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Evaluation of heavy metals content in the canned/packed fruit juices from local and imported origin in Lahore, Pakistan

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ABSTRACT

This study was conducted to determine the mean concentration of heavy metals such as lead (Pb), copper (Cu), zinc (Zn), chromium (Cr), manganese (Mn), nickel (Ni), selenium (Se), magnesium (Mg), and iron (Fe) in canned/packed fruits juices, collected from various stores in Lahore in a period of three months. These juices were categorized into four groups; local packed and canned and also imported packed and canned products. Every group consisted of ten samples. By using the di-acid digestion method, the collected samples were digested and analyzed under Atomic Absorption Spectrophotometer (AAS). The results indicated that the mean values of 7 out of 9 tested heavy metals including Pb, Mg, Ni, Fe, Cr, Se and Mn were above permissible limits (set by WHO) in all four understudy groups. Therefore, it was concluded that commercially available fruit juices are not all safe according to their heavy metals content for the human consumption despite their nutritive values.

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1. Introduction

The heavy metals such as chromium, lead, nickel, zinc, copper, arsenic, cobalt, manganese, cadmium and mercury in food are important contaminants, because all of them are toxic at a certain level. Exposure of heavy metals to humans is mainly by diet, therefore dietary intakes should be monitored to quantify them.

Recently, consumption of fruit juices has increased by considering them as an essential part of healthy diet as they contain many nutrients like minerals, trace elements, vitamins, and photochemical antioxidants (1,2). They contribute significantly to the good health of people irrespective of their ages (3). Fruit juices work

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effectively against chronic inflammation, cancer, heart and bone diseases (4) and act as a detoxifier (5).

The nectar and juices are known for their ability to increase the strength for oxidation inhibition. Naturally, the oxidation stress and infections are resisted by fatty and sugary food (6). Fruit juices are easily available around the globe in canned, packed, and other forms. As liquid consumption increases during summers, these juices become as one of the main sources of dietary intake, particularly for the people living in towns and cities.

Due to their wide consumption worldwide, it is important to test industrial fruit juices for their contamination of any kinds (7). Although, there are significant scientific data that establishes the benefits of fruit juices (i.e., they are anti mutagenic or anti carcinogenic), presence of some elements (heavy metals) in industrially produced juices have been recognized as a cause of mutation and cancer (8) as they accumulate in human bodies and can lead to nutritional dysfunctionalities (9).

Heavy metals concentration differs in fruit juices based on their storage and processing technologies to be used (10). These elements affect humans and animals of all ages but their effects on children are severe (11,12). Heavy metals particularly Pb, Ar and Cd are toxic for the environment as well as for human health. Prolonged intake of Cd can cause permanent harm to human kidneys. It can also exchange itself with Zn causing high blood pressure. Lead is also a risk to human health and nature. Short-term exposure to As can cause breathing, skin and stomach disorders etc., and can lead to death (13,14). Zn is essential for humans in small amounts and its high concentration can pose serious issues to the human health (15).

Therefore, the quantification of food items and beverages for their heavy metals content is necessary (10,16,17). The aim of the current study was to know the concentrations of heavy metals in different commercially available fruit juices including local packed, imported packed, local canned and imported canned, and compare the results with WHO standards to discover whether they are safe to consume or not.

2. Materials and Methods

This study was designed to evaluate the heavy metal concentrations in canned/packed fruit juices of various brands (local & imported) available in Pakistan in a period of three months.

2.1 Sample Collection

Juice samples of different brands were collected from different shops, bakeries, and super-markets of Lahore. They were divided into four groups each containing ten fruit juices.

i) **Group1 (Local Packed) includes:**
Brand 1, Brand 2, Brand 3, Brand 4, Brand 5, Brand 6, Brand 7, Brand 8 Brand 9 and Brand 10

ii) **Group 2 (Imported Packed) includes:**
Brand 11, Brand 12, Brand 13, Brand 14, Brand 15, Brand 16, Brand 17, Brand 18, Brand 19 and Brand 20

iii) **Group 3 (Local Canned) includes:**
Brand 21, Brand 22, Brand 23, Brand 24, Brand 25, Brand 26, Brand 27, Brand 28, Brand 29 and Brand 30

iv) **Group 4 (Imported Canned) includes:** Brand 31, Brand 32, Brand 33, Brand 34, Brand 35, Brand 36, Brand 37, Brand 38, Brand 39 and Brand 40.

2.2. Digestion Process

Samples of fruit juices were digested in Lab by using di-acid digestion method. In Kjeldha's digestion tube, 1 g of sample was taken and 7 mL of HNO_3 was added, then after a few minutes, 3 mL of $HClO_4$ was added too. This solution was placed into digestion block and heated up to 150°C for 30 min, then temperature was increased to 250°C till the digestion was completed with the end point of vine green or clear water color (19). A solution of 25 mL volume was made with distilled water for heavy metals analysis.

2.3.Analysis of Samples

The digested samples were analyzed under Atomic Absorption Spectrophotometer (AAS) (Model No: Polarized Zeeman Z-8230). (The Wavelength Adjustment for each heavy metal is presented in table 1.

Table 1. Wavelength Adjustment for Heavy Metals in AAS

Heavy Metals	Wavelength (nm)
Cu	324.8
Pb	283.3
Mg	285.2
Ni	232.0
Fe	248.3
Cr	357.9
Zn	213.9
Se	196.0
Mn	279.5

2.4. Statistical Analysis

The results were analyzed by one-way ANOVA test in SPSS software.

3.Results

3.1. Copper (Cu) Concentration

The permissible limit of Cu is 2 ppm set by WHO. The results revealed that no Cu was detected in local and imported packed groups, whereas the mean concentration of Cu in local canned products was 48.23±42.64 ppm and for imported canned products 13.56±0.81 ppm was obtained. Table 2 presents the mean concentration of Cu in all detected groups.

Table 2. Concentration of Cu (ppm)

WHO	2
B23	95.00±1.71
B25	38.20±4.3
B26	11.50± 1.11
B32	14.50±1.05
B36	13.00±0.9
B38	13.20±2.05

3.2. Lead (Pb) Concentration

The standard limit of Pb is 0.01 ppm set by WHO. Results showed that mean concentration of Pb in local packed group was 8.03±2.55 ppm and in imported packed group 11.07±2.59 ppm was recorded. On the other hand, its mean concentration in local canned group was 11.71±4.35 and in imported canned group it was 9.84±3.54 ppm. In Local Packed Brand 4 showed the highest concentration i.e., 11.25 ppm, whereas in imported packed group, Brand 19 showed the highest level i.e., 15.3 ppm. Among local canned juices, Brand 22 indicated the highest level 17.3 ppm, whereas in imported canned group, Brand 37 showed the highest concentration of 14.75 ppm. The data are presented in Figure 1.

3.3. Magnesium (Mg) Concentration

The standard limit of Mg set by WHO is 50 ppm. Results showed that mean concentration of Mg in local packed group was 55.89±13.15 ppm and in imported packed group 63.67±31.57 ppm was recorded. On the other hand, its mean concentration in local canned group was 50.33±17.10 and in imported canned group it was 56.3±33.33 ppm. In local Packed, Brand 06 showed the highest level i.e., 88.5 ppm whereas, in imported packed group, Brand 12 showed the highest level i.e., 122.5 ppm. Among local canned juices, Brand 28 indicated the highest level 68.5 ppm, whereas in imported canned group, Brand 36 showed the highest concentration of 119.5 ppm. Figure 2 presents the mean value of Mg in all groups.

3.4. Nickel (Ni) Concentration

The permissible limit of Ni as per WHO is 0.07 ppm. Results showed that mean concentration of Ni in local packed group was 11.78±7.67 ppm and in imported packed group 13.3±14.3 ppm was recorded. On the other hand, its mean concentration in local canned group was 6.66±3.25 and in imported canned group it was 8.51±5.87 ppm. Among local packed juices group, Brand 4 showed high Ni value of 30.75 ppm, whereas imported packed Brand 16 had highest level i.e., 48 ppm. Similarly, local canned Brand 27 showed the highest content of 12 ppm among all local canned juices. Among imported canned juices, Brand 34 indicated a high concentration of 19.5 ppm as compared to others. The Concentration of Ni in all groups is shown in Table 3.

3.5. Iron (Fe) Concentration

The permissible limit for Fe set by WHO is 1 ppm. The results of this study indicated that the mean concentration of Fe in local packed juices group was 73.4±12.42 and 73.0±30.61 ppm in imported packed group. Whereas it's mean concentration in local canned juices group was 68.14±42.11 ppm and 59.3±5.77 ppm in imported canned group. Among local packed juices group Brand 4 showed high Fe value of 100.58 ppm whereas, imported packed Brand 18 had highest level i.e., 158.25 ppm. Similarly, local canned Brand 25 showed the highest content of 185.25 ppm among all the local canned juices. Among imported canned juices Brand 39 indicates he highest concentration of 68.58 ppm as compared to others. The data are presented in Figure 3.

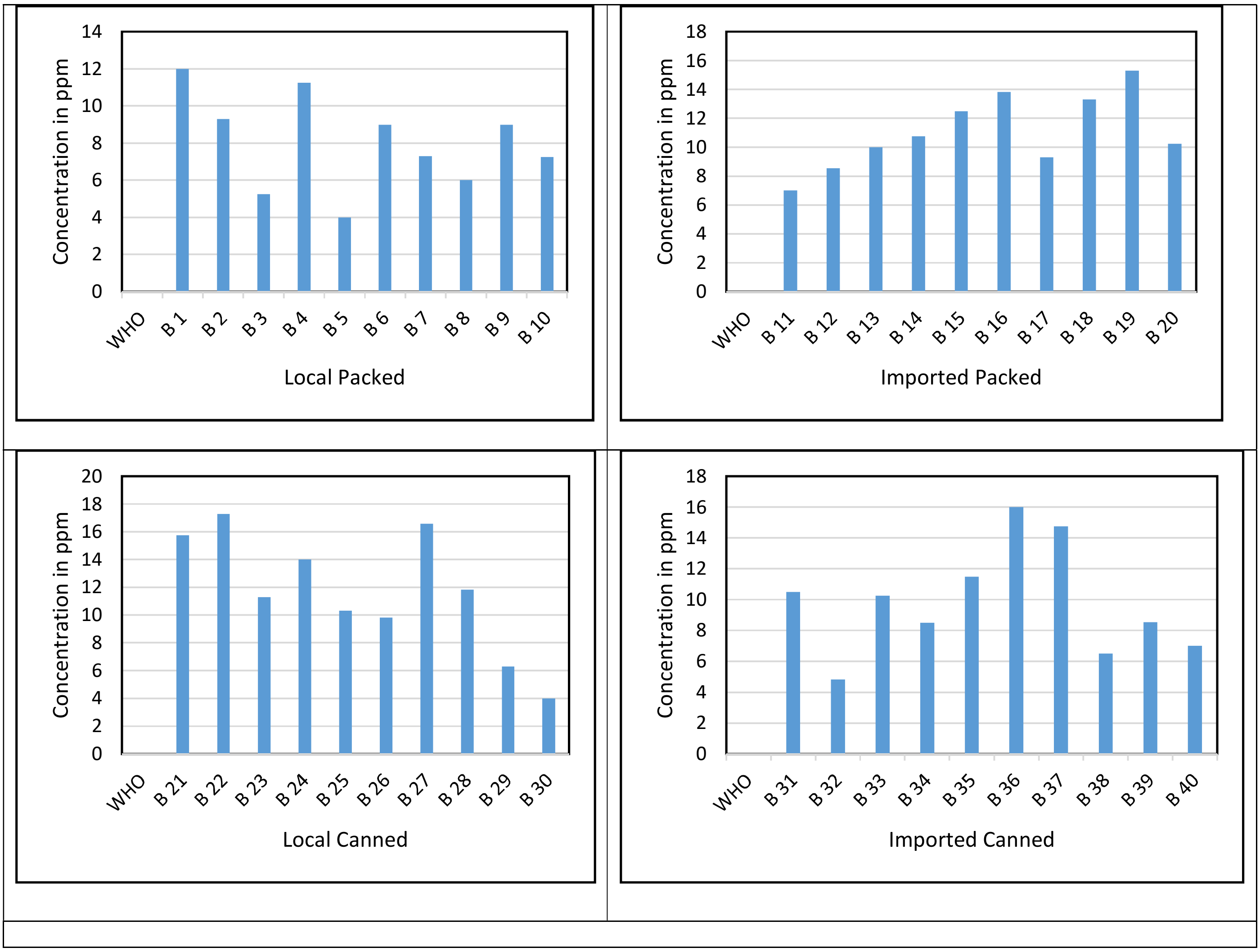

Figure 1. Concentration of Pb

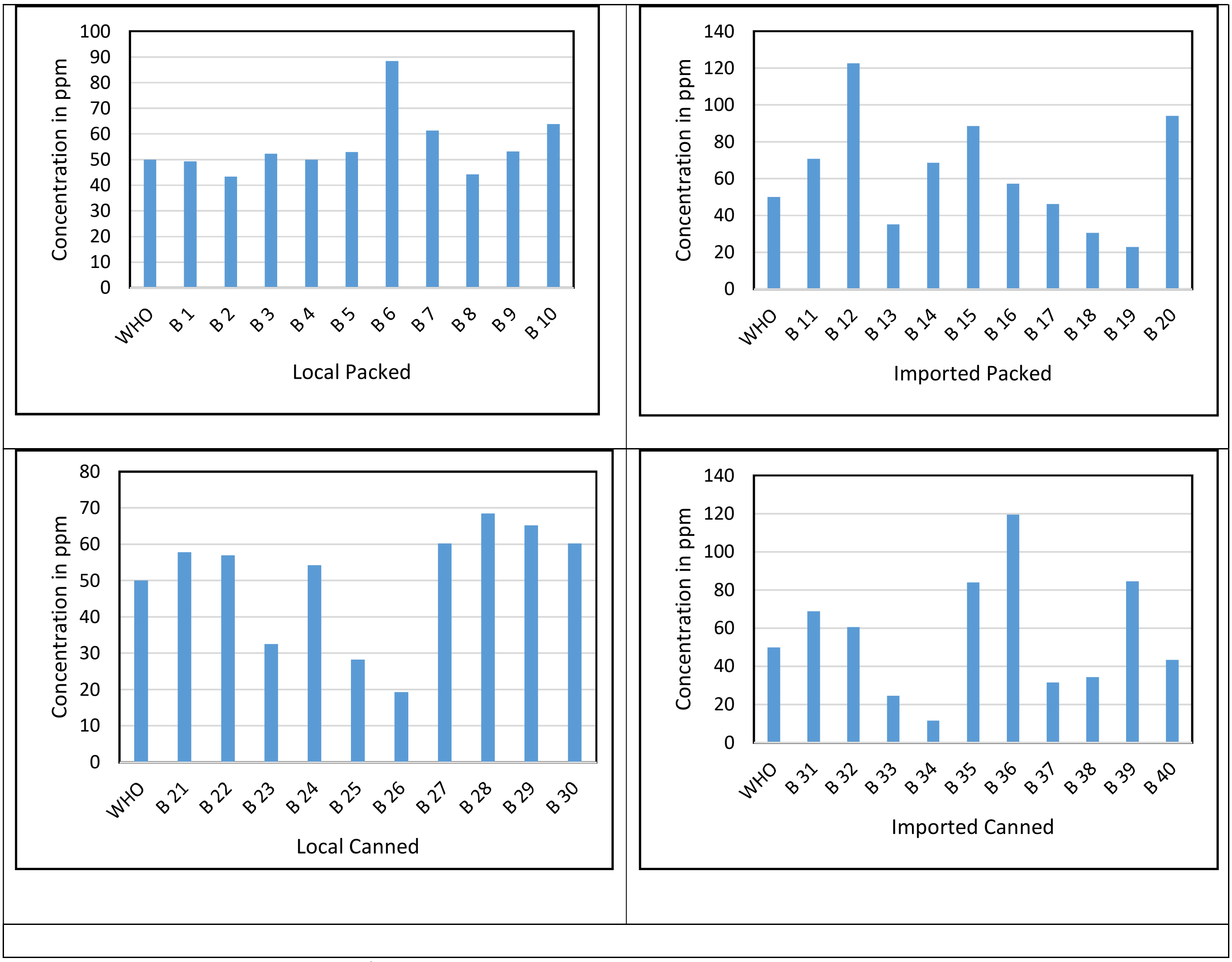

Figure 2. Concentration of Mg

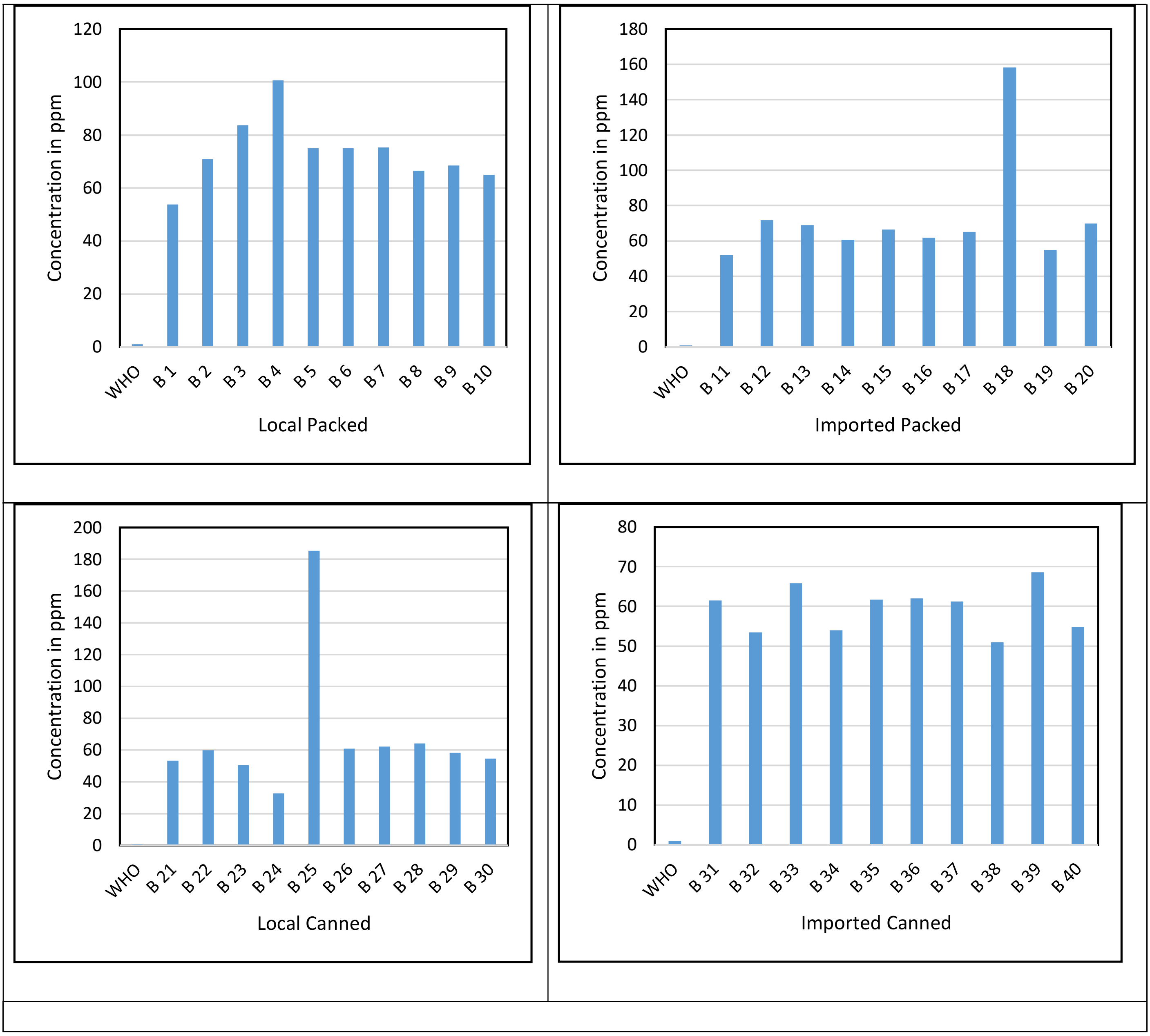

Figure 3. Concentration of Fe

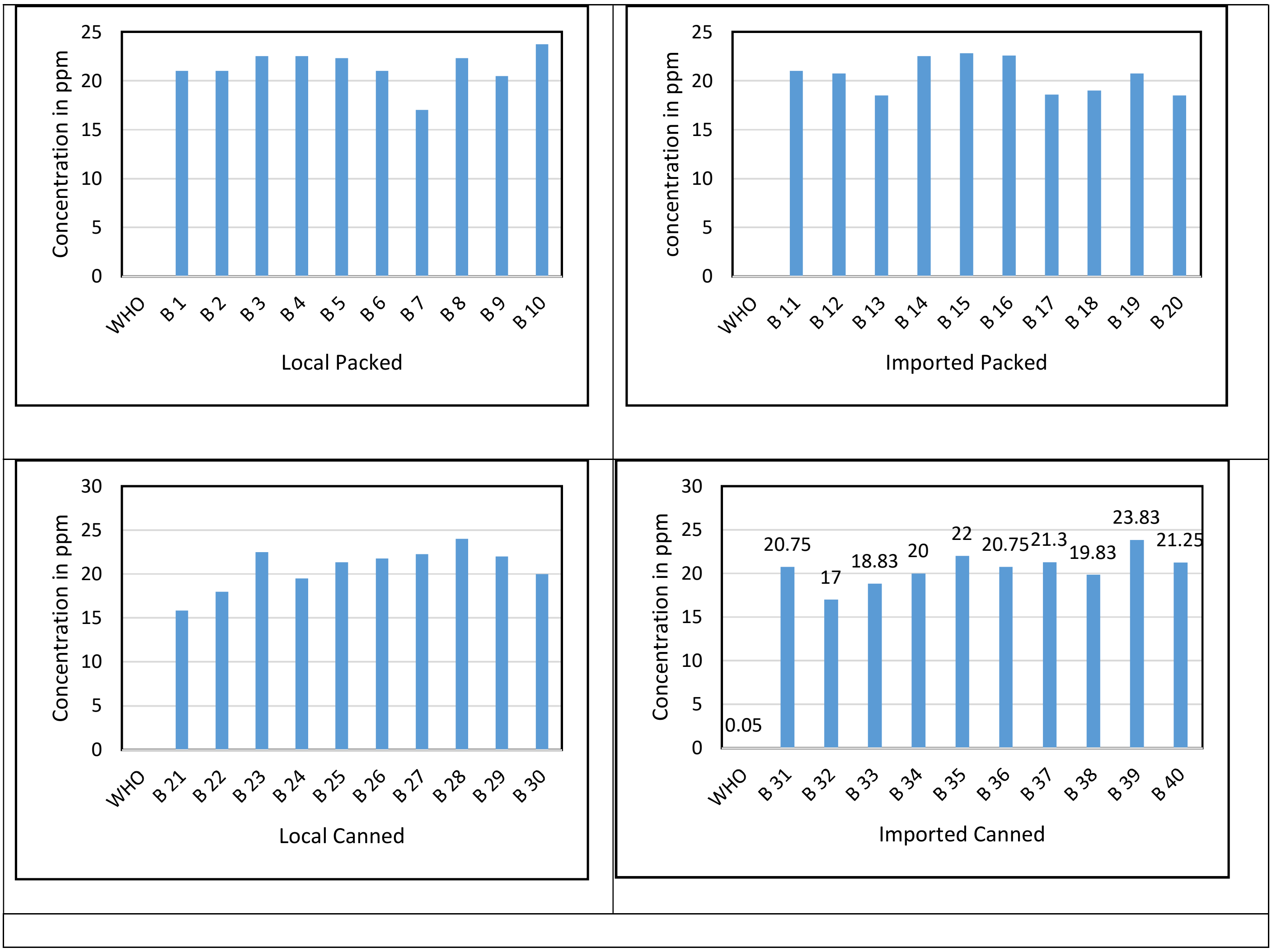

Figure 4. Concentration of Cr

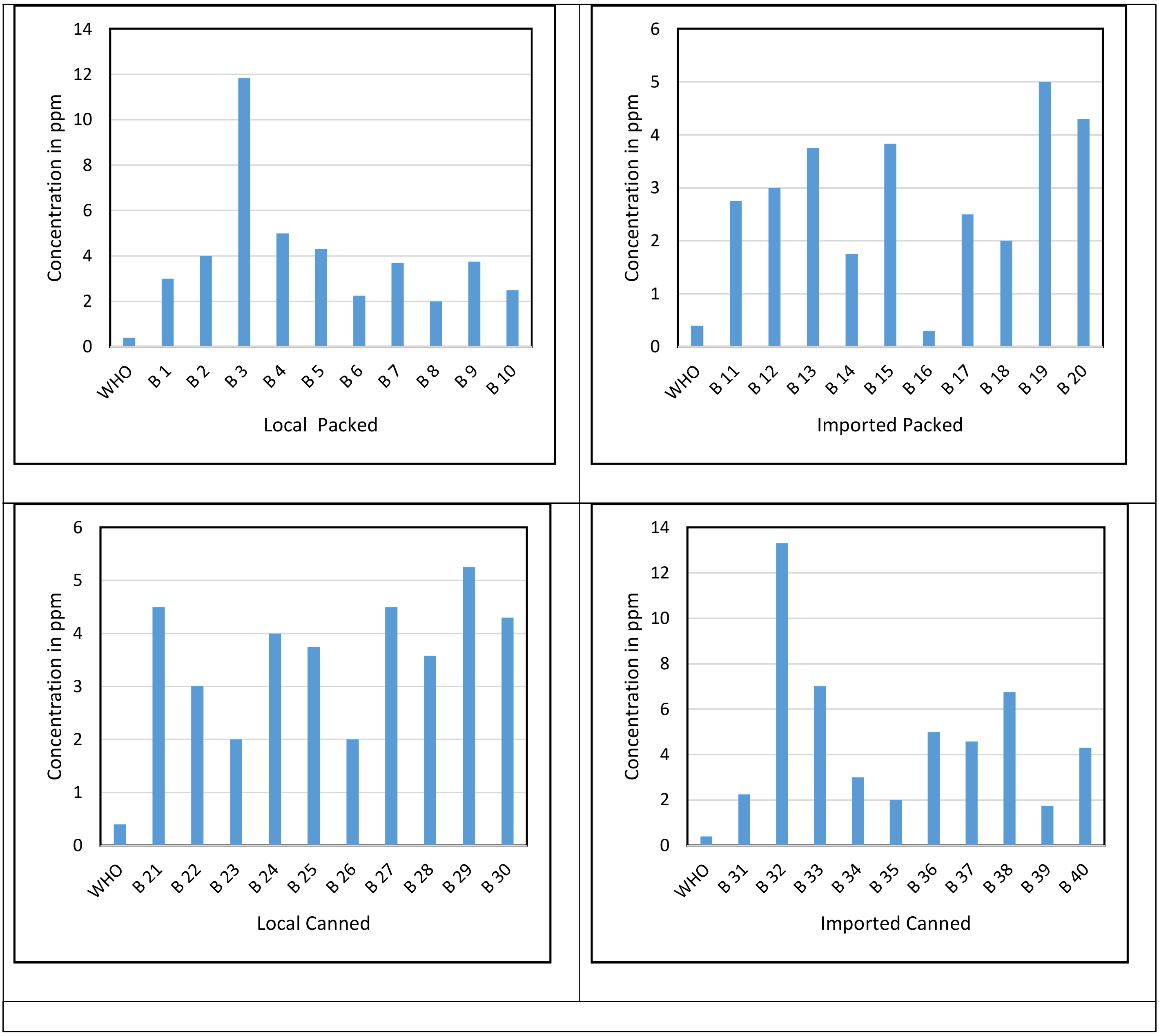

Figure 5. Concentration of Mn

Table 3. Concentration of Ni (ppm)

Local Packed		Imported Packed		Local Canned		Imported Canned	
B1	6.83±2.31	**B11**	8.25±1.4	**B21**	8.75±1.92	**B31**	6.75±0.75
B2	19.00±1.1	**B12**	N.D	**B22**	0.30±0.04	**B32**	N.D
B3	9.00±0.89	**B13**	N.D	**B23**	6.83±2.31	**B33**	5.00±0.34
B4	30.75±2.7	**B14**	6.25±0.96	**B24**	5.75±1.42	**B34**	19.50±1.5
B5	8.00±0.85	**B15**	7.75±0.25	**B25**	6.75±1.88	**B35**	N.D
B6	10.75±1.86	**B16**	48.00±0.75	**B26**	6.33±0.80	**B36**	1.25±0.18
B7	7.83±2.30	**B17**	7.75±0.7	**B27**	12.00±0.75	**B37**	10.50±1.76
B8	12.41±1.3	**B18**	5.50±0.5	**B28**	N.D	**B38**	4.75±0.66
B9	7.50±1.01	**B19**	14.75±2.12	**B29**	N.D	**B39**	6.33±1.30
B10	5.75±1.6	**B20**	7.83±1.07	**B30**	6.58±0.38	**B40**	14.00±1.01

WHO limit: 0.07 ppm. N.D: Not Detected

Table 4. Concentration of Zn (ppm)

Local Packed		Imported Packed		Local Canned		Imported Canned	
B1	4.00±1.82	**B11**	0.25±0.20	**B21**	N.D	**B31**	0.25±0.36
B2	5.00±0.45	**B12**	4.50±0.34	**B22**	N.D	**B32**	N.D
B3	4.25±0.7	**B13**	0.25±0.12	**B23**	N.D	**B33**	N.D
B4	6.50±0.65	**B14**	1.25±0.11	**B24**	N.D	**B34**	N.D
B5	7.58±0.52	**B15**	0.15±0.05	**B25**	2.00±0.20	**B35**	N.D
B6	4.50±0.56	**B16**	1.25±0.52	**B26**	2.00±0.21	**B36**	1.75±0.12
B7	1.58±0.59	**B17**	N.D	**B27**	4.00±0.16	**B37**	N.D
B8	0.58±0.11	**B18**	N.D	**B28**	27.50±2.1	**B38**	N.D
B9	2.50±0.41	**B19**	N.D	**B29**	N.D	**B39**	N.D
B10	3.25±0.56	**B20**	N.D	**B30**	N.D	**B40**	N.D

WHO limit: 5 ppm. N.D: Not Detected

Table 5. Concentration of Se (ppm)

Local Packed		Imported Packed		Local Canned		Imported Canned	
B1	N.D	**B11**	N.D	**B21**	N.D	**B31**	8.00±0.1
B2	N.D	**B12**	7.5±0.95	**B22**	N.D	**B32**	8.75±0.22
B3	N.D	**B13**	25.50±1.21	**B23**	7.30±0.35	**B33**	N.D
B4	2.50±0.5	**B14**	N.D	**B24**	4.60±0.6	**B34**	N.D
B5	5.58±0.33	**B15**	N.D	**B25**	7.30±0.2	**B35**	10.30±0.18
B6	N.D	**B16**	2.50±0.35	**B26**	N.D	**B36**	N.D
B7	N.D	**B17**	5.00±0.84	**B27**	N.D	**B37**	N.D
B8	7.80±0.24	**B18**	5.00±0.36	**B28**	N.D	**B38**	27.70±0.3
B9	N.D	**B19**	N.D	**B29**	2.50±0.56	**B39**	N.D
B10	N.D	**B20**	N.D	**B30**	5.00±0.37	**B40**	25.50±0.53

WHO limit: 0.04 ppm. N.D: Not Detected

3.6. Chromium (Cr) Concentration

Its permissible limit set by WHO is 0.05 ppm. Study results indicated that the mean concentration of Cr was 21.38±1.83 ppm in local packed group and 20.47±1.76 ppm in imported packed group. On the other hand, in local canned group, 20.70±2.41 ppm was observed as an average value, whereas it was recorded as 20.05±1.83 ppm in imported canned group of juices. In local Packed, Brand 10 showed the highest level i.e., 23.75 ppm whereas, in imported packed group, Brand 15 showed the highest level i.e., 22.83 ppm. Among local canned juices, Brand 28 indicated the highest level 24 ppm, whereas in imported canned group, Brand 39 showed the highest concentration of 23.83 ppm. The mean concentration of Cr is shown in Figure 4.

3.7. Zinc (Zn) Concentration

The standard limit of Zn as per WHO is 5 ppm. Results indicated that the mean concentration of Zn was 3.94±2.13 ppm in local packed group and 1.5±1.75 ppm in imported packed group. On the other hand, in local canned group, 8.87±12.45 ppm was observed as an average value, whereas it was recorded as 1.0±1.1 ppm in imported canned group of juices. Among local packed fruit juices, Brand 5 showed the highest Zn content value of 7.58 ppm as compared to others, whereas among imported packed group, Brand 12 had the highest level i.e., 4.5 ppm. Similarly, local canned Brand 28 showed the highest level of 27.5 ppm among all local canned juices, whereas in imported canned group, Brand 36 showed the highest level i.e., 75 ppm. The Concentration of Zn in all groups is presented in Table 4.

3.8. Selenium (Se) Concentration

The permissible limit of Se set by WHO is 0.04. Results revealed that the mean concentration of Se was 5.29±2.66 ppm in local packed group and 9.1±9.33 ppm in imported packed group. On the other hand, in local canned group, 5.34±2.03 ppm was observed as an average value, whereas it was recorded as 16.05±9.69 ppm in imported canned group of juices. Local packed juice named as Brand 8 revealed the highest Se concentration i.e., 7.8 ppm, while imported packed juice Brand 13 showed the highest level of 25.5 ppm. In local canned group, Brand 23 and Brand 25 had the highest Se content as 7.3 ppm, whereas in imported canned group, Brand 38 had the highest level of 27.7 ppm than others in the group. Table 5 shows the Se concentration in all groups.

3.9. Manganese (Mn) Concentration

The WHO standard limit for Mn is 0.4 ppm. Results indicated that the mean concentration of Mn was 4.23±2.83 ppm in local packed group and 2.91±1.37 ppm in imported packed group. On the other hand, in local canned group, 3.68±1.07 ppm was observed as an average value, whereas it was recorded as 4.99±3.45 ppm in imported canned group of juices. Among local packed brands of juices, Brand 3 indicated the highest value of Mn i.e., 11.83 ppm whereas, in imported packed group Brand 19 showed the highest concentration of 5 ppm. Similarly, in local canned brands of juices, Brand 29 showed the highest level of 5.25 ppm, whereas in imported canned juice, Brand 32 showed the highest level of 13.5 ppm as compared to others in the group. The concentration of Mn in all groups is shown in figure 5.

4.Discussion

The heavy metal content in 10 samples of each commercially Packed/Canned fruit juices of local and imported origin available in Lahore, were determined by using wet digestion and AAS.

Copper is an important metal for human body, however its higher concentration causes serious health problem. The Lab analysis of samples revealed that no Cu was found in local and imported packed juices whereas its value exceeded the permissible limit in canned juices both local and imported. These findings were comparable to an Egyptian study that found very high levels of Cu in fruits and vegetables (18). Unlike this, Sobukola et al, in 2010 (20) reported lower Cu content i.e., 0.003 mg/kg in canned orange and 0.015 mg/kg in pineapple. According to Bolger et al, in 2000 (21), food items should be lead free because it is a toxic metal, it bio-accumulate in the human body and poses serious impacts on the human health. Its long-term exposure can permanently damage human liver. The current study reveals that Pb concentration was above the permissible limit in all four categories of juices, Similar to a Polish study that was conducted to know heavy metal concentrations in fruit juices and discovered that 88 % of fruit juices met Polish national standards, whereas, in only 12 % of juices, Pb & Cd content was above the permitted limits (22).

Another heavy metal under examination was Mg which is an important mineral required by the human body for its many functions and performances. The results of this study revealed that Mg content was higher than standard limits in all four groups of fruit juices. These results were compatible with those of Anna (23). Next heavy metal was Ni about which research is still under way to find the mechanism of Ni effects on human body. The current study identified higher Ni concentration than standard limit in all four under study groups. In a similar study, heavy metals contamination was studied in 20 samples of fruit juices of different flavors. Cu and Cd were lower than the limits, but the Ni was above the limit (24).

Iron is another essential metal as it performs important role in electron and oxygen transport and hemoglobin formation in human circulatory system. The concentration of Fe reported by current study in all four groups of juices, was different from the findings of a similar study on berry juices from Serbian market, where it was within the range of 0.0003 to 0.0021 ppm (25). Next element was Chromium, a non-essential metal and its continued exposure pose serious threats to human health. The results revealed that Cr concentration in each of the under study groups was exceeding the WHO limit which was similar to the findings of another study, where Cr concentration ranged between 0-17.61 μg/L in the juice samples collected from a market in Spain (26).

Zinc is also an important trace metal required by the human body for its growth and proper functioning. It is less toxic as compared to other metals. The current study found that mean Zn concentration was normal ($>$ 5 ppm) in three groups i.e., packed local, imported and local canned juices whereas it was beyond the permitted limit in imported canned juices. A similar study conducted in Brazil revealed that Zn content of juices ranged from 86.7 to 1122.5 µg/L (27). The current study also tested juices for Se which is an important part of an enzyme named glutathione peroxidase that works for the prevention of the cell damage and it also converts thyroxine to iodothyronine in liver. The deficiency of Se causes hypothyroidism. According to the present study, higher mean value of Se was found in all four groups of juices than the permissible limit of WHO. These results were compatible with another study in which beverages were tested to measure levels of Se, Zn and Cu. Levels of Zinc were within range but Cu and Se were higher than limits. Moreover, Se levels were also high in non-canned products (28).

Lastly, Mn concentration was also tested in 4 groups. Mn causes a number of negative impacts on the environment as well as human body if its concentration increases. According to the present study, higher mean concentration of Mn was found in all four groups of juices than the permissible limit of WHO. Similarly, another study found higher concentration of Mn in blueberry juice (2.24 ppm) and red fruits juice 1.17 ppm. One more study found that heavy metals such as Pb, Ni, Mn and Fe were higher than recommended values in four different fruits, however, Zn was within the recommended values (29,30).

5.Conclusion

The results indicated that the mean values of 7 out of 9 tested heavy metals such as Pb, Mg, Ni, Fe, Cr, Se and Mn were higher in all four under study groups except for Cu and Zn which were only exceeding in canned juices. Hence, the study concluded that commercially available fruit juices are not all safe for the human consumption despite their nutritive values. This study does not explore or compare the causes of exceeding values in packed/canned fruit juices. However, it lays basis for further complete investigation to know whether contaminated water/soil are responsible for fruits contamination or it is the process of packing, canning and preservation that increases the amount of heavy metals in fruit juices.

Conflict of Interest

The authors declare no conflicts of interest.

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