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Assessment of Heavy Metals in Some Local and Imported Vegetables in Erbil Market.

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Abstract

In this study, Four types of vegetables were collected from Erbil city of Iraq, some grown locally and some imported. The vegetables they studied were Pepper (Capsicum annuum), Eggplant (Solanum melongena), Tomato (Lycopersicon esculentum), and Zucchini (Cucurbita pepo), which are commonly found both locally and imported. Additionally, they looked at 3 local vegetables: Radish (Raphanus raphanistrum), Cress (Lepidium sativum), and Parsley (Petroselinum crispum). They collected 12 samples of each vegetable from the Erbil market The heavy metals found in vegetables, such as silver (Ag), aluminum (Al), cadmium (Cd), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), zinc (Zn), and arsenic (As), were examined using inductively coupled plasma (ICP). To identify health problems, the following metrics were calculated: carcinogenic risks (CR), daily intake (DI), and target hazard quotient (THQ). The majority of veggies generally had metal levels that were under daily dietary guidelines. The amounts of cadmium and silver in imported pepper, local and imported eggplant, imported zucchini, imported tomatoes, radish, cress, and parsley were greater than those deemed safe for daily use. There may be health dangers associated with this. These veggies were determined to be unhealthy when we examined several health hazard indices.

1. Introduction:

The presence of toxic metals in veggies is a global concern since it can have serious consequences for food quality and health for humans. Heavy metals are naturally occurring elements, however their presence in plants can be attributed to both natural and anthropogenic causes. Lead (Pb), cadmium (Cd), arsenic (As), and mercury (Hg) are among the heavy metals commonly found in vegetables. Here's a rundown of the heavy metals found in veggies. [1]. Toxic metals pollute the planet and are among the major toxins in our food supply [2]. Crops are known to be capable of accumulating substantial levels of harmful metals without altering their look or yield [3]. Sufficient harmful metal buildup in agricultural soils due to sewage irrigation may cause soil pollution and increased toxic metal absorption by legumes, affecting the safety and purity of food [4]. Peppers are a colorful and adaptable vegetable that come in a variety of hues and tastes, including sweet bell peppers and hot chili peppers. They are a great source of antioxidants and provide color and nutrition to food. These also include a lot of vitamins A and C..[5]. Eggplant, a vegetable with glossy purple color and a creamy texture, is low in calories and high in vitamins, minerals, and dietary fiber. It is frequently utilized in Asian and Mediterranean cooking. [6].

Tomato widely enjoyed worldwide, tomatoes are not just delicious but also nutritious. Rich in lycopene, a powerful antioxidant, they are beneficial for heart health. Tomatoes can be eaten raw in salads, cooked in sauces, or used in various dishes [7]. Zucchini this mild-flavored summer squash is a great source of vitamins and minerals, including vitamin C and potassium [8]. Radish a crunchy and peppery root vegetable, radishes are low in calories and high in vitamin C

and potassium. They add a refreshing crunch to salads and can be enjoyed raw or pickled [9]. Cress often referred to as watercress, this leafy green is rich in vitamin K, vitamin C, and calcium. Its slightly peppery taste makes it a great addition to salads, sandwiches, and soups [10]. Parsley a popular herb, parsley adds bright flavor to dishes and is an excellent source of vitamin K and vitamin C. It's commonly used as a garnish, but it also enhances the taste of various dishes, from salads to sauces. [11].

Regular consumption of vegetables plays a vital role in reducing the risk of heart disease and several types of cancers, with a particular impact on lowering the risk of digestive tract tumors [12]. Their inclusion in a balanced diet promotes overall health and well-being. [13]. Veggies are high in nutrients such as fiber, vitamins, and minerals, and they have antioxidant properties as well. Consuming poisonous metal-contaminated veggies, on the other hand, may endanger the well-being of people. Perhaps the most essential areas of food quality assurance is harmful metal exposure [14]. One of the major mechanisms for hazardous contaminants to reach the human body is through contamination in the alimentary chain. Harmful metal uptake in plants varies by species, and the effectiveness of various species of plants in absorbing dangerous metals is assessed using plant uptake or soil-to-plant transfer factors [15]. oxic metals are ubiquitous in our surroundings as a result of both natural and human activities, and individuals are exposed to them through a variety of channels [13]. Nonetheless, eating greens grown in heavy metal-contaminated soil can be harmful to a someone's biochemical and physiological processes [14].

Excessive use of inorganic as well as organic fertilizers in agricultural areas might result in toxic metal deposition in crop plants. This offers a serious threat to individuals who consumes these items [15]. Concerns among experts worldwide have escalated regarding the health implications of elevated concentrations of hazardous substances found in soil, water, and plants. The potential for harm arising from these factors has raised significant alarms. Numerous documented cases of heavy metal contamination in various products further emphasize the seriousness of the issue. [16]. Due to their non-biodegradable nature, heavy metals tend to accumulate in the soil, posing a potential threat to the local environment, including plants, animals, and humans. [17].

Heavy metal exposure can have major health consequences, including malignancy, genetic abnormalities, and toxic effects. Humans are most commonly exposed to these hazardous metals through uptake and intake. [18]. Because heavy metals are consumed by humans, they are mostly exposed to certain of these metals through the soil-crop system. [19]. The risk evaluation of hazardous metals in regularly consumed vegetables is critical for a variety of causes. For starters, vegetables are a vital source of nutrition for a huge number of the people in Erbil, Iraq, and are an important element of the regional food system. A number of investigations, however, have revealed that hazardous elements such as lead, cadmium, and mercury may accumulate in these veggies, which is harmful to human health. Second, identifying harmful metals in vegetables and determining their level of danger can aid in changing food safety regulations and guidelines to safeguard public health. By examining how much of these metals are present in commonly consumed veggies, this study can give local authorities with crucial information that they can utilize to avoid or mitigate any health risks. The health risk evaluation for harmful metals in frequently consumed vegetables can thereby educate policymakers, safeguard public health, and enhance public awareness of the potential dangers of ingesting food that has been tainted. The results achieved here could represent a valuable and pertinent contribution to food hygiene and overall wellness, especially in rural areas where vegetables are a staple diet. [20]. A range of health complications may occur according to the form of heavy metal, such as arsenic, chromium, and cadmium. These metals have been associated to the occurrence of numerous malignancies, neurotoxicity, respiratory problems, teratogenic and mutagenic effects. Exposure to these heavy metals can also cause a variety of other health issues [21]. Few comprehensive studies are currently available on this subject. Some researchers has worked in Iraq before like [22] conducted a study to determine the concentrations of potentially toxic elements (PTE) in soils and the edible sections of field-grown vegetables in order to estimate possible dangers to the health of the local people. [23]. The study focused on the buildup of heavy metals in vegetables grown in areas where wastewater is used for irrigation, as well as the influence on human health. To assess possible dangers to human health, the researchers used bio-concentration factor (BCF), daily intake (DI), and health risk index (HRI) estimates. Water, soil, and vegetables were found to be contaminated with nickel (Ni), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), and zinc (Zn). According to the study, local farmers irrigating crops with untreated wastewater caused a large accumulation of heavy metals in soil and vegetables, posing a health risk to the surrounding people. The major goal is to measure heavy metal levels in locally grown and imported vegetables accessible in Erbil's city markets, as well as to investigate the possible health risks linked with eating these veggies.

2. Materials and Methods:

2.1 Study Area:

Erbil, the capital of Iraqi Kurdistan, is a bustling city with a population of over a million residents. Recently, a specific location within the city has been chosen for a project. The selected site is situated at Latitude 36.17803 (DD) Decimal degrees and Longitude 43.922652 (DD) Decimal degrees; it is the largest vegetable market in Erbil. All local and imported

fruits and vegetables are distributed to all neighborhood shops and supermarkets

2.2 Sampling:

Fresh vegetables were collected in 12 repetitions from the sample zone and kept in marked polythene sampling bags before being transported to the laboratory. Stainless steel tool was employed to obtain edible parts of various local and imported vegetables: the studied vegetables include eggplant (Solanum melongena L.), zucchini (Cucurbita pepo), tomato (Solanum sp. L.), and pepper (Capsicum annuum) Pepper (Capsicum annuum), Eggplant (Solanum melongena) Tomato (Lycopersicon esculentum), and Zucchini (Cucurbita pepo)and 3 types only local vegetables Radish (Raphanus raphanistrum), Cress (Lepidium sativum), Parsley (Petroselinum crispum) were collected from Erbil market. Before checking the vegetables, we made sure they were really clean. We washed them a lot with regular tap water and then rinsed them with distilled water to get rid of any dirt or dust. Then, we cut the parts of the veggies that people eat into small pieces and let them dry in the air for two days [13].

After that, we put them in an oven at 70 degrees Celsius to make sure they were completely dry. Once they were all dried out, we turned them into a powder using a special kitchen blender. We kept this powder safe in plastic bags until we were ready to use it for our tests [24]. For the wet digestion process, 0.5 grams of the previously dried vegetable sample were used. The digestion was carried out using a mixture of hydrogen peroxide and sulfuric acid until transparent fumes were observed. After digestion, the samples were allowed to cool down, and then the solution was filtered using Whatman filter paper no. 1 to remove any solid residues [13]. To achieve the desired concentration, the filtered solution was adjusted by adding distilled water, making the final volume of the solution to 100 ml. This prepared solution is now ready for further analysis and testing [24]. The concentrations of heavy metals Silver (Ag), Aluminum (Al), Cadmium (Cd), Chromium (Cr), Iron (Fe), Manganese (Mn), Nickel (Ni), Lead (Pb), Zinc (Zn), and Arsenic (As) in digested edible parts of vegetables in each Vegetables sample were determined by ICPE-9820 Shimadzu. The method was conducted according to ICP multi – element standard solution IV.

2.3 Health Risk Assessment:

2.3.1 Daily Intake of Heavy Metals (DITM):

The DITM value (expressed in mg kg^{-1} d^{-1}) represents the estimated amount of heavy metal intake per kilogram of body weight per day from consuming the vegetables in question. This calculation helps in evaluating the potential health risks associated with the presence of heavy metals in the vegetables that people consume regularly.

$$DITM = \frac{DIV \times C}{BW} \tag{1}$$

Where C reflects the concentration of metals in the edible part of the vegetable in mg kg^{-1}, DIV is a daily intake (the daily vegetable consumption rate for adult residents was 40.62, 38.58, 89.62, 36.63, 26.29, 8.86, and 5.61 g fresh weight basis for Pepper, Eggplant, Tomato, Zucchini, Radish, Cress, and Parsley, respectively, according to the responses to the questionnaire survey of this study (350 sample), and BW indicates body weight in (kg) which assumed 70 kg for adult.

2.3.2 Target Hazard Quotient:

The Target Hazard Quotient (THQ) is a statistic for assessing possible health concerns linked with hazardous element exposure, notably in compounds such as vegetables. This evaluation entails estimating the ratio of a given harmful element's exposure level to its matching reference dosage. The reference dosage is particular to each trace element and specifies the maximum quantity that may be taken without generating negative health consequences. The THQ is a useful measure for determining noncarcinogenic health hazards associated with toxic element exposure. A THQ value less than one indicate that there is no estimated possible health risk because the exposure amount is less than the safe reference dosage. A THQ value greater than one, on the other hand, indicates the probability of unfavorable health effects owing to exposure beyond the safe limit. Importantly, a THQ score greater than one does not inherently indicate an increased risk of cancer or other serious health problems. The THQ calculation adheres to EPA guidelines, ensuring a standardized and reliable assessment of potential health risks associated with exposure to toxic elements in the environment, including those found in veggies and other food-related substances [25].

$$THQ = \frac{E_{FR} \times E_d \times E_{IR} \times C}{RfD \times BWa \times ATn} \times 10^{-3} \tag{2}$$

Where ^{E}FR is that people are exposed to the trace component, ^{E}d is the period of being exposed, ^{E}d is the exposure duration (70 years), ^{E}IR is the food consumption rate in grams per day for the appropriate food item, C is the trace element concentration in a wet weight in the given food item, and ^{R}fD is the oral reference dose of the trace element in, $mg.kg^{-1}.day^{-1}$ The oral reference dosages were calculated using on 0.0003, 0.0005, 1.5,1, 0.004, 0.02, 0.033, 0.7, 0.3 and 0.005 $mg.kg^{-1}.day^{-1}$ for As, Cd, Cr, Al, Pb, Ni, Mn, Fe, Zn and Ag respectively, [26]

BWa is the reference body weight of 70 kg and ATn is the averaged exposure time (365 days × 70yrs) and 10^3 is the unit conversion factor(convert the result from $g.kg^{-1}$ to $mg.kg^{-1}$).

Totaling the target hazard quotients of the items evaluated for each food category yields the hazard index (HI). The HI presupposes that a single serving of a certain meal would expose a person to several potentially harmful substances. Consistent eating may have negative health consequences even if the THQs of the food's constituent components are below unity on their own. Non-cancerous health problems may occur if the HI is greater than 1 [25].The equation for HI is:

$$HI = \Sigma_{N=1}^{i} THQn \tag{3}$$

2.3.3 Cancer Risk:

A statistic called the Cancer Risk (CR) is used to evaluate the possible risk associated with a person's lifetime exposure to carcinogenic chemicals. An oral slope factor is used to estimate the Target Hazard Quotient (THQ) in place of an oral reference dose. This component influences the likelihood of an elevated cancer risk throughout the course of the exposed person's lifetime, along with the dosage of the carcinogenic material. The following is the equation used to determine CR:

$$CR = \frac{E_{FR} \times E_d \times E_{IR} \times C \times CPSa}{BWa \times ATc} \times 10^{-3} \tag{4}$$

In the overall meaning of this calculation, ^{E}FR denotes the frequency of arsenic exposure, ^{E}D denotes the duration of exposure (set at 70 years), ^{F}IR denotes the food ingestion rate measured in grams per day for the specific food item, and C denotes the trace element concentration in wet weight in the given food item. The oral cancer slope factors for arsenic (As), cadmium (Cd), and chromium (Cr) are 1.5, 0.38, and 0.5, respectively, in milligrams per kilogram per day. BWa is the reference body weight of 70 kg, ATc is the averaged carcinogen exposure time (calculated as 365 days multiplied by 70 years), and 10^{-3} is the unit conversion factor. [27].

TCR is an aggregated metric that analyzes the total cancer risk associated with all carcinogenic target heavy metals. The combined cancer risk (TCR) rating criteria are the same as the individual cancer risk (CRi). [28]. When the CR and TCR value is less than (10^{-6} - 10^{-4}), no potential health risk consequences are anticipated. If the CR and TCR is $> 10^{-4}$ there is the potential for adverse carcinogenic health effects. The equation used for calculating TCR was:

$$TCR = \sum_{N=1}^{i} CRn \tag{5}$$

3. Results and Discussion:

For the purpose of this investigation, we carefully selected seven distinct types of vegetables in the city of Erbil. These vegetables included Pepper, Eggplant, Tomato, Zucchini, Radish, Cress, and Parsley. The rationale behind the selection of these particular vegetables stems from the fact that they constitute the most commonly consumed vegetables by the population residing in the city of Erbil. Pepper, Eggplant, Tomato, Zucchini, Radish, Cress and Parsley heavy metal concentrations show in Table 1.

Silver (Ag) concentrations in vegetables were found to range from 66 to 149 mg $kg^{-}1$. Notably, local Zucchini and several imported vegetables, including Pepper and Tomato, exhibited levels higher than the safe limits set by WHO2004/FAO 1994. On the local vegetables only zucchini levels higher than the safe limits, unintentional accumulation in vegetable may result from the increased concentration of silver linked to agricultural activities, such as the use of fertilizers or pesticides containing silver, their incorrect application, or their overuse because Upon conducting an investigation and consulting with farmers, it became evident that the usage of pesticides was the source of the rise in silver, about 80 pesticide products are registered which contain silver as an active ingredient. [29].However, regarding the imported vegetables that contain silver deviated from the permissible level, because the imported farmer is unknown, we have to explain the reason in the form of possibilities and hypotheses, Silver particles can be present in the vegetables may be due to Contaminated Soil, Atmospheric Deposition, Water Contamination, Silver Nanoparticles, Silverware or Containers [30].

Vegetables containing greater than recommended quantities of silver cause health issues. Extended exposure to high concentrations of silver can cause argyria, a disorder characterized by bluish-gray staining of the skin, eyes, and internal organs. [31]. This discolouration is irreversible and may cause psychological and social problems. Additionally, consuming large amounts of silver can upset your stomach and cause diarrhea. Therefore, in order to protect the public's health, it is important to monitor and control the use of products containing silver in agriculture and make sure that safe limits are followed. Additionally, precautions should be taken to avoid any potential health risks related to excessive silver accumulation in vegetables, especially those that are meant for consumption. [32].

Most vegetables did not have amounts of aluminum (Al) or chromium (Cr) above FAO/WHO guidelines. However, it was discovered that the Al values for both imported and locally grown tomatoes and eggplant were greater than the FAO/WHO recommended levels. These particular veggies may have a higher than average amount of aluminum because of their special capacity to absorb and transfer metal from the soil into their edible portions, which may be different from previous studies conducted on different vegetables [33]. It is

Table 1. Heavy metal concentration of vegetable samples (mg.kg^{-1}).

Heavy metals as mg.$^{-1}$										
Vegetables	Ag	Al	Cd	Cr	Fe	Mn	Ni	Pb	Zn	As
Pepper (local)	N.D.	291	5.88	0.12	84	8.00	N.D.	24.43	13.40	0.21
Pepper (import)	118	387	13.20	0.18	110	19.30	0.12	53.50	16.80	0.90
Eggplant(local)	N.D.	232	10.43	1.02	103	11.05	N.D.	37.55	16.15	0.36
Eggplant(import)	66	1755	10.83	5.07	89	13.16	10.95	62.47	29.53	0.79
Tomato (local)	N.D	1490	7.97	1.06	81	8.57	N.D.	46.10	20.90	0.32
Tomato (import)	120	1510	11.90	1.90	101	9.70	0.32	40.70	16.80	0.43
Zucchini (local)	149	704	11.80	0.45	98	13.60	2.34	39.80	32.90	0.30
Zucchini(import)	125	503	12.90	1.23	132	26.70	4.54	53.00	17.40	N.D
Radish	N.D.	391	12.00	0.38	101	12.20	N.D.	59.80	11.60	0.43
Cress	66	792	11.09	2.15	98	12.14	10.95	53.27	19.09	0.53
Parsley	N.D.	979	11.31	2.53	96	12.50	N.D.	58.51	20.08	0.58
FAO	1.50	1000	0.20	2.30	450	300	67.00	0.30	60.00	0.43

N.D.: Not detected
Minimum concentration
Maximum concentration

noteworthy that the elevated aluminum concentrations found in tomatoes and eggplants may provide health hazards if ingested on a regular basis, beyond the recommended thresholds established by global health bodies. Protecting the public's health and averting negative consequences from excessive aluminum consumption may be achieved by ensuring food safety and following advised recommendations. [34]. Parsley was found to have high amounts of chromium (Cr), beyond WHO/FAO recommended limits. This is probably because Erbil's vegetable farms are located close to sewage regions, iron and other industrial factories, and other manufacturing facilities [35].

The veggies may absorb pollutants during growing as a result of being close to these sources of pollution. [36]. Consequently, these tainted veggies are shipped to the vegetable market in Erbil where they are sold to customers. To address the sources of pollution, guarantee food safety, and safeguard public health, immediate action is required. The concentrations of Fe, Mn, Ni, and Zn did not above the FAO/WHO-established limitations. Numerous variables, including as soil type, farming techniques, climate, and plant genetics, can affect the concentration of important metals such as iron (Fe), zinc (Zn), nickel (Ni), and manganese (Mn) in vegetables. Although the buildup of heavy metals may be concerning in some situations, it's crucial to remember that these vital metals are necessary for plants to grow and develop normally and are also vital nutrients for human health. [37].

The results showed that the Cd, Pb, and as were the metals high accumulated by plants, compared to other metals (Table 1). Cd, Pb, and as concentration exceed the limits determined by FAO/WHO, (0.20, 0.30, and 0.43). This explains that there is significant risk in terms of the and concentrations in studied vegetables, except the concentration of As in local tomato and local Zucchini was under limits determined by FAO/WHO. Salano [38] concluded that Cd is very hazardous and has been linked to multiple incidents of food contamination; little amounts of Cd produce harmful alterations in the arteries of human kidneys; and Cd biochemically substitutes zinc, causing high blood pressure and kidney damage, and also, replaced Ca and caused Itai-Itai disease (is a painful and debilitating condition that affects the bones and kidneys).

Pb poisoning in children and adults may cause brain and immune system abnormalities, anemia, cardiovascular disease, bone metabolism, renal and reproductive failure [39]. Arsenic can have serious health effects on humans. Long-term exposure to high levels of arsenic can lead to cancer, skin lesions, and other health problems. In addition to cancer, chronic exposure to arsenic can cause neurological effects, cardiovascular disease, diabetes and reproductive harm. [39].

3.1 Health Risk Assessments:

The human health risks resulting from eating vegetables watered with wastewater or well water were assessed using

Table 2. Heavy metal concentration of vegetable samples (mg.kg^{-1}).

	Daily intake $\times 10^{-3}$									
Vegtables	Ag	Al	Cd	Cr	Fe	Mn	Ni	Pb	Zn	As
Pepper (local)	N.D	18.55	0.37	0.01	5.36	0.51	N.D	1.56	0.85	0.01
Pepper (import)	7.52	24.66	0.84	0.01	7.03	1.23	0.01	3.41	1.07	0.06
Eggplant(local)	N.D	14.04	0.63	0.06	6.28	0.67	N.D	2.27	0.98	0.02
Eggplant(import)	4.04	106.25	0.66	0.31	5.42	0.80	0.66	3.78	1.79	0.05
Tomato (local)	N.D	16.13	0.50	0.02	4.17	0.50	N.D	2.47	0.48	0.02
Tomato (import)	0.93	11.03	0.15	0.03	1.36	0.17	0.15	0.74	0.27	0.01
Zucchini (local)	N.D	8.63	0.10	0.02	0.85	0.11	N.D	0.52	0.18	0.01
Zucchini(import)	N.D	209.49	1.12	0.15	11.51	1.20	N.D	6.48	2.94	0.04
Radish	16.96	212.30	1.67	0.27	14.26	1.36	0.04	5.72	2.36	0.06
Cress	7.22	28.90	0.74	0.07	7.59	1.53	0.26	3.05	1.00	N.D
Parsley	8.56	40.45	0.68	0.03	5.63	0.78	0.13	2.29	1.89	0.02
RfD.	0.005	1	0.0005	1.5	0.7	0.033	0.02	0.004	0.3	0.0003

N.D.: Not detected
Minimum concentration
Maximum concentration

four standard metrics: the Daily Index (DI), the Hazard Quotient (HQ), and the Carcinogenic Risk (CR). These measures were used to evaluate the possible dangers to human health caused by ingesting vegetables cultivated using such irrigation strategies. Table 2 illustrates the daily intake of hazardous metals. Human exposure to these metals can occur through various pathways, including soil, water, air, and food [19].

Table 2 shows DIM values. The values of daily metal consumption in vegetables were within the RfD limits, except for Ag from imported Pepper, imported tomato, Radish, Cress and Parsley, Cd from imported Pepper, local and imported Eggplant, imported Zucchini , Radish, Cress and Parsley were higher the RfD. These studies imply that consuming these may harm for people [27].

3.2 Non- Carcinogenic Risk:

3.2.1 Target Hazard Quotient (THQ)

Table 3 displays the findings of the THQ and HI calculations, which were designed to assess the health hazards associated with the ingestion of metals found in vegetables. The THQ, which is defined as the ratio of a pollutant's computed dosage to a reference dose level, is used to assess the possible dangers caused by contaminated vegetables to adult populations. Toxicological Hazard Quotient (THQ) values greater than one suggest an elevated risk of sickness in individuals exposed. The metals Ag, Cd, Pb, and As were found to be more than unity in all vegetables except local Eggplant, local and imported tomato, local Zucchini, and Parsley for As, whereas Al was found to be greater than unity (THQ $>$ 1) in imported eggplant, imported Zucchini, Radish, Cress, and Parsley. The other remaining metals had THQ 1, indicating the substantial possible health concerns linked with all vegetable eating. According to the statistics, people of the region may be at risk for adverse health impacts from Cd and Pb ingestion from all vegetables, as well as Al and Ag in select vegetables. Several prior researches have verified this observation. [18], [40], [41], [42], [43].

The HI was used to examine the potential threats to human health since it illustrates how everything interacts. Table 3 shows that eating vegetables increases HI. Noncarcinogenic adverse health effects are present at an alarmingly high level, as demonstrated by the HI ranges of (3.19-86.63), Pepper, Eggplant, Tomato, Zucchini, Radish, Cress, and Parsley had HI values for Ag, Al, Cd, Cr, Fe, Mn, Ni, Pb, Zn, and as that were significantly higher than recommended levels. This implies that persons living in the investigated location are at risk of having negative health impacts, and that steps should be done to reduce heavy metal concentrations and protect the local population.

3.2.2 Carcinogenic Risks (CR):

Arsenic, cadmium, and chromium are all classified as "carcinogenic to humans" by the International Agency for Re-

Table 3. Estimated THQ, and HI. for metals.

Vegetables	THQ Ag	THQ Al	THQ Cd	THQ Cr	THQ Fe	THQ Mn	THQ Ni	THQ Pb	THQ Zn	THQ As	HI
Pepper (local)	N. D	0.23	4.68	0.0001	0.1	0.19	N. D	4.87	0.04	0.42	10.53
Pepper (import)	18.8	0.31	10.52	0.0001	0.13	0.47	0.005	10.65	0.04	1.79	42.71
Eggplant(local)	N. D	0.18	7.89	0.001	0.11	0.25	N. D	7.1	0.04	0.68	16.25
Eggplant(import)	10.1	1.33	8.2	0.003	0.1	0.3	0.41	11.81	0.07	1.49	33.81
Tomato (local)	N. D	0.2	6.19	0.0001	0.07	0.19	N. D	7.71	0.02	0.56	14.94
Tomato (import)	2.32	0.14	1.93	0.0002	0.02	0.06	0.1	2.32	0.01	0.23	7.12
Zucchini (local)	N.D	0.11	1.24	0.0002	0.02	0.04	N.D	1.61	0.01	0.16	3.19
Zucchini(import)	N.D	2.62	14.01	0.001	0.21	0.46	N.D	20.25	0.12	1.39	39.05
Radish	42.39	2.65	20.91	0.002	0.25	0.52	0.03	17.88	0.1	1.89	86.63
Cress	18.06	0.36	9.27	0.001	0.14	0.58	0.16	9.52	0.04	N.D	38.12
Parsley	21.41	0.51	8.48	0.0002	0.1	0.3	0.08	7.15	0.08	0.54	38.63

Minimum concentration
Maximum concentration

Table 4. Estimated THQ, and HI. for metals.

Cancer risk (CR) and Target cancer risk (TCR) $\times 10^{-3}$				
Vegetables	CR As	CR Cr	CR Cd	TCR
Pepper (local)	0.25	0.05	0.005	0.30
Pepper (import)	1.08	0.07	0.011	1.16
Eggplant(local)	0.41	0.39	0.008	0.80
Eggplant(import)	0.89	1.92	0.008	2.82
Tomato (local)	0.33	0.10	0.006	0.44
Tomato (import)	0.14	0.19	0.002	0.33
Zucchini (local)	0.10	0.14	0.001	0.24
Zucchini(import)	0.83	0.93	0.014	1.78
Radish	1.13	1.67	0.021	2.82
Cress	N.D.	0.44	0.009	0.45
Parsley	0.32	0.16	0.008	0.49

Minimum concentration
Maximum concentration

search on Cancer (IARC), since they can have both noncarcinogenic and carcinogenic effects depending on exposure levels. [44]. Table 4 displays the results of estimated vegetable consumption. In all veggies, the As, Cd, and Cr CR values ranged from 0.10×10^{-4} to 1.13×10^{-3} , 0.5×10^{-3} to 1.92×10^{-3} , and 0.001×10^{-3} to 0.021×10^{-3} , respectively. Because the CR values for As and Cr are above the threshold value ($CR > 10^{-4}$), except for local and imported Pepper ($CR < 10^{-4}$), and Cd is below the threshold value ($CR > 10^{-4}$), these elements may provide a cancer risk to individuals who consume the analyzed vegetables. (Pepper, Eggplant, Tomato, Zucchini, Radish, Cress and Parsley). The Target cancer risk (TCR) for the present study ranged from 0.24×10^{-3} to 2.82×10^{-3} in this research, with the highest TCR observed at imported eggplant and Radish while the lowest TCR reported at local Pepper. Consuming (Pepper, Eggplant, Tomato, Zucchini, Radish, Cress and Parsley) collecting in Erbil market provides a potential cancer risk to the adult population because to the presence of As, Cd, and Cr.

4. Conclusion:

1. In most cases, the amount of metals in vegetables you eat every day is usually lower than what experts recommend. However, some vegetables like imported Pepper, imported Tomato, Radish, Cress, and Parsley have more Silver than what's considered safe. Also, imported Pepper, local and imported Eggplant, imported Zucchini, Radish, Cress, and Parsley have more Cadmium than the recommended levels.

2. Eating vegetables from this area, like imported pepper, eggplant, zucchini, and radishes, can be bad for your health. It's because they have too much Cadmium (Cd) and Lead (Pb) in all veggies and Silver (Ag) and Aluminum (Al) in imported Eggplant, Zucchini, and Radish. In fact, based on this study, all the vegetables are not safe to eat.

3. The levels of Arsenic (As) and Chromium (Cr) in the vegetables studied, like pepper, eggplant, tomato, zucchini, radish, cress, and parsley, are higher than what's considered safe. This means that people who eat these vegetables might be at risk of developing cancer.

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تقييم المعادن الثقيلة في بعض الخضروات المحلية والمستوردة في سوق أربيل

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الخلاصة

في هذه الدراسة، جمعت اربعة انواع من الخضراوات من مدينة اربيل في العراق، بعضها يزرع محليا وبعضها مستورد. الخضروات التي كانت الفلفل (*Capsicumannuum*) ، الباذنجان (*Solanummelongena*) ،الطماطم (*Lycopersiconesculentum*) ، والكوسا (*Cucurbitapepo*) وثلاثة أنواع فقط من الخضروات المحلية الفجل (*Raphanusraphanistrum*) ، الرشاد (*Lepidiumsativum*) ، البقدونس (*Petroselinumcrispum*) تم جمع 12 تكرار في كل، الخضروات في سوق أربيل. تم استخدام البلازما المقترنة بالحث لتحليل المعادن الثقيلة، بما في ذلك الفضة والألمنيوم والكادميوم والكروم والحديد والمنغنيز والنيكل والرصاص والزنك والزرنيخ في الخضروات، وتم حساب الاستهلاك اليومي وحاصل الخطر المستهدف والمخاطر المسببة للسرطان لتحديد المخاوف الصحية. بشكل عام، تحتوي معظم الخضروات على مستويات معدنية ضمن الحدود الموصى بها للاستهلاك اليومي. ومع ذلك، كانت هناك استثناءات قليلة. مستويات الفضة في الفلفل المستورد، الطماطم المستوردة، الفجل، الرشاد، والبقدونس، وكذلك مستويات الكادميوم في الفلفل المستورد، الباذنجان المحلي والمستورد، الكوسة المستوردة، الفجل، الرشاد، والبقدونس، كانت أعلى مما يعتبر آمنا للاستهلاك اليومي. هذا يثير مخاوف بشأن المخاطر الصحية المحتملة. عندما نظرنا إلى مؤشرات المخاطر الصحية المختلفة، وجد أن هذه الخضروات غير مناسبة للأكل.

الكلمات الدالة: تقييم المخاطر الصحية؛ المعادن الثقيلة؛ حاصل المخاطر (*HQ*) ؛ مخاطر السرطان (*CR*) ؛ الخضروات.

التمويل: لايوجد.

بيان توفر البيانات: جميع البيانات الداعمة لنتائج الدراسة المقدمة يمكن طلبها من المؤلف المسؤول.

اقرارات:

تضارب المصالح: يقر المؤلفون أنه ليس لديهم تضارب في المصالح.

الموافقة الأخلاقية: لم يتم نشر المخطوطة أو تقديمها لمجلة أخرى، كما أنها ليست قيد المراجعة.