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RESEARCH ARTICLE

Determination of heavy metals in canned fruits and vegetables sold in Jordan market

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Abstract In this study, the concentrations of selected heavy metals including Pb, Zn, Cr, Ni, Cu, As, and Cd in different brands of canned vegetables and fruits including canned tomato sauce (ketchup), canned green beans, canned whole carrots, and canned juice (pineapple) imported to Jordanian market were determined by acid digestion and atomic absorption spectroscopy. Samples were collected from popular Jordanian markets, Irbid city, Northern Jordan (11 samples of each type). The metal concentrations in the samples analyzed were found to be in the range of 2.6–3.0 mg/kg for Pb, 0.50–0.60 mg/kg for Cd, 2.50–5.10 mg/kg for As, 0.84–0.91 mg/kg for Cu, 0.32–3.02 mg/kg for Zn, 0.66–1.71 mg/kg for Cr, and 0.97–2.94 mg/kg for Ni. The results obtained showed that Pb and As have the highest concentrations in the most of samples analyzed, whereas, the lowest concentrations obtained were mainly in Cd. For example, in canned tomato sauce, the average concentrations of heavy metals are 3.50 mg/kg for As, 0.50 mg/kg for Cd, 0.66 mg/kg for Cr, 0.89 mg/kg for Cu, 1.15 mg/kg for Ni, 2.95 mg/kg for Pb, and 1.02 mg/kg for Zn. The results of this study reveal that the concentration of some toxic heavy metals (Pb, Cr, Ni, As, and Cd) in canned vegetable and fruit samples being sold in Jordanian markets exceeded the permissible limits set by different health organizations.

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Introduction

In the last years, human exposure to heavy metals has attracted much attention as a serious health problem overall the world. Human exposure to heavy metals has increased significantly as result of continuously using these metals as starting materials in different industrial processes (Al-Thagafi et al. 2014). Generally, heavy metals are classified as essential (if they have important role in human biochemical processes such as Iron (Fe), Copper (Cu), Zinc (Zn), Cobalt (Co), Manganese (Mn), or Molybdenum (Mo)) and as toxic (if the metals are classified as with no basic role in human biochemical processes like Mercury (Hg), Cadmium (Cd), Lead (Pb), Tin (Sn), Chromium (Cr), or Arsenic (As)). Deficiency or high concentrations of these metals may have adverse effects on the human health. Therefore, estimation the concentration of toxic heavy metals in environmental and food samples has been an important topic and received great attention (Majolagbe et al. 2011; Oluwole et al. 2013; Fiamegkos et al. 2015).

Toxic heavy metals are considered to be the most hazardous form of pollutants when consumed in a large amount through contaminated foods. Their toxicity stems from the fact that they are nonbiodegradable and accumulate in important human organs like the lungs, kidney, heart, or liver (Belay and Abisa 2015; Salihu et al. 2014; Usman et al. 2015). Consequently, the continuous consumption of food samples contaminated with toxic heavy metals exceeding the safe permissible limits may result in serious health problems (Elbagermi et al. 2012; Sulyman et al. 2015). Several cases of human diseases, disorders, breakdowns, and deformation of organs as a result of metal toxicity have been reported

(Mandal and Suzuki 2002; Al-Rajhi 2014). Soil is considered to be the main source of metals for plants. Other sources of heavy metals may occur due to irrigation with contaminated water, dumping of wastes, using of herbicides or insecticides, industrial emission, or through the ingestion of contaminated food that contains high levels of toxic heavy metals (Belay and Abisa 2015; Sulyman et al. 2015; Usman et al. 2015).

Toxic heavy metals are known to be very toxic even at very low concentrations. For example, Sn is a highly toxic metal with the maximum limit of 250 mg/kg in canned foods and 150 mg/kg in canned beverages (FAO/WHO (Food and Agriculture Organization/World Health) 1989; Codex Alimentarius-Codex Commission 2001). High contents of Sn in food samples may cause serious health problems for human beings such as gastrointestinal symptoms provoking nausea, vomiting, diarrhea, abdominal cramps, bloating, fever, and headache (Codex Alimentarius-Codex Commission 1998). Cd is another toxic heavy metal that can be detrimental to human health if it intake excessively over a long period through contaminated food or drink. Over a long period of intake, Cd accumulates in the human body and may induce several health problems such as kidney dysfunction, skeletal damage, and reproductive deficiencies (Commission of the European Communities 2006; Maduabuchi et al. 2006). It was reported that the maximum level permitted for Cd in foods set by FAO/WHO (Food and Agriculture Organization/World Health) (1972) is 0.5 mg/kg. Another toxic metal is As, which is classified as a highly toxic metal that causes adverse health effects to humans such as dermal changes, respiratory, cardiovascular, gastrointestinal, hematological, neurological, reproductive, genotoxic, mutagenic, and carcinogenic effects (Mandal and Suzuki 2002).

On the other side, essential heavy metals are considered essential in nutrition as they play an important role in biological systems. However, they can become harmful at higher concentrations (Ogunlana et al. 2015). For example, Zn is known to be essential for human health. If excessive amounts of Zn are consumed, stomach cramps, nausea, and vomiting may occur (Belay and Abisa 2015). On the other side, Zn deficiency can lead to loss of appetite, growth retardation, skin changes, and immunological abnormalities (Malakootian et al. 2011).

Canned foods are considered important sources of carbohydrates, proteins, vitamins, minerals, and trace elements (Dospatliev et al. 2012; Mohod 2015). Canned foods such as canned vegetables, canned fruits, canned meat, canned drink, or canned fish are popular food sources overall the world (Mol 2011; Korfali and Abou Hamdan 2013). During the last years, there has been increasing interest in estimation of contamination levels of toxic heavy metals in canned foods. This is because they are widely consumed by people and thus contribute to a large extent in heavy metals intake. Generally, canned foods are subjected to heavy metals contamination as a result of naturally incurred contamination of the foodstuffs or by migration of toxic heavy metals from the metallic packaging material (Fiamegkos et al. 2015). Another source of contamination of canned foods is solder, which is used in the manufacture of cans (Voegborlo et al. 1999; Korfali and Abou Hamdan 2013; Fiamegkos et al. 2015). This is because solder is mostly composed of tinplate, chromium coated steel, or aluminum (Fiamegkos et al. 2015).

In 2014, Al-Thagafi et al. (2014) performed a comparison study in which they determined the concentration of several essential and toxic heavy metals in samples of canned and corresponding fresh food collected from Saudi Arabia using inductively coupled plasma-atomic emission spectrometer (ICP-AES). The authors found that the toxic heavy metals have relatively high concentrations in canned food than those of the corresponding fresh food samples. In addition, the authors found that some of these metals concentrations were exceeded the permissible limits reported by different heath organizations. In a similar study, Hadiania et al. (2014) determined the content of several toxic heavy metals (Pb, Cd, and As) in canned tomato paste and tomato sauces (ketchup) samples collected from Iran during the period 2010–2013. Samples were analyzed by graphite furnace atomic absorption spectrophotometer (for Pb and Cd) and by hydride vapor generation (for As). The authors found that the content of these heavy metals in all analyzed samples were lower than the limits of national and international standards. They concluded from their investigations that consumption of canned tomato paste and ketchup in Tehran during the period of study, were safe according to Iranian and Codex limits.

The main objectives of this study were (1) to estimate the concentration of selected heavy metals (Pb, Zn, Cr, Ni, Cu, As, and Cd) in different brands of canned vegetables and fruits food samples sold in Jordanian market, Irbid city, Northern Jordan including canned tomato sauce (ketchup), canned green beans, canned whole carrots, and canned juice (pineapple), (2) to compare the results obtained in this study with those reported in neighboring countries and other countries in the world, and (3) to estimate the prevalence rates of canned food with exceeding permissible limits of these metals.

Materials and methods

Chemicals and reagents

All chemicals and reagents used were of analytical grade. Materials and reagents were used including standard solutions of 1000 ppm of each tested element Zn, Pb, Ni, Cu, Cr, Cd, and As (analytical grade, Scharlau Chemie, Barcelona, Spain), 70% (*v*/*v*) HNO_3 (Scharlau Chemie, Barcelona, Spain), 70% (*v*/*v*) $HClO_4$ (Scharlau, Spain) and $NH_4H_2PO_4$ (99.99%, Sigma-Aldrich, St. Louis, MO, USA). The working standard solutions of each examined metal were freshly prepared by diluting an appropriate aliquot of the stock solutions using 0.1% (*v*/*v*) HNO_3.

Sample preparation and acid digestion method

In this study, sample solutions were prepared as recommended by Tuzen and Soylak (2007) and Voegborlo et al. (1999) as in the following sequence of steps:

1. Each canned food sample was homogenized thoroughly using a food blender with stainless steel cutters.
2. A weight of 10.0 g of each homogenized food sample was placed into a porcelain evaporating dish and dried in an oven at 70 °C for 24 h.
3. A weight of 1.0 g dry weight sample was placed into a porcelain evaporating dish, then 10.0 mL of 70% (*v*/*v*) HNO_3 and 70% (*v*/*v*) $HClO_4$ was added with a ratio of (7:3 *v*/*v*).
4. The solution in a porcelain dish was heated until dryness.
5. Few drops of 0.15% (*w*/*v*) NH_4 H_2PO_4 were added to each sample as a matrix modifier.
6. After cooling, an aliquot of 5.0 mL of 0.1% (*v*/*v*) HNO_3 was added, then the solution was filtered into a 25.0mL polyethylene volumetric flask; the volume was made up to the mark with de-ionized water.
7. Each extract solution of canned food sample was analyzed by flame atomic absorption spectrophotometry (FAAS). All samples were performed in triplicates using an air-acetylene flame. For As determination, nitrous oxide-acetylene flame was used.
8. Blank solution was prepared by using the same procedures.

Instrumentation

Atomic absorption spectrophotometer (AAS) (Anal Jena, AG, model NOVAA300) with Auto sampler model (Type AS 51S, U 24 V DC APP-Nr-402071) equipped with a deuterium background correction was used for determination the content of the examined heavy metals in the tested canned food samples. Analysis using AAS was carried out at the most analytical spectral lines of the metals (Zn 213.9 nm, Pb 283.3 nm, Ni 232 nm, Cu 324.8 nm, Cr 357.9 nm, Cd 228.8 nm, and As 193.7 nm). For As determination, the slotted tube atom trap with an inert gas/hydrogen held in the flame by a simple holder, which clips to the burner was used to enhance the flame sensitivity and thus improve the detection limit for As.

Quality control and assurance

In this study, in order to confirm the reliability of the proposed method used for the analysis of the examined heavy metals in canned food samples, Quality control method was used and standard reference materials of these metals were analyzed. In this context, two certified reference materials (CRM 281; rye grass) and spinach leaf (SRM1570a) were analyzed to assess the accuracy of the method used in this study. Results indicated that there is a good agreement between the measured values and the certified values for the tested metals. The percentages of recovery of (CRM 281) reference material for Cd 96.1%, Cu 97.2%, Pb 94.5%, Zn 97.7%, and Ni 96.6%, whereas the percentage of recovery of (SRM1570a) for Cd 95.5%, Cu 95.3%, Pb 94.0%, Zn 96.6%, Ni 96.2%, As 94.4%, and Cr 96.1%.

Results and discussion

In this study, canned vegetable and fruit food samples of different brands were purchased from Jordanian market, Irbid city, including canned tomato sauce (ketchup), canned green beans, canned whole carrots, and canned juice (pineapple) (11 samples of each type). These samples were evaluated for assessment of selected seven heavy metals including Zn, Pb, Ni, Cu, Cr, Cd, and As using acid digestion and atomic absorption spectroscopy. The (mean ± standard deviation) concentration of each examined metal in canned food samples are shown in Figs. 1, 2, 3, and 4 and presented in Table 1. The average metal concentrations (mg/kg) are in the following order for canned tomato sauce (ketchup): As > Pb > Ni > Zn > Cu > Cr > Cd (Fig. 1); canned green beans: Pb > As > Cr > Ni > Cu > Zn > Cd (Fig. 2); canned pineapple: As > Pb > Cr > Ni > Cu > Cd > Zn (Fig. 3); canned whole carrots: As > Zn > Ni > Pb > Cr > Cu > Cd (Fig. 4). Data presented in Table 1 reveal a presence of a significant variation in the metal concentrations for As, Cr, Ni, and Zn between different food cans of the same type but different brands. This can be clearly seen from the values of the standard deviation associated to the average concentrations of these metals as shown in Table 1. For example, the results obtained for the canned tomato sauce (ketchup) samples indicated that the concentrations of heavy metals (mg/kg) were varied for As, from 4.54 to 1.38 with a mean of 3.50 mg/kg; Cd, from 0.51 to 0.48 with a mean of 0.49 mg/kg; Cr, from 0.94 to 0.02 with a mean of 0.66 mg/kg; Cu from 0.91 to 0.87 with a mean of 0.89 mg/kg; Ni, from 2.53 to 0.34 with a mean of 1.15 mg/kg; Pb, from 3.35 to 2.72 with a mean of 2.95 mg/kg; and Zn, from 0.1.43 to 0.63 with a mean of 1.02 mg/kg. This variation in the metals concentration might be attributed to the source of food itself, type of can, or possibility of corrosion of the inside body of the used can. Moreover, result showed that the highest metal concentrations

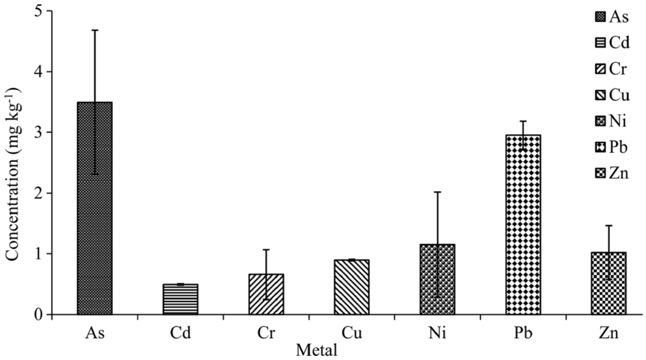

Fig. 1 Average concentrations of As, Cd, Cr, Cu, Ni, Pb, and Zn in canned tomato sauce (ketchup) samples

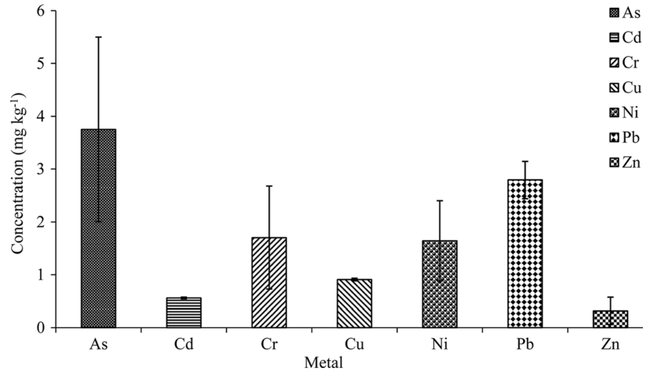

Fig. 3 Average concentrations of As, Cd, Cr, Cu, Ni, Pb, and Zn in canned juice (pineapple) samples

in canned tomato sauce, canned pineapple, and canned whole carrots were in As 3.50, 3.75, and 5.10 mg/kg, respectively, whereas, the lowest concentrations were in Cd for canned tomato sauce and canned whole carrots 0.49 and 0.60 mg/kg, respectively, and in Zn for canned pineapple 0.32 mg/kg as shown in Figs. 1, 3, and 4. One possible explanation for the high concentrations of As in canned tomato sauce, canned pineapple, and canned whole carrots might be the addition of food additives such as stabilizers, preservatives, and synthetic coloring agents (Oduoza 1992), food processing and cans processing (Voegborlo et al. 1999; Al-Thagafi et al. 2014). In canned green beans samples, it was found that the highest concentrations were in Pb 3.01 mg/kg, whereas, the lowest concentrations were in Cd 0.52 mg/kg as shown in Fig. 2. The high concentrations of Pb in canned green beans might be due to solder used in manufacture of cans which recognized as important source of contamination of food by Pb (Commission of the European Communities 2005) and other toxic metals during the canning process (Voegborlo et al. 1999).

The average concentrations obtained for Cu and Zn in all food samples analyzed in this study were found to be in the range of 0.91–0.84 mg/kg and 0.32–3.02 mg/kg, respectively. According to Romanian Ministry of Public Health Ordinance no 975/1998 (Harmanescu et al. 2007), the maximum Cu and Zn levels permitted for canned tomato sauce are 10 and 20 mg/kg, respectively. These findings indicate that the average concentrations obtained for Cu and Zn in the canned tomato sauce samples analyzed in this study were found to be below the prohibited limits for these metals. However, it is worth to mention that there are no national limits for Cu and Zn in the other canned food samples investigated in this study. The highest Cu and Zn concentrations were found in canned green beans and whole carrots samples with a mean of Cu 0.91 mg/kg and Zn 3.02 mg/kg, respectively, while the lowest Cu and Zn concentrations were found in canned whole carrots and pineapple samples with a mean of Cu 0.84 mg/kg and Zn 0.32: mg/kg, respectively.

Results obtained in this study showed that the average concentrations obtained for Pb, Cd, Ni, Cr, and As in the analyzed samples were found to be above the limits set by health organizations such as Codex standard 193-1995 (Codex 2010) as shown in Figs. 1, 2, 3 and 4. The Codex standard 193-1995 (Codex 2010) established the maximum Pb level permitted in canned pineapple, canned green beans, and canned carrots as 1.0 mg/kg, while the Kenyan and East African standards (Kenya Standard 2005; East African Standard 2010) set this level as 1.0 mg/kg for canned tomato sauce (ketchup). According to the data presented in Table 1 and shown in

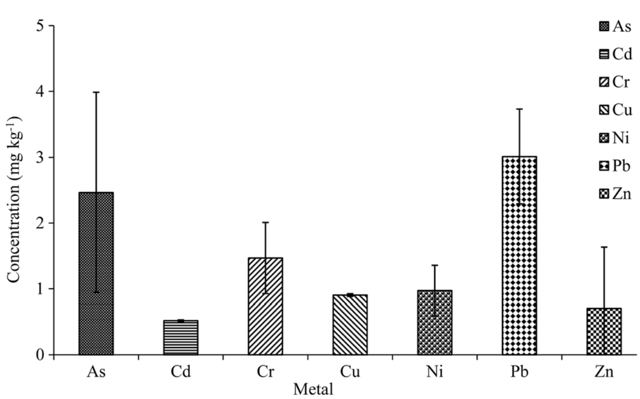

Fig. 2 Average concentrations of As, Cd, Cr, Cu, Ni, Pb, and Zn in canned green beans samples

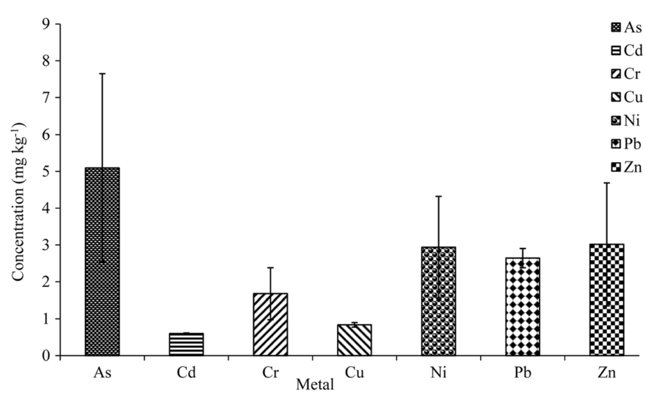

Fig. 4 Average concentrations of As, Cd, Cr, Cu, Ni, Pb, and Zn in canned whole carrots samples

Table 1 Mean ± SD and range of As, Cd, Cr, Cu, Ni, Pb, and Zn (mg/kg) in canned tomato sauce (ketchup), canned green beans, canned whole carrots, and canned juice (pineapple) samples. Data shown are the average of 11 runs

	As Mean ± SD range	Cd Mean ± SD range	Cr Mean ± SD range	Cu Mean ± SD range	Ni Mean ± SD range	Pb Mean ± SD range	Zn Mean ± SD range
Tomato sauce (ketchup)	3.50 ± 1.19	0.49 ± 0.01	0.66 ± 0.41	0.89 ± 0.02	1.15 ± 0.87	2.95 ± 0.23	1.02 ± 0.44
	4.54–1.38	0.51–0.48	0.94–0.02	0.91–0.87	2.53–0.34	3.35–2.72	1.43–0.63
Green beans	2.46 ± 1.52	0.52 ± 0.01	1.47 ± 0.54	0.91 ± 0.02	0.97 ± 0.39	3.00 ± 0.72	0.70 ± 0.93
	4.40–0.29	0.53–0.51	2.25–0.91	0.92–0.87	1.41–0.59	3.66–2.32	2.08–0.08
Pineapple juice	3.75 ± 1.74	0.56 ± 0.02	1.71 ± 0.97	0.91 ± 0.03	1.64 ± 0.76	2.80 ± 0.35	0.32 ± 0.26
	6.33–1.78	0.58–0.54	2.66–0.22	0.95–0.88	3.10–0.89	3.06–2.33	0.59–0.08
Whole carrots	5.10 ± 2.55	0.60 ± 0.02	1.68 ± 0.71	0.84 ± 0.06	2.94 ± 1.38	2.64 ± 0.26	3.02 ± 1.66
	8.21–2.28	0.62–0.58	2.25–0.84	0.89–0.75	4.41–1.20	3.10–2.49	4.77–0.91

Figs. 1, 2, 3 and 4, the highest Pb concentration was found in canned green beans samples with a mean of 3.0 mg/kg, while the lowest Pb concentration was found in canned whole carrots samples with a mean of 2.64 mg/kg. These findings indicate that the concentrations of Pb in the analyzed food samples were higher than those levels set by various health organizations. The significant increase in the concentrations of Pb in the analyzed food samples might be attributed to the fact that solder used in manufacture of cans is recognized as a source of Pb contamination during canning process (MAFF (Ministry of Agriculture and fisheries and food) 1995; Voegborlo et al. 1999).

The Codex standard 193-1995 (Codex 2010) established the maximum Cd level permitted in canned tomato sauce and canned carrots as 0.05 and 0.1 mg/kg, respectively. However, there are no national limits for Cd level in canned pineapple and canned green beans. Data show that the highest Cd concentration was found in canned whole carrots samples with a mean of 0.60 mg/kg, while the lowest Cd concentration was found in canned tomato sauce with a mean of 0.49 mg/kg (Table 1, Figs. 1, 2, 3, and 4). This means that the concentrations of Cd obtained in this study were generally exceeded the permissible limits set by health organizations.

The maximum As level permitted in canned pineapple is 0.01 mg/L according to United States Environmental Protection Agency (US-EPA). Moreover, the Kenyan and East African standards (Kenya Standard 2005; East African Standard 2010) set this level as 500 ng/g (= 0.5 mg/kg) in canned tomato sauce (ketchup). In this study, the average As concentrations in canned pineapple and canned tomato sauce samples were 3.75 and 3.50 mg/kg, respectively. These findings indicate that the concentrations obtained for As in the analyzed samples were generally exceeded the permissible limits set by health organizations.

According to United States Environmental Protection Agency (US-EPA), the maximum Ni concentration permitted in canned pineapple is 0.1 mg/kg. The lowest and highest Ni concentrations were 0.97 mg/kg in canned green beans and 2.94 mg/kg in canned whole carrots as described in Table 1. This implies that the average concentrations obtained for Ni in the samples analyzed in this study were found to be above the prohibited limits for this metal.

The maximum Cr concentration permitted in canned pineapple is 0.1 mg/kg according to United States Environmental Protection Agency (US-EPA) and 0.03 mg/kg in canned tomato sauce according to Romanian Ministry of Public Health Ordinance no. 975/1998 (Harmanescu et al. 2007). Results show that the highest Cr concentration was found in canned pineapple samples with a mean of 1.71 mg/kg, while the lowest Cr concentration was found in canned tomato sauce with a mean of 0.66 mg/kg. These results indicate that the average concentrations obtained for Cr in the analyzed canned food samples in this study were found to be above the prohibited limits for this metal as shown in Figs. 1, 2, 3, and 4 and described in Table 1.

The average concentrations obtained for Pb, Cd, and As in canned tomato sauce in this study were found to be higher than those reported by Hadiania et al. (2014). The authors investigated the levels of Pb, Cd, and As in canned tomato paste and canned tomato sauce (ketchup) samples collected from Tehran, Iran using graphite furnace atomic absorption spectrophotometer (GF-AAS) for Pb and Cd and hydride vapor generation (HG-AAS or VGA) for As. The authors reported that the average concentrations of Pb in the most of the analyzed ketchup samples were lower than LOQ (< 3 ng/g) and in other samples were 25.0 ng/g, and for Cd, the average concentrations in 10% ketchup samples were lower than LOQ (<0.6 ng/g) and in other samples were 14.1 ng/g. For As, the authors reported that all analyzed ketchup samples had a total As content above LOQ (3 ng/g) with a mean of 48.2 ng/g. In addition, the obtained results for Cr, Pb, and Cd in canned tomato sauce in this study are higher than those reported by David et al. (2008) (Cr 0.18 mg/kg, Fe 219.58 mg/kg, Pb

0.27 mg/kg, Cd 0.043 mg/kg, Sn 73.78 mg/kg, Al 36.64 mg/kg, and Zn 4.03 mg/kg).

On the other side, the obtained results concerning Pb, Cd, As, Zn, Cu, and Cr in canned carrots, canned green beans, and canned pineapple are lower than those reported by Al-Thagafi et al. (2014), except for Cr. The authors determined the concentrations of toxic heavy metals in canned food samples and corresponding fresh food, for comparison collected from different local markets in Saudi Arabia using inductively coupled plasma-atomic emission spectrometer (ICP-AES). The authors reported that the concentrations of the examined heavy metals were as follows: for canned carrots, Pb 5.4 mg/kg, Cd 1.00 mg/kg, As < D.L., Zn 34.0 mg/kg, Cu 6.0 mg/kg, and for Cr 0.2 mg/kg. For canned green beans, Pb 4.6 mg/kg, Cd 0.80 mg/kg, As < D.L., Zn 33.4 mg/kg, Cu 8.6 mg/kg, and for Cr 0.4 mg/kg. For canned pineapple, Pb 79.0 mg/kg, Cd 1.0 mg/kg, As < D.L., Zn 2.2 mg/kg, Cu 3.4 mg/kg, and for Cr 0.4 mg/kg.

As the concentration levels for As, Pb, Cd, Ni, and Cr in the examined canned food samples obtained in this study were found to be above the permissible limits for these metals set by health organizations and higher than reported results found in the literature, several strict procedures have to be taken with the aim to eliminate or reduce the risk comes from these toxic heavy metals such as performing a routine analysis of the toxic heavy metals content in canned food samples sold in Jordanian market and using the advances technology in packaging (Ngoddy and Ihekomonye 1992).

Statistical analysis of results

Analysis of variance (ANOVA) one way was employed for analysis of data achieved in the present work. These findings suggest that there was a significant difference in metal concentrations between different types of canned food samples analyzed in this study ($p < 0.05$). The p values for Cd, Cu, Ni, and Zn concentrations were 0.00, 0.009, 0.008, and 0.02, respectively. On the other side, the p values for As, Cr, and Pb (0.15, 0.06, and 0.053, respectively) indicate that there was a nonsignificant difference in metal concentrations between the analyzed canned food samples ($p > 0.05$). One possible explanation of the variation of the metals concentration between the analyzed canned food samples investigated in this study (canned tomato sauce, canned green beans, canned pineapple, and canned whole carrots) might be stemmed from the type of can, possibility of corrosion of the inside body of the used can, or leaching of the metals from unlacquered cans.

Conclusion

Results obtained in this study revealed that the concentrations of toxic heavy metals Pb, Ni, Cr, Cd, and As in the analyzed canned food samples sold in Jordanian markets were exceeded the permissible limits set by different health organizations. Therefore, it can be concluded that consumption of canned vegetable and canned fruit food samples sold in Jordan, Irbid city were not safe according to these health organizations. Because the consumption rate of canned tomato sauce (ketchup), canned green beans, canned whole carrots, and canned fruit juice (pineapple) is very high in Jordan and there are no studies about them, these findings might be of use as a basis for comparison with any further investigations.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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