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Determination of some heavy metal content in orange juices consumed in Libya

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تحديد محتوى بعض المعادن الثقيلة في عصائر البرتقال المستهلكة في ليبيا

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Abstract:
Atomic Absorption Spectrometry (AAS) was used to assess the amounts of Cd, Cu, Pb, and Fe in ten samples of two separate types of orange juice. Both juices contained amounts of copper and iron, and one sample had a cadmium concentration. Juices marketed in Libya have a metal concentration below the acceptable limits established by health organizations. Although commercially available fruit juices are safe worldwide, more risk-based monitoring research has to be done to reduce exposure to harmful metals from fruit juice sources.

Keywords: Orange juice, Iron (Fe), Lead (Pb), Cadmium (Cd), Copper (Cu), Atomic absorption spectrometry.

Abbreviations: WHO, World Health Organization ; **SAC**, Standardization Administration of China ; **US-EPA**, United States Environmental Protection Agency ; **ND**, non-detectable.

الملخص
تم استخدام جهاز مطيافية الامتصاص الذري (*Atomic Absorption Spectrometry*) لتقييم كميات الكادميوم والنحاس والرصاص والحديد في 10 عينات من نوعين من عصير البرتقال. يحتوي كلا العصيرين على كميات من النحاس والحديد، كما وجدت كميات من الكادميوم في إحدى العينات. تحتوي العصائر التي يتم تسويقها في ليبيا على تركيز من المعادن الثقيلة أقل من الحدود المقبولة التي وضعتها المنظمات الصحية. وعلى الرغم من أن عصائر الفاكهة المتوفرة تجاريًا آمنة في جميع أنحاء العالم، إلا أنه يجب إجراء المزيد من الابحاث لمراقبة المخاطر وللحد من التعرض للمعادن الضارة من مصادر كعصير الفاكهة.

الكلمات المفتاحية: عصير البرتقال الطبيعي، الحديد(*Fe*)، الرصاص (*Pb*)، الكادميوم (*Cd*)، النحاس (*Cu*)، مقياس الامتصاص الذري الطيفي.

الاختصارات: ***WHO***، منظمة الصحة العالمية؛ ***SAC*** ، إدارة التقييس الصينية؛ ***US-EPA*** ، وكالة حماية البيئة الأمريكية؛ ***ND*** ، غير قابل للكشف.

Introduction

Since the accumulation of heavy metals in food crops at greater concentrations might pose a substantial risk to human health if the products ingested, contamination of fruits, vegetables, and other crops is a major concern (Ahmad et al., 2018; Salem et al., 2025; Salem & moftah Mohamed, 2025). Food crops have been shown to contain higher concentrations of arsenic, lead, zinc, and other metals than the recommended daily amount. Metals like copper, zinc, and iron are vital components of plants because of their physiological roles, even if many other heavy metals have no discernible effect on plant health. Due to their involvement in numerous enzymatic systems inside the human body, critical elements are extremely significant. High quantities, however, are (Elderwish et al., 2019; Salem & Salem, 2023; Sönmez et al., 2012). The application of certain pesticides, industrial and sewage effluent, discharges into agricultural fields, metal aerosol deposition from automobile emissions, and other sources are the origins of these metals in food crops. Additionally, these trace metals move from the soil solution to other plant components via the roots (Kabasakalis et al., 2000; Shahid et al., 2017). A significant portion of the farmers' revenue comes from the cultivation of citrus fruits.Higher concentrations of these heavy metals in fruits could pose a major health risk to people if they consumed. Consequently, the study's goal was to: Assess the concentrations of Fe, Cu, Pb, and Cd in oranges that are cultivated in Libya. The concentrations of the different metals found in this study compared to the dietary reference values that advised in other nations.

Material and methods

Collection of Samples

Samples of oranges were collected at random from different sites, put in bags with the proper labels, and transported to the lab for examination. There were four samples collected for every citrus cultivar.

Sample Treatment

After washing the fruits with tap water and then distilled water, the juice was extracted and transferred into several beakers. Each sample yielded about 250 mL of juice. Before analysis, the juice was filtered, thoroughly blended, and refrigerated. A 250 mL beaker was filled with 50 mL of the sample. 50 milliliters of 36% HCl and 63% $HNO3$ was added. A watch glass was placed over the liquid, which was then heated and allowed to reflux on a hot plate. After adding another 10 milliliters of (HCl and $HNO3$) the mixture was heated until it turned a pale yellow. After repeating the previous step , the solution evaporated until it reached a volume of roughly 15-20 milliliters. To guarantee thorough digestion, 10 mL of 30% $H2O2$ was added to the cooled solution and heated without boiling until there was very little effervescence. The volume decreased to roughly 10 mL after the heating was maintained. After cooling on the hot plate, the beaker was taken off, and the walls were washed using double-distilled water. The digest was diluted with double-distilled water to the 50 mL mark after being filtered using Whatman No. 4 filter paper into a 50 mL volumetric flask. This approach was used to digest four samples of orange juice apiece. An Atomic Absorption Spectrometry (AAS) was used to analyze all of the digested samples for Fe, Cu, Pb, and Cd.

Results and discussion

Fruits are a great source of nutrients and are less affordable and readily available than nutritional supplements. Consuming fruits on a daily basis has been closely linked to a lower risk of heart disease, stroke, some types of cancer, and other chronic illnesses. All of the orange juice samples contained iron and copper, but just one sample had cadmium, and none of the samples contained lead. Iron and copper contents varied from 1.8 to 2.0 mg/L and 0.7 to 0.1 mg/L, respectively (Table 1). Even if the amount of cadmium in the juice samples is within the allowable limit, its presence suggests that there was contamination from other sources in the fruit juices.

Table 1 Concentration of heavy metals in orange juices A and B (mg/L) compared to some reference values.

Samples	Pb	Cd	Cu	Fe
A	ND	0.01	0.7	1.8
B	ND	ND	0.1	2.0
Libyan/WHO limits	0.01	0.003	2	1
US-EPA Limits	1.5	0.005	1.3	-
European Union	1.5	0.03	3.5	-
SAC Limits	0.05	0.03	3	2
Indian Standard	2.5	1.2	-	-

The World Health Organization states that fruit juice can contain up to 2.0 mg/L of copper, 0.01 mg/L of lead, and 0.003 mg/L of cadmium (WHO). Consequently, all of the heavy metal contents (lead, cadmium, and copper) in every juice sample were below the WHO-permissible levels.

The findings on copper and cadmium are similar to those of a study conducted in Pakistan by (Fatima et al., 2021) , in which no samples contained cadmium, but copper was found at concentrations high. In general, the heavy metal levels in the current study are lower than those in other commercial juices from other nations. The concentrations of copper, lead, and cadmium, for instance, ranged from 2.65 to 2.72, 0.50 to 0.66, and BDL to 0.002 mg/L, respectively, in canned pineapple drinks, and from 2.56 to 3.45, 0.002 to 0.006, and 0.38 to 0.60 mg/L, respectively, in canned mango drinks, according to a study conducted in Nigeria by Iwegbue et al (2010) (Iwegbue et al., 2010).

Copper levels in commercial mango juice in Egypt ranged from 5.2 to 13.64 mg/kg, according to (Hassan et al., 2014). In Minna, Nigeria, (Ajai et al., 2014) discovered copper in canned pineapple and mango juices at levels as high as 0.40 mg/L; lead and cadmium were not found. (Mohammadi & Ziarati, 2015)found that packaged fruit juices contained lead and cadmium. Lead levels in pineapple juice varied from 0.0427 ± 0.0003 to 0.345 ± 0.0003 mg/L, whereas those in mango juice ranged from 0.0452 ± 0.002 to 1.9621 ± 0.0013 mg/L.The samples of pineapple juice and mango juice had cadmium contents ranging from BDL to 0.064 mg/L and BDL to 0.157 ± 0.0024 mg/L, respectively.

The fact that fresh fruit juices are typically diluted with a lot of water, but commercial fruit juices are typically concentrated, may help to explain the findings of lower quantities of heavy metals in fresh fruit juices compared to those observed in commercial (canned) fruit juices.

Conclusion

Heavy metals are vital for physiological and biochemical processes as well as for preserving health throughout life. The issue occurs when industrial and sewage-fed lakes, rivers, or tainted groundwater are used as irrigation water. Fruits and other agricultural products can contain harmful heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), and arsenic (As). A portion of them transforms into highly hazardous substances. Food products must be tested and analyzed to make sure that the levels of these heavy metal contaminants match the established international standards, taking into account the possible toxicity, persistent nature, and cumulative behavior as well as the intake of fruits and vegetables. The levels of contamination in samples may increase due to the use of contaminated water and poor post-harvest handling practices that disrespect food safety regulations. The information will be used to determine the level of heavy metals in fruits and juices, ensure food safety, and safeguard consumers from potentially harmful fruits and juices. It is concluded that fruit juices consumed contain heavy metals less than their permissible levels.

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