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Assessment of Some Heavy Elements in Selected Fruits from the Markets of Anbar Governorate: Implications for Human Health

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ABSTRACT

Eating fruit can be a useful way to enhance health and reduce the risk of many diseases. At the same time, if this fruit exceeds the permissible limit, it can be a source of diseases dangerous to human health. Therefore, this issue presents a complex and multifaceted challenge. The current study aims to assess the concentration of certain heavy metals (chromium, iron, nickel, copper, manganese) in the pulp and peels of selected fruits from the markets of Anbar Governorate, Iraq. Ten types of fruits were selected (quince, fig, orange, apple, banana, mango, watermelon, carrot, pomegranate, kiwi) and compared with internationally permissible limits. The concentrations were measured using an atomic absorption spectrometer. The results indicated the concentration of some metals exceeding limits of the international standard. For instance, it was noted that the concentration of Ni in the peels very high and the samples that exceeded the international limit were; A2 – B2 – C2 – K2 – M2 – P2 – S2 where samples had 6.548, 3, 3.645, 3.323, 17.516, 4.290 and 5.258 mg/L of Ni. In the pulp, nickel was found at high concentrations exceeding the international limits in samples (A1 - B1 - C1 - K1 - M1 - O1 - P1 - S1), with concentrations of (23.645 - 3.968 - 6.226 - 13.645 - 2.355 - 8.806 - 19.129) mg/L. The highest Ni was found in apple pulp at 23 mg/L while the lowest concentration of Ni was found in orange peel and fig pulp at 0.097 mg/L.

Keywords:

Heavy elements; Nickel concentration; Molecule structural; Multifaceted challenge; Anbar

1. Introduction

Fruits are some of the vital consumptions to ensuring good nutrition. Fruits have found a way into healthy eating patterns in at least the amounts recommended due to the vast amount of essential nutrients. Fruits serve as a good supply of vitamins and dietary fibre minerals which can influence the health of an individual. Some of the nutrients include potassium, vitamin C, and folate among others. Fruits have been used as a measure to ensure the general health of an individual and help in the

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prevention of many diseases and nutrient deficient conditions such as vitamin A and vitamin C inadequate among others [1].

There are many ways to use fruit peels; these are the extraction of essential oils and manufacturing confectionery. Among the beneficial nutrient, several elements are available in some fruit peels, but the quantity of which determine the fruit type [2]. Eating fruits with their peels may provide one with higher amounts of vitamins, minerals, and some plant compounds than fruits with their peels removed [3-5]. Peels also have sugar, organic acids, and phenolic compounds with antioxidant, antibacterial, and antiviral activities. Moreover, the consumption or use of fruit and vegetable peels increases one's dietary fibre intake while reducing food loss, making it good for the environment [6].

Some fruits, like citrus fruits, are distinguished by their high content of vitamin C, B2, B6, calcium, magnesium, and potassium, as well as anti-inflammatory flavonoids despite their bitter taste. Therefore, they can be used grated in salads. It is preferable to consume fruits with their peels to benefit from the fibre and nutrients present in them [7].

A study published in 2012 indicated that fruit peels have a higher antioxidant capacity compared to their inner pulp [8]. Individuals who consume a diet rich in vitamin C, polyphenols, and carotenoids are less susceptible to heart disease, certain types of cancer, and cognitive impairment. Additionally, a laboratory study published in 2010 revealed that mango peel extract possesses antioxidant properties and contains phenolic compounds that have a greater anti-cancer activity than fruit extracts. Furthermore, some pesticides may penetrate fruit peels, and in such cases, it is better to peel the fruits [9,10]. Besides, pesticides have been associated with various harmful health effects, such as neurological problems, hormonal imbalances, and certain types of cancer. It is worth mentioning that when desiring to consume fruit peels, it is advisable to purchase organic fruits that are not sprayed with pesticides [11].

Despite known essential vitamins and minerals, the understanding of fruits from a nutritional value perspective is rather incomplete without acknowledging their composition. It has been relatively recently when studies began applying more scrutiny to the presence of heavy elements in fruits highlighting their potential implications for human health. Develops heavy elements, including multiple heavy metals such as lead, cadmium, and mercury, tend to accumulate in plants due to a variety of environmental factors and can further put consumers at risk upon the consumption of fruits.

Therefore, it is essential to measure the concentration of these heavy elements in fruits to assure the quality of food and the safety of the general public. Hence, the present research aims to measure the levels of heavy elements in selected fruits, which were obtained from markets in the Anbar Governorate, Iraq. By measuring these heavy metals, insight can be gained on the fruits readily available in the local markets and their safety and quality. This research is relatively important since, in areas where specific fruits are cultivated or weather conditions or specific agricultural practices can pose an enhanced danger of contamination. Consequently, this research and the following assessment into acceptable limits will be an essential study to safeguard the public in the region.

Based on the above discussion, this research is focused on assessing the pollution levels caused by metals (such, as chromium, iron, nickel, copper, manganese) present in the skin and peels of specific fruits sourced from the markets in Anbar Governorate, Iraq. Ten varieties of fruits including quince, fig orange, apple, banana, mango, watermelon, carrot, pomegranate and kiwi were selected for evaluation against accepted standards. Additionally, the study aims to investigate the impacts of these metals, on humans, animals and plants.

2. Material and Method

Here are the steps involved in the work process:

i. Gathering Samples: Various fruits such, as oranges, apples, mangoes, figs, kiwis, watermelons, quinces, bananas, pomegranates and carrots were collected from markets in Anbar Governorate.
ii. Grinding Process: The collected samples underwent a cleaning process with water followed by peeling. The pulp and peels were. Left to dry under sunlight for 15 days. Once completely dried the peels were ground into powder using a mortar and pestle before being stored in plastic containers.
iii. Digestion Procedure: The digestion phase took place at the College of Education for Pure Sciences at the University of Anbar. It involved combining hydrochloric acid and nitric acid in a 3;1 ratio. Using a balance scale 1 gram of samples was. Heated with the acid mixture at 100°C, for 2 3 minutes.
iv. Analysis and Measurement Stage: After cooling the samples, 5ml of HCl and 50ml of distilled boiling water at 350°C were added, and the mixture was heated again until boiling for 2-3 minutes at 160°C. The digested samples were then transferred to plastic bottles and kept in a dark room until ready for measurement. The concentrations of heavy metals (chromium, iron, nickel, copper, manganese) were measured using an atomic absorption spectrometer in the laboratories of the College of Engineering at the University of Anbar. Table 1 in the study lists the sample names and their corresponding codes.

Table 1
Lists the sample names and their corresponding codes

T	Name	Pulp	Peels
1	apple	A1	A2
2	banana	B1	B2
3	carrots	C1	C2
4	fig	F1	F2
5	kiwi	K1	K2
6	Mango	M1	M2
7	orange	O1	O2
8	pomegranate	P1	P2
9	watermelon	W1	W2
10	quince	S1	S2
ND		Not Detected	

A series of concentrations of standard solutions (0.1 ppm), (0.5 ppm), (1 ppm), (1.5 ppm) and (2 ppm) were prepared from (100 ppm) prepared in advance from the standard solution (1000 ppm), for each of the standard solutions of the studied elements, the absorption measurement process was carried out with the atomic absorption device shown in Figure 1 and extract the calibration curve [12].

For the purpose of using the atomic absorption device for measurement, the best conditions for measurement have been fixed before the start of work and according to the following:

i. Choosing the optimal current of the cathode lamp for each element with a constant standard concentration from it.

ii. Choosing the optimal height of the acetylene-air burner with a fixed standard concentration for each element.
iii. Finding the linear calibration curve for each element using a series of dilute standard solutions and measure them under optimal conditions of the device and draw the direct calibration curve.

In the laboratory, the samples were filtered by a Behner filter to ensure that the ablation tube in the atomic absorption system is not clogged.

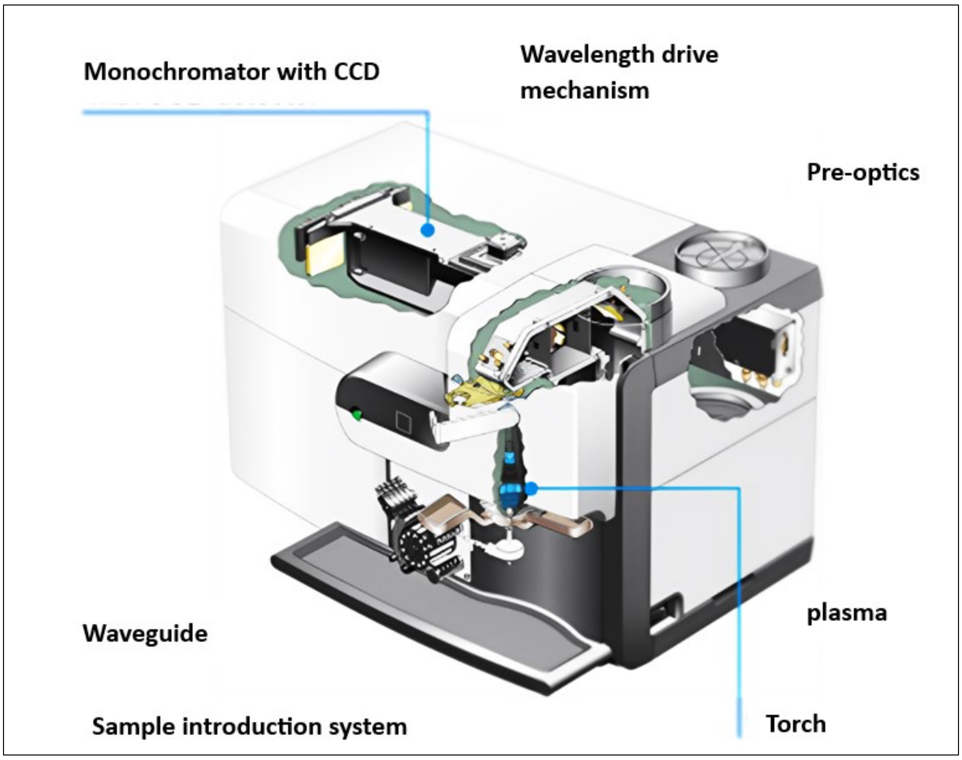

Fig. 1. Atomic absorption system employed in the current study

3. Result and Discussion

The results of the analysis obtained in Table 2 and Table 3 below demonstrate the concentrations of the studied heavy elements (chromium, iron, nickel, copper, manganese) in samples of fruit pulp and peels (apple, fig, banana, orange, watermelon, carrot, kiwi, mango, quince, pomegranate) under investigation, comparing them with globally permissible values [12].

Table 2
Results of the analysis of heavy elements in fruit peels

	Sample/Peels	Icon	Cr mg/l	In mg/l	Ni mg/l	Cu mg/l	From mg/l
1	Apple	A2	N. D	5.475	6.548	0.429	1.429
2	Banana	B2	0.113	2.196	3	0.429	6.429
3	Carrots	C2	N. D	3.016	3.645	0.429	5
4	Fig	F2	N. D	4.492	0.742	0.905	16.429
5	Kiwi	K2	0.113	4.820	3.323	0.429	N. D
6	Mango	M2	N. D	2.852	17.516	N. D	N. D
7	Orange	O2	N. D	3.016	0.097	2.810	18.571
8	Pomegranate	P2	N. D	7.115	4.290	N. D	N. D
9	Watermelon	W2	N. D	4.656	0.742	0.429	N. D
10	Quince	S2	0.01	5.475	5.258	0.429	3.571
11	FAO/WHO [12]		2.3	425	1.5	40	500

The findings indicate that the majority of the notable concentrations of the studied elements are lower than the maximum allowable limits set by FAO/WHO, making them safe for human consumption. However, hospital, household, and industrial waste can lead to soil contamination with both minor and heavy elements. Improper disposal of such waste, whether by dumping or burying it in the soil, results in soil pollution, which can then transfer to groundwater and eventually to fruits [13]. Moreover, industrial concentration in urban areas, coupled with scientific, commercial activities, and increased transportation means, contributes to the transformation of the environment in many cities, especially industrial ones, into a polluted environment with gases and metallic elements. Heavy metals are one of the highly hazardous pollutants. The pathways of heavy metal pollution related to humans involve the transfer of these elements to fish and plants, and subsequently to humans through consumption [14].

Table 3
Results of the analysis of heavy elements in fruit pulp

	Sample /Pulp	Icon	Cr mg/l	In mg/l	Ni mg/l	Cu mg/l	From mg/l
1	Apple	A1	N. D	7.607	23	N. D	N. D
2	Banana	B1	N. D	5.457	3.645	N. D	0.714
3	Carrots	C1	N. D	2.525	3.968	N. D	2.143
4	Fig	F1	N. D	2.525	0.097	1.857	16.429
5	Kiwi	K1	N. D	8.754	6.226	N. D	N. D
6	Mango	M1	N. D	2.525	13.645	N. D	0.714
7	Orange	O1	N. D	4	2.355	N. D	7.857
8	Pomegranate	P1	N. D	3.344	8.806	4.714	17.857
9	Watermelon	W1	N. D	2.361	N. D	0.905	6.429
10	Quince	S1	N. D	3.836	19.129	N. D	N. D
11	FAO/WHO [12]		2.3	425	1.5	40	500

Chromium values ranged between [0.01 in S2-0.113 in B2, K2 in the samples' peels] mg/L, compared to the globally permissible values set by FAO/WHO [12] of 2.3 mg/L. Reviewing the results in Table 1 and Table 2 above indicates that chromium concentrations in all the aforementioned samples are minimal or nearly absent. Chromium is present in the earth's crust and exists in trivalent or hexavalent forms [14-17]. Hexavalent chromium is rapidly absorbed in the intestinal tract more than trivalent chromium and can penetrate cell membranes [18,19]. Figure 2 and Figure 3 demonstrate the concentration of chromium in the peels and pulp of the studied fruits, respectively.

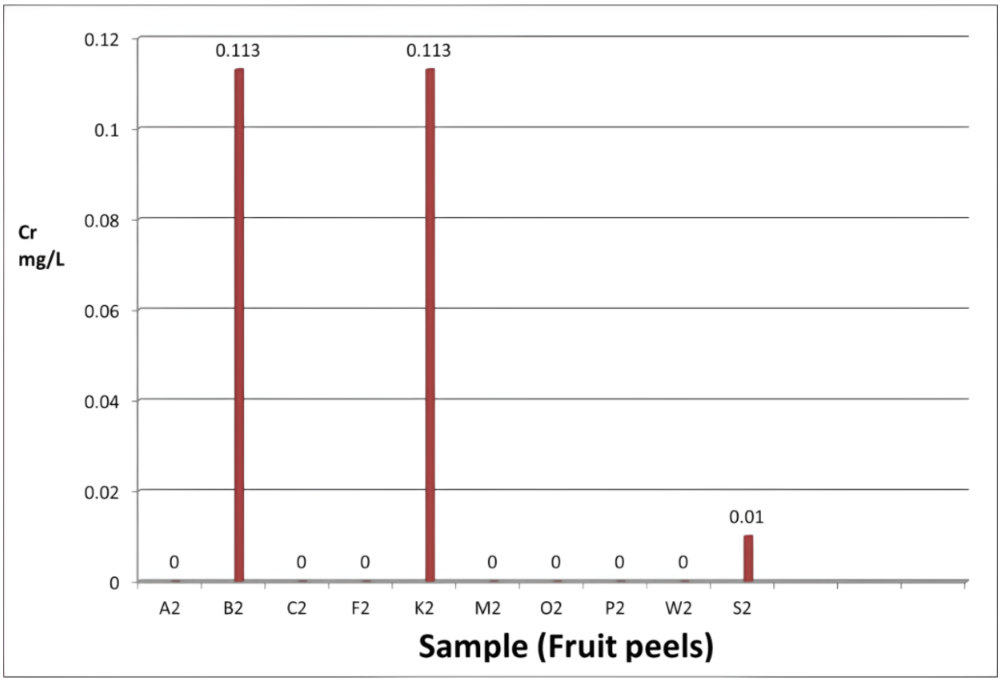

Fig. 2. Concentrations of Cr in the scales of the samples under study

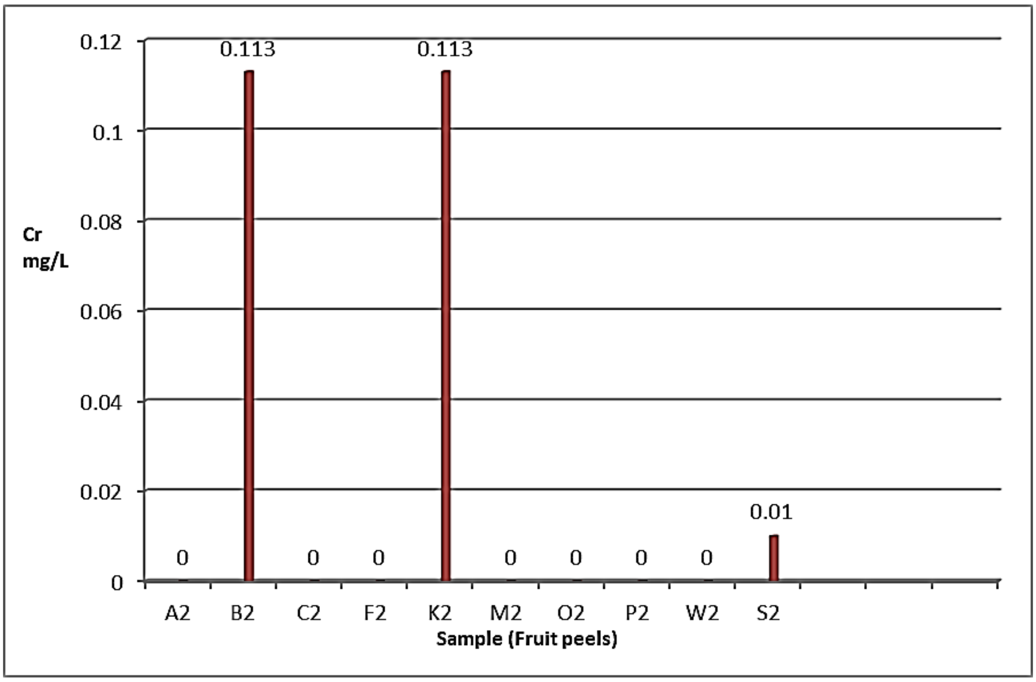

Fig. 3. Concentration of Cr in the pulp of the samples under study

The levels of chromium in the peels, however, varied from 0.01 mg/L to 0.113 mg/L. As previously mentioned, the permissible international limit according to the FAO/WHO is set at 2.3 mg/L. This means chromium is nearly absent in the samples, which is positive as excessive levels of this element do considerable damage [20-22].

Moving to analysis the findings of Nickel, it's clear that Nickel values ranged between [0.097 in F1, O2 - 23 in A1] mg/L [23-25]. Through the results listed in Table 1 and Table 2 above, it is evident that nickel is present at very high concentrations in samples (A1, S1, M2, M1), with concentrations reaching (13.6, 17.12, 19.12, 23 mg/L) respectively. In samples (P1, A2, S2, K1), the concentrations were (6.22, 5.25, 6.5, 8.8 mg/L) respectively, while in samples (P2, K2, C2, B2, B1, C1, O1), the concentrations were (4.29, 3.32, 3.6, 3, 3.9, 3.6, 2.35 mg/L) respectively. These ratios are higher than the internationally permissible limit set by FAO/WHO [12] (5 mg/L). Meanwhile, the concentration in samples (F2, W2) was (0.74, 0.74 mg/L) respectively, which is close to the internationally permissible limit, while the concentrations in the rest of the samples were very minimal. Figure 4 and Figure 5 demonstrate the concentration of nickel in the peels and pulp of the studied fruits, respectively.

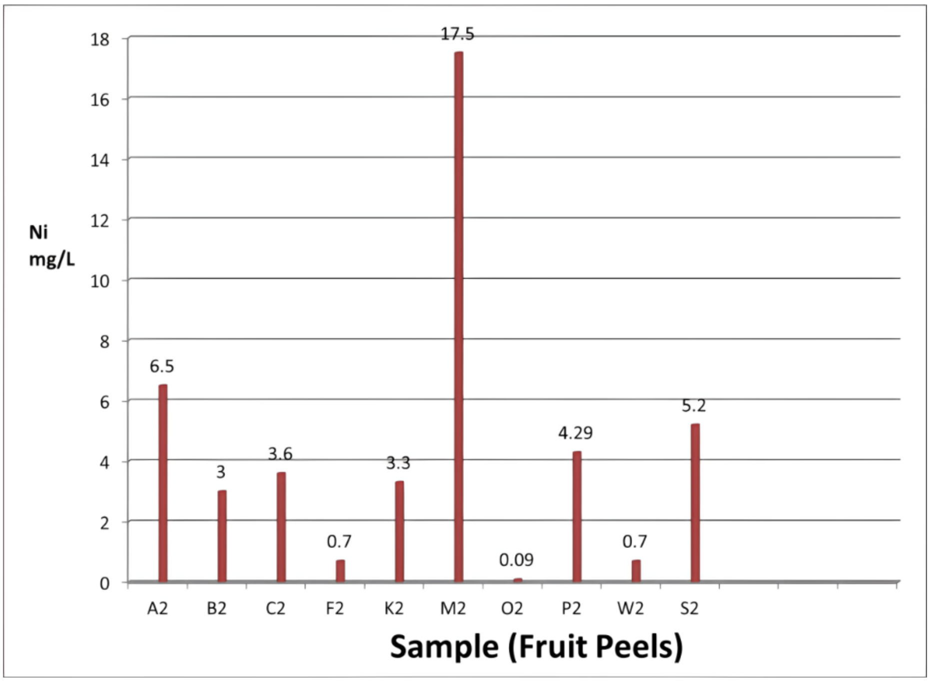

Fig. 4. Concentration of Ni in the scales of the samples under study

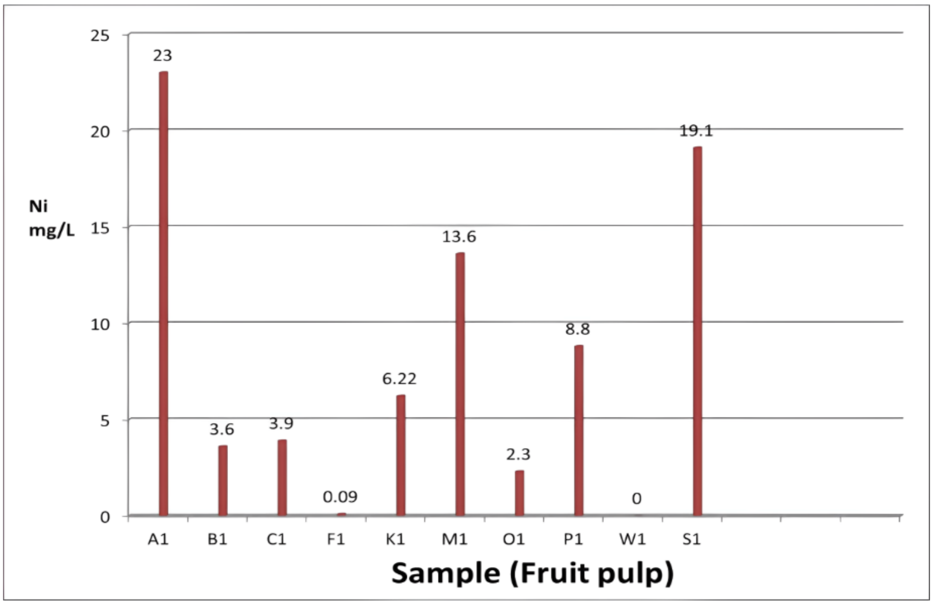

Fig. 5. Concentration of Ni in the pulp of the samples under study

The results reveal that Nickel concentrations in the samples vary widely with values ranging from 0.097 to 23 mg/L [26-28]. Some samples analysed revealed very high values which were in exceedance of the FAO/WHO limit of 5 mg/L. This is a significant concern as the samples could be contaminated.

Another metal under consideration is Copper [0.429 in A2, B2, C2, K2, W2, S2 in the peels of the samples – 4.714 in P1] mg/L. As can be observed in the results of the previous Table 1 and Table 2 above; the copper concentration observed in the different samples were very minimal compared to the "FAO/WHO internationally permissible limits [12]" of 40 mg/L. In Figure 6 and Figure 7 below, the copper concentration in the peels and pulp of the considered fruits can be observed respectively. In this regard, Copper ranged between 0.429 to 4.714 mg/L. All of these were in the permissible limits of 40mg/L FAO/WHO that is a clear indicator that the Copper contamination in the samples was very minimal.

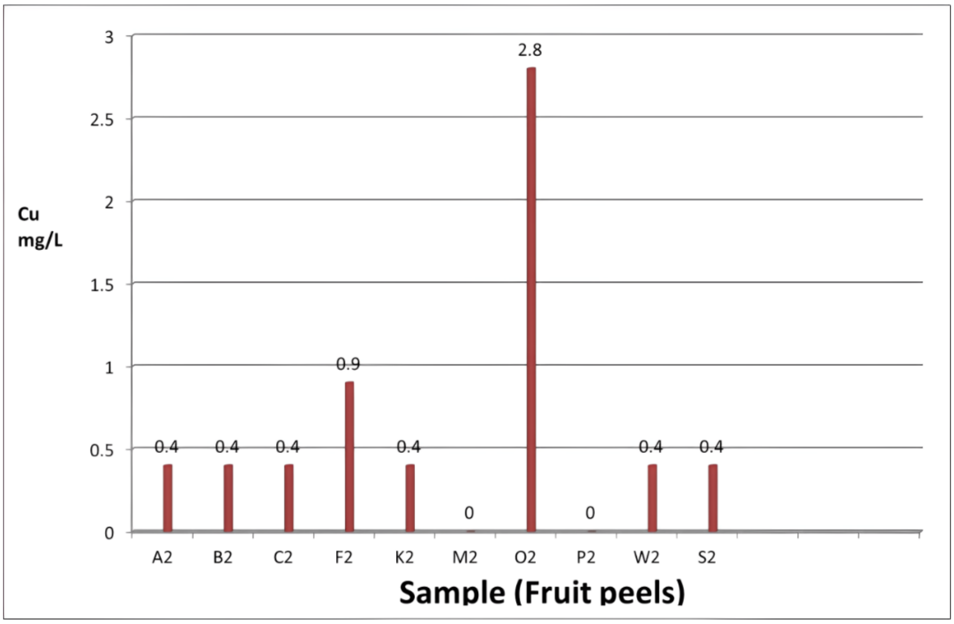

Fig. 6. Concentration of Cu in the scales of the samples under study

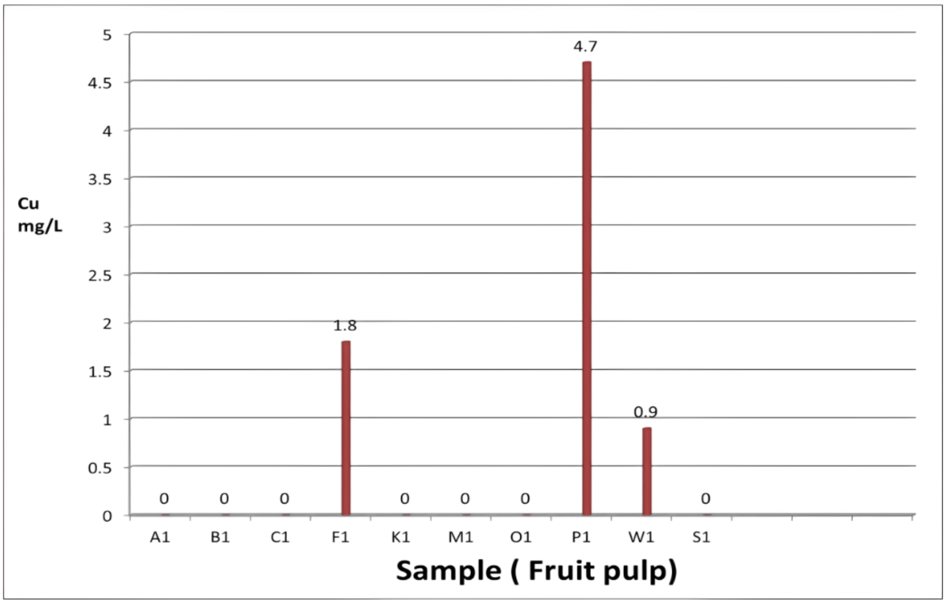

Fig. 7. Concentration of Cu in the pulp of the samples under study

Furthermore, the present study covered the analysis of manganese. The manganese had values of [0.714 in B1, M1 in pulp to 18.571 in O2] mg/L. All concentrations illustrated in the above Table 1 and Table 2 are within the minimum values compared to the recommended international values by

FAO/WHO [12 500] mg/L. Figure 8 and Figure 9 shows the manganese concentration in the peels and pulps of the fruits understudy, respectively. From the figure, it can be deduced that Manganese had a concentration range of between 0.714 to 18.571 m/L. Again, all concentrations were minimal compared to the permissible 500 mg/L, per FAO/WHO [29-31].

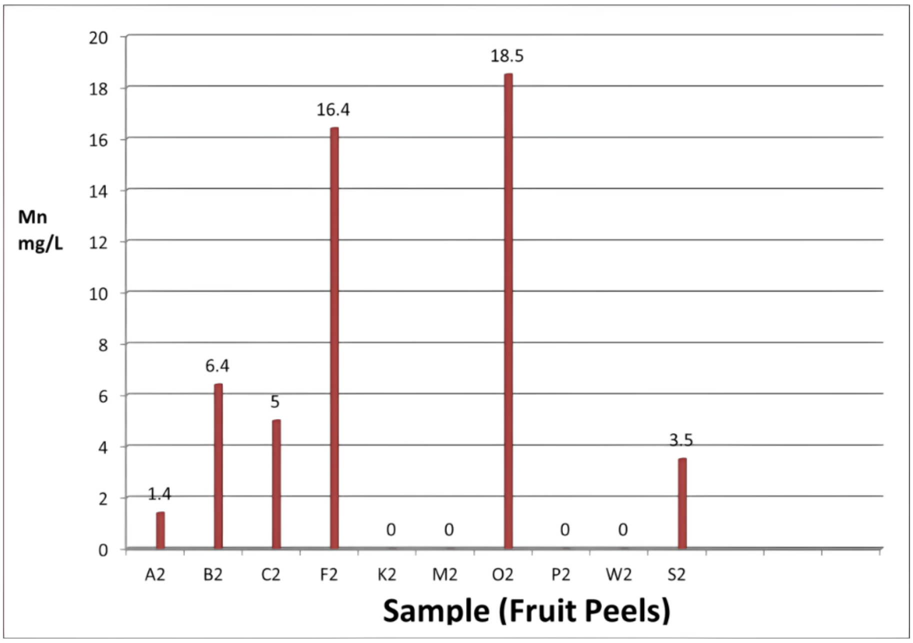

Fig. 8. Concentration of Mn in the scales of the samples under study

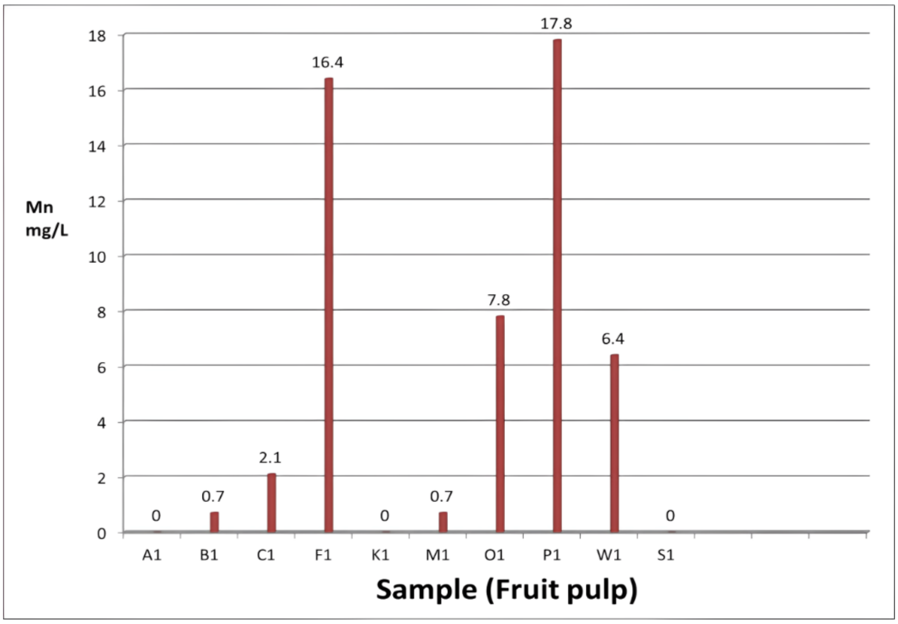

Fig. 9. Concentration of Mn in the pulp of the samples under study

As for iron, the results of his study are presented in Figure 10 and Figure 11 which display those concentrations of iron varied between 2.196 and 8.754 mg/L. According to the results obtained from the Table 1 and Table 2 for iron above, as can be seen, all the concentration is very minimal compared to the internationally permissible knowledge standard by FAO/WHO [32,33]. (425 mg/L). The concentration of iron varied from [2.196 in B2 in the peels of the samples – 8.754 in K1 in the pulp of the sample] mg/L [34]. Figure 10 and Figure 11 show the concentrations of iron in the peels and pulp of the studied fruits, respectively.

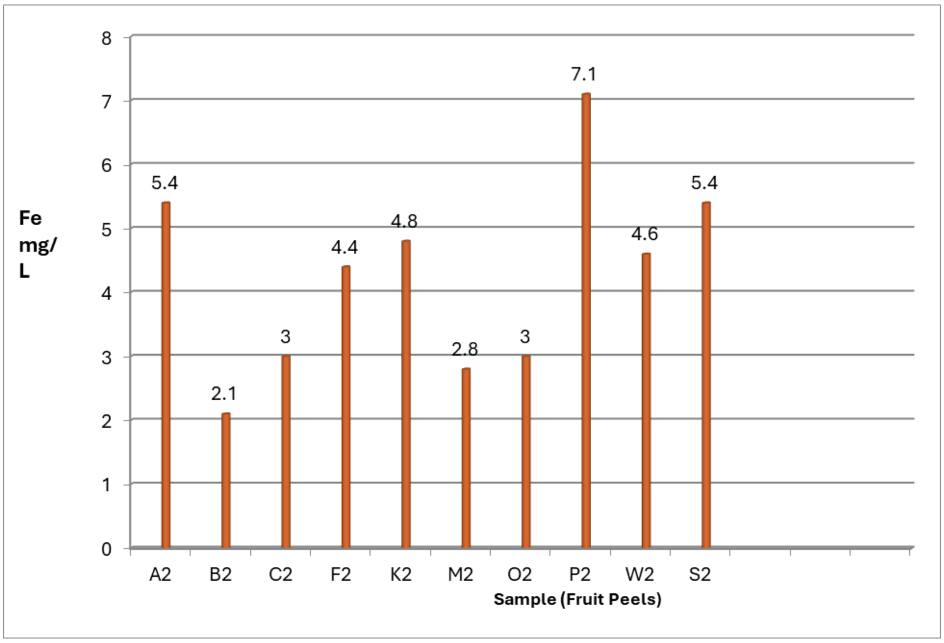

Fig. 10. Concentrations of Fe in the scales of the samples under study

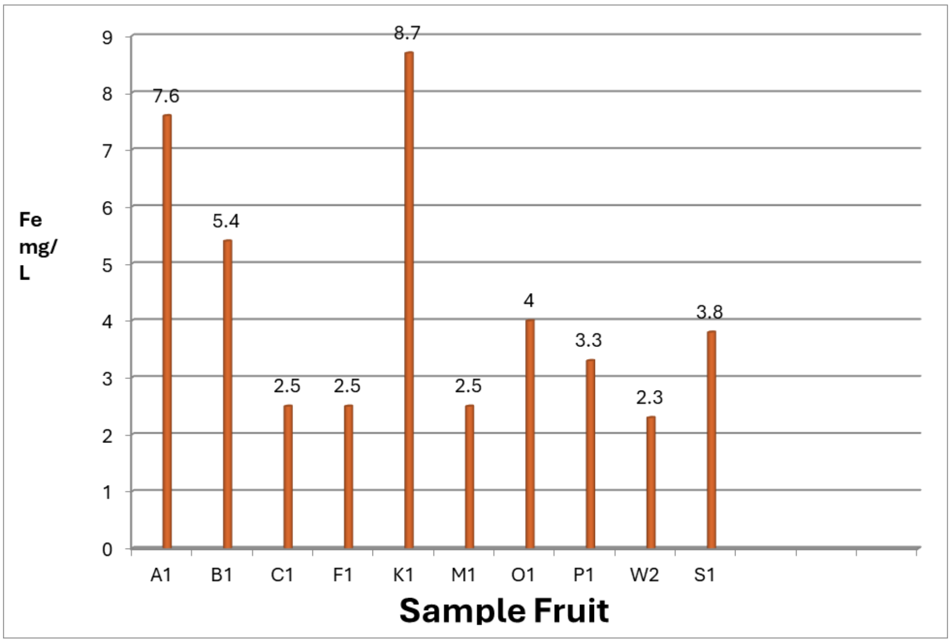

Fig. 11. Concentrations of Fe in the scales of the samples under study

4. Conclusion

The results showed that the majority of the observed concentrations of the studied elements are lower than the maximum permissible limits set by FAO/WHO, indicating their safety for human use. in specifically, the study indicates minimal levels of chromium, copper, manganese, and iron in the samples, which is generally favourable. However, there are concerns regarding high nickel concentrations in some samples, suggesting potential contamination issues that may require further investigation or remediation measures. additionally, this study encourages food and drug control centres, agricultural research centres, and relevant authorities to conduct numerous studies and analyses on all agricultural products including vegetables, fruits, grains, legumes, and animal feed to ensure their safety for human, animal, and environmental health.

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