Assessing Health Risks of Heavy Metals in Juices and Soft Drinks in Baghdad, Iraq, and their Impact on Human Health

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Abstract: The current study assessed the levels of health risks resulting from exposure to concentrations of some heavy metals (Ag, Al, As, Cd, Co, Cr, Cu) found in juices and soft drinks that are consumed daily and available in local markets in Baghdad/Iraq. 45 samples of these products were collected and luminiu using by ICP-OES device. The results showed that most of the concentrations in these measured samples were within the permissible limits according to World Health Organization standards, while the concentrations of some elements recorded slightly high levels. Such as silver (Ag), which reached (0.54) parts per million, and the concentration of luminium (Al) in Fresh powder juice reached (0.46) parts per million in Rani juice, and the average concentration and standard deviation reached For silver (Ag) (0.2746 ± 0.15857), which is higher than the permissible limit set by the World Health Organization (0.1), and the P-Value (0.0916) was greater than 0.05, unlike the other elements, the values were less than the permissible limit previously. The World Health Organization (WHO) also calculated the daily intake dose (DID) and hazard index (HQ) for the subjects taken and studied. The results of the study showed that some of the permissible reference doses for some elements, such as silver and aluminium, were exceeded, which indicates the presence of potential health risks. The current study also recommended the importance of following up on these food products and strengthening control over them, especially for juices and soft drinks, in order to avoid potential health risks that could occur. To which consumers are exposed.

1 INTRODUCTION

Juices and soft drinks are considered refreshing, non-alcoholic drinks. Many people consume them daily, regardless of age, gender, or social and economic status. They are characterized by their sweet and refreshing taste. The reason for the great demand for soft drinks is due to the ability of these drinks to give a feeling of refreshment and happiness, in addition to It is easy to obtain and relatively low cost [1]. Although these juices and soft drinks may be refreshing and add a kind of pleasure to daily life, consuming them excessively may lead to major health risks, such as weight gain, high blood pressure, tooth decay, heart disease, and other health problems [2], and recent studies have indicated that consuming juices and soft drinks may lead to negative effects on bone health, as they increase the risk of fractures [3]. Some of these drinks may contain high levels of heavy metals that may exceed permissible limits [4]. Heavy metals pose a major threat to a person's general health as a result of their accumulation in his body, as their presence in juices and soft drinks represents a major risk in the long term, including the risk of cancer, and also leads to organ damage over time [5]. Some studies have also shown the presence of heavy metals in some beverages that may be toxic, including silver, luminium, copper, cobalt, cadmium, and arsenic, which causes real risks to consumers [6]. Exposure to luminium may lead to health problems related to the nervous system. Including memory loss or Alzheimer's disease, it also affects the bones and reduces their mineral density, causing osteoporosis, and luminium also causes various problems for the body as a result of its accumulation in various tissues [7]. Arsenic is also considered one of the most dangerous toxic elements in the body, and exposure to it through drinks contaminated with this element may lead to the risk of developing blood pressure, diabetes, as well as other heart diseases, in addition to damage to the blood vessels and atherosclerosis [8]. As for cadmium, it is a metal. It is toxic and may cause major health problems such as kidney failure and osteoporosis. Continued exposure to cadmium increases the risk of bladder cancer as well as lung cancer, and small amounts of it are harmful in the long term. Long-term accumulation in the body may lead to potentially toxic effects on vital organs in the body, including the kidneys and bones [9]. Although copper is considered essential for the human body, exposure to it in large quantities may cause damage to the liver and kidneys in the long term. It also causes problems in the digestive system such as nausea, vomiting, and diarrhea, and this confirms the danger of copper accumulation on the health of vital organs [10]. Necessary preventive measures must be taken, such as monitoring the quality of products and limiting the consumption of juices and soft drinks that may contain unsafe levels of heavy metals.

2 MATERIALS AND METHODS

2.1 Sample Collection

A total of 45 samples of juices and soft drinks were collected from different areas in the capital, Baghdad/Iraq, based on the presence of major commercial markets and retail stores in residential neighborhoods. This approach was taken to ensure a good representation of the types of juices and soft drinks available in local markets. The sampling included about 15 types of products and was conducted during a period of 30 days, from November 3, 2024 to January 6, 2025. The sampling process included products from local and imported brands to ensure product diversity and obtain accurate results. The samples were carefully selected, then placed in clean and sterile containers to preserve their safety from any external contamination, and then transported to the laboratory to conduct the necessary analyzes and determine the concentrations of heavy metals.

2.2 Chemical Analysis

A one milliliter sample was taken and put into glass container to be analyzed later. Following this, 1 milliliter of a 69% sulfuric acid solution was introduced to the container, alongside 1 milliliter of 35% hydrogen peroxide and 4 milliliters of nitric acid. Subsequently, this solution underwent microwaving at an intensity that allowed the temperature to rise from 25° C to 180° C over a fifteen minute duration. This was then followed by 30 minutes of cooking the solution at a constant temperature of 180° C in order to fully complete the digestion. After waiting for the digestion as well as the rest of the mixture to sufficiently cool down, special filters were used to separate the desired sample from the rest of the mixture. This filtered sample was then diluted volumetrically to 30 milliliters using distilled water. In the end, the heavy metals concentration found in liquid samples were measured using an Agilent ICP-OES device located at the atomic energy authority [11].

2.3 Calculating the Health Risks of Heavy Metals

The health risks of heavy metals in juices and soft drinks were calculated by calculating the Daily Intake Dose (DID), the Hazard Quotient (HQ) for each element, and the Hazard Index (HI) for multiple exposures to the elements.

2.3.1 Calculating the Daily Intake Dose (DID)

The dose of daily handling of each element was calculated based on the average concentration of the element in the sample, where the daily consumption rate of soft drinks and juices is 0.5 liters per person, and a weight of 70 kilograms for adults [12].

$$DID = (Concentration \times Intake\ Rate)/(body\ weight)$$

2.3.2 Reference Doses (RfD)

Reference doses for assessing health risks from exposure to heavy metals in food and beverages have been adopted by the US Environmental Protection Agency (EPA).

2.3.3 Calculating the Hazard Quotient (HQ)

The hazard quotient (risk index) for each element was calculated to assess whether the daily intake dose exceeds the safe reference dose. It is calculated by [13]:

$$HQ = DID/RfD.$$

2.3.4 Calculating the Overall Hazard Index (HI)

The overall hazard index was calculated by summing the hazard quotients for all elements [14]:

$$HI=HQ_1+HQ_2+HQ_3+\cdots+HQ_n.$$

2.4 Statistical Analysis

Statistical analyzes of the data obtained by the SPSS (version 22), to ensure reliable and accurate results. Where the averages and standard deviation were calculated. Anova testing was also conducted to find out whether there are statistically significant moral differences between different groups of samples.

3 RESULTS AND DISCUSSION

3.1 Results

The results of Table 1 showed that the highest concentration of silver (Ag) was in Rani juice, reaching 0.54 ppm, while the lowest concentration was recorded in Al-Shater juice at 0.12 ppm (see Fig. 1). For aluminum (Al), the highest concentration was in Fresh Powder juice, measuring 0.46 ppm, while the lowest concentration was in Fayrouz Pomegranate juice, where it reached 0.00 ppm. Arsenic (As) recorded the highest concentration of 0.1 ppm in Limonza Powder juice, while it was not detected (ND) in the rest of the samples. Cadmium (Cd) and chromium (Cr) were not detected (ND) in any of the samples. The highest cobalt (Co) concentration was in Dalia Orange and Mom Orange juices, reaching 0.05 ppm, while it was absent in other samples. Copper (Cu) showed low concentrations, with the highest concentration recorded in Al-Shater juice at 0.02 ppm, and the lowest in Coca-Cola metal can juice at 0.00 ppm.

Table 1: Concentrations of heavy metals (mg/L) in various juices and soft drinks in Iraq.

Juices and soft drinks	concentration						
	Ag	Al	As	Cd	Co	Cr	Cu
Coca-Cola metal can	0.26	0	0	0	0	0	0
Cola Ugarit juice	0.25	0.13	0	0	0	0	0
Al-Shater juice	0.12	0.05	0	0	0	0	0.02
Jaffa orange juice	0.17	0.04	0	0	0	0	0
Caspian powder juice	0.27	0	0	0	0	0	0
Fresh powder juice	0.13	0.46	0	0	0	0	0
Limonza powder juice	0.35	0	0.1	0	0	0	0
Daily orange juice	0.43	0.03	0	0	0	0	0
Rani juice	0.54	0.04	0	0	0	0	0
Fayrouz pomegranate juice	0.37	0	0	0	0	0	0
Ugarit Cola Iraq	0.38	0.01	0	0	0	0	0
Rand orange juice	0.47	0.04	0	0	0	0	0
Cola Tamim	0.38	0.01	0	0	0	0	0
Dalia orange juice	0	0.09	0	0	0.05	0	0
Mom's orange juice	0	0.16	0	0	0.05	0	0

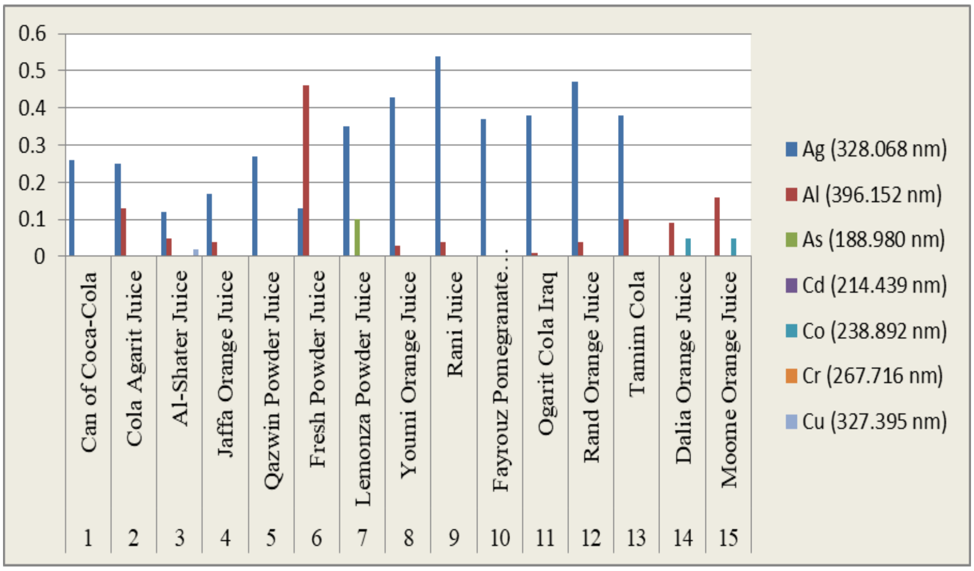

Figure 1: Concentration of heavy metals (mg/L) in different beverage samples.

The chart illustrates the concentrations of heavy metals for each beverage sample, where the colored bars within the chart represent the specific color for each element, while their lengths indicate the concentration levels of each element in the sample.

The results of Table 2 showed that the mean concentrations and standard deviations for all samples of silver (Ag) were (0.2746 ± 0.15857), which is higher than the permissible limit set by the World Health Organization (0.1). The P-value (0.0916) was greater than 0.05. As for aluminum (Al), the mean concentration was (0.08214 ± 0.11323), which is lower than the WHO limit of (0.2), and the P-value (0.1561) was greater than 0.05. Regarding arsenic (As), it reached (0.00666 ± 0.02494), which is below the permissible limit set by WHO (0.01), and the P-value was (0.0942), greater than 0.05. For cadmium (Cd) and chromium (Cr), the mean concentration and standard deviation were (0.00000 ± 0.00000), indicating that these elements were not detected in the samples. On the other hand, cobalt (Co) recorded (0.00666 ± 0.01699), which is lower than the permissible limit set by WHO (0.1), and the P-value was (0.0437), less than 0.05. Copper (Cu) was (0.00133 ± 0.00498), which is lower than the WHO limit of (0.2), and the P-value for these elements was less than 0.05.

The results of Table 3, showed that the daily doses consumed of silver and aluminum amounted to (0.00784) and (0.00234), which is higher than the reference dose specified by health authorities for silver, which amounted to (0.005), and for aluminum (0.001). It also showed the risk index for silver amounted to (1.569143), and the aluminum index reached (2.346857), which is higher than 1. As for the daily doses consumed for arsenic and cadmium, they reached (0.00019) and (0.00000), which are less than the reference dose (0.0003) and (0.0001), and the risk index for arsenic and cadmium reached (0.634286) and (0.000000), which is less than 1, While the daily dose of cobalt was (0.00019), which is less than the reference dose (0.0003), and the risk index for cobalt was (0.634286), . It is less than 1, and the daily dose of chromium was (0.00000), which is less than the reference dose (0.003), and the risk index for it was (0.00000). It is less than 1, while the daily dose of copper was (0.000038).) which is much less than the reference dose (0.04), and the risk index was (0.000950), which is less than 1. Figure 2 shows the hazard index (HQ) for each of the different heavy elements (Ag, Al, As, Cd, Co, Cr, Cu) in juices and soft drinks. The dashed red line also indicates the overall Hazard index (HI) which reached 5.1855.

Table 2: Calculating average concentrations of heavy metals, standard deviation, and P-value, and comparing them to the permissible limits according to World Health Organization standards.

Elements	Mean±Std	WHO Limite	P-Value
Ag (PPM)	0.2746 ±0.15857	0.1	0.0916
Al (PPM)	0.08214±0.11323	0.2	0.1561
As (PPM)	0.00666±0.02494	0.01	0.0942
Cd (PPM)	0.0000±0.00000	0.003	(N/A)
Co (PPM)	0.00666±0.01699	0.1	0.0437
Cr (PPM)	0.00000±0.00000	0.05	(N/A)
Cu (PPM)	0.00133±0.00498	2.0	0.0192

Table 3: Daily dose taken, reference dose, and hazard index (HQ) for some heavy metals.

Elements	Daily Intake Dose (DID) (mg/kg/day)	Reference dose (RfD) (mg/kg/day)	Danger indicator (HQ
Ag (PPM)	0.00784	0.005	1.569143
Al (PPM)	0.00234	0.001	2.346857
As (PPM)	0.00019	0.0003	0.634286
Cd (PPM)	0.00000	0.0001	0.000000
Co (PPM)	0.00019	0.0003	0.634286
Cr (PPM)	0.00000	0.003	0.000000
Cu (PPM)	0.000038	0.04	0.000950
Overall Hazard Index (HI)			5.1855

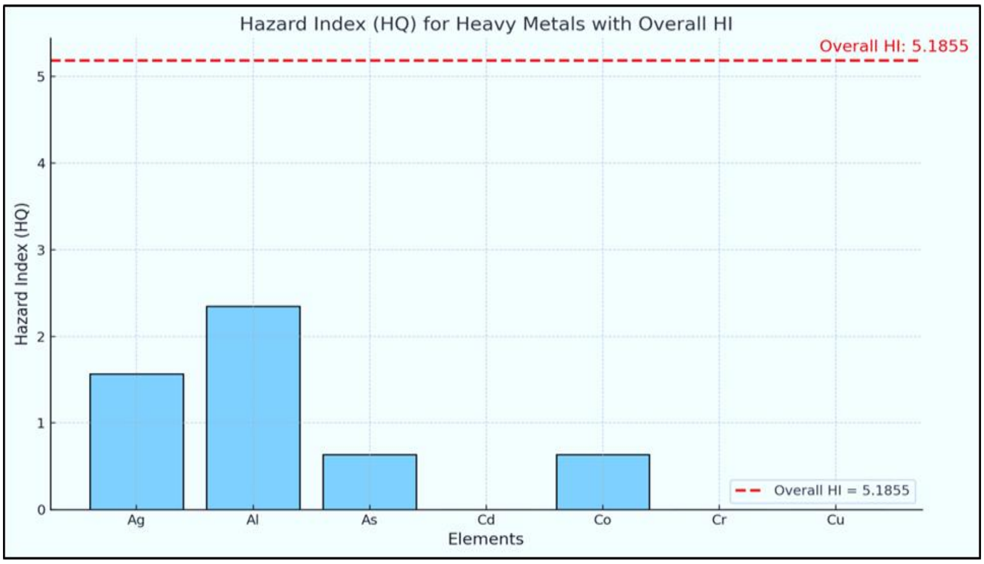

Figure 2: Hazard index of heavy metal concentrations in juices and soft drinks.

3.2 Discussion

The results of this study showed that the average concentration of silver (Ag) in the analyzed beverages exceeded the permissible limit set by the World Health Organization (WHO), with a statistically significant difference indicated by a P value of less than 0.05. This finding raises potential health concerns, especially given the cumulative toxicity of silver in humans. The results of a similar study conducted in European coastal waters, carried out by a research team led by Tapin and others in Europe in 2010, which analyzed silver concentrations in beverages, showed that the results showed that the average concentration of silver in the samples exceeded the permissible limit according to the standards of the World Health Organization (WHO). This indicates potential health risks associated with chronic exposure [15]. Another different study was conducted by a group of researchers led by “Athanasiadis, V.” And others in 2023. The study focused on analyzing caffeine and mineral elements in different types of drinks. The study indicated that the levels of mineral elements were within permissible limits, which indicates that these drinks are safe for consumption in terms of mineral content [16], which requires treatment of these Problems require more stringent measures. Take regulatory measures and strengthen quality control in beverage production. The study also showed that the average concentration of aluminum (Al) was less than the permissible limits set by the World Health Organization, indicating minimal health risks associated with exposure to aluminum from beverages sampled, and these differ with the results of Nicholas and Ekoha (2013) in the study he conducted on canned foods and beverages sold in Nigerian markets. The results showed that some products had high concentrations of aluminum, indicating the possibility of aluminum leaking from the containers into the content [17]. In a study conducted by Abercrombie and Fowler in 1997 on the potential content of aluminum in canned beverages, the results showed the presence of varying amounts of aluminum in samples of canned beverages, and the average aluminum concentration was less than the permissible limit. This is due to the fact that proper protective coatings and appropriate storage reduce the leakage of aluminum into the Drinks[18]. The concentrations of arsenic (As), cadmium (Cd), and chromium (Cr) also showed no presence and were within permissible limits, which reflects compliance with safety standards in most samples. In a study conducted by Leconte et al. (2021) in France showed that chronic exposure to cadmium represents a health risk, even at low levels. [19] They also focused on lowering the guideline values for cadmium to ensure better protection of public health, as shown by the study conducted by Lazović et al. (2023) in Serbia, which focused on measuring levels Cadmium, lead, mercury, and arsenic in vegetables and fresh vegetable products during the period from 2015 to 2017, as some samples that exceeded permissible limits were detected. This confirms the need to improve agricultural practices and monitor the water sources used [20]. Cobalt (Co) levels were within permissible limits, but the Hazard Quotient (HQ) indicates the possibility of long-term health effects if exposure continues. Although copper (Cu) is essential to human health in trace amounts, it has been found in concentrations well below permissible limits, indicating no immediate health risks. These results are consistent with the study of Katsina State in Nigeria, which showed that copper levels were few within the permissible level, and the reason is due to the lack of industrial activity in those areas [21]. Another study conducted in northeastern Ethiopia to determine the levels of some Heavy elements in herbal preparations, including cadmium and copper, as results for copper (Cu) showed less than permissible limits, according to international safety standards, as well as results for Cadmium (Cd) and arsenic (As) in drinks did not exceed the permissible limits [22]. as the hazard index (HQ) for these two elements was less than 1. On the contrary, the results of a study conducted by Edirisinghe & Jinadasa (2020) showed that the concentrations of cadmium The arsenic in Sri Lankan rice exceeded the permissible limit, increasing potential health risks, especially for the most vulnerable people [23], while cadmium was not detected. (Cd), in the juices and soft drinks in the current study, and this indicates that these juices and soft drinks are not affected by industrial activities. On the contrary, the study conducted by Du and others in China (2020) showed that industrial activities, such as mining and smelting, contributed to an increase in the concentration of cadmium in beverages and foods, which clearly leads to increased environmental and health risks [24].

4 CONCLUSIONS

The study revealed that most of the juices and soft drinks available in local markets in Baghdad contain levels of heavy metals that fall within acceptable limits according to World Health Organization standards. However, recording excesses in the concentrations of some elements such as silver (Ag), chromium (Cr), and aluminum (Al) in some samples indicates the need to be careful, especially with repeated use of these products. The results also showed the importance of strengthening control over food products, whether imported or locally manufactured, in order to adhere to health safety standards. The study also stressed the importance of conducting additional research to understand the sources of pollution and determine appropriate ways to reduce risks. It is worth noting that consumer awareness plays an important role in reducing health risks. Therefore, it is recommended to moderate the consumption of these drinks and choose healthy alternatives when possible.

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