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Determination of heavy metals in varieties of fresh and packaged fruit juices along with powdered fruit drink mixes in Kathmandu Valley

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ABSTRACT

Analysis of heavy metals was performed in packaged and fresh fruit juices along with powdered fruit drink mixes (Tangs), purchased from different stores of Kathmandu Valley, using Flame Atomic Absorption Spectroscopy (FAAS). Selection of Fruit Juices and Tangs was done from five different fruits, viz., apple, orange, pineapple, pomegranate, and mango in an attempt to quantify four heavy metals, i.e., Zinc (Zn), Manganese (Mn), Iron (Fe) and Lead (Pb). The wet digestion technique was employed for the decomposition of samples. Variability in the concentration of heavy metals was observed in various types of fruit juices, thereby verifying that the levels of heavy metals are dependent on the types of fruits as well as fruit juices. The mean concentrations of all the investigated metals (Fe, Pb, Mn, and Zn) were below the maximum permissible limit in the selected juices and tangs. Irrespective of the types of fruits or nature of juices, i.e., either packaged or fresh fruit juices or tangs, the studied samples are safe for human consumption based on studied heavy metals toxicity.

Keywords: Fruit juices, powdered fruit drink mixes, Flame Atomic Absorption Spectroscopy, Maximum permissible limit, Heavy metals

INTRODUCTION

Fruit Juices and powdered fruit drink mixes (Tangs) are among the most commonly consumed non-alcoholic beverages by different age groups in both developed and developing countries (Dosumu et al., 2009). Commercially available packaged fruit juices and powdered fruit drink mixes as well as freshly squeezed fruit juices consist of numerous physiologically and nutritionally pivotal compounds for human health such as bioactive phytochemicals, vital nutrients, vitamins, and various essential elements (Jalbani et al., 2010; Krjpcio et al., 2005). Apart from their use as thirst quenchers, fruit juices and tangs render a positive effect on promoting physical and mental well-being as well as preventing diet-related diseases owing to their antioxidant activity and other beneficial effects (Orak, 2009).

The effect of metals on human health depends on their types and concentrations. Essential heavy metals such as iron (Fe), zinc (Zn), and manganese (Mn), at optimum concentration, exert beneficial effects on human health due to their ability to participate in various biochemical processes in the human body; however, both low and high concentrations of these metals cause adverse health effects (Anastacio et al., 2018). For instance, iron deficiency in the human body leads to anemia while its excessive intake increases the risk of colorectal cancer. Zinc could lead to electrolyte imbalance, nausea, anemia, and lethargy if consumed in excessive quantities (Anastacio et al., 2018). Excessive consumption of manganese could lead to diseases such as gastrointestinal disorders, cancer, and respiratory problem (Powell, 2000). In contrast, a non-essential heavy metal such as Lead (Pb) imparts toxic effects on human health even when present at low concentrations (Houston, 2007; Hsu, 2002). The maximum permissible limit (MPL) of lead, zinc, iron, and manganese as recommended by WHO/FAO in fruit and vegetables are 0.3, 99.40, 425, and 100 mg/kg dry weight respectively (Banerjee et al., 2010).

Determination of heavy metals in varieties of fruit juices and powdered fruit drink mixes is of considerable importance because the information regarding the nutritional value and safety of these beverages could be ensured to consumers (Alwakeel et al., 2008). The matrix of fruit juices and tangs contains a surplus amount of organic compounds, which can cause interferences during heavy metals determination by atomic spectrometry methods (Pohl et al., 2013). Thus, it is essential to decompose fruit juices and tangs using different digestion procedures to release metals into sample solutions as simple ions (Cindric et al., 2011). The most commonly used digestion technique for fruit juices and powdered fruit drink mix samples is the wet digestion method (Tormen et al., 2011). In the case of the wet-digestion technique, conducted in an open-vessel system, samples are treated with mineral acids or their mixtures followed by heating using hot plates or digestion blocks to digest and reduce the volume of sample solutions (Tufuor et al., 2011).

Atomic Absorption Spectrometric (AAS) method is used for the determination of heavy metals in fruit juices and tangs (Nascentes et al., 2004). AAS is an analytical technique that involves atomization of the elemental samples followed by absorption of radiation from a light source by the free atoms to obtain concentrations of heavy metals in unknown samples (Welz et al., 2008). Among different atomic spectrometry methods, flame atomic absorption spectrometry (FAAS) is the most commonly employed technique in elemental analysis of fruit juices and tangs owing to the relatively low costs of equipment, its operation, and maintenance (Ajai et al., 2014; Santos et al., 2014).

Although numerous researches have been performed for the determination of different heavy metals in various fruit juices, the studies including heavy metals estimation in powdered fruit drink mix in addition to its comparison with fresh and packaged fruit juices are lacking to date in Nepal. In an attempt to address this lacuna in research, the present study focuses on the determination of heavy metals, viz., Iron (Fe), Manganese (Mn), Zinc (Zn), and Lead (Pb) using Flame Atomic Absorption Spectroscopic (FAAS) technique in fresh/packaged fruit juices and powdered fruit drink mixes (Tangs) of five different fruits, including orange, pineapple, mango, apple and pomegranate available in Kathmandu Valley.

MATERIALS AND METHODS

Analytical grade nitric acid (HNO_3) and deionized water were used throughout the experiments. Certified Reference Solutions (1000 mg/L) of respective metal ions required for the Atomic Absorption Spectrometer were obtained from Sigma-Aldrich (Fluka Analytical), Germany.

Samples Collection

Altogether ten fruit juices of two different varieties, i.e., freshly squeezed and packaged fruit juices, and five powdered fruit drink mixes (Tang) were collected from different shops in Kathmandu Valley. Fruit juices of five different fruits, viz., apple, pineapple, mango, pomegranate, and orange, were procured.

Digestion of fruit juice samples

The fresh and packaged fruit juice samples were digested by the addition of 10 mL of concentrated nitric acid (HNO_3) into 5mL of samples in a beaker followed by heating the solution on a hot plate for one hour to reduce the total volume of sample to one-third of its original volume. The digested sample was then allowed to cool, then filtered into a 50mL volumetric flask, and made up to mark with distilled water. The final samples were then stored in a refrigerator maintained at a temperature of 8°C before analysis. In the case of Tang, the powdered samples equivalent to 20 g were initially dissolved in 200 mL of deionized water, then 5 mL of the resultant solution was taken and similarly proceeded for digestion process as fresh and packaged fruit juice samples.

Instrumentation

The digested fruit juice and tang samples were analyzed for the concentrations of heavy metals (Fe, Zn, Pb, and Mn) using Flame Atomic Absorption Spectrophotometer (FAAS), 240S AA (200 Series AA).

RESULTS AND DISCUSSION

Determination of heavy metals in fruit juices and tangs

The mean concentrations of various heavy metals obtained from the varieties of digested fruit juices and powdered fruit drink mix (tang) samples are presented in Table 1.

Table 1: Concentration of heavy metals obtained in Packaged/Fresh Fruit Juices and Powdered Fruit Drink Mix (Tang)

Fruit Juice Samples	Types of Fruits	Concentration (mg/L)			
		Iron (Fe)	Manganese (Mn)	Zinc (Zn)	Lead (Pb)
Packaged Fruit Juice	Orange	0.26	<0.01	0.19	<0.01
	Pineapple	0.1	0.03	0.55	<0.01
	Mango	<0.1	<0.01	0.39	<0.01
	Apple	2.91	0.15	0.78	<0.01
	Pomegranate	3.63	<0.01	0.19	<0.01
Fresh Fruit Juice	Orange	1.15	0.41	0.29	<0.01
	Pineapple	0.29	<0.01	0.05	<0.01
	Mango	0.27	<0.01	<0.01	<0.01
	Apple	<0.1	0.11	<0.01	<0.01
	Pomegranate	1.02	0.94	<0.01	<0.01
Powdered Fruit Drink Mix (Tang)	Orange	0.52	<0.01	<0.01	<0.01
	Pineapple	1.29	<0.01	<0.01	<0.01
	Mango	0.12	<0.01	<0.01	<0.01
	Apple	1.82	0.16	<0.01	<0.01
	Pomegranate	1.58	<0.01	<0.01	<0.01

Determination of Iron (Fe) content in fruit juices and tangs

The variation of iron (Fe) concentration concerning different varieties of packaged/fresh fruit juice and powdered drink mix samples is depicted in Figure 1(a). Regarding packaged fruit juice, the iron content in the pomegranate sample was highest (3.63 mg/L) followed by apple (2.91 mg/L), orange (0.26 mg/L), and pineapple (0.1 mg/L) and mango (<0.1 mg/L) juice. However, in the case of fresh fruit juice samples, maximum and minimum iron content was found in orange (1.15 mg/L) and apple (<0.1 mg/L) respectively. Likewise, the powdered fruit drink mix sample showed maximum iron content for the apple-flavored sample (1.82 mg/L) and minimum for mango-flavored tang (0.12 mg/L). From the obtained results, it is evident that the concentrations of iron in all the investigated fruit juices and tangs are below the Maximum Permissible Limit (MPL) of 425 mg/kg as reported by WHO/FAO, thereby verifying the non-toxic level of iron in these beverages.

Although considered a trace mineral, diets lacking iron can contribute to the deficiency known as anemia, a condition with a reduced number of red blood cells (Scholl et al., 2000). In contrast, iron overload in the vital organs of the body may lead to liver disease, heart attack, diabetes, etc (Fleming et al., 2012). Regarding the resultant data, consumption of packaged pomegranate juice might be relatively beneficial for people suffering from diseases like anemia because the same juice showed the highest quantity of iron (3.63 mg/L) compared to other types of juices and tangs.

Determination of Manganese (Mn) content in fruit juices and tangs

The concentration of manganese (Mn) in all the samples is demonstrated graphically in Figure 1(b). The manganese content in packaged juice of orange, mango, and pomegranate was found less than 0.01mg/L; in the case of apple and pineapple samples, it was obtained in the range of 0.15 and 0.03 mg/L respectively. Fresh fruit juice of mango and pineapple had manganese concentration below 0.01 mg/L while that of pomegranate showed the highest content of Mn (0.94 mg/L). In the case of powdered fruit drink mix, apple-flavored tang showed Mn concentration in the range of 0.16 mg/L while other fruit types had their concentration below 0.01 mg/L.

Manganese is a potent neurotoxin when accumulated in the human body at high concentrations (Eneji et al., 2015). However, evidence of Mn content below its maximum permissible limit, i.e., 100 mg/kg in the experimented fruit juice and tang samples excludes manganese toxicity. Based on data obtained from the present study, freshly squeezed pomegranate juice could serve as a useful beverage for people suffering from prolonged deficiency of manganese showing symptoms like retarded growth, digestive disorders, male and female sterility, etc (Eneji et al., 2015). The aforementioned inference is indicative of the highest manganese content of 0.94 mg/L for fresh pomegranate juice.

Determination of Zinc (Zn) content in fruit juices and tangs

The differences in Zinc (Zn) content concerning various packaged/fresh fruit juices and powdered drink mix is represented in Figure 1(c). The concentration of Zn in powdered mix samples for all investigated fruit groups was below 0.01 mg/L. A similar observation in terms of Zn content was observed in fresh fruit juice samples of mango, apple, and pomegranate; however, Zn content of orange and pineapple fruit juice samples lay in the range of 0.29 and 0.05 mg/L. The concentration of Zn in packaged fruit juice samples was comparatively higher than in tang and fresh juice. Apple flavored packed juice showed a maximum (0.78 mg/L) concentration of Zn while orange and pomegranate juice showed Zn content in the minimum range of 0.19 mg/L.

Since the concentration of zinc is very less than its maximum permissible limit, i.e., 99.40 mg/kg, its overdose in all the fruit juices and tangs is ruled out. In comparison to other types, apple-flavored packaged juice might be more helpful for people suffering Zn deficiency symptoms which is due to the highest content of Zn (0.78 mg/L) in the latter sample. In addition, the obtained data demonstrate that the fresh fruit juices (except orange and pineapple) and tangs do not serve as useful beverages for the patients requiring zinc in their dietary supplements since these samples showed an insignificant quantity (<0.01 mg/L) of zinc.

Determination of Lead (Pb) content in fruit juices and tangs

The concentration of lead (Pb) in all the varieties of fruit juices and tang was found below 0.01 mg/L which is demonstrated in Figure 1(d). This value is below the maximum permissible limit (0.3 mg/kg) for the lead which rules out the possibility of lead toxicity in the investigated fruit juice and powdered drink mix samples. Since lead is one of the most non-essential toxic elements, thus the exclusion of lead poisoning could ascertain the safety of these fruit juices and tangs in terms of human consumption.

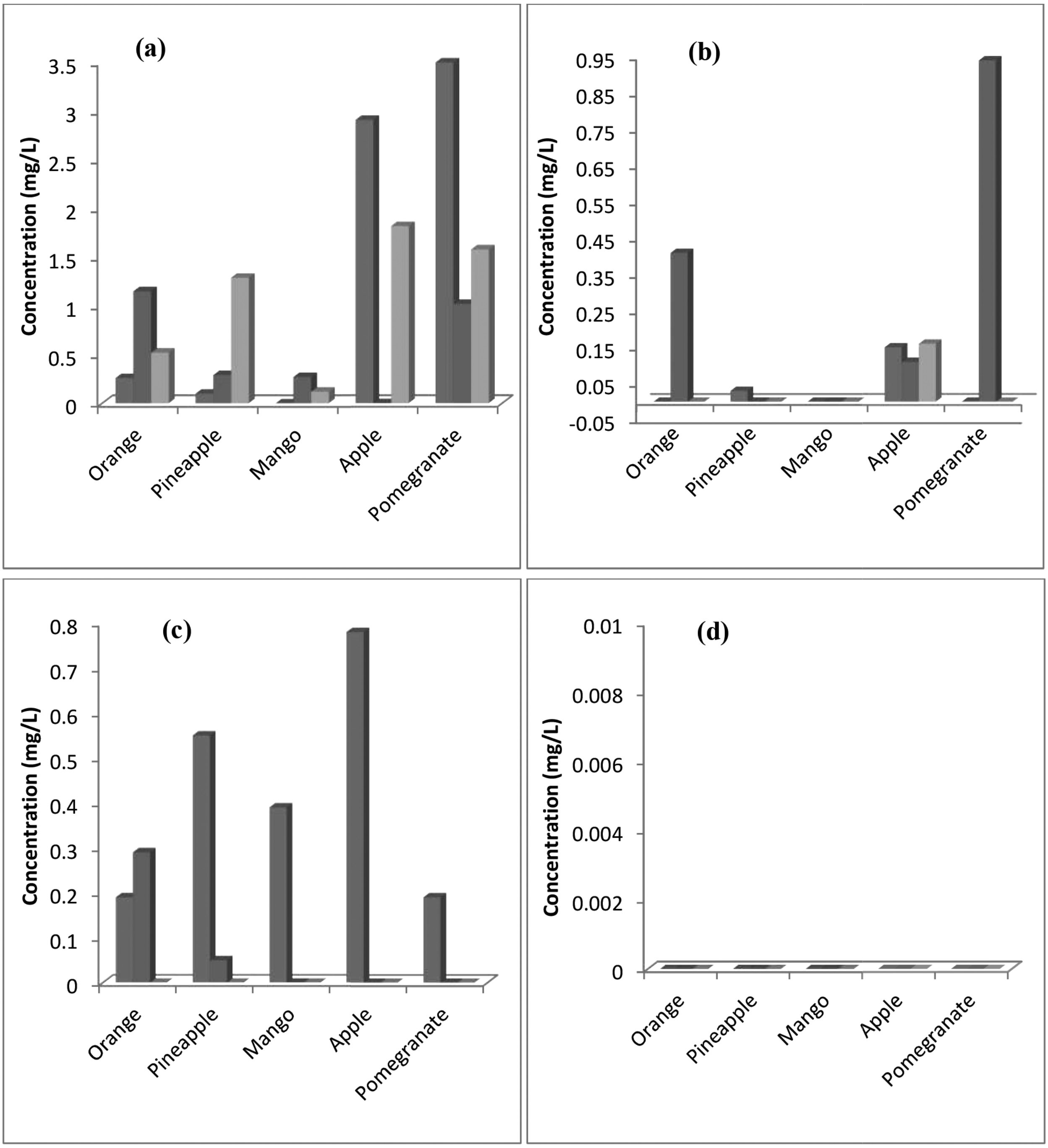

Figure 1. Variation in concentrations of heavy metals, including (a) Iron (Fe), (b) Manganese (Mn), (c) Zinc (Zn) and (d) Lead (Pb) in different fruits-flavoured packaged juices ( ), fresh juices ( ) and powdered fruit drink mixes, i.e., tangs ( )

CONCLUSION

The concentrations of various heavy metals in fresh/packaged fruit juices and tangs of five different fruits, purchased from Kathmandu Valley, were successfully determined using Flame Atomic Absorption Spectroscopy (FAAS). The maximum concentration of iron (Fe) was observed in packaged pomegranate juice while fresh pomegranate juice showed the highest manganese (Mn) content. The highest value of Zn content was found in apple-flavored packaged juice. However, the concentration of lead (Pb) in all types of juices and tangs was observed below 0.01 mg/L. Although concentrations of heavy metals varied concerning different varieties of fruit juices and tangs, none of the samples exceeded the maximum permissible limit for any of the studied heavy metals. The obtained results led to the conclusion that the studied fruit juices and tangs are free of toxic trace metals like lead and the contents of essential elements like iron, manganese, and zinc are within the safest limit for the consumer. Thus, the present study ascertains the fact that the studied fruit juices and tangs of Kathmandu Valley are safe for human consumption concerning the toxicity of investigated heavy metals.

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