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Heavy Metals Concentration in Commercial Rice Available at Erbil City Markets, Iraq and Soaking Effects

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Abstract

Heavy metal (HM) pollution has long been a significant source of environmental deterioration and a problem for the safety of food. Iraqis prefer rice over any other food, and since heavy metals have a direct impact on health, their traces in rice have drawn particular attention. Before cooking rice, it is usual in Iraq to wash and soak it. Some 55 varieties of imported and local rice were sampled from Erbil city markets in 2022 with the aim of determining the concentration of As, Cd, Cr, Ni and Pb before and after soaking. Standard procedure of acid digestions was applied on the raw and soaked samples. The solutions were analyzed using ICPE-9820 Shimadzu. The mean concentrations of As, Cd, Cr, Ni and Pb (in mg/kg) in the rice samples before soaking was 0.655, 0.170, 0.160, 0.387, 0.489, respectively and after soaking 0.421, 0.109, 0.115, 0.124 and 0.336, respectively. The concentration of As and Pb was found to be beyond the optimum level of 0.2 mg/kg codex standards for rice; whereas Cd and Cr were within the proposed level of codex standards. Moreover, local rice showed higher concentration of (Cd and Cr), whereas (AS and Pb) concentration in imported rice was higher. Further, results validated that rice soaking can decrease levels of As, Cd, Cr, Ni and Pb (32.5%, 40.2%, 27.9%, 61.6% and 31.3%, respectively). These findings suggest that soaking as a kitchen practice has efficiency to evaporate metals and has a great influence on the reduction of toxic heavy metals and thus reduces exposure to toxic metals in rice.

Keywords: Comparative analysis, Heavy metals, Permissible limitations, Rice grains, Rice soaking.

Introduction

Rice, particularly white rice from the *Oryza sativa* L. plant, is a common ingredient in the diet of many people, notably those from Asian nations. For the Iraqi diet, rice is a staple and is considered vital food component. The Kurdish community in the north prefers medium-grain rice, even though Iraq is primarily a market for long-grain milled rice and over 90 lbs of rice are consumed annually per person. Nearly 90% of the rice consumed every day in Iraq is imported[1]. Due to its significant potential damage to the environment and public health, toxic heavy metals are one of the most significant hazardous chemicals and have frequently been mentioned as a potential pollutant in rice. International attention has been focused on heavy metal contamination in agricultural soil during the past few decades[2] because they tend to accumulate in their tissues in quantities according to the vegetation types[3]. There are several sources of heavy metal contamination in agricultural areas in Iraq, including industrial activities such as metal smelting and power plants, which can release heavy metals into the environment through emissions, spills, and waste disposal practices[4, 5]. Contaminated irrigation water can also be a source of heavy metal contamination, either if it is sourced from industrial or municipal wastewater treatment plants or if it passes through soil or sediment that is contaminated with heavy metals[4, 6]. Pesticides and fertilizers containing heavy metals as active ingredients can also contribute to heavy metal contamination in agricultural areas, as can natural sources such as minerals present in the soil[4, 7]. Cadmium (Cd), arsenic (As) and lead (Pb) have been found to be the three most common metals in rice cultivation[4]. Exposures to these metals can cause cancerous and non-cancerous outcomes. The International Agency for Research on Cancer has classed As, Cd, chromium (Cr), and nickel (Ni) as group 1 carcinogens. Since prolonged exposure increases the risk of several cancers, including tumor suppressor gene expression disruptions and enzyme activities that contribute to metabolism by oxidative damage[5]. One of the metals that pose a severe risk to public health is As, which gradually makes its way into humans' regular diets.

Like As, Cd similarly accumulates more than other cereal grains than rice[6]. Humans are exposed to cadmium from various sources such as milk[7] and tobacco[8]. The grains of wheat and rice are one of the main sources of cadmium exposure worldwide. Cr interacts with a number of metabolic processes. Cr toxicity manifests in plants as diminished root growth and phytomass, chlorosis, photosynthetic impairment, stunting, and ultimately plant death[9]. When people have either acute or prolonged exposure to nickel (Ni), there are potential adverse health impacts. The most typical cause of sensitization in the general population is Ni. Individuals who are susceptible to nickel may develop allergic contact dermatitis after consuming nickel orally[10]. The second-most harmful toxic element is Pb. Due to its prevalence, persistence, and toxicity, Pb is a contaminant that poses a serious threat to public health[11]. The maximum and minimum concentrations of Pb are found in the roots and grains of mature rice plants, respectively. Children with chronic lead exposure have a lower intelligence quotient because of the pathological changes and damage that are induced in their organs and central nervous systems[12]. Although rice is grown in Iraq and imported from other countries[13], there is less evidence available regarding the levels of toxic heavy metals in rice grains. In addition, the researchers are aware of the effects on consumer health that can occur from ingesting heavy metal pollutants in excess of the recommended guidelines, which can be hazardous to health. Therefore, the aim of this study was to assess the concentrations of some toxic heavy metals in commercial rice obtained from local markets in Erbil City. Moreover, pre and post soaking effects on metal concentrations are also discussed.

Materials and Methods

Samples Collection

A total of 55 rice packages (local and imported) were randomly purchased from different local markets located in Erbil City, in 2022. We selected fifteen common brands and of six origins. According to study findings, all of them were common rice types that are frequently found in nearby supermarkets and are the most popular type of rice consumed in the city. In this study, we chose to use Sadri and Amber rice as local samples. These two types of rice are commonly consumed in the Erbil city and available at local markets in the city; and represent a range of growing conditions and time periods. Based on rice popular consumption, the types of rice collected were local and imported from other countries. Rice samples were local and imported from several countries, such as India with 28 samples, Iraq with 10 samples, the USA with 8 samples, Russia with 4 samples, and Turkey with 6 samples, Table 1. Each sample of rice weighed about 1 kilogram, which was placed in a clean ziplock bag and delivered to the laboratory where they were kept at -4 °C until the samples were prepared.

Table 1. Common rice types and samples of different rice types according to their origin.

No.	Brand Code	N	Origin	Country
1	AR	5	Imported	India
2	BY	3	Imported	Turkey
3	DR	3	Imported	Turkey
4	GF	4	Imported	India
5	KL	4	Imported	Russia
6	MH	5	Imported	India
7	MJ	4	Imported	India
8	NR	4	Imported	USA
9	QW	4	Imported	India
10	RM	3	Imported	India
11	SA	4	Imported	USA
12	SB	3	Imported	India
13	AK	3	Local	Iraq/Akre
14	CS	3	Local	Iraq/Sharazur
15	HR	3	Local	Iraq/Harir

Sample Preparation

High-purity deionized water (DW) was used throughout this study. Each sample of rice was prepared before cooking using a practice popular among locals; the grains were soaked for 30 minutes in DW at a temperature of 35 °C. DW was used for soaking rice with a mass ratio (1:3, rice: water in grams). Tap water is usually used for various washing and soaking purposes in the city. However, the primary sources of tap water in Erbil are mainly surface and groundwater. Consequently, a variety of heavy metals from various sources may be anticipated[14], hence we used DW for soaking rice to prevent additional heavy metal contamination from tap water. Drying the rice took placed at room temperature, then dried in an oven at 70 °C for at least 48 hours. Samples of rice were powdered very finely in a clean commercial grinding machine (IKA®). The average levels of five toxic heavy metals in the untreated and treated rice were calculated and presented as raw rice (unwashed samples) and soaked rice (treated samples). Based on the weight of the rice, metal concentrations were estimated and represented as mg/kg dry weight (DW).

Sample Digestion

Standard acid digestion under heating on a hot plate was performed by using two mixture, namely, hydrogen peroxide (H_2O_2; 34% by volume) and nitric acid (HNO_3; 65%)[15]. All glass goods were cleansed with 8% HNO_3, rinsed with DW, and dried before sample digestion. Block digestion was used to digest rice powder. For each sample digestion, 0.5 g of each raw and soaked rice powder sample was weighted on balance with 0.001g precision (ae adam, model PGW 253i). Prediestion was done to the samples with 5 ml of trace metal-grade HNO_3 (65%) in a glass digestion tube and left for at least 24 hours in hood. In the hot plate procedure, the samples digested in an acid mixture HNO_3:H_2O_2 = 3:2 and heated at 130 ºC for 2-3 hours. The mixture was heated until a clear residue remained. After completing digestion and cooling to room temperature, a digested clear aliquot was filtered through Whatman No. 42 (0.45 µm pore) ash-free filter paper before samples transferred to 25 mL volumetric flasks and completed the volume with DW. The blank digestions were also carried out in the same way. Heavy metal analysis was performed for these solutions by ICPE-9820 Shimadzu at Razga Laboratory for food quality control in Bashmakh.

Statistical Analysis

R ver. 4.2.1 (<www.r-project.org>) used to perform the statistical analyses of this study and the significance level was considered at $p<0.05$. Descriptive analyses included means and standard deviations. Variables were tested for normality distribution prior to analysis. Paired t-test was performed to compare the average of every heavy metal in raw and soaked rice, and imported and local rice. The means among common rice brands were compared using a one-way ANOVA test.

Results and Discussion

Toxic Heavy Metals Concentrations in Rice

The mean concentrations of five heavy metals in raw (untreated samples) of fifteen common rice brands are presented in Table 2. The concentrations are the means and standard deviations; and are expressed in m/kg, dry weight. The total mean concentrations (mean±SD) of heavy metals in raw rice were 0.655±0.095, 0.170±0.016, 0.016±0.016, 0.387±0.102, and 0.489±0.051for As, Cd, Cr, Ni and Pb, respectively. The highest concentrations (in mg/kg) of As (1.799), Cd (0.595), Cr (0.216), Ni (0.802), and Pb (0.926) in raw rice were from AR, HR, KL, NR and AR, respectively. Minimum As, Cd, Cr, Ni and Pb concentrations (in mg/kg) in raw rice were from AK (0.129), GF (0.079), BY (0.087), KL (0.171) and BY (0.104), respectively, Table 2.

Mean As concentrations were higher than other heavy metals in rice. The increased transfer of As from soil to grain has resulted in rice exhibiting higher levels of As absorption than other metals, according to previous studies[16, 17]. Additionally, because it is a staple food, humans consume harmful, inorganic As from rice[17]. Maximum As concentrations were recorded in the AR brand (1.799 mg/kg) which is imported rice, whereas the lowest concentrations were in the AK brand (0.129 mg/kg) which is local rice, Table 2. This range was exceeding the maximum allowable limits of 0.2 mg/kg set by FAO and WHO[18]. A study found similar results of As in market rice in Iraq that ranged from 0.026 mg/kg to 1.836 mg/kg[19]. A lower mean As concentration (0.369 mg/kg) in local market rice in Iran was reported by[20]. It is noticeable that as concentrations in 14 out of 15 rice brands were above the limits allowed by FAO and WHO organizations of 0.2 mg/kg.

The concentrations of Cd (in mg/kg) in the tested rice samples ranged from 0.079 to 0.595 in GF and HR, respectively. Cd concentrations for all brands were within the permissible limits of 0.4 mg/kg set by FAO and WHO, except HR exceeded the Codex standards for Cd in polished rice[18]. This may due to wastewater that refers to domestic water are used for agriculture and irrigation purposes in some areas around Erbil[21]. A study conducted by Abu-Amaaly[19] indicated Cd concentrations in rice available in local markets in Iraq ranged from 0.01555 to 0.12955 mg/kg, which is lower compared to this study. Lower Cd concentration (0.0337 mg/kg) was also reported in local market rice in Iran[20]. Concentrations of Cr (in mg/kg) in the rice samples ranged from 0.087 and 0.216 in By and KL, respectively. Noteworthy is the fact that Cr concentrations in all rice brands were lower than the 0.2 mg/kg identified by FAO and WHO[18] in polished rice, except in HR and KL. The lower range of mean Cr concentrations in market-rice reported in Thailand[22], ranged from 0.248 to 0.660 mg/kg. China set a 1.00 mg/kg by national regulations as the maximum permitted level of Cr in cereal agricultural products, but the amounts that were identified in this study did not exceed that level.

The concentrations of Ni in mg/kg in the tested rice samples ranged from 0.171 to 0.802 in KL and NR, respectively, Table 2. The total Ni mean concentration was 0.387±0.102 mg/kg and this was higher compared to Ni concentrations reported from other countries. Relatively lower levels of Ni (0.16 mg/ kg) were found in rice (0.174 mg/kg) in Iran[9]. However, higher Ni levels were 0.49 mg/kg in milled rice in China[23], 0.655 mg/kg in commercial market rice in Liberia[24] and 0.54 mg/kg found in wheat in Belgium[25]. However, the

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standard for the maximum level of Ni in rice and other food products has not been defined or established by the FAO or WHO[18]. Mean Pb concentrations in rice samples ranged from 0.104 mg/kg to 0.926 mg/kg in BY and AR, respectively, it should be noted that all Pb concentrations in rice brands were higher than 0.2 mg/kg standard for the maximum level identified by FAO and WHO[18], except in HR and KL. A study reported lower mean Pb concentrations of 0.123 mg/kg in Iran[20]. Nevertheless, a higher mean concentration 1.70 mg/kg was found in Indian local market rice[26]. By comparison, these concentrations were much lower than the average Pb concentration 0.489 mg/kg in rice reported in this study. ARG1 helps regulate the transport and balance of nickel in rice chloroplasts, preventing them from disrupting essential components of photosynthesis. The variation between rice species is due to natural differences in the ARG1 gene[27].

Table 2. Toxic heavy metal concentrations in raw rice (unwashed samples) (n = 55). Concentrations are means (mg/kg, Dry Weight) and standard deviation (SD).

Brand Code	As		Cd		Cr		Ni		Pb	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
AK	0.129	0.020	0.169	0.024	0.164	0.023	0.253	0.062	0.307	0.038
AR	1.799	0.090	0.156	0.016	0.187	0.034	0.708	0.150	0.926	0.060
BY	0.574	0.035	0.112	0.006	0.087	0.010	0.243	0.287	0.104	0.011
CS	0.157	0.001	0.151	0.007	0.131	0.003	0.202	0.029	0.294	0.051
DR	0.660	0.094	0.195	0.037	0.156	0.015	0.474	0.153	0.593	0.021
GF	0.450	0.031	0.079	0.012	0.142	0.046	0.228	0.025	0.198	0.014
HR	0.625	0.085	0.595	0.021	0.212	0.062	0.356	0.098	0.463	0.030
KL	0.847	0.058	0.160	0.016	0.216	0.043	0.171	0.049	0.539	0.030
MH	1.014	0.515	0.142	0.018	0.143	0.038	0.303	0.069	0.755	0.073
MJ	0.843	0.074	0.153	0.012	0.179	0.021	0.656	0.102	0.924	0.046
NR	0.532	0.067	0.108	0.024	0.154	0.019	0.802	0.048	0.343	0.036
QW	0.644	0.276	0.108	0.007	0.120	0.009	0.304	0.102	0.352	0.101
RM	0.537	0.043	0.120	0.006	0.153	0.024	0.299	0.114	0.518	0.106
SA	0.718	0.024	0.155	0.015	0.174	0.011	0.216	0.095	0.565	0.029
SB	0.300	0.019	0.142	0.015	0.182	0.008	0.585	0.149	0.459	0.114
Range	0.129-1.799		0.079-0.595		0.087-0.216		0.171-0.802		0.104-0.926	

The mean concentrations of As, Cd, Ni and Pb in local rice from Iraq were significantly different from those of imported rice, Figure 1. The difference in As mean concentration between local rice (mean = 0.3039 mg/kg; SD = 0.245) and imported rice (mean = 0.7916; SD = 0.439) was significant ($t = 4.6749$; $df = 19.814$; $p < 0.00015$). Cd concentration in local rice (mean = 0.3047 mg/kg; SD = 0.218) was significantly differ ($t = -2.3149$; $df = 8.0724$; $p < 0.049$) from imported rice (mean = 0.1359; SD = 0.033). The mean concentration of Ni in local rice (0.2703 mg/kg; SD = 0.09) was significantly different ($t = 3.2267$; $df = 34.198$; $p < 0.0028$) from imported rice (mean = 0.4209 mg/kg; SD = 0.242). Also, the mean Pb concentration between local rice (0.355 mg/kg; SD = 0.089) and imported rice (0.5450 mg/kg; SD = 0.261) was statistically significant ($t = 3.9364$; $df = 38.472$; $p < 0.00034$). However, only Cr mean concentration in local rice (0.1691 mg/kg) and imported rice (0.1591 mg/kg) was not significant ($p < 0.576$). Mean concentrations of Cd and Cr were higher in local rice compared to imported rice. A study found that average concentrations (in mg/kg) in Iranian grown/imported rice of 0.046/0.057, 0.16/0.13, 0.22/0.76, 0.196/0.55 and 0.29/0.29 for As, Cd, Cr, Pb and Ni, respectively[28]. Results in this study indicated that the rice grains irrigated by wastewater enrich rice with Cd more than other toxic metals. Iraqi rice samples HR, Table 2, may have been contaminated with heavy metals as a result of the water-related soil contamination in Erbil governorates due to wastewater that had been used for irrigation purposes[21]. Numerous studies[29-31] that studied the correlation between soil contamination and rice cultivation in these areas found that excessive concentrations of heavy metals in the soil may result in the plant's rice system absorbing these elements. Additionally, the likelihood of contamination with heavy metals is increased by the use of agricultural fertilizers such as phosphate, which may increase the amounts of heavy metals in the agricultural land and then transfer to rice, when using sewage-contaminated water to irrigate crops.

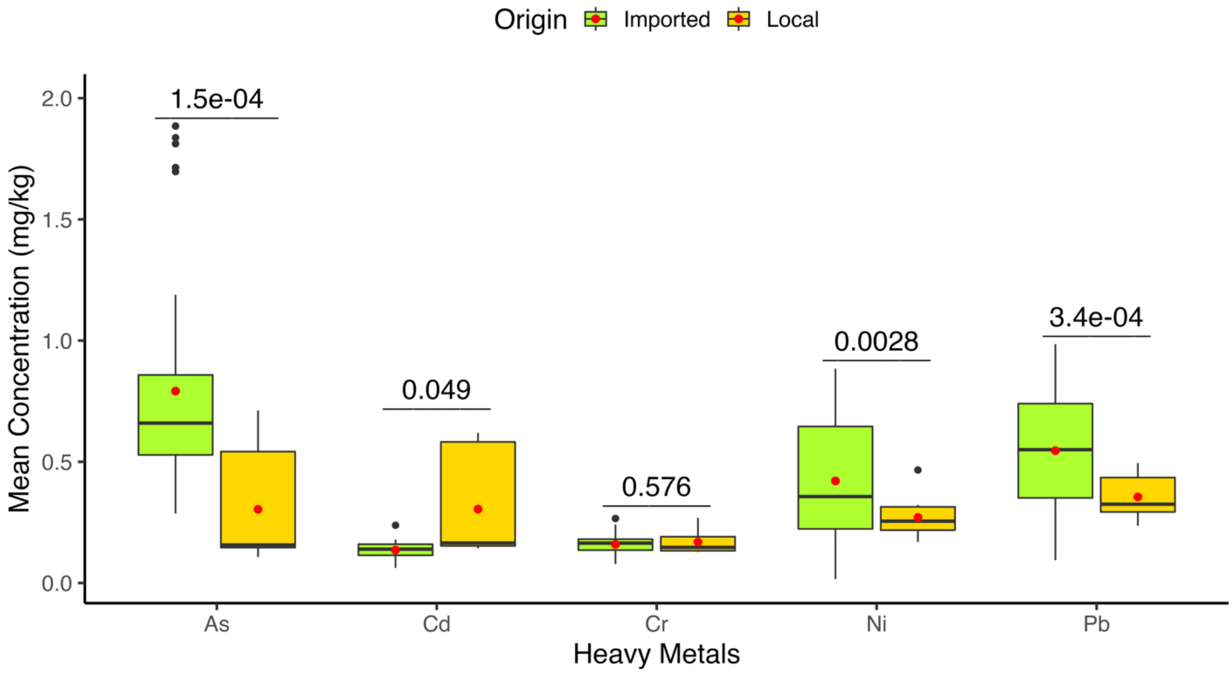

Figure 1. Toxic heavy metals (As, Cd, Cr, Ni, and Pb) concentrations (mg/kg) in rice according to origin; imported (N=55) and local (N=55); the lines in the plots indicate median concentrations. Red dots represent means, whereas black dots represent extreme values. Numbers are p-values and based on paired t-tests of the means, statistically significant (*p<0.05) concentrations were calculated.

Mean concentrations of toxic heavy metals in rice according to country of origin in presented in Figure 2. Mean As concentrations (in mg/kg) were only significantly different ($p < 0.009$) in rice originally from India and Iraq (mean = 0.869 and 0.304), respectively. Mean Cd concentrations in rice from Iraq was significantly different from India and USA ($p < 0.0001$ and 0.004, respectively). Iraq had mean concentrations in (mg/kg) at 0.305 for Cd, as well as 0.13 and 0.131 in rice from India and USA, respectively. This result was not similar to the study in Iraq that found the range of 0.0155–0.1955 mg/kg (n=36) in[19]. Mean Cr concentrations in rice (0.216 mg/kg) from Russia was significantly different from India (0.158 mg/kg) with $p < 0.031$. Nevertheless, there were no significant differences found in average concentrations of Ni in the considered countries. Rice from Iraq had the lowest Pb mean concentrations of 0.355 mg/kg and was significantly different from Indian rice with a mean concentration of 0.6154 mg/kg ($p < 0.03$). Rice from Iraq, India, Turkey, Russia and Iraq showed the lowest average concentrations for As, Cd, Cr, Ni and Pb, respectively. However, rice from India, Iraq, Russia, USA, and India showed the highest mean concentrations for As, Cd, Cr, Ni and Pb, respectively. For instance, studies have found average As concentrations in market rice (in mg/kg) ranging from 0.0226–1.8368, 0.062–0.202, 0.07–0.31 and 0.0204–0.1708 in Iraq, USA, India, and Turkey, respectively[19, 32]. These results were alike to the data found in Iraqi rice (0.0226–1.8368 mg/kg)[19]. The concentrations of Cd were found in other studies at the range (in mg/kg) of 0.0084–0.0775, 0.0084–0.0775 and 0.0066–0084 in Turkey[33], the USA[32], and Iran[20], respectively. The mean ranging (in mg/kg) concentrations of Pb in rice were 0.0002–0.032, 0.015–0.355 and a mean of 0.66 from the US[32], Iran[20] and China[34] in market-surveyed rice, respectively.

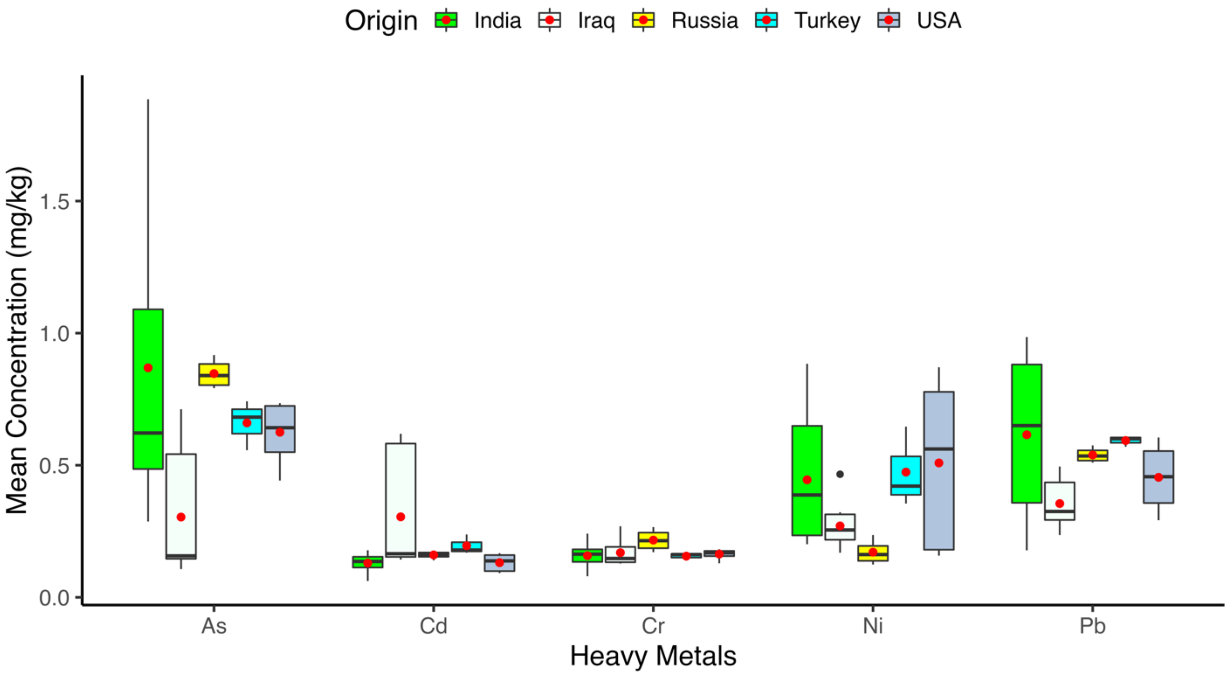

Figure 2. Toxic heavy metals (As, Cd, Cr, Ni, and Pb) concentrations (mg/kg) in rice according to country of origin; India (N=28), Iraq (N=9), Russia (N=4), Turkey (N=6) and USA (N=8); the lines in the plots indicate median concentrations. Red dots represent means, whereas black dots represent extreme values.

The mean range concentration (in mg/kg) of Cr is reported in this study (ranging from 0.08 to 0.269 mg/kg) lower than values in the literature. Studies reported higher Cr concentrations of 0.33–0.44 in domestic rice in Iran[35], 0.196–3.17 in irrigated rice grains in Bangladesh[36], 0.13–0.56 in rice grains in India[37]; and Nigeria reported a much higher mean Cr concentration of 14.17 mg/kg in rice grains[38]. An average Ni concentration of 0.49 mg/kg in milled rice in China[23], is similar to the result of this study. A lower concentration of 0.064 mg/kg and 0.038 mg/kg were reported in imported rice in Saudi Arabia[39] and in commercial rice in France[40]. Even a higher level of Ni (0.72–0.79 mg/kg) was reported in local rice in Iran[35].

Effect of Soaking Process on the Concentrations of Toxic Heavy Metals in Rice

The mean concentrations of all toxic heavy metals were significantly different of raw rice from soaked rice samples Figure 3. Heavy metal concentrations were significantly lowered after the soaking process. The difference in As concentration between raw rice (mean = 0.712 mg/kg; SD = 0.451) and soaked rice (mean = 0.449; SD = 0.248) was significant ($t = 3.78$; $df = 83.87$; $p < 0.00029$).

Cooked rice grains' As content may be significantly reduced with changes to cooking procedures. Numerous studies have suggested washing rice first before boiling it to lower the overall As content[41, 42]. The concentrations of As in water and uncooked rice grains, how frequently rice is washed, and sample sizes can all have an impact on the results of washing rice, both good and bad. The average concentration of Cd in raw rice (mean = 0.165 mg/kg; SD = 0.109) was least significantly different ($t = 3.014$; $df = 105.74$; $p < 0.003$) from soaked rice (mean = 0.105 mg/kg; SD = 0.094) compared to others toxic heavy metals. Iranian rice samples lost Cd concentration (in mg/kg) from

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0.01328 to 0.01231; corresponding to 7.2 %, after washing and soaking[43]. There was a statistically significant difference ($t = 5.977$; $df = 106.75$; $p < 3.04E-08$) between the average concentration of Cr in raw rice (mean = 0.161 mg/kg; SD = 0.041) and soaked rice (mean = 0.116 mg/kg; SD = 0.037). The most significant difference in mean concentrations ($t = 8.656$; $df = 58.98$; $p < 4.31E-12$) of toxic heavy metals between raw rice (mean = 0.396 mg/kg; SD = 0.23) and soaked rice (mean = 0.121 mg/kg; SD = 0.05) was Ni. A study found that soaking was ineffective at removing heavy metals like As, Cd, Cr, Pb and Ni from the brown rice[44] while the results of another study found that soaking the rice was very efficient practice in decreasing the heavy metal contents such as Pb, Cd, Ni, and Cr[45]. Also, Pb means concentration in raw rice (0.515 mg/kg; SD = 0.251) and soaked rice (0.349 mg/kg; SD = 0.156) was statistically significantly different ($t = 4.141$; $df = 90.277$; $p < 7.77E-05$). A study showed that Pb concentration (in mg/kg) in Iranian samples was reduced from 0.27517 to 0.23696 after the soaking process. Therefore, after washing and soaking, the Pb concentration dropped by 15% which is less than the result of this study[43].

The soaking process significantly dropped the level of toxic heavy metals and the distribution of Cd, As, and Pb in rice kernels and rice morphology may be linked to the decline brought on by washing[41]. Maximizing the number of washing steps resulted in a loss of vitamins and minerals in rice, which is one drawback of washing rice. Washing time during the soaking process and temperature also have a great impact on the loss of nutrient contents and are considered one of the biggest limitations of cooking practice[19, 43, 46].

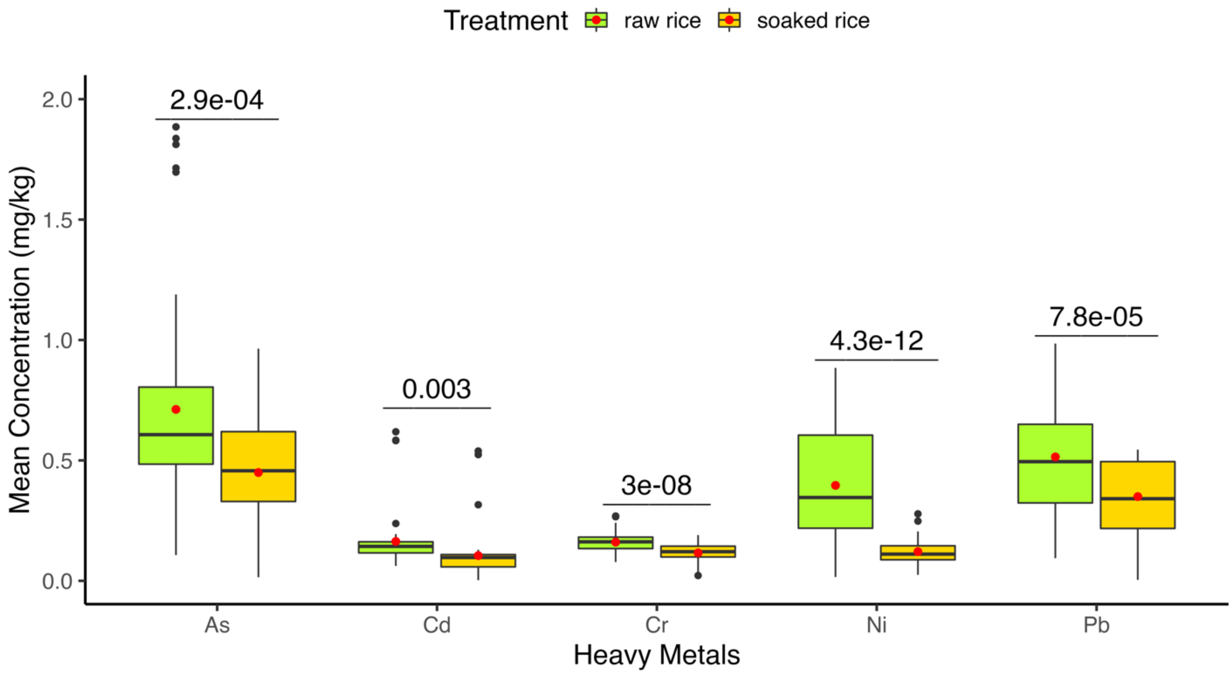

Figure 3. Toxic heavy metals (As, Cd, Cr, Ni, and Pb) concentrations (mg/kg) in raw rice (N=55) and soaked rice (N=55); the lines in the plots indicate median concentrations. Red dots represent means, whereas black dots represent extreme values. Numbers are p-values and based on paired t-tests of the means, statistically significant (*p<0.05) concentrations were calculated.

The percentage of toxic heavy metal loss from soaked rice samples is presented in Figure 4. Under the soaking process, each of the five heavy metals displayed a distinct variation pattern. Arsenic was considerably removed under the soaking condition with a significant reduction rate of 32.5%. Similar patterns were seen for Pb and Cd in rice with a reduction of 31.3% and 40.2%, respectively. However, Cr exhibited the minimum reduction rate metal with a total percentage loss of 27.9%. Notably, the loss of Ni was recorded with a maximum reduction rate of 61.6% in total under soaking conditions, Figure 4. All heavy metals were significantly removed ($p<0.05$) as the five heavy metals concentrations showed a downward trend under soaking process, Figure 3.

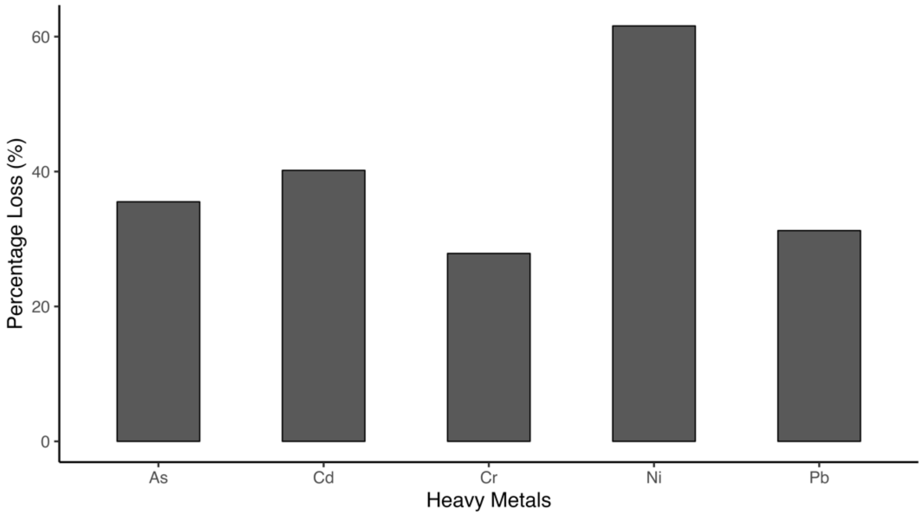

Figure 4. Percentage loss of heavy metals under soaking condition (N=55).

Naito et. al. in a study found that the mean As the concentration of brown rice and white rice dropped to 81–84% and 71–83% after three washing with DW, respectively[46]. Raab et al. discovered that washing basmati rice grains decreased their total As concentration by 13–15%[42]. It should be noted that soaking is an important factor in decreasing heavy metals in rice. These reductions have a great impact on the ingestion levels of toxic elements; however, complex organisms are not simple homogeneous receptors as there are several routes of exposure such as milk[7] and tobacco[8].

Conclusion

Erbil city receives multiple imported and local rice commodities for human consumption. To test suitability in terms of metal concentration and to test pre and post soaking prevalence demonstrates that As and Pb concentration in imported rice exceeds permissible limitation of FAO and WHO. However, Cr did not surpass the codex permissible limit. Only the mean concentrations of Cd and Cr were higher in local rice samples, whereas As, Pb and Ni were higher in imported rice samples. There were statistically significant differences between toxic heavy metals in local and imported rice samples; except Cr was not significantly different. This study also demonstrated that how soaking process reduce metal concentrations from rice.

Author's Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine/ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- The author has signed an animal welfare statement.
- Authors sign on ethical consideration's approval.
- Ethical Clearance: The project was approved by the local ethical committee in Salahaddin University-Erbil.

Author's Contribution Statement

This work was carried out in collaboration between all authors. F Z. J contributed to the design of the study, collected samples and digested, analyzed the data, and wrote the paper with input from all authors. D A. D conceptualized and contributed to the implication of the study, supported data analyzing, and reviewed and edited the final manuscript draft. All authors read and approved the final manuscript.

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تركيز المعادن الثقيلة في الأرز التجاري المتوفر في أسواق مدينة أربيل، العراق وتأثير النقع

فارس زيدان جرجيس و دلشاد عزيز درويش

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الخلاصة

لطالما كان تلوث المعادن الثقيلة مصدرًا مهمًا للتدهور البيئي ومشكلة لسلامة الغذاء. يفضل العراقيون الأرز على أي طعام آخر، وبما أن المعادن الثقيلة لها تأثير مباشر على الصحة، فقد لفتت آثارها في الأرز اهتمامًا خاصًا. قبل طهي الأرز، من المعتاد في العراق غسله ونقعه. تم أخذ عينات من حوالي 55 نوعًا من الأرز المحلي والمستورد من أسواق مدينة أربيل في عام 2022 بهدف تحديد تركيز As و Cd و Cr و Ni و Pb قبل النقع وبعده. تم تطبيق الإجراء القياسي للهضم الحمضي على العينات الخام والمنقوعة. تم تحليل الحلول باستخدام ICPE-9820 Shimadzu. كان متوسط تركيزات As و Cd و Cr و Ni و Pb (بالملجم / كجم) في عينات الأرز قبل النقع 0.655 و 0.170 و 0.160 و 0.387 و 0.489 على التوالي وبعد النقع 0.421 و 0.109 و 0.115 و 0.124 و 0.336، على التوالي. وجد أن تركيز As و Pb يتجاوز المستوى الأمثل البالغ 0.2 مجم / كجم من معايير الكودكس للأرز؛ بينما كان Cd و Cr ضمن المستوى المقترح لمعايير المخطوطات. علاوة على ذلك، أظهر الأرز المحلي تركيزًا أعلى من (الكادميوم والكروم)، بينما كان تركيز (AS و Pb) أعلى في الأرز المستورد. علاوة على ذلك، تؤكد النتائج أن نقع الأرز يمكن أن يقلل من مستويات As و Cd و Cr و Ni و Pb (32.5٪ و 40.2٪ و 27.9٪ و 61.6٪ و 31.3٪ على التوالي). تشير هذه النتائج إلى أن النقع كممارسة في المطبخ له كفاءة في تبخير المعادن له تأثير كبير على تقليل المعادن الثقيلة السامة وبالتالي يقلل من التعرض للمعادن السامة في الأرز.

الكلمات المفتاحية: تحليل مقارن، معادن ثقيلة، حدود مسموح بها، حبوب الأرز، ، نقع أرز.