Original Article

Heavy Metal Concentration in Commonly Consumed Fruits from Ed-damer City, Sudan.

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Abstract:

Fruits play an important role in meeting daily dietary needs by providing essential vitamins, iron, calcium, potassium, and trace metals that serve as dietary supplements or function as crucial elements in hormones or enzymes at low concentrations. However, at high concentrations, these metals can become toxic and have harmful effects. This study aimed to detect the concentration levels of certain heavy metals in the most commonly consumed fruits in Sudan: banana, orange, guava, and lemon. These fruits were randomly collected from the market in Eddamer city.

The samples were analyzed, and the concentrations of Cu, Cd, Cr, Mn, and Pb were determined using atomic absorption spectroscopy (AAS). When compared with permissible levels established by the World Health Organization (WHO) and the Sudanese Standards and Metrology Organization (SSMO), the results showed an increase in some elements across most samples. Notably, high concentrations of Pb were observed in banana samples (1.00 mg/kg), oranges (0.81 mg/kg), guava (0.79 mg/kg), and lemon (0.53 mg/kg). The Cd concentrations in banana samples (0.23 mg/kg), oranges (0.28 mg/kg), and lemon (0.17 mg/kg) were also high, except in guava (0.05 mg/kg), which remained within the permissible limits set by WHO and SSMO. This elevated presence of Cd and Pb may be attributed to environmental pollution.

In contrast, the concentrations of other elements, including Co, Cr, and Mn, were low in all samples, remaining within safe limits defined by WHO and SSMO. Overall, the study's findings are consistent with values reported in existing literature.

Keywords: Heavy metal, Fruits, permissible level, WHO, SSMO.

Introduction:

Food quality and safety have become major public concerns worldwide. Over the last few decades, increasing demand for food safety has spurred research into the risks associated with consuming foodstuffs contaminated by heavy metals, pesticides, and/or toxic substances [1,2]. Food is the primary intake source of toxic trace elements for humans. Heavy metals are widely acknowledged to adversely affect the nutritional value of agricultural produce due to their harmful effects on human health. As a result, national and international regulations on food quality have established maximum permissible levels of toxic metals in human food. An increasingly important aspect of food quality assurance is the control of heavy metal concentrations in food.

Fruits are a staple food, especially when consumed raw. In Sudan, people from middle- and low-income groups consume significant quantities of fruits. Fruits are of great nutritional value; they are essential sources of vitamins and minerals and, thus, a vital part of the human diet. They are commonly used for culinary and dietary purposes, composed mainly of cellulose, hemicellulose, and pectin, which give them texture and firmness. Fresh fruits are especially important in the diet due to their content of vitamins and mineral salts such as calcium, iron, sulfur, and potash [3,4]. Humans are encouraged to eat more vegetables and fruits because they are good sources of vitamins, minerals, and fiber, all of which are beneficial to health. However, high levels of heavy metals in the environment pose potential risks to human health due to their toxicity [5]. The extensive use of heavy metals in industry, agriculture, medicine, and technology has led to their widespread distribution in nature, raising concerns about their effects on human health and the environment [6]. The effects of these metals on human health depend on the metal type and chemical form. These effects are also dose-dependent; several studies have shown that heavy metal exposure causes long-term health problems, with some metals causing both acute and chronic toxicity [7].

Monitoring and assessment of heavy metal concentrations in fruits from market sites have been carried out in some developed and developing countries, but limited data are available on heavy metal concentrations in fruits from market sites in Sudan [1]. Abdurrahman [8] studied and compared trace element concentrations in six types of fresh and canned fruits and vegetables consumed in Khartoum State using XRF (X-ray fluorescence) techniques. His study indicated that most trace elements appeared in lower concentrations in canned samples, with K and Ca showing the highest values and Pb, Zn, and Cu revealing the lowest concentrations across all fresh and canned samples.

Another study [9] measured the concentration of various metals in fruits randomly collected from local markets in Khartoum State using atomic absorption spectroscopy (AAS) techniques. Additional research determined the concentrations of Cu, Pb, Zn, Co, Ni, and Cd in selected fruits and vegetables from the Misurata city market in Libya, also using AAS [10]. Ali et al. investigated the concentrations of Fe, Mn, Cu, Zn, Pb, Cd, and Hg in various vegetables grown in four major industrial

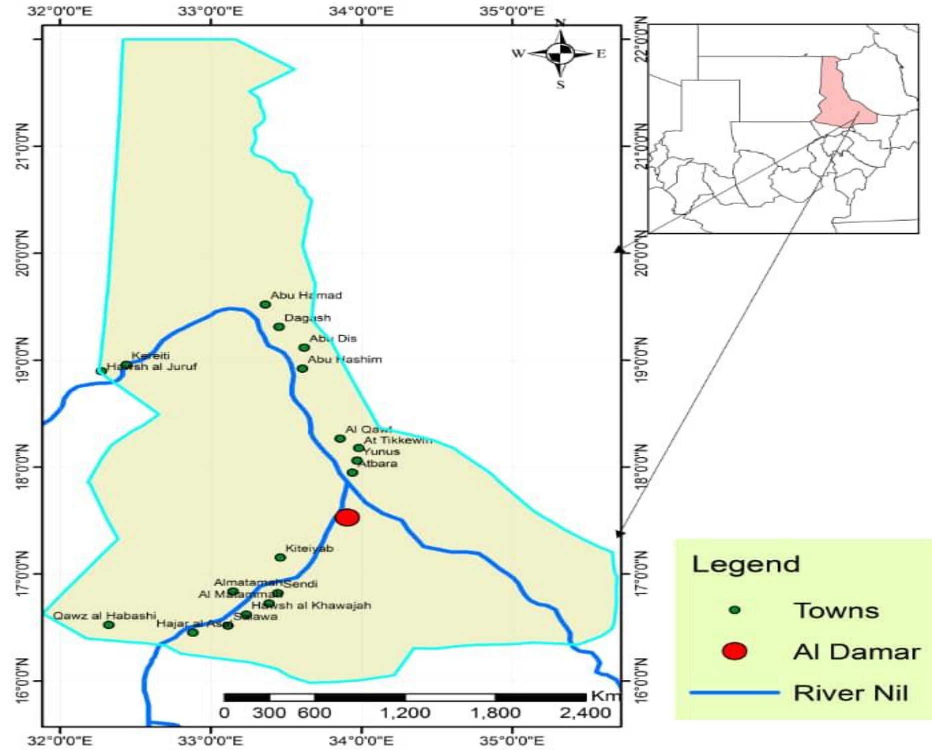
and urban sites in Saudi Arabia [11]. A study conducted in Lagos, Nigeria, found that the fruits and vegetables collected from selected markets contained heavy metals within the safe limits prescribed by WHO/FAO, except for Pb [12].

The aim of the current study was to investigate the pollution level in selected fruits collected from the study area, focusing on contamination by certain heavy metals.

Material and Methods:

Study area:

Addamer is the capital of the River Nile state in Sudan. It lies on the right (east) bank of the Nile River, at an elevation of 1,158 feet (353 meters), about 155 miles (250 km) northeast of Khartoum, with a population of about 122,944 (estimated 2012). Its famous market (Soug as-Sabit) is the most important in the area. Addamer is an example of a Sudanese African-Islamic city founded toward the end of the fifteenth century Scheme (1)



Scheme (1): Map of study area

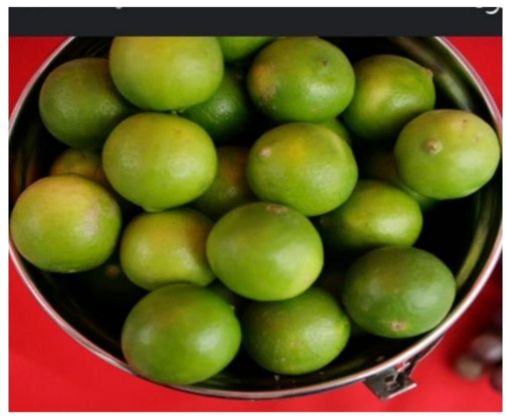
Samples collection:

Fruit samples were collected from local market of Eddamer city, during January 2020. These samples include Orange, Banana, Guava, Lemon scheme (2,3,4,5), these fruits were chosen as it's the most consumed fruits in Sudan. The samples were ashed and rinsed with distilled water then chopped into small pieces and inner edible portion was obtained: 3gm of each fruit were weighed.

Scheme(2):Banana

Scheme (3): Orange

Scheme (4): Guava



Scheme (5) Lemon

Preparation of solution for mineral identification:

One gm from each sample was ashed to a constant weight. The sample was ashed in a muffle furnace at 600 C°x temperature degree to a constant weight.

Ten ml of HCl (from LOBACHEME, 32 - 36 % purity M. W about 36. 46 and w_t per ml at 20C° about 1.18 g) 10 % Conc. was added to the ash, the content placed on a water path for one hour, and the sample filtered with filter paper and the content transferred to 50ml volumetric flask, the volume completed to 50 ml using distilled water [1,2].

Samples Analysis:

Analysis of heavy metals was performed using Atomic Absorption Spectrophotometer (AAS), Model Buck Scientific 205 figure (1), made in USA, at the Chemistry laboratory, National

Research Center and industrial research, Khartoum - Sudan. Lamps for Pb, Cr, Cd, Mn, Co at wavelengths of 217, 228.8, 259.35, 253, 285. 21 nm, respectively [1,3]. The limit of detection (LOD) of the Analytical method for each metal was calculated as double the standard deviation of a series of measurements of a solution, the concentration of which is distinctly detectable above, but close to blank absorbance measurement.

Scheme (6): Shows Bulk Atomic Absorption Spectrometry

Results and Discussion:

Heavy Metals Concentrations:

The mean concentration of heavy metals in the selected fruits obtained in this study are shown in Table (1) and also the permissible limit of studied metals according to SSMO WHO [1,4]. The results obtained revealed that there is a relatively higher concentration of Lead (Pb), Cadmium (Cd) in fruit samples procured from Eddamer market than SSMO/ WHO. The concentration of cobalt (Co), chromium (Cr), manganese (Mn) observed in the fruits were substantially lower than the maximum permissible values by WHO. The relatively high level of heavy metals in samples may be due to that samples in this study are comes from different regions of the country, the sources of production of the fruits is unknown and the other reason may be contamination at the time of transportation or stocking process.

Table (1): Mean Concentration of heavy metals Concentration in the present study and (SSMO, WHO) in mg /kg.

Type of fruit	Element	WHO	SSMO	This work	Metals	Food stuff
Banana	Lead	0.5	0.2	1		
Orange		0.5	0.2	0.81		
Guava		0.5	0.2	0.79		
Lemon		0.5	0.2	0.53		
Banana	Cobalt	2	-	0.36		
Orange		2	-	0.26		
Guava		2	-	0.18		
Lemon		2	-	0.28		
Banana	Chromium	1.2	-	0.25		
Orange		1.2	-	0.31		
Guava		1.2	-	0.28		
Lemon		1.2	-	0.11		
Banana	Manganese	5	-	0.25		
Orange		5	-	0.28		
Guava		5	-	0.27		
Lemon		5	-	0.23		
Banana	Cadmium	0.05	0.1	0.23		
Orange		0.05	0.1	0.28		
Guava		0.05	0.1	0.05		
Lemon		0.05	0.1	0.17		

* [-] Not Found

Lead:

Results obtained showed that the concentration of Lead obtained in fruits samples collected from Ed-damer market were Banana 1.00 mg/Kg, Orange 0.81 mg/Kg, Guava 0.97mg/Kg, Lemon o.53mg/kg, Table (1).

The content of lead reported in this study was generally higher than the permissible levels set by SSMO/WHO in the fruits. Thus, the study showed that lead content is not within the permissible limit SSMO (0.2mg) and WHO (0.5mg) and this indication to pollution presence

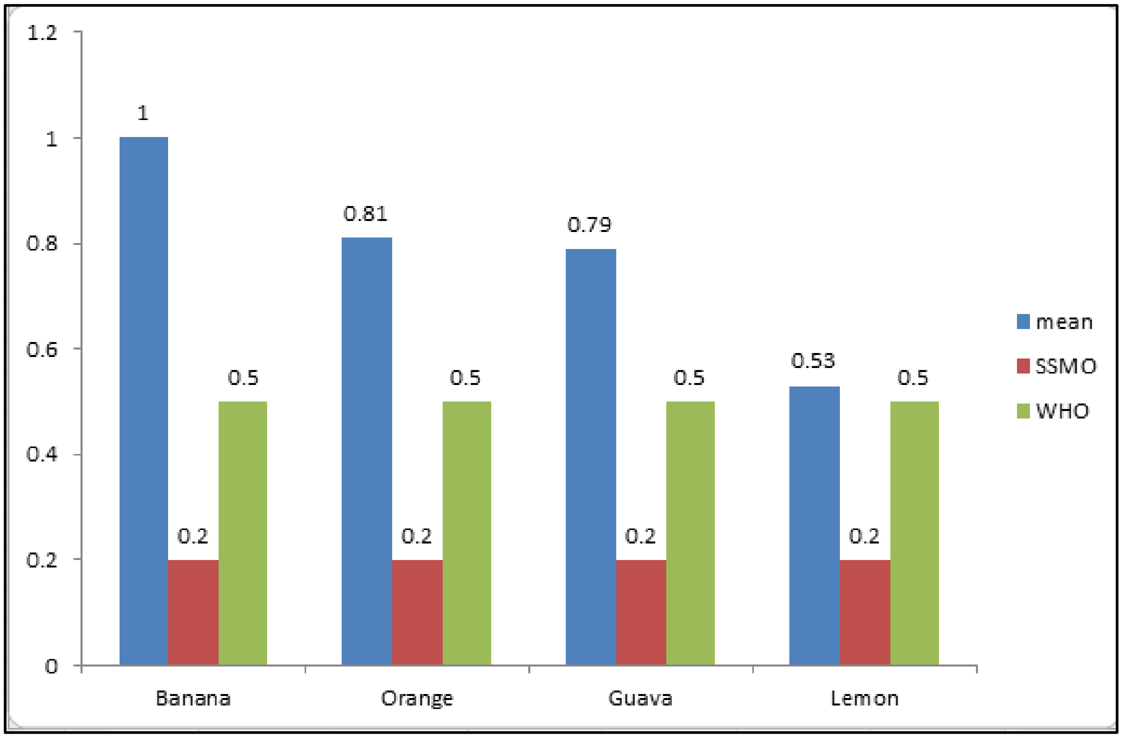


Figure (1): Lead mean contents in Consumed fruits from Ed-damer related to the standers by (SSMO and WHO)

Cobalt:

The content of Cobalt reported in this study is lower than the permissible levels set by SSMO /WHO in fruits (2.0mg/kg), as can be seen from Table(1) . The concentration of Cobalt was found in Banana (0.36mg/kg), Lemon (0.2mg/kg), Orange (0.26mg/kg), and Guava (18mg/kg)

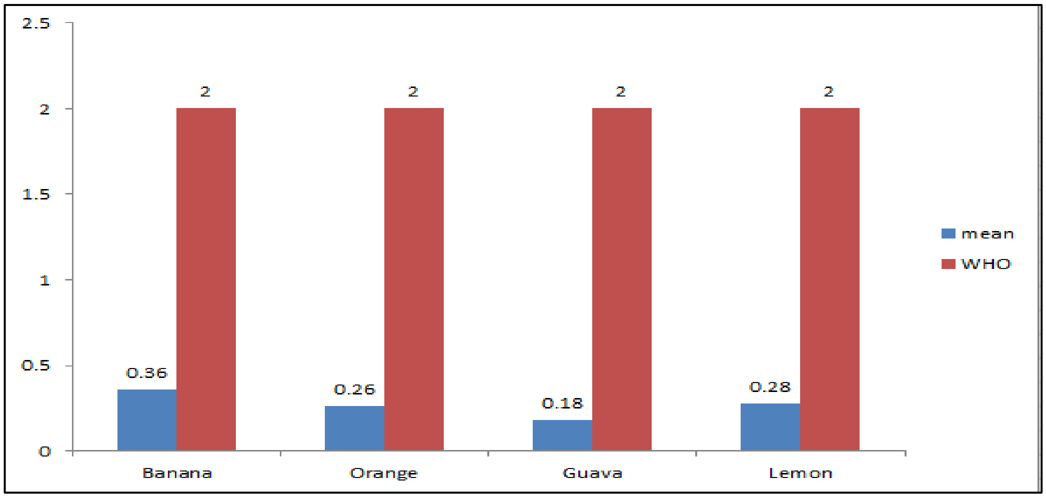


Figure (2): Cobalt mean contents in Consumed fruits from Eddamer related to the standards by WHO.

The maximum concentration of Chromium is observed in Orange (0.31mg/kg), and the minimum in Lemon sample (0.11mg/kg), as can be seen in Table [4-7]. These values are lower than the permissible limit of (1.2mg/kg) by SSMO /WHO [5-7].

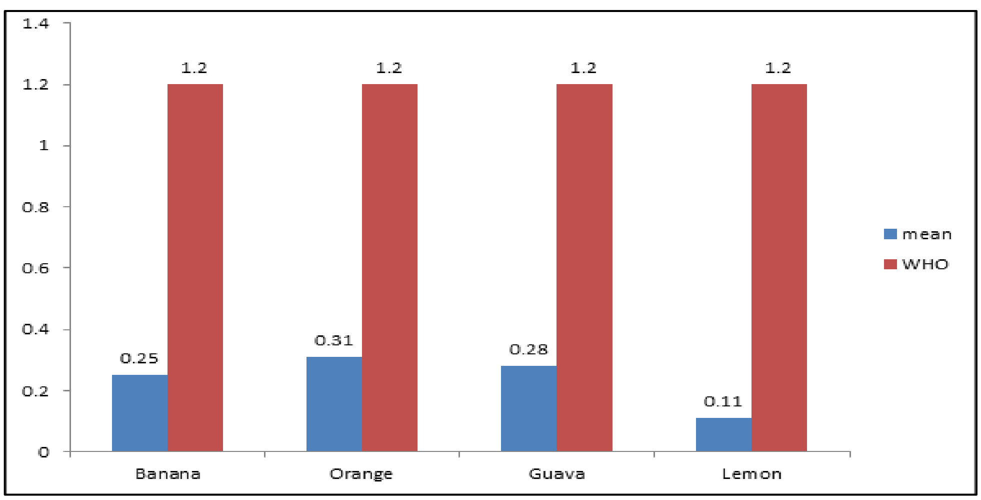


Figure (3): Chromium mean contents in Consumed fruits from Eddamer related to the standers by WHO.

Manganese:

Results showed that the concentration of Manganese obtained in samples were Orange (0.28mg/kg), Banana (0.25mg/kg), Guava (0.27mg/kg), Lemon (0.23mg/kg), Table (4-8). The content of manganese reported in this study was generally lower than in WHO in fruits (5.0mg/kg).

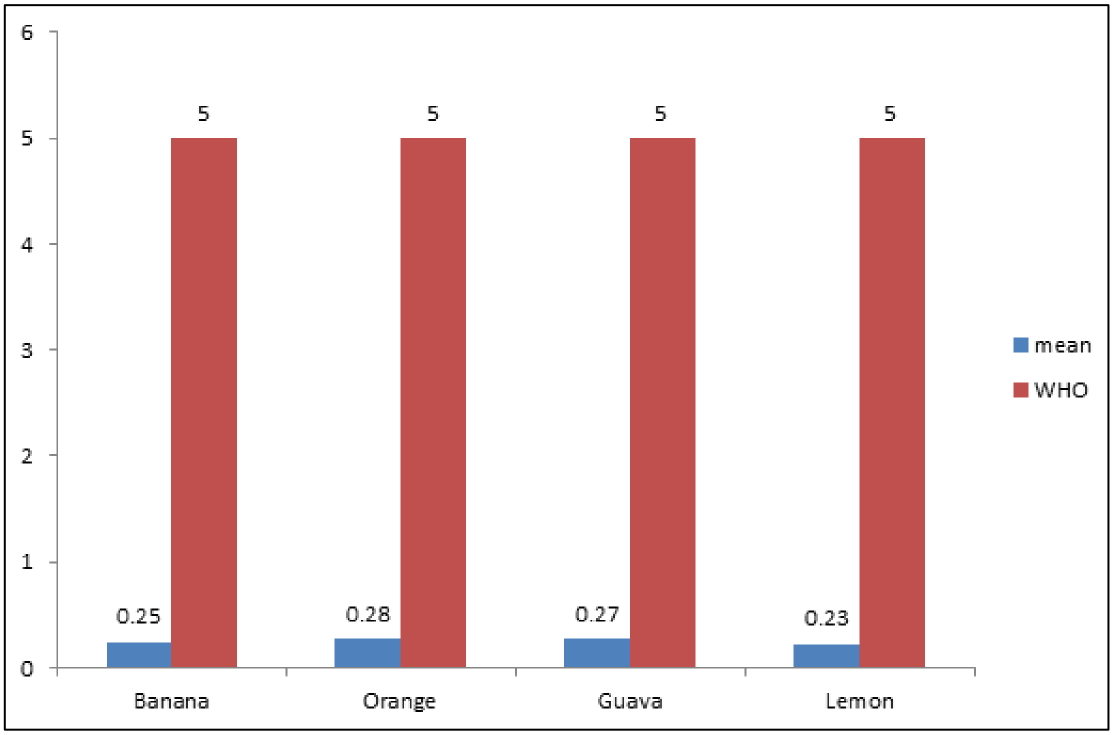


Figure (4): Manganese mean contents in Consumed fruits from Eddamer related to the standards by WHO.

Cadmium:

The maximum concentration of Cadmium was found in Orange (0.28mg/kg), and the minimum in Guava (0.05mg/kg), in fruit sample from Ed-damer market as can be seen from Table (1) Figure (5). These values in this study are higher than the permissible level set by SSMO (0.1mg/kg) and WHO (0.05 mg/kg)

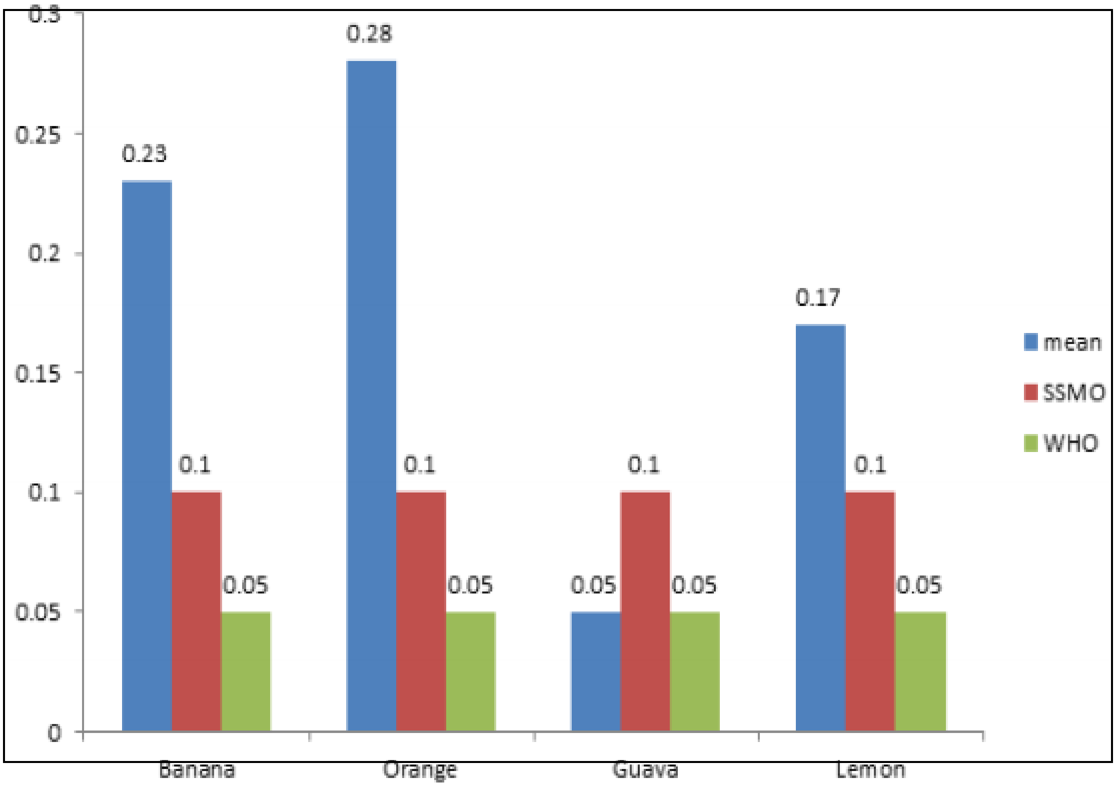


Figure (5): Cadmium mean contents in Consumed fruits from Ed-damer related to the standard by (SSMO) and (WHO).

Comparison between the results of the presents and previous studies ; **Lead:**

Table (2): Comparison of Lead Levels in this study with previous studies from similar Fruits.

	Our study	Ref. [1,3]	Ref. [1,5]	Ref. [1,6]	Ref. [10]	Ref. [1,4]	Samples
Banana	1.00	0.01	0.07	1.79	0.10	ND	
Orange	0.81	0.07	0.12	-	0.20	ND	
Guava	0.79	-	-	2.85	-	ND	
Lemon	0.53	-	-	-	-	-	

(Ref.) ; Reference

[-] Not studies

[ND] Not detected

When comparing the results of our study to other studies as in Table (2). The lead content of banana (1mg/kg), higher than found in (0.10mg/kg) [1,90]. And (0.01 mg/kg) [1,,3]. and lower than study found (2.85mg/kg) [1,6]. And (0.07mg/kg)

[1,5]. Also the concentration of orange (0.81mg/kg), higher than (0.33mg/kg), and (0.20mg/kg), and (0.12mg/kg), (0.07mg/kg) [12] as indicated in the above table, the level of lead in Guava lower [1,6] The high levels of lead in some of these fruits may probably be attributed to pollutants in irrigation water, farm soil or due to pollution from the high ways traffic.

Cobalt:

Table (3): Comparison of Cobalt levels in this study with the previous studies from similar fruits.

Samples	Our study	Ref.[1,21]	Ref. [1,5]	Ref.[17]	Ref. [1,4]
Banana	0.36	0.01	0.02	0.10	0.32
Orange	0.26	0.02	0.05	0.26	0.20
Guava	0.18	-	-	0.17	0.25
Lemon	0.28	-	-	-	-

[-] Not studies
[ND] Not detected

When comparing the result of this study to other studies as in Table (3).
Cobalt recorded results in banana (0.36mg/kg), higher than (0.10mg/kg) [1,7]. and (0.01mg/kg) and [11] (0.02mg/kg [15], and (0.32mg/kg) [1,4]. Cobalt also recorded a concentration of orange (0.26 mg/kg), was similar to those found in (0.26mg/kg), and higher than the other results in the above table. Also gave cobalt in guava (0.18mg/kg) this results lower than those found in (0.17mg/kg) [17] and (0.25mg/kg) [14].

Chromium:

Table (3): Comparison of Chromium levels in this study with the previous studies from similar fruits.

Samples	Our study	Ref. [19]	Ref. [20]	Ref. [1]	Ref.[1,4]
Banana	0.25	88.32	0.06	0.14	ND
Orange	0.31	16.25	-	0.28	ND
Guava	0.28	27.17	-	-	ND
Lemon	0.11	227.50	-	-	-

[-] Not Studies
[ND] Not detected

Chromium content of orange (0.31mg/kg) higher than (0.28mg/kg) [1], and less than the result in (16.32mg/kg) [20]. While chromium concentration in guava (0.28mg/kg), were lower than in the above study (27.17mg/kg),
Also gave chromium in banana (0.25mg/kg) higher than (0.14mg/kg [1]),

and less than (88.32mg/kg {20}and also less than in [2,90].

Manganese:

Table (4): Comparison of Manganese levels in this study with the previous studies from similar fruits.

Samples	Our study	Ref. [19]	Ref. [1]	Ref. [14]
Banana	0.25	417.39	1.70	0.37
Orange	0.28	17.51	1.30	0.18
Guava	0.27	10.86	-	0.30
Lemon	0.23	11.05	-	-

[-] Not studies [ND] Not detected

Comparison with other studies as can be seen Table (4), it was found that the manganese content of orange (0.28mg/kg), lower than (1.30mg/kg[1] and less than the study result (17.51mg/kg) [19]. Manganese also recorded a concentration of banana (0.25mg/kg) lower than the other study results [19,4,1]. Manganese recorded result in guava (0.27mg/kg), lower than in {60,62} .Also the concentration of Manganese in lemon in our study(0.23mg/kg)less than the other study [19].

Cadmium:

Table (5): Comparison of Cadmium levels in this study with the previous studies from similar fruits.

Samples	Our study	Ref. [19]	Ref. [1]	Ref. [16,]	Ref. [1,90]	Ref. [14]
Banana	0.23	13.36	ND	0.02	0.05	0.05
Orange	0.28	15.39	ND	0.04	0.03	0.03
Guava	0.05	7.58	-	-	-	0.10
Lemon	0.17	9.09	-	-	-	-

[-] Not studies [ND] Not detected

Comparing the results of this study to other studies as in Table (5). The Cadmium content in this study of orange (0.28mg/kg), higher than in (0.03mg/kg 4,1,9]), (0.04mg/kg) [16], Cadmium recorded result in banana (0.23mg/kg), higher than in (0.05mg/kg) [1], and (0.02mg/kg) [16], and lower than the value (13.36mg/kg) reported by [19]. The cadmium showed in guava (0.05mg/kg), lower than found of (0.10mg/kg [14]), and (7.58mg/kg) [19]. The higher level of Cd in these sites may be related to highly traffic density. These fruits may be grown in a contaminated soil or by irrational uses of fertilizers, particularly super phosphate which elevates the cadmium content in the soil and consequently in plant tissues. Therefore, it will be difficult to eliminate by washing because it was held up by plants tissues, or the tap water used for washing may have considerable levels of Cadmium. In either case the original source of the pollution may be from water borne sources such as industrial effluents or from industrial or vehicular air pollution.

Conclusion:

The results obtained revealed that there is a relatively higher concentration of (Pb, Cd) in fruit samples procured from Ed-damer market than the limited prescribed by the SSMO / WHO. The results of this study compared with similar studies from other published works. The relatively high level (Pb, Cd) in samples in this work may be due to that samples in this area comes from different regions of the country, the sources of production of the fruits is unknown and the other reason may be contamination at the time of transportation or stocking process.

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