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Migration of Iron and some Toxic Metals to Foodstuffs During Storage

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Abstract

Heavy metal contamination is a severe threat because of its toxicity, bioaccumulation, and biomagnification in the food chain. Using an atomic absorption spectrophotometer, the concentrations of heavy metals such as cadmium, lead, aluminum, and mercury and trace elements like iron were measured in various foodstuff obtained from a local market. According to the findings, the greatest mean amounts of Fe and Al were found in canned red kidney beans. The red kidney bean cans had the lowest mean of Cd values, while the fava bean cans had the highest. The highest lead levels were found in canned fava beans, whereas the lowest was in red kidney beans. Fe levels in canned sardine samples are greater than in canned tuna samples. Pb and Cd levels were higher in canned tuna, while mercury levels were lowest. All hazardous metals were detected in all samples (milk, white cheese, and cheddar), and their concentrations were in the order Fe > Al > Pb for trace metals in milk and cheddar cheese samples. All canned juices have a higher iron level than fresh juices. In addition, mango juice in a tin container contained the most iron, whereas apple juice in a carton container contained the least. Except for mango juices packaged in a tin, no cadmium was found in fresh or canned juices. In conclusion, concentrations of major examined metals were higher than the Joint FAO/WHO, and EC Committees suggested maximum tolerable values.

***Keywords**: Foodstuffs, Metals, health risks.*

Introduction

Heavy metals are found in nature and its necessary for life, but they can accumulate in organisms and become hazardous. Heavy metals can also harm the human metabolic system, create skin illnesses, and cause cardiac difficulties, among other things. The most frequent heavy metals include arsenic, cadmium, chromium, copper, nickel, lead, and mercury. Mining, industrial production, smelters, petrochemical facilities, pesticide manufacture, chemical industry, untreated sewage sludge, and diffuse sources such as metal piping, traffic, and combustion by-products, among others, are all sources of heavy metals. Fruits and vegetables are a highly nutritious sort of food that is consumed by humans. These foods are said to be contaminated with dangerous and health-threatening compounds (1). They are non-biodegradable and have the potential to build up in various human organs, causing undesirable side effects (2). Heavy metals produced by industries and automobiles may settle on vegetable surfaces throughout production, transportation, and marketing. Because of their capacity to travel large distances in the atmosphere, mercury, lead, and cadmium are deadly heavy metals (3). The elevated level of heavy metals in the urban environment of developing countries such as Egypt, Iran, and China are due to rapid and unplanned urban and industrial expansion (4&5) etc. They're all over the place in the environment. One of the most critical areas of food quality assurance is heavy metal contamination of food items. Heavy metals are one of the most common contaminants in our food supply, and they may be the most serious threat to our ecosystem (6).

Heavy metals are naturally present in the Earth's crust. Because of their persistence, highly poisonous nature, and tendency to accumulate in the ecosystem, heavy metals pose a significant health risk to humans (7). Consumer exposure to heavy metals is a significant concern, and many studies have been conducted on it in recent decades. These metals can enter the human body through things that come into contact with food (8). They find their way into the food chain and can be found in varying concentrations in human meals. Fruits and vegetables are high in nutrients and serve as a staple meal in human diets. Due to their short shelf life, they are highly perishable (9). Sharma et al., (10) and Sharma et al., (11) found that air deposition can dramatically increase the levels of heavy metal contamination in vegetables sold in Varanasi marketplaces. Toxic and health-hazardous substances have been found in certain food products, according to reports. Publicity about the concentration of heavy metals in fruits and vegetables, according to Radwan and Salama, (12) will induce worry and fear in the public about the presence of heavy metal residues in their daily food. Given the potential toxicity and long-term persistence of heavy metals, as well as the widespread consumption of vegetables and fruits, it is vital to test these foods to guarantee that the levels of these pollutants exceed internationally agreed-upon standards. Because the readings were below the recommended daily consumption of these metals, Sajib et al., (13) concluded that daily intake of arsenic, cadmium, lead, mercury, and chromium through fresh fruits may not pose a health risk to consumers. However, if the fruits are consumed in big numbers, these levels can be dangerous. To prevent excessive build-up of toxic metals in the human food chain, it is proposed that the use of adulterants in fruits be rigorously forbidden. The use of

adulterants must be properly regulated and managed due to its potentially harmful nature. It is not simply the government's responsibility; citizens must also become aware and refrain from eating infected fruits. Chronic exposure to Hg and Hg compounds, according to Chahid et al., (14), is hazardous to human health, particularly in fetuses and children during early stages of development. This metal has the potential to harm and disrupt the central nervous system (CNS). The hematological system, the central nervous system, and the renal system are all affected by chronic Pb exposure. Long-term exposure to cadmium decreases kidney function. Parkar and Rakesh, (15) discovered that long-term ingestion of high-concentration heavy metals through foods such as fruits and vegetables can lead to chronic accumulation, which can cause damage to the heart, nervous system, liver, kidney, blood, lungs, bone, and spleen, as well as mutagenesis, carcinogenesis, and teratogenesis. Several incidences of human disease, abnormalities, deformity, and organ failures have been described as a result of metal poisoning.
The purpose of this study was to assess Fe, Pb, Al, Cd and Hg concentrations in different kinds of edible food and its products consumed in Egyptian markets.

Materials And Methods

Materials

Collection of samples:

A total of 150 random some plant and animal foods and drink samples (50 each of plant, animal and drink sample) were collected in their original package from different markets in Sheben El-Kom City, Menoufia Governorate, Egypt.
Each sample was labeled to identify the source, site and date of sampling. Collected samples were classified into four groups.
Red kidney beans, corn, tomatoes sauce, mango and fava beans.

1. Fish (tuna, and sardine), sterilized milk and cheese (white and cheddar).
2. Some juices (apple, prune, guava, mint lemon and mango juices).
3. Selected foods (chocolate cream, molasses, and mayonnaise).

All food samples canned in three packaged (tin plate, bottles, and cartons).

Methods:

All groups were analyzed by atomic absorption spectrophotometer and determine the level of heavy metals (Fe, Pb, Al, Cd and Hg) and to study the effect of storage on the distribution of these metals in tested food samples.

Sample preparation:

The cans were obtained from local market, Shibin El-Kom City, Menoufia Governorate, Egypt. The cans were opened, the liquid content was drained off within 30 minutes, using plastic sieve and then each food sample was homogenized for later digestion and metal analysis. The collected samples were washed with different water to remove any contaminated particles. Then samples were cut to small pieces. Samples were dried in an oven at 100 ºC using a ceramic mortar and stored in polyethylene bags until use for acid digestion. Food samples were storage at ambient temperature until analysis for 24 months.

Acid digestion of samples

For determination of Fe, Pb, Al, Cd and Hg, the tube of each prepared sample was digested using acid mixture (10 mL, 70% high purity HNO3 and 65% HClO4, 4:1 v/v) was added to the beaker containing 2 g dry sample according to Canli and Atli, (16). The mixture was then digested at 80 ºC till the transparent solution was achieved. After cooling, the digested samples were filtered using Whatman no. 42 filter paper and the filtrate was diluted to 50 mL with deionized water.

Analysis of the prepared samples:

For determination of aluminum the procedure was carried out on the second tube according to Dabeka and Mckenzie (17). All filled samples were analyzed for their metal contents. Samples were achieved by atomic absorption spectrophotometer (Shimadzu Model 6800 with graphite furnace Model GFA 7000, Hydride unit was used for determination of mercury) according to methods of Medine et al., (18).

Statistical analysis:

The data were analyzed using a completely randomized factorial design according to SAS (19) when a significant main effect was detected; the means were separated with the Student-Newman-Keuls Test. Differences between treatments of ($P \leq 0.05$) were considered significant using Costat Program. Biological results were analyzed by One Way ANOVA.

Results And Discussion

Data tabulated in Table (1) show the ranges of categories as (red kidney bean, corn and fava bean) of Fe and toxic metals (Pb, Al and Cd) in the fresh samples (no storage) and after storage for (24-36) month. It is clear to notice that the analysis of the variance (ANOVA) indicated a significant statistical difference ($P<0.001$) of all tested heavy metals (Fe, Pb, Al and Cd). Well as mean values in respective food types. The highest mean values of Fe and Al were detected in canned red kidney bean. The mean values were 10.824 and 0.803 ppm, respectively, with respective ranges between 9.80 - 11.57 ppm, and 0.701 – 0.913 ppm, and the lowest mean value of Fe in corn (2.33 ppm). The values as indicated by the same Table (1).

The highest value of Pb in canned fava bean being 0.524 ppm, with a range between 0.411-0.600 ppm. While, the lowest lead values in red kidney bean being 0.386 ppm, with a range between 0.30-0.460 ppm.

The Pb values in fava bean and red kidney bean cans are likewise greater than the stated EU (20) maximum allowable values in legumes (0.2 mg/kg), and our level in fava beans is higher than the FAO/WHO research on lead incidence in different food categories for European and Asian countries (21). (A maximum of 0.063 mg/kg and a mean of 0.004 mg/kg).
The lowest mean Cd values were found in red kidney bean cans, at 0.29 mg/kg, with a range of 0.21- 0.48 mg/kg, whereas the highest mean Cd values were found in fava bean cans, at 0.91 ppm, with a range of 0.21- 0.48 mg/kg (0.8- 1.00 mg/kg). The levels in fava bean were greater than the European Council's limit permissible values (0.1 mg/kg) (20). The high levels in canned vegetables and legumes manufactured in Egypt, on the other hand, are mostly owing to the overuse of phosphate fertilizers in agricultural zones.

Table (1): Concentration (ppm) of iron and toxic metals (Al-Pb) in fava beans, red kidney beans and corn (canned in tin)

Samples	Mean ± SD	Fava beans	Red kidney beans	Corn	LSD (P≤0.05)
Fe	**Fresh samples**	4.80a±0.16	5.60a±0.10	1.20b±0.14	0.940
	Canned samples	5.92b±0.11	10.82a±0.13	2.33c±0.10	1.310
	Minimum	5.0	9.80	1.26	---
	Maximum	7.85	11.57	3.21	---
Al	**Fresh samples**	0.06b±-0.11	0.65a±0.11	0.18a±0.13	0.530
	Canned samples	0.15b±0.12	0.80a±0.11	0.28b±0.13	0.562
	Minimum	0.065	0.701	0.190	---
	Maximum	0.250	0.913	0.422	---
Pb	**Fresh samples**	0.40a±0.14	0.26a±0.12	0.28a±0.10	0.241
	Canned samples	0.54a±0.10	0.39a±0.12	0.41a±0.13	0.250
	Minimum	0.411	0.30	0.29	---
	Maximum	6.00	0.460	2.03	---
Cd	**Fresh samples**	0.25a±0.10	0.20a±0.14	0.13a±0.10	0.210
	Canned samples	0.91a±0.10	0.29b±0.15	0.43b ±0.13	0.463
	Minimum	0.8	0.21	0.33	---
	Maximum	1.00	0.48	0.51	---

Each value represents mean of three replicates± standard deviation. Means in the same letters with different superscript letters are significantly different at P≤0.05.

Iron is a necessary micronutrient, but excessive amounts can be harmful to one's health. Table (2) shows the mean value and ranges of this metal in the canned fish samples studied, as well as the higher mean value of Fe in canned sardine samples (27.63 ppm) with ranges between (11.2 – 28.30 ppm) than canned tuna samples (17.80 ppm) with

respective ranges between (12.5 – 26.32 ppm). Our reported values of iron in canned fish are higher than the reported values by Tuzen and Soylak (22).
Sardine higher than tuna in toxic metals except pb as mentioned below. Results in table 2 indicate that amount of Pb in canned tuna 0.383a±0.10 higher than caned sardine by range 0.18 – 0.65.
Aluminum is not regarded as a necessary component of human life. The maximum amount of Al that can be consumed during an examination is 60 mg per day (23). Al content in fish spouse has been reported in the range of 0.02 to 5.41 ppm dry weight, according to Turkmen et al., (24). However, the Al levels in canned fish samples reported by (20) in canned tuna (0.45 mg/g) and sardine (0.98 mg/g) were greater than those reported by Tuzen and Soylak (22) in canned tuna (0.45) and sardine (0.98). They were also within the range reported by Turkmen et al., (0.02 to 5.41 mg/kg).
In terms of Pb value in canned fish, tuna had greater values of Pb (0.382 ppm) than sardine (0.127 ppm). The findings are consistent with those of (25 & 26), who suggested a Pb in fish limit of (0.3, 0.218-0.441) in Iranian tuna fish.
The mean Cd levels in canned fish tuna and sardine samples which were (0.275 and 0.289 ppm) were somewhat higher than those maximum level (0.052 – 0.61 ppm) for tuna and sardine, respectively.
Mercury had its lowest value in canned fish, with mean Hg values of 0.13 and 0.125 ppm in tuna and sardine, respectively, with a range of (0.074 – 0.190 ppm). Nonetheless, the indicated amounts in canned fish are fewer than the metal's upper limit in fish, which is 0.5 ppm (27).

Table (2): concentration (ppm) of iron and toxic metals (Al-Pb-Cd-Hg) in tuna and sardine (Canned in tin):

Samples	Mean ± SD	Tuna	Sardine	LSD (P≤0.05)
Fe	Fresh samples	3.00b±0.16	7.00a±0.14	1.531
	Canned samples	17.80b±0.13	27.63a±0.15	2.740
	Minimum	12.50	11.20	---
	Maximum	26.32	28.30	---
Al	Fresh samples	0.35a±0.10	0.50a±0.13	0.235
	Canned samples	1.20b±0.12	2.90a±0.11	0.911
	Minimum	0.81	0.55	---
	Maximum	1.76	4.10	---
Pb	Fresh samples	0.01a±0.12	0.02a±0.10	0.105
	Canned samples	0.38a±0.10	0.13a±0.12	0.330
	Minimum	0.18	0.065	---
	Maximum	0.65	0.22	---
Cd	Fresh samples	0.03a±0.13	0.02a±0.15	0.014

Samples	Mean ± SD	Tuna	Sardine	LSD (P≤0.05)
	Canned samples	0.28a±0.15	0.29a±0.11	0.172
	Minimum	0.050	0.083	---
	Maximum	0.61	0.520	---
Hg	Fresh samples	0.25a±0.11	0.05a±0.11	0.112
	Canned samples	0.13a±0.12	0.13a±0.13	0.140
	Minimum	0.075	0.074	---
	Maximum	0.186	0.190	---

Each value represents mean of three replicates± standard deviation. Means in the same letters with different superscript letters are significantly different at P≤0.05.

Table (3) shows the levels of iron and hazardous metals (Fe, Pb, Al) in milk, white cheese, and Cheddar. It is obvious that all three elements were detectable in all samples, and their amounts in milk and cheddar cheese samples were in the order Fe > Al > Pb for trace metals.

Aluminum was found in the highest concentration in white cheese, while iron was found in the highest concentration in cheddar cheese (0.122 ppm). The concentrations of Al in white cheese samples ranged from 19.95 to 22.50 ppm, with a mean of 21.07±0.17 ppm. Iron content in milk, white cheese, and cheddar cheese samples, on the other hand, ranged from 0.36 to 0.48, and 0.8 to 1.11 ppm, respectively, with mean concentrations of 0.21±0.10, 0.394±0.15, and 0.922 ±0.10 ppm.

In terms of lead content, research showed that lead was found in all milk, white cheese, and cheddar cheese samples. When compared to fresh samples, all canned milk, white cheese, and cheddar cheese samples had a higher percentage. In addition, canned cheddar cheese had the highest lead level, whereas sterilized milk had the lowest. 0.55 ppm and 0.025 ppm, respectively, were the mean values. These findings are consistent with (28) findings that cheese can be contaminated with lead from contaminated salt and, in the case of Damietta cheese, metals from tin containers. Water loss cannot explain the subsequent increase in lead levels in ripened cheese; instead, environmental factors at the ripening sites are most likely to blame. Pb contamination in cheese can also be caused by feeding cows roadside grass, which can be avoided by selecting sources of fodder that are free of Pb contamination. Lead can build up in bones and remain dormant for years, only to become a problem later in life when it is mobilized by events like pregnancy, breastfeeding, osteoporosis, and hyperthyroidism and hyperparathyroidism, which mobilize lead reserves in the bones.

Furthermore, all of the cheese samples tested had lead amounts above the maximum limit of 0.02 mg/kg wet weight (29). The FAO/WHO (30) established a heavy metal intake limit based on body weight. The preliminary tolerated daily intake (PTDI) for lead for an average adult (60 kg body weight) is 0.214 mg/kg.

Iron is a necessary component of life and our meals. Anemia is caused by a lack of iron in the body. 40, 20, 13.3, 60, 20, and 33.3 percent of the Cheddar, Gouda, Processed, Feta, Damietta, and Kareish cheese samples tested were below the Fe (0.01 mg/l) detection limit (DL= 3 standard deviation of the mean of the blank tests) (31).
According to (32), the recommended amount for daily diet (Recommended Daily Allowance- RDA) is 8 mg/kg per day Fe for men and 18 mg/kg per day Fe for women.
In conclusion, extremely dangerous heavy metals Pb and Cd were detected above the toxicity levels in all types of analyzed cheese samples, whereas levels of Fe, Cu, and Zn were within the recommended daily intake.

Table (3): Concentration (ppm) of iron and toxic metals (Al-Pb) in cheese, sterilized milk and cheddar cheese

	Mean ± SD	White cheese Carton	Sterilized milk Carton	Cheddar cheese Bottle	LSD (P≤0.05)
Fe	Fresh samples	0.34b±0.16	0.10b±0.12	0.64a±0.13	0.361
	Canned samples	0.39b±0.15	0.22b±0.10	0.92a±0.10	0.570
	Minimum	0.36	0.10	0.80	---
	Maximum	0.48	0.56	1.11	---
Al	Fresh samples	19.95a±0.16	0.05b±0.11	0.64b±0.10	1.024
	Canned samples	21.07a±0.17	0.07b±0.15	0.69b±0.14	1.305
	Minimum	19.95	0.054	0.64	---
	Maximum	22.50	0.090	0.75	---
Pb	Fresh samples	0.025b±0.13	0.03b±0.10	0.50a±0.14	0.490
	canned samples	0.032b±0.13	0.047b±0.11	0.55a±0.16	0.511
	Minimum	0.028	0.041	0.509	---
	Maximum	0.047	0.055	0.600	---

Each value represents mean of three replicates± standard deviation. Means in the same letters with different superscript letters are significantly different at P≤0.05.

The concentrations of iron and hazardous metals (Al-Pb) in tomato sauce are shown in Table (4). All three elements were detected in all samples, and their amounts were in the order Fe > Al > Pb for trace metals in tomato sauce samples, according to the data.
The highest level of iron was found in fresh tomato sauce packaging in a bottle. While the lowest level of tomato sauce packaging in tin has been observed. The averages were 19.19 and 3.80 parts per million, respectively. The values were 20.94 ppm for canned tomato sauce and 6.28 ppm for fresh tomato sauce.
Aluminum and lead, on the other hand, were found in higher concentrations in canned tomato sauce than in fresh tomato sauce. The mean values were (0.45 &0.089) and (2.54 &0.36) ppm, respectively.

In terms of cadmium levels, studies revealed that cadmium was only detected in tomato sauce tin packing. The highest level ever recorded for tin-packaged canned tomato sauce. On the other side, the lowest reported for tin packaging of fresh tomato sauce. The averages were 0.5 and 0.14 parts per million, respectively. Cadmium was not found in tomato sauce packaging in either the carton or the bottle. These findings support those of Akbudak et al., (33), who found that canned tomato pastes are one of the most often consumed canned vegetables in many countries' diets, providing flavour, colour, vitamin, and mineral advantages.

They may, however, be a source of heavy metal toxicant exposure through the food. Heavy metals may be present in canned tomato paste as a result of plants absorbing them from contaminated soil, polluted water, or agrochemicals. Harvested fruits can also be polluted during the canning process or by metal containers leaching into the canned product during storage (34).

Preservatives, stabilizers, and synthetic colourants may also contaminate processed tomato paste, resulting in heavy metal contamination (35).

All of the tomato samples exhibited the highest content of iron, ranging from 1.68±1.63 mg/kg to 58.57±14.52 mg/kg. All of the canned tomato samples had Cd levels that were below the detection limit. Fe was found in concentrations ranging from 1.68±1.63 to 58.57±14.52 mg//kg. In canned tomatoes, mean levels of Mn, Pb, and Hg are 2.62±0.334 to 5.75±0.465 mg /kg, 0.07±0.003 to 0.116±0.012 mg/kg, and 0.011±0.001 to 0.102±0.001 mg/kg, respectively. Heavy metal levels were observed to decrease in the following order in six brands of canned tomato paste: Fe >Zn>Mn>Pb>Hg >Cd Metal concentrations in five brands of canned tomatoes were within WHO/FAO food safety guidelines (36).

Table (4): Concentration (ppm) of iron and toxic metals (Al-Pb) in tomato sauce

Container	Mean ± SD	Carton	Tin	Bottle	LSD (P≤0.05)
Fe	Fresh samples	12.71b±0.14	3.80c±0.11	19.19a±0.15	2.051
	Canned samples	13.55b±0.16	6.28c±0.12	20.94a±0.13	2.341
	Minimum	12.90	5.80	19.89	---
	Maximum	14.10	6.90	22.80	---
Al	Fresh samples	1.76a±0.13	1.60a±0.10	0.031b±0.12	0.554
	Canned samples	2.54a±0.10	1.68b±0.15	0.045c±0.10	0.620
	Minimum	2.03	1.76	0.038	---
	Maximum	3.10	2.50	0.052	---
Pb	Fresh samples	0.26a±0.10	0.25a±0.13	0.05c±0.10	0.160
	Canned samples	0.36b±0.14	0.52a±0.14	0.09c±0.15	0.183
	Minimum	0.29	0.28	0.059	---
	Maximum	0.43	1.35	0.11	---

Container	Mean ± SD	Carton	Tin	Bottle	LSD (P≤0.05)
Cd	Fresh samples	0.0	0.14±0.15	0.0	---
	Canned samples	0.0	0.50±0.14	0.0	---
	Minimum	0.0	0.15	0.0	---
	Maximum	0.0	1.75	0.0	---

Each value represents mean of three replicates± standard deviation. Means in the same letters with different superscript letters are significantly different at P≤0.05.

The concentrations of iron and hazardous metals (Al-Pb) in various juices are shown in Table (5). It goes without saying that the iron content of all canned juices was higher than that of fresh juices, with a significant difference (P≤0.05). Also, mango juice in a tin container had the highest level of iron, whereas apple juice in a carton container had the lowest, with a significant difference (P≤0.05). The mean values were 3.73 and 0.66 ppm, respectively.

Aluminum levels in all-canned juices, on the other hand, were greater than those in fresh juices with no significant difference (P≤0.05). Also, mango juice in a tin container had the greatest level of aluminum in jounces, while apple juice in a carton container had the lowest, with no significant difference (P≤0.05), at 0.91 and 0.28 ppm, respectively.

When it came to lead levels, canned juices had a greater level than fresh juices, but there was no statistically significant difference (P≤0.05). Also, mango juice in carton container had the greatest level of lead in juices, whereas prune and guava by mean 0.15 in carton container had the lowest, with no significant difference (P≤0.05), at 0.91 and 0.28 ppm, respectively.

In terms of cadmium content, data showed that cadmium was not detected in any of the fresh or canned juices, with the exception of mango juices packaged in tin, where there was a significant difference (P≤0.05) between fresh and canned mango juices. Also, with a significant difference (P≤0.05), the highest level of cadmium in mango jounces was observed for canned mango juice in tin container, while the lowest was found for fresh mango juice in tin container, with 0.85 and 0.20 ppm, respectively. These findings are consistent with those of Ona et al., (37), who stated that lead and cadmium exposure pose the greatest harm to human health from heavy metals. Lead is a naturally occurring element that can be dangerous at high concentrations. Cadmium is a heavy metal that is known to be hazardous to plants and is categorized as a human carcinogen.

The nature of the fruit, the mineral composition of the soil from which it came, the composition of the irrigation water, the weather conditions, agricultural methods such as the types and amounts of fertilizers employed, and other factors may all influence the trace element levels in fruit juices (38).

Aluminum (Al) was found in the highest concentration in the examined juices and nectars, according to Kowalska et al., (39), with average concentrations ranging from 1.34 mg/kg

in orange juices (glass) to 4.26 mg/kg in black currant nectar (glass). Fruit juices and nectars stored in tetra pack packaging had higher concentrations of Al and antimony (Sb) than those kept in glass packaging, which had much higher concentrations of as than those held in tetra pack packaging. Exposure to non-carcinogenic factors was demonstrated despite average trace element concentrations being lower than the standard limit.
According to Tufuor et al., (40), evidence of essential and non-essential heavy metals was found in citrus fruits from Ghana's Abura- Asebu- Kwamankese District. The citrus fruits tested included Fe, Zn, Pb, Cu, and arsenic (as), with mean amounts of 1.2065, 2.40110, 2.9210-2 ppm, 4.31310-3 ppm, and 1.09010-3 ppm, respectively. No Cr or Ni were found in any of the samples. Cu, Zn, and Fe levels in the critical metals were well below the necessary daily consumption. As a result, eating oranges, lemons, or limes from Ghana's Abura- Asebu- Kwamankese District is safe, as the levels of all metals identified in them were significantly lower than the dietary reference values established by the UK Department of Health and the US Environmental Protection Agency.
Heavy metal concentration (Pb, Cd, Fe, Cu, and Zn) was identified at various levels in the collected samples (apple, orange, and mango juices). Natural levels of Cu, Zn, and Fe were observed in apple, orange, and mango juice samples, but all collected fruit juice samples (60) were free of any detectable Cd and Pb residues. Our findings show that heavy metal contamination levels in fruit juices were often lower than those set forth in Commission Regulation (EC) No 1881/2006 Abdel-Rahman and Abdellseid, (41).

Table (5): Concentration (ppm) of iron and toxic metals (Al-Pb) in various juices

	Mean± SD	Apple Juice Carton	Mango juice Tin	Mango juice Carton	Prune juice Carton	Mint and lemon juice Carton	Guava juice Carton	LSD (P≤0.05)
Fe	Fresh	0.59±0.10	3.20a±0.13	0.85b±0.10	1.11b±0.13	0.78b±0.13	0.96b±0.11	0.442
	Canned	0.66b±0.11	3.73a±0.14	0.99b±0.12	1.27b±0.10	1.00b±0.13	1.31b±0.14	0.485
	Min.	0.59	3.5	0.91	1.16	0.90	0.99	----
	Max.	0.71	4.00	1.07	1.40	1.50	1.60	----
Al	Fresh	0.19a±0.13	0.10b±0.14	0.16b±0.12	0.37a±0.13	0.10c±0.10	0.12b±0.12	0.213
	Canned	0.29c±0.15	0.54b±0.13	0.91a±0.12	0.57b±0.15	0.28c±0.10	0.40b±0.12	0.201
	Min.	0.20	0.21	0.60	0.40	0.19	0.14	----
	Max.	0.39	2.20	1.20	0.80	0.37	0.60	----
Pb	Fresh	0.05b±0.10	0.26a±0.10	0..03b±0.1	0.07b±0.1	0.06b±0.10	0.08b±0.14	0135
	Canned	0.07a±0.14	0.44b±0.12	0.57a±0.10	0.15a±0.15	0.81a±0.12	0.15a±0.13	0.051
	Min.	0.060	0.29	0.09	0.070	0.70	0.081	----
	Max.	0.080	0.65	1.25	0.24	0.89	0.190	-----
Cd	Fresh	——	0.20a±0.12	——	——	——	——	——

Canned	——	0.85b±0.12	——	——	——	——	——
Min.	——	0.60	——	——	——	——	——
Max.	——	1.10	——	——	——	——	——

Each value represents mean of three replicates± standard deviation. Means in the same column with different superscript letters are significantly different at P≤0.05.

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انتقال الحديد وبعض المعادن السامة إلى المواد الغذائية أثناء التخزين

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الملخص العربى
بسبب سميتها وتراكمها فى الكائنات الحية وتضخمها في السلسلة الغذائية ، فإن التلوث بالمعادن الثقيلة يمثل تهديدًا خطيرًا. باستخدام مقياس الطيف الضوئي للامتصاص الذري ، تم قياس تركيزات المعادن الثقيلة مثل الكادميوم والرصاص والألمنيوم والزئبق ، وكذلك العناصر النادرة مثل الحديد ، في عينات متنوعة من المواد الغذائية التي تم الحصول عليها من السوق المحلي. وفقًا للنتائج ، تم الحصول على أكبر متوسط من Fe ، Al في الفاصوليا الحمراء المعلبة. علب الفاصوليا الحمراء كانت تحتوي على أقل متوسط للكادميوم ، في حين أن علب الفاصولياء احتوت على أعلى نسبة. تم تسجيل أعلى مستويات للرصاص في الفول المعلب ، بينما سجلت أقل المستويات في الفاصوليا الحمراء. مستويات الحديد في عينات السردين المعلبة أعلى من عينات التونة المعلبة. كانت مستويات الرصاص والكادميوم أعلى في التونة المعلبة ، بينما كانت مستويات الزئبق أقل. تم الكشف عن جميع المعادن الخطرة في جميع العينات (اللبن والجبن الأبيض والشيدر) ، وكانت تركيزاتها بالترتيب Fe> Al> Pb للمعادن في عينات اللبن وجبن الشيدر. تحتوي جميع العصائر المعلبة على نسبة حديد أعلى من العصائر الطازجة. بالإضافة إلى ذلك ، احتوى عصير المانجو في عبوة من الصفيح على معظم الحديد ، بينما احتوى عصير التفاح في عبوة كرتونية على أقلها. باستثناء عصائر المانجو المعبأة في علب ، لم يتم العثور على الكادميوم في أي من العصائر الطازجة أو المعلبة. في الختام ، تم الحصول على تركيزات المعادن الرئيسية التي تم فحصها لتكون أعلى مما اقترحته اللجان المشتركة بين منظمة الأغذية والزراعة ومنظمة الصحة العالمية والمفوضية الأوروبية للقيم القصوى المسموح بها.

الكلمات الدالة: المواد الغذائية ، المعادن ، المخاطر الصحية.