickel) were within the limits permitted by ANZFA, NIST, WHO and Institute of Medicine (USA). And some mineral elements are unknown and there are no studies or limits to their levels, especially the elements (Strontium, Tantalum, argon, Palladium, Bromine, thallium, Antimony, Zirconium and Tungsten). Therefore, broader studies are needed to understand the toxic levels of these elements, whose levels have been determined in the liver and kidney tissues of Kurdi sheep.

4. Conclusion

In this study, the accumulation of trace elements (selenium, zinc, iron, cobalt, copper, molybdenum, tin, arsenic, lead, chromium, nickel) was within the limits permitted by ANZFA, NIST, WHO and Institute of Medicine (USA). And some metallic elements are unknown and there are no studies or limits to their levels, especially the elements (strontium, tantalum, argon, palladium, bromine, thallium, antimony, zirconium and tungsten). Therefore, there is a need for more studies to understand and determine the levels of accumulation and toxicity of the mineral elements that were detected in this study in the liver and kidney tissues of the Kurdi sheep, where selenium and zinc act on the interactions and absorption of some mineral elements and their accumulation in the liver and kidney tissues.

References

- AMAP. (2002). Arctic pollution Arctic monitoring and assessment programme (AMAP). Oslo: AMAP; 111 p.
- ANZFA (Australia New Zealand, Food Authority) Wellington, New Zealand.
- Berger, L.L (1996). Variation in the trace mineral content of feedstuffs. Prof. Anim. Sci., 12 (1996), pp. 1-5.
- Biehl ML, Buck WB. (1987). Chemical contaminants their metabolism and their residues. J Food Protect. 50:1058,73.
- El-Salam NMA, Ahmad S, Basir A, Rais AK, Bibi A, Ullah R, et al. (2013). Distribution of Heavy Metals in the Liver, Kidney, Heart, Pancreas and Meat of Cow, Buffalo, Goat, Sheep and Chicken from Kohat market Pakistan. Life Sci; 10: 14-9.
- Falandysz J. (1993). Some toxic and essential trace

- metals in cattle from the northern part of Poland. *Sci Total Environ.* 136: 177-91.
- FAO/WHO, (2011). Joint FAO/WHO food standards programme Codex Committee on contaminants in foods fifth session working document for information and use in discussions related to contaminants and toxins in the GSCTFF (Prepared by Japan and the Netherlands). CF/5 INF/1.
- Food Safety Authority of Ireland (2009). Mercury, lead, cadmium, tin and arsenic in food. Toxicology factsheet series nr 1, 1–13.
- Ihedioha J, Okoye C. (2012). Cadmium and lead levels in muscle and edible offal of cow reared in Nigeria. *Bull Environ Contam Toxicol* 88: 422-7.
- Institute of Medicine (2003) Dietary Reference intakes: applications in dietary planning. Subcommittee on interpretation and uses of dietary reference intakes and the standing committee on the scientific evaluation of dietary reference intakes. Washington, DC: Institute of Medicine of the National Academies, the National Academies Press, pp. 248.
- Katoh, Y. Sato, T. and Yamamoto, Y. (2002). Determination of multielement concentrations in normal human organs from the Japanese. *Biological Trace Element Research*, vol. 90, no. 1–3, pp. 57–70, View at: Publisher Site | Google Scholar.
- Khalafalla F, Abdel-Atty N, Mariam A, Omima I, Rofaida B. (2015). Assessment of heavy metal residues in retail meat and offals. *Am Sci* 11: 12-9.
- McDowell LR. (2003). Minerals in animal and human nutrition. 2nd ed. Amsterdam: Elsevier Science; 660 p.
- Nicholson FA, Smith SR, Alloway BJ, Carlton-Smith C and Chambers BJ (2003). An inventory of heavy metals inputs to agricultural soils in England and Wales. *Science of the Total Environment* 311, 205–219.
- Palani ZMR, Al-Jaf H I., Raheem S M. (2019). Effect of addition of selenium to kurdi sheep and its interactions with some necessary and toxic elements on health and the environment. *Plant Archives* Vol. 19 No. 2, pp. 3963-3970.
- Palani, Z. M. R., Ahmed, K. A., Al-Obaidy, M. H. A., & Palani, D. M. R. (2022b). Cooperative and antagonistic reactions of heavy metallic elements and its impact on health that are supplemented with selenium and zinc in Kurdi sheep. *International Journal of Health Sciences*, 6(S2), 5236–5246.
- Palani, Z. M. R., Al-Obaidy, M. H. A., Palani, D. M. R., & Ahmed, K. A. (2022a). Effect of changes in some beneficial elements and dangerous heavy metals in cow and sheep manure on human and animal health and the environment. *International Journal of Health Sciences*, 6(S1), 6250–6256.
- Palani, ZMR, Al-Obaidy, M. H.A. Hameed, K. and Sirwan K. (2020). Effect of Selenium and Zinc supplements on each individual or mixture on some carcass characteristics and Glutathione activity in Male Lambs Kurdi Breed Sheep. *Plant Archives*. Vol. 20, Supplement 1.231-234.
- Reis, L. S. L. S. Pardo. P. E. Camargos A. S. and Oba, E. (2010). Mineral element and heavy metal poisoning in animals. *Journal of Medicine and Medical Sciences* Vol. 1(12) pp. 560-579.
- Smith, O B and Akinbamijo, O O. (2000). Micronutrients and reproduction in farm animals. *Animal Reproduction Science*. Vol. 60–61, (2), pp. 549-560.
- The International Program of Chemical Safety (IPCS). (2011). JECFA glossary of terms. The International Program of Chemical Safety (IPCS). Geneva: WHO; [cited 2011 Jan 7]. Available from: <http://www.who.int/foodsafety/chem/jecfa/glossary.pdf>.
- Underwood, E.J. (1981). *The Mineral Nutrition of Livestock*, Commonwealth Agric. Bureaux, Slough, UK, p. 10.
- WHO. (2010). Summary and Conclusions, Joint FAO/WHO Expert Committee on Food Additives (JECFA/73/SC), 73rd Meeting, Geneva, 817 June. Geneva: WHO; 2010 [cited 2011 Jan 7]. Available from: <http://www.who.int/foodsafety/publications/chem/msummary73.pdf>.
- Yabe J, Nakayama SM, Ikenaka Y, Muzandu K, Ishizuka M, Umemura T. Uptake of lead, (2011). cadmium, and other metals in the liver and kidneys of cattle near a lead zinc mine in Kabwe, Zambia. *Environ Toxicol Chem*; 30: 1892-7.
- Zukowska J, Biziuk M. (2008). Methodological evaluation of method for dietary heavy metal intake. *J Food Sci.* 73: R21R9.