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Trace Toxic Metal Levels in Canned and Fresh Food: A Comparative Study

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Abstract: The concentration of 27 elements of mineral and toxic heavy metals have been determined in 55 samples of canned and corresponding fresh food, for comparison. These samples (30 of them is canned food and the rest is fresh food) were collected from different local markets of western district of Saudi Arabia. For reliable, accurate and precise measurements, Inductively Coupled Plasma - Atomic Emission Spectrometer (ICP-AES) has been used to quantify the levels of the studied metals in the food samples after digestion using microwave system. The results obtained showed that, the mean ranges of the elements analyzed in (mg kg^{-1}) between the fresh and canned food are as follows: Fe (34.35 – 164.1), Al (6.63 – 41.14), Mn (11.73 – 17.95), Pb (2.31 – 7.11), Zn (24.14 – 26.76), Cu (6.22 – 8.03), Ca (1611 – 8557), Mg (1669 – 1206), Na (9918 – 23787), respectively. Some of the measured values found, not only relatively high in canned compared to fresh food samples, but also exceeds the international tolerance levels. The monitoring of mineral and heavy metals in fresh and canned food samples is vital important challenge to control and improve the food industry strategies.

Keywords: Toxic Metals; Microwave; Inductively coupled plasma atomic emission spectrometer (ICP-AES); Fresh Food; Canned Food.

I. Introduction

Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in bio-systems through contaminated water, food, soil and air. Therefore Monitoring programs for residues and contaminants contribute to improving food safety, warn of actual and potential food scares, and facilitate evaluation of possible health hazards by providing continuous information on levels of environmental pollution in the country [1]. Trace heavy metals are important in daily diets, because of their essential nutritious value and possible harmful effects. Metals like iron, copper, zinc, cobalt and manganese are essential metals since they play an important role in biological systems; whereas mercury, lead, cadmium, etc. are non-essential metals which can be toxic even in trace amounts. The essential metals can also have harmful effects when their intakes exceed the recommended quantities significantly [2]. Heavy metals are metallic elements which have a high atomic weight and a density much greater (at least 5 times) than water. There are more than 20 heavy metals, but four are of particular concern to human health: lead (Pb), cadmium (Cd), mercury (Hg), and inorganic arsenic (As) [3]. Further, some of the chemical pollutants such as the heavy metals are toxic, persistent and not easily biodegradable [4]. Some transition metals at trace level in our metabolism play effective roles for healthy life. Heavy metals normally occurring in nature are not harmful, because they are only present in very small amounts. However, if the levels of these metals are elevated, then they can show negative effects. Indeed, the effects of toxic metals that may result in symptoms and disease can be broken into two distinct, (a) Direct toxic effects that damage tissues and interfere with normal metabolic processes.(b) Displacement and/or depletion of essential nutrients leading to nutritional deficiencies and associated health concerns [5]. The main sources of heavy metal ions are directly foods, water and indirectly industrial activities and traffic in the investigated area, etc [6]. Sources of toxic metals are many and varied. They occur naturally in nature and may accumulate in the food chain and water supply due to high levels in particular locations. However, anthropogenic (manmade) sources account for a large amount of the toxic metals we are exposed to in the modern day. On the other hand, canned foods offer a shortcut in meal preparation which is most favoured by those who are stretched for time. The subject of heavy metals is receiving increasing scrutiny in food industry due to increasing incidents of contamination in agriculture and seafood sources. Apart from the threat from polluted environment, canned food is subjected to heavy metals contamination during the canning process. Solder used in manufacture of cans has been recognized as a source of lead contamination during canning. Environmental contamination and exposure to heavy metals such as mercury, cadmium and lead is a serious growing problem throughout the world. Human exposure to heavy metals has risen dramatically in the last 50 years as a result of an exponential increase in the use of heavy metals in industrial processes and products [7]. Many occupations involve daily heavy metal exposure; over 50 professions entail exposure to mercury alone. In today's industrial society, there is no escaping exposure to toxic chemicals and metals. In light of that, routine monitoring is performed to ascertain the metal contents are within the range of the permitted levels. In addition, it is essential to identify the interaction between the foodstuff and its package, particularly when it is being purchased and consumed nationwide on a regular basis [8]. The ingestion of food is an obvious means of exposure to metals, not only because many metals are natural components of food stuffs, but also environmental contamination and contamination during processing [9]. Therefore, the continuous monitoring of the levels of the mineral, toxic and heavy metals in fresh and canned food stuffs using accurate and precise tools become a vital challenge to control the food quality.

II. MATERIALS AND METHODS

1. **Sampling:** A total of fifty five investigated food samples (thirty canned food and twenty five fresh food samples) table 1 were collected from the different local markets of western province of Saudi Arabia. The different samples were transported to the laboratory and stored in a clean dry place prior to the digestion and analysis.
2. **Reagents:** All reagent used were of Analytical Reagent Grade unless otherwise stated. Deionized water with conductivity <0.2 µS/cm obtained from a Milli-Q water system (Millipore, France, Elix 10) was used to prepare standard samples, dilute the digested food samples and washing all glassware throughout. Nitric acid (69%) was purchased from Sigma-Aldrich (Germany). All the plastics and glassware were cleaned by soaking in dilute nitric acid, washed by distilled water and were rinsed with de-ionized water and air dried before use. Mixed working standard solutions of the investigated mineral and toxic heavy metal ions were prepared by appropriate stepwise dilutions of certified stock atomic spectroscopy standards (5% HNO_3, 3-500 mg kg^{-1}, Perkin Elmer, USA) were used for ICP-AES validation measurements.
3. **Apparatus:** A Perkin-Elmer (Optima 2100 DV, Norwalk, CT, USA) inductively coupled plasma atomic emission spectrometer (ICP-AES) instrument connected with an AS 93 Plus auto-sampler was used in this study. The 40-MHz free-running generator was operated at a forward power of 1300 W; the outer, intermediate and Ar carrier gas flow rates were 15.0, 0.2 and 0.8 L/min, respectively. The pump flow rate was 1.5 mL/min. The carrier gas flow rate was optimized to obtain maximum signal-to-background ratios. Microwave digestion system (Closed Vessel Acid Digestion -MARS System -CEM) procedure was chosen for the digestion of all the investigated food samples, because of shorter required time, smaller deviations, excellent recovery and precision than other procedures [2]. The optimum digestion condition of microwave digestion system (maximum power 1600 watts, maximum pressure 800 psi, maximum temperature 300 ^oC) equipped with closed vessel (Easy Prep) of Teflon reaction vessels was used in all the digestion procedures of food samples. The reaction vessels were cleaned using 5 ml of concentrated nitric acid and thoroughly rinsed with de-ionized water before each digestion.
4. **Sample Preparation:** The collected fresh food samples were thoroughly washed and rinsed with de-ionized water. The samples were then sliced to small pieces and put in Petri dishes, then oven dried at 120˚C for 4 hours. The dried samples were stored in a fresh plastic bag after cooled ready for digestion. However the canned food samples were directly put in Petri dishes without washing with de-ionized water. The samples were then oven dried at 120˚C for 6 hours. The dried samples were stored in a fresh plastic bag after cooled ready for digestion.
5. **Sample Digestion:** Digestion of all food samples for mineral and toxic heavy metals analysis involved a high performance microwave assisted digestion using (Closed Vessel Acid Digestion - MARS System- CEM). In this case, portions of 0.5g of dried samples were weighed and deposit directly onto the base of clean, dry Teflon microwave digestion vessels (Easy Prep vessel). A total of 10 mL of concentrated nitric acid HNO_3 (69%) were added to the investigated food samples that were sealed and digested via one stage temperature ramping (ramped

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to 200 °C for 25 minutes, held for 15 minutes). Two blank samples containing only nitric acid were prepared in the same way. The solution was allowed to cool, quantitatively transferred into a 100 ml volumetric flask and then, diluted to the mark with de-ionized water. After dilution, all digested sample solutions were clear before to be analysis by ICP-AES.

6. **Mineral and Heavy Metal Analysis:** The mineral and toxic heavy metal ions were analyzed using ICP-AES under optimized plasma condition. Using the auto-sampler, the measured samples were nebulized downstream to the plasma and the concentrations were automatically determined using the standard calibration graph. The ranges of standard concentrations used varied between 0.03 (e.g., Pb) and 50 (e.g., Ca) mg L^{-1} depending on the nature of the investigated metal ions. The system was adjusted to measure the samples in triplicates and the relative standard deviation was automatically calculated. The RSD was < 2 % and the correlation coefficient was > 0.99998.

Table 1. The investigated fresh and canned food samples

III. RESULTS AND DISCUSSION

No.	Fresh Food		Canned Food	
	Type	Origin	Type	Origin
1	Beef	Saudi Arabia	Corned Beef	Brazil
2	Beet	Saudi Arabia	Beet	France
3	Black Olives	Spain	Black Olives	Spain
	Olive	Spain		
4	Broad Beans	Egypt	Broad Beans	United Arab Emirates
5	Carrot	Saudi Arabia	Carrot	United States
6	Chicken	Saudi Arabia	Chicken	Denmark
7	Chicken sausage	Saudi Arabia	Chicken sausage	Denmark
8	Chickpeas	Mexico	Chickpeas	Lebanon
9	Coconut	India	Coconut	Thailand
10	Corn	Saudi Arabia	Corn	Thailand
11	Green beans	Saudi Arabia	Green beans	United States
12	Green Olive	Spain	Green Olive	Spain
13	Mango	Indonesia	Mango	Thailand
14	Mushrooms	Saudi Arabia	Full mushrooms	Indonesia
			Mushroom pieces	China
15	Papaya	Yemen	Papaya	Thailand
16	Peach	America	Peach	China
17	Peas	Saudi Arabia	Peas	Saudi Arabia
18	Pineapple	Kenya	Pineapple	Thailand
19	Sardines	Saudi Arabia	Sardines	Morocco
			Sardines in tomato sauce	Philippines
20	Spinach leaves	Saudi Arabia	Spinach leaves	United States
21	Strawberry	United States	Strawberry	Spain
22	Tomatoes	Saudi Arabia	Tomatoes	Italy
			Tomato paste	United States
23	Tuna	Saudi Arabia	Tuna	Indonesia
			Tuna	Yemen
24	White beans	Saudi Arabia	White beans	America
			Red beans	United States
			Black beans	United States

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In a comparison studies, the concentration of about 27 elements of the mineral, toxic and heavy metals have been detected in about 55 samples of fresh and canned foodstuffs using ICP-AES under the optimum conditions and after digestion using closed vessel microwave digestion system. Thus, this new digestion technique results in a reasonable high accuracy and accuracy of the results obtained. These can easily detectable from the standard deviation and noticed correlation of the data obtained. The investigated samples were collected from local market of western province of Saudi Arabia.

Under the optimized condition which mentioned in the experimental part, a numerous number of alkali metals, alkaline earths, transition metals and toxic heavy metals have been detected using the inductively coupled plasma-atomic emission (ICP-AES) technique. The multi element detection have been performed in all the investigated fresh and canned food samples directly after the digestion using closed vessel based microwave system. ICP-AES has been selected in our study based on its advantages of multi-elementary characteristics that allow rapid analysis, with good precession and accuracy.

1. **Major and mineral elements:** Minerals are important components required by humans in their daily food Humans need. These include more than 22 mineral elements: some of them are required in large amounts such as calcium (Ca), magnesium (Mg) and potassium (K), etc., but others, such as copper (Cu), zinc (Zn) and selenium (Se), are required in trace amount because higher concentration of such elements can be harmful [10]. Based on the preceding facts, about 5 elements of the major and mineral elements (Ba, Mg, K, Ca and Na) have been measured in 55 fresh and canned food samples using ICP-AES under the optimized condition and after microwave digestion. The results obtained were presented as mg of metal per kg of food samples. The mineral elements (Ba, Mg and K) have almost the same level in both fresh and canned food samples. It worth mentioned here that, the high correlation of the levels of these elements indicates that they have the same source which means they come from the food itself, but the contents of Ca and Na in fresh food were found to be in the range of 2.60 – 10938 mg kg^{-1} for calcium and <D.L – 72280 mg kg^{-1} for sodium with the means values of 1611and 9918 mg kg^{-1}, respectively. While these metals in canned food were found to be in the range of 153.2 – 115540 mg kg^{-1} for calcium and 90.00 – 112460 mg kg^{-1} for sodium with the means values of 8557and 23787 mg kg^{-1}, respectively. The levels of major and mineral elements (Ca and Na) detected in canned food samples are relatively high in comparison with those obtained with the corresponding fresh food samples. The high percentage of Ca and Na in canned food may be attributed to the spices which are widely consumed for adding flavours. These additives generally, provide sources of some important minerals in such canned foodstuffs. Moreover, the high levels of (Na^+) in canned food samples may also due to another additive as sodium nitrite which used as food preservatives. Such observations were reported in similar studies [2].

2. **Toxic Metals:** Heavy metals have health hazards if their concentrations exceed allowable limits. Even when the concentrations of metals do not exceed these limits, there is still a potential for long–term contamination, since heavy metals are known to be accumulated within biological systems. In recent years, increasing awareness of the environmental impact of heavy metals has prompted a demand for the purification of industrial waste water prior to discharge into natural waters. This has led to the introduction of more strict legislation to control water pollution [11]. Since the aim of this study was to gather information on the concentration of toxic and heavy metals in a variety of foodstuffs around Saudi Arabia. About 11 toxic elements have been determined in 55 fresh and canned food samples using ICP-AES, after microwave digestion. The data was presented as mg kg^{-1} and summarized in table 2 (a), (b), (c). Based on the data shown in fig. 1 (a), (b) and in order to compare between the investigated heavy metal levels in fresh and the corresponding canned food samples, their means values of the investigated metals Pb, Cd, Se, Zn, As and Cu have a greater values in the canned food than in the fresh food. While the mean values of the rest of the investigated metals La, Li, Ti and Sr showed nearly the same values both in the fresh and canned food. The relatively high values of the toxic heavy metals in canned food samples than those determined in the corresponding fresh food samples were attributed to the preservation additives, food processing and cans processing.

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Table 2. Toxic metals levels of (a) Pb, Cd and Se, (b) As, Zn and Cu , (c) Li and Ti in fresh and canned food

(a)

Sample	Fresh Food, mg kg $^{-1}$			Canned Food, mg kg $^{-1}$		
	Pb	Cd	Se	Pb	Cd	Se
1	2.00	0.40	4.40	4.00	1.00	6.40
2	2.20	0.40	1.80	4.20	1.00	4.40
3	3-A 1.80	0.60	4.20	4.00	1.00	6.60
	3-B 2.00	0.60	4.40			
4	2.20	0.20	2.80	4.80	1.00	5.20
5	2.40	0.20	2.60	5.40	1.00	5.40
6	2.00	0.40	4.20	4.20	1.00	7.20
7	3.20	0.40	4.20	3.40	1.00	7.40
8	2.40	0.20	3.40	3.80	1.00	6.20
9	2.00	0.40	3.80	3.80	1.00	7.60
10	2.80	0.20	2.80	5.40	1.00	5.60
11	2.00	0.20	3.00	4.60	0.80	3.20
12	2.20	0.60	3.40	3.20	0.80	3.00
13	2.60	0.20	2.40	3.80	1.00	4.60
14	2.20	0.60	3.40	14-A 4.80	1.00	6.20
				14-B 4.20	1.00	7.20
15	3.00	0.60	2.20	3.80	1.00	3.20
16	2.20	0.20	1.60	3.60	1.00	4.00
17	1.80	0.20	2.60	4.80	18.80	4.80
18	2.00	0.40	1.80	79.00	1.00	4.00
19	2.60	0.60	6.20	19-A 3.00	1.80	8.00
				19-B 4.60	1.40	7.60
20	3.40	0.60	3.40	3.40	1.20	4.20
21	2.00	0.20	2.20	4.20	1.00	4.00
22	1.60	0.20	2.60	22-A 5.40	1.00	3.40
				22-B 13.80	1.60	3.60
23	2.60	0.40	5.60	23-A 3.60	1.00	6.00
				23-B 4.00	1.00	7.00
24	2.60	0.20	2.00	24-A 4.00	1.00	4.40
				24-B 4.00	0.80	5.20
				24-C 8.60	1.00	4.80
Mean	2.31	0.37	3.24	7.11	1.64	5.35

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(b)

Sample	Fresh Food, mg kg $^{-1}$			Canned Food, mg kg $^{-1}$		
	As	Zn	Cu	As	Zn	Cu
1	<D.L	146.0	2.20	<D.L	106.2	2.80
2	<D.L	13.40	5.40	<D.L	24.60	8.40
3	3-A <D.L	9.60	10.40	<D.L	4.00	10.00
	3-B <D.L	1.20	14.80			
4	<D.L	15.60	4.80	<D.L	27.60	7.20
5	<D.L	7.00	2.20	<D.L	34.00	6.00
6	<D.L	19.80	0.80	<D.L	33.40	2.00
7	<D.L	17.00	1.20	<D.L	40.60	3.20
8	<D.L	30.20	9.80	<D.L	23.00	10.60
9	<D.L	12.80	6.80	<D.L	7.80	4.20
10	<D.L	10.60	1.20	<D.L	15.20	3.00
11	<D.L	22.40	5.80	<D.L	33.40	8.60
12	<D.L	<D.L	4.20	<D.L	2.40	6.60
13	<D.L	<D.L	3.40	<D.L	<D.L	3.20
14	<D.L	52.60	32.00	14-A <D.L	43.40	15.20
				14-B <D.L	48.20	26.60
15	<D.L	0.40	2.20	<D.L	<D.L	1.40
16	<D.L	5.00	5.60	<D.L	1.20	3.20
17	<D.L	27.00	6.60	<D.L	22.60	9.20
18	<D.L	3.40	4.60	<D.L	2.20	3.40
19	<D.L	51.80	4.60	19-A 1.00	19.80	3.60
				19-B <D.L	36.80	6.80
20	<D.L	62.80	11.40	<D.L	56.40	11.20
21	<D.L	8.80	3.20	<D.L	3.40	3.20
22	<D.L	3.00	3.80	22-A <D.L	18.60	12.40
				22-B <D.L	32.00	31.00
23	<D.L	11.40	2.80	23-A <D.L	20.00	2.40
				23-B <D.L	11.60	2.00
24	<D.L	23.40	5.60	24-A <D.L	28.80	9.80
				24-B <D.L	22.20	11.00
				24-C <D.L	30.00	12.60
Mean	-	24.14	6.22	-	26.76	8.03

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(c)

Sample	Fresh Food, mg kg $^{-1}$		Canned Food, mg kg $^{-1}$	
	Li	Ti	Li	Ti
1	<D.L	3.80	<D.L	4.20
2	<D.L	9.00	1.40	4.40
3	3-A 2.20	2.20	0.20	3.20
	3-B 6.00	3.80		
4	<D.L	5.20	<D.L	3.20
5	0.20	3.80	<D.L	2.80
6	<D.L	4.00	<D.L	4.80
7	<D.L	4.60	<D.L	3.80
8	<D.L	4.00	<D.L	3.20
9	<D.L	3.60	<D.L	3.60
10	<D.L	10.80	<D.L	3.20
11	0.20	3.80	0.20	7.80
12	0.40	2.80	3.60	4.80
13	<D.L	5.60	<D.L	4.20
14	0.20	5.80	14-A <D.L	4.00
			14-B 1.00	22.40
15	<D.L	5.00	<D.L	3.80
16	<D.L	4.00	<D.L	3.20
17	<D.L	3.60	<D.L	4.00
18	<D.L	4.20	<D.L	3.40
19	0.40	6.00	19-A 0.40	3.60
			19-B 0.40	2.80
20	0.20	10.80	1.20	2.20
21	<D.L	10.20	<D.L	4.20
22	<D.L	3.20	22-A 0.20	5.00
			22-B 2.20	9.80
23	<D.L	4.80	23-A <D.L	3.60
			23-B <D.L	4.20
24	<D.L	4.00	24-A <D.L	3.20
			24-B 0.20	4.40
			24-C <D.L	3.80
Mean	1.23	5.14	1.00	4.69

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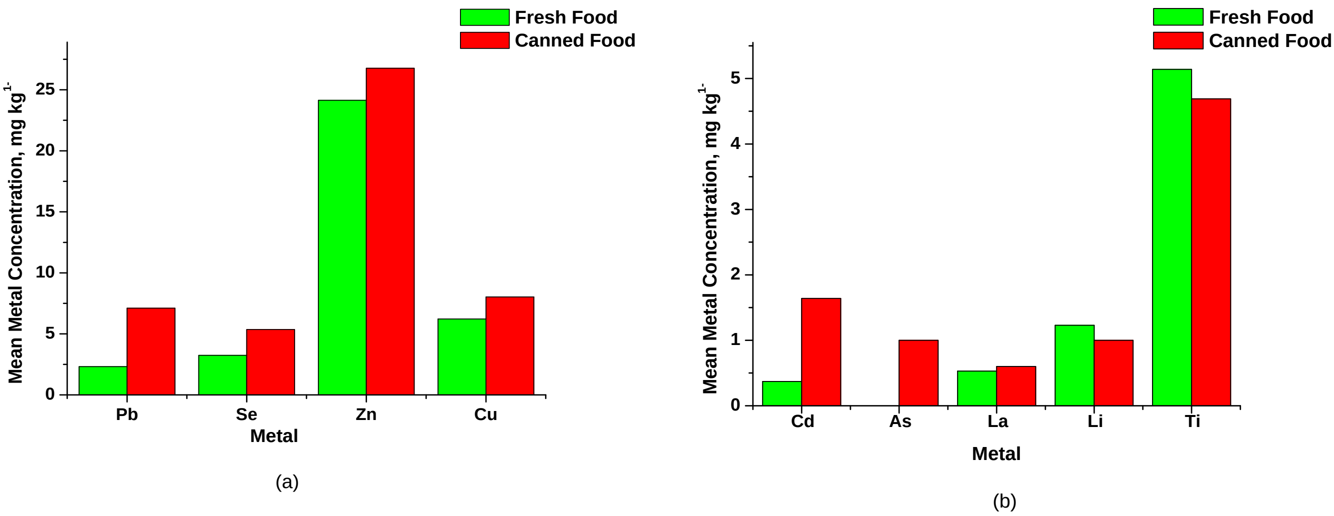

Fig. 1. Toxic metals concentrations of (a) Pb, Se, Zn and Cu, (b) Cd, As, La, Li and Ti in fresh and canned food sample

3. Food Contact Metal: Metals and alloys such as: Al, Fe, Cr, Co and Ni are used as food contact materials, mainly in processing equipment, containers and household utensils but also in foils for wrapping foodstuffs [12]. For comparison, the mean values of the food contact metals measured in the investigated fresh and corresponding canned food samples have been presented. The data was presented as mg kg^{-1} and summarized in table 3 (a), (b). The distribution of concentrations of food contact metals in food samples are shown in fig. 2 (a), (b). As can be seen, the elements (Fe, Al, Sb, Cr, Ag and Mn) have a greater percentage in the canned food than in the fresh food whatever their levels fall below or above the maximum tolerance levels. The relatively high levels of such elements particularly in canned food samples may be attributed to the use of these elements and their alloys as food contact materials and the use of their organic and inorganic compounds as additives for food. Moreover five elements namely; Be, Ni, Co, V and Tl have been also determined in all the investigated fresh and canned food samples using ICP-AES under the same optimized conditions. The levels of these elements were below the detection limits of the used method in all investigated fresh and canned food samples.

Table 3. Food contact metals levels of (a) Sb, Cr and Ag, (b) Mn, Fe and Al in fresh and canned food

(a)

Sample	Fresh Food, mg kg^{-1}			Canned Food, mg kg^{-1}		
	Sb	Cr	Ag	Sb	Cr	Ag
1	1.20	<D.L	<D.L	2.80	0.40	0.80
2	0.40	<D.L	<D.L	0.60	0.20	<D.L
3	3-A 1.00	<D.L	<D.L	2.20	<D.L	8.60
	3-B 1.20	<D.L	<D.L			
4	0.40	<D.L	<D.L	2.00	0.20	<D.L
5	<D.L	<D.L	<D.L	0.80	0.20	<D.L
6	1.00	<D.L	<D.L	2.60	<D.L	<D.L
7	0.60	0.20	<D.L	2.60	1.00	<D.L
8	0.20	0.20	<D.L	1.80	0.40	<D.L

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9	1.80	<D.L	<D.L	2.80	0.40	<D.L
10	<D.L	<D.L	<D.L	2.40	<D.L	23.60
11	0.60	<D.L	<D.L	<D.L	0.40	<D.L
12	0.60	<D.L	<D.L	<D.L	<D.L	1.00
13	0.40	<D.L	<D.L	1.40	<D.L	0.40
14	<D.L	<D.L	<D.L	14-A 1.80	0.40	<D.L
				14-B 2.20	0.20	<D.L
15	0.60	<D.L	<D.L	<D.L	1.40	<D.L
16	<D.L	<D.L	<D.L	<D.L	<D.L	<D.L
17	<D.L	<D.L	<D.L	1.60	0.60	<D.L
18	0.40	<D.L	<D.L	<D.L	0.40	<D.L
19	1.20	<D.L	<D.L	19-A 2.20	0.20	<D.L
				19-B 1.40	0.40	4.00
20	<D.L	<D.L	<D.L	<D.L	0.40	<D.L
21	0.40	<D.L	<D.L	1.20	<D.L	<D.L
22	1.00	<D.L	<D.L	22-A <D.L	0.80	<D.L
				22-B 0.80	0.40	<D.L
23	0.80	<D.L	<D.L	23-A 1.80	<D.L	<D.L
				23-B 1.80	0.20	<D.L
24	0.40	<D.L	<D.L	24-A 2.00	<D.L	<D.L
				24-B 1.80	<D.L	<D.L
				24-C 1.80	0.20	<D.L
Mean	0.74	-	-	1.84	0.44	6.40

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(b)

Sample	Fresh Food, mg kg $^{-1}$			Canned Food, mg kg $^{-1}$		
	Mn	Fe	Al	Mn	Fe	Al
1	<D.L	56.80	3.60	<D.L	257.0	202.6
2	26.20	17.60	3.60	20.00	221.6	14.20
3	3-A 12.40	139.4	3.00	3.60	698.0	10.20
	3-B 1.40	5.60	8.60			
4	11.00	32.40	4.20	21.00	58.00	18.80
5	2.40	7.00	2.60	12.20	125.6	7.60
6	<D.L	8.60	2.00	1.40	140.8	7.60
7	1.80	12.00	4.60	1.60	203.4	277.4
8	32.00	71.80	5.00	26.00	52.20	81.00
9	17.60	29.00	1.60	57.20	29.60	90.80
10	3.00	7.00	1.40	5.00	10.00	2.00
11	16.00	48.60	4.00	33.80	1168	33.00
12	0.20	<D.L	10.00	3.80	120.0	12.80
13	1.00	5.60	5.60	1.60	91.80	12.00
14	4.40	20.40	16.20	14-A 3.80	263.8	157.2
				14-B 14.20	230.6	89.60
15	1.80	11.00	4.00	1.80	11.80	4.60
16	1.60	6.40	2.40	0.80	8.60	2.00
17	9.80	51.20	3.40	7.80	54.00	9.40
18	19.80	4.00	2.00	89.80	11.40	5.20
19	<D.L	46.00	5.60	19-A 0.40	47.80	7.20
				19-B 7.60	330.4	11.20
20	37.60	110.2	49.00	87.40	251.6	55.80
21	25.80	45.00	13.80	13.20	37.60	9.00
22	4.20	5.80	2.20	22-A 14.40	81.00	42.00
				22-B 14.20	82.00	33.40
23	<D.L	37.40	2.60	23-A <D.L	29.40	5.00
				23-B <D.L	29.40	6.00
24	16.40	45.60	4.80	24-A 15.60	117.2	3.00
				24-B 16.20	78.00	8.00
				24-C 10.40	82.60	15.60
Mean	11.73	34.35	6.63	17.95	164.1	41.14

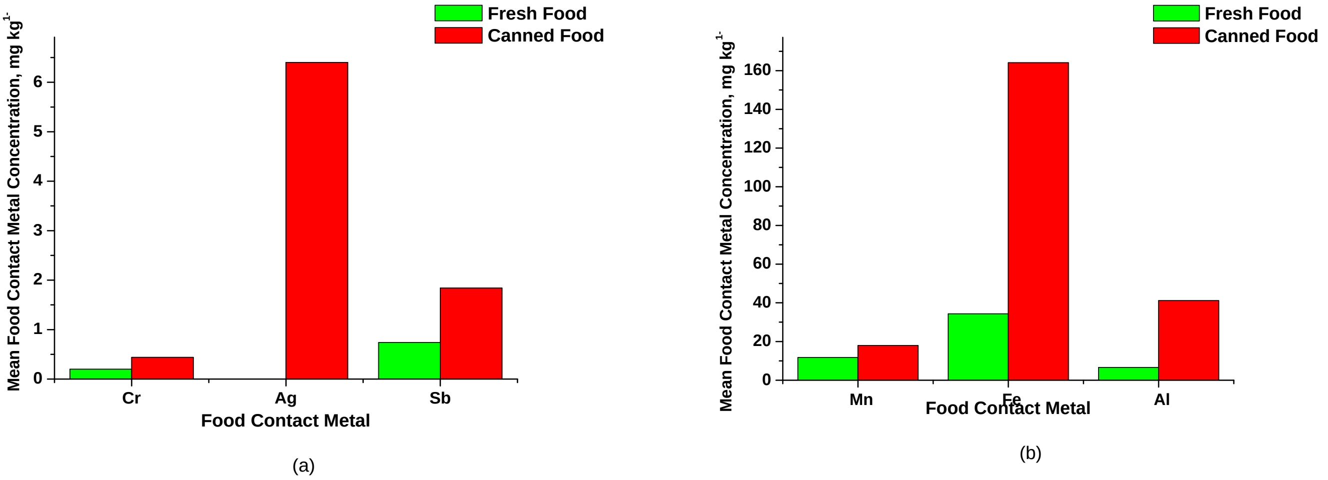
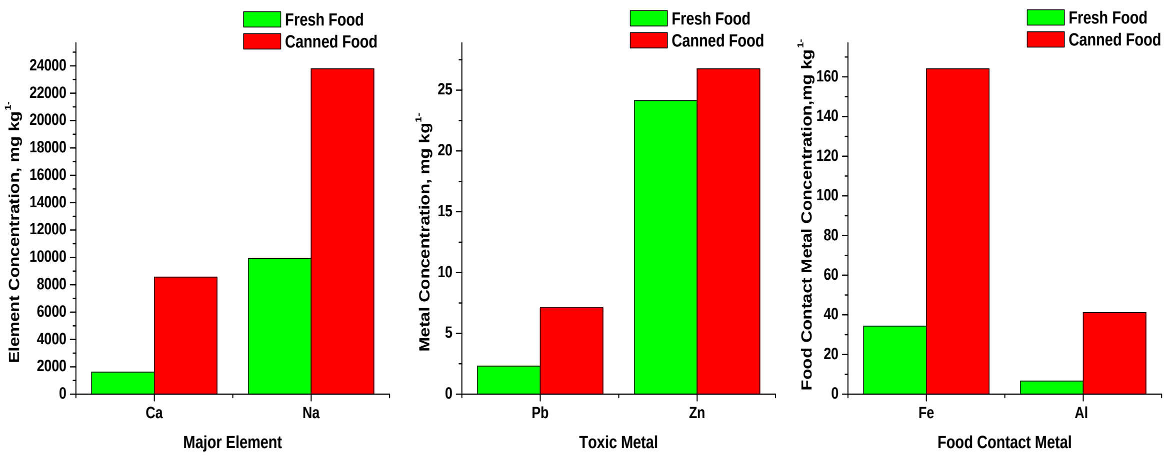


Fig. 2. Food contact metals concentrations of (a) Cr, Ag and Sb, (b) Mn, Fe and Al in fresh and canned food sample

On the other hand, presents the mean values of the levels of some selected metals and other elements of the investigated elements for fresh food samples in comparison with those determined in canned food samples. As shown in this figure, the Levels of these elements in canned food higher than fresh food in most samples Fig. 3.
The data obtained showed that, the heavy and toxic metals have relatively high levels in canned food than those of the corresponding fresh food samples. In addition, some of these metals levels were above the maximum tolerance levels reported by the food international regulatory standards. However, the mineral elements (e.g., Mg, K,..) have almost the same levels in both investigated fresh and canned food samples. The observed relatively high percentage of some of the food contact materials (e.g., Fe, Al,..) in the canned food samples was attributed to the preservative additives, food and



cans processing or corrosion of the container upon long term storage table 4.

Fig. 3. Comparison study of the investigated elements in fresh and canned food sample

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Table 4. The sample which contain metals outside the MTLs, “mg kg^{-1}” of toxic in canned food

No.	Sample Number	Sample	Type	Origin	Contaminated Metal	Value, mg kg^{-1}	MTLs, mg kg^{-1}
1	18	Pineapple	Canned Food	Thailand	Pb	79.00	6
2	22-B	Tomato Paste	Canned Food	United States	Pb	13.80	6
3	24-C	Black Beans	Canned Food	United States	Pb	8.60	6
4	17	Peas	Canned Food	Saudi Arabia	Cd	18.80	2
5	11	Green Beans	Canned Food	United States	Fe	1168	48
6	3	Black Olives	Canned Food	Spain	Fe	698.0	48
7	19-B	Sardines in Tomato suces	Canned Food	Philippines	Fe	330.4	48
8	1	Corned Beef	Canned Food	Brazil	Fe	257.0	48
9	7	Chicken sausage	Canned Food	Denmark	Al	277.4	200 mg L^{-1}

IV. CONCLUSION

In a comparison studies, the concentration of about 27 elements of the mineral, toxic and heavy metals have been detected in about 55 samples of fresh and canned foodstuffs using ICP-AES under the optimum conditions and after digestion using closed vessel microwave digestion system. The investigated samples were collected from local market of western province of Saudi Arabia. The data obtained showed that, the heavy and toxic metals have relatively high levels in canned food than those of the corresponding fresh food samples. In addition, some of these metals levels were above the maximum tolerance levels reported by the food international regulatory standards. However, the mineral elements (e.g., Mg, K,..) have almost the same levels in both investigated fresh and canned food samples. The observed relatively high percentage of some of the food contact materials (e.g., Fe, Al,..) in the canned food samples was attributed to the preservative additives, food and cans processing or corrosion of the container upon long term storage.

V. RECOMMENDATIONS

Although, manufactures must ensure that products are safe and do not pose a risk to consumers by law, quality control and quality assurance of canned foodstuffs in local and international markets are essential. Moreover, great attention should be paid by consumers to the nature, origin, production and expiry dates of the canned foodstuffs.

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