Determination of Heavy Metal Content in Several Commercially Available Fruit Juices in Sri Lanka

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***Abstract*:- Fruit juice samples (27) packaged in plastic bottles purchased from several retail stores in the Colombo district of Sri Lanka were analyzed for heavy metals. The fruit juice samples belonged to three categories, namely mango (9), wood apple (9), and mixed fruit (9). All samples were acid digested using ultrapure nitric acid. The concentrations of cadmium (Cd) and lead (Pb) in these digested samples were analyzed using atomic absorption spectrometry. Recovery efficiency for Cd and Pb were 98.03±0.23% and 96.97±0.53% respectively. The levels of Cd in 14 fruit juice samples were above the recommended concentration (3ppb), as stated by WHO. However, the Cd level in all samples was below the stated value by UA-EPA and EU (5ppb), except for one sample which was 6.48±1.81 ppb. The Pb analyzed in all samples was below the recommended level as stated by WHO, EU (10ppb), and UA-EPA (15 ppb). These results show that the commercially available bottled fruit juice samples are safe for consumption and that the Cd and Pb content present on the juices may not have a toxic effect.**

***Keywords*: Fruit juices, Nitric acid, Digestion, Heavy metals, Atomic absorption spectrometry (AAS).**

I. INTRODUCTION

Fruit juice can be considered as an important part of one's daily diet. People are encouraged to include fruits or processed forms of fruits, such as juice into their diet, due to the high content of vitamins, minerals, and fiber contained in them. Apart from the freshly prepared juices, there is a wide variety of fruit juices available in the market, which are readily consumable and are packed in plastic bottles, cans, and laminated paper packets, in order to improve their shelf life and preserve freshness [1].

In general, heavy metals are not found to be occurring naturally in water bodies and soil. However, such heavy metals can be found in water bodies and soil that is polluted by industrial effluents and agrochemicals [2]. Heavy metals have a high density. Unlike certain organic compounds, heavy metals cannot be detoxified by the human body, which leads to its accumulation [3]-[5]. As a result, even a trace amount of accumulated can cause toxicity [5]. Such toxic metals include lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), and chromium (Cr). Water can be contaminated by lead, through the dissolution of lead-containing compounds. The primary contribution of lead-based contamination of water occurs through household plumbing systems such as fittings, solders, and pipes which contain lead [6]. Polyvinyl chloride (PVC) pipes also contain a certain percentage of lead, which can leach into water [6].Accumulation of lead consequences on several health issues which cause various harmful effects in both adults and children. Neurotoxic effects have been reported in children whose bodies had accumulated considerable amounts of lead. It is also reported that both children and adults suffer alike from renal failure and coma, due to lead-toxicity [7].

Cadmium contamination of water can result due to the dissolution of Cd- containing pipes, solders, fittings, and water heaters/ coolers. Cadmium is also present as an impurity in Zn-galvanized pipes which also contributes to dissolved Cd in water [8]. Ingested cadmium is excreted from the body but can be reabsorbed by the kidneys. Long term exposure to high levels of Cd can lead to the damage of kidneys [8]. Accumulation of Cd within the lungs can lead to respiratory diseases, which may further result in chronic lung effects [7]. The estimated lethal oral dose of Cd is 350-3500 mg [8]. Cadmium quantification can be done through either direct aspiration into a flame or introducing into the graphite furnace of an atomic absorption spectrophotometer [8].

Heavy metal quantification in fruit juice is of importance at present, due to its increased consumption. Several methods are being used to determine heavy metal content in commercially available fruit juices, out of which wet digestion and dry ashing followed by acid dissolution are two commonly practiced techniques [9]. In general, the method of wet digestion is preferred over ashing, due to the reduced loss of analyte [10]. Aqueous samples such as fruit juices/ beverages etc have to be acidified with a mineral acid such as nitric or hydrochloric, immediately after collection of samples. The pH of such samples is maintained below 2, in order to stabilize the sample. This will reduce the adsorption of metal ions on to the walls of the stored container, co-precipitation, and formation of volatile compounds [11]. Microwave or conventional digestion methods are used for digesting samples. The most popular method is conventional digestion, due to the low cost and requirement of low technology [10].

Single acids, as well as acid mixtures, can be used to digest the samples. The use of a mixture of nitric/ sulfuric acid will efficiently digest samples but will interfere with the determination of lead, due to absorption signal suppression by sulfuric acid[10]. Hot nitric acid readily oxidizes most of the organic substances present in fruit juices [11]-[13]. After digestion, the samples are introduced into the atomic absorption spectrophotometer, by which the amount of energy absorbed by the samples are measured in the form of photons [14].

II. MATERIALS and METHODS

A. Materials

Commercially available fruit juices packaged in plastic bottles (27) were purchased from various parts of Colombo district, Sri Lanka. The purchased juices were of 3 varieties, mango (9), wood apple (9), and mixed fruit (9).

Chemicals

Ultrapure nitric acid was used to digest the fruit juice samples. Analytical grade nitric acid was used for the preparation of the acid bath.

Storage of Digested Samples

The digested samples were stored in polypropylene tubes, which were gamma radiation sterilized. Tubes were plug-sealed with screw-on caps. The tubes were conical bottomed and included white printed graduation.

B. Method

Cleaning Procedure

All glassware used (beakers, funnels, glass rods. Pipettes, etc.) were immersed in a 5% nitric acid bath overnight and was washed with deionized water 4-5 times.

Sample Digestion

Wet digestion method was employed to digest the fruit juice samples. The original bottles containing fruit juice were shaken well, before transferring into a beaker. An aliquot of 10.00 mL fruit juice was transferred into a beaker (100 mL), followed by the addition of ultrapure nitric acid (30.00 mL). A glass rod was inserted into the beaker and the beaker was closed with a watch glass. This was heated at 90°C until no brown fumes (nitrogen dioxide) were observed. During the process of heating, the samples were stirred well occasionally, followed by increasing heating temperature, which facilitated evaporation. When the solution reached a volume of 5 mL, the beaker was taken from the heater and was allowed to cool down to room temperature. The cooled solution was filtered through a Whatman filter paper (no. 42) and the filtrate was collected into polypropylene tubes. The beaker was washed with deionized water and the washings were also filtered through the same filter paper. The filtered washings were also collected into polypropylene tubes. The samples were then diluted upto mark (25.00 mL) using deionized water. The prepared samples were then stored at 4°C until further use.

Instrumentation

Sample analysis was carried out with an atomic absorption spectrophotometer (ZA3000).

Quality Control (Recovery Efficiency)

Recovery efficiency was carried out for lead and cadmium in selected samples. These tests were performed by spiking a known amount of standard solutions into the samples having the same matrix effect and were reanalyzed. Recovery efficiency was 96.97±0.53% and 98.03±0.23% for lead (Pb) and cadmium (Cd) respectively.

III. RESULTS and DISCUSSION

All samples were analyzed using AAS. Each result represents the mean of fruit juice samples (each sample was injected three times in AAS), where the heavy metals Cd and Pb were analyzed. Table (I) includes the permitted maximum levels of metal ion concentrations (ppb) in drinking water, as stated by several organizations, mean concentrations of heavy metals assessed in the fruit juice samples (27) are summarized in Table II.

TABLE I. WORLD STANDARDS for ALLOWABLE LEVELS of HEAVY METALS in WATER

Heavy metals contamination	WHO Limits (ppb)	UA-EPA Levels (ppb)	European Union (ppb)
Cd	3	5	5
Pb	10	15	10

According to the results obtained, all the analyzed samples contain a certain amount of Cd. The WHO standard for Cd is 3 ppb. 14 (sample number 5, 6, 7, 8, 10, 12, 13, 14, 15, 16, 19, 20, 25, and 26) out of the 27 samples detected exceed the Cd content in comparison to the WHO standard. Sample numbers 5, 6, and 25 are around 3 ppb, and the rest of the 11 samples are clearly above 3 ppb. However, according to UA-EPA and EU, the recommended Cd concentration is 5 ppb. Considering this value as the standard, there was only one sample (sample 13) that exceeded 5 ppb, of which the concentration was 6.48±1.81 ppb.

All the analysed samples of fruit juice contained lead in microgram levels. The permitted Pb content is 10 ppb as mentioned by the WHO and EU. The Lead contained in all the samples were lower than the values recommended by WHO and EU, and these are lower than 2 ppb. The permitted Pb content is 15 ppb as mentioned by UA-EPA. The lead content in all the samples is very lower than the recommended values by UA-EPA. According to these standards, the lead content of all the analyzed samples was below recommended maximum level.

TABLE II. VARIATION of HEAVY METALS inµg L^{-1}in ANALYZED FRUIT JUICES PURCHASED from RETAIL MARKETS in COLOMBO DISTRICT of SRI LANKA.

Fruit juice samples	Cadmium (Cd) Con. (ppb)	Lead (Pb) con. (ppb)
Sample 1	2.21±0.57	1.62±0.53
sample 2	1.10±0.56	1.87±0.25
sample 3	0.95±0.85	1.56±0.30
sample 4	1.15±0.77	1.10±0.13
sample 5	3.13±0.23	1.18±0.15
sample 6	3.31±0.76	1.17±0.03
sample 7	4.47±0.65	1.20±0.09
sample 8	3.97±1.63	1.23±0.15
sample 9	2.68±1.23	1.19±0.10
sample 10	4.76±1.46	1.30±0.11
sample 11	2.21±0.77	1.09±0.10
sample 12	3.97±0.55	1.43±0.42
sample 13	6.48±1.81	1.20±0.09
sample 14	4.59±1.26	1.28±0.18
sample 15	4.18±1.88	1.38±0.30
sample 16	4.81±0.69	1.11±0.05
sample 17	2.72±0.21	1.30±0.16
sample 18	1.48±1.71	1.31±0.30
sample 19	4.15±1.65	1.20±0.09
sample 20	3.96±0.58	1.09±0.06
sample 21	2.49±0.45	1.16±0.08
sample 22	1.92±0.92	1.15±0.04
sample 23	2.25±1.11	1.08±0.11
sample 24	2.18±0.62	1.38±0.47
sample 25	3.19±1.01	1.19±0.03
sample 26	4.97±1.40	1.14±0.08
sample 27	2.98±0.69	1.44±0.30

IV. CONCLUSION

According to the analyzed results, it can be concluded that the purchased bottled fruit juices within Colombo district has safe levels of Cd and Pb and are thus safe for human consumption.

ACKNOWLEDGEMENT

The authors are grateful to the former rector of College of chemical Sciences, Institute of Chemistry Ceylon, late professor J.N.O. Fernando. The authors also thank- dean/ rector at time for the funding provided to carry out this project.

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