

Determination of Some Heavy Metal Levels in Soft Drinks from Turkey Using ICP-OES Method

MEHMET BINGÖL¹, GÜLDEREN YENTÜR², BUKET ER² and AYSEL BAYHAN ÖKTEM²

¹Laboratory of Vitamin Analysis, Food Safety and Nutrition Research Department, Refik Saydam National Hygiene Center, Ankara, Turkey; ²Department of Food Analyses, Faculty of Pharmacy, Gazi University Ankara, Turkey

Abstract

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Total number of 104 canned soft drinks collected from several regions in Turkey were analysed. The purpose of this study was to determine the levels of heavy metals in the drinks commonly consumed in Turkey. Quantitative determination of heavy metals: arsenic, copper, zinc, cadmium, and lead in all samples was carried out by ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry) method. The mean levels (\pm SE) of arsenic, copper, zinc, cadmium, and lead were found to be 0.037 ± 0.002 mg/kg, 0.070 ± 0.009 mg/kg, 0.143 ± 0.012 mg/kg, 0.005 ± 0.0003 mg/kg, and 0.029 ± 0.002 mg/kg, respectively, in soft drinks. Our data revealed that arsenic, copper, zinc, cadmium, and lead mean levels found in all soft drinks, collected from several regions in Turkey, were within the Turkish Food Codex (TFC) values.

Keywords: heavy metals; soft drinks; ICP-OES

Environmental pollution is the main cause of heavy metal contamination in the food chain. Lead and cadmium are two potentially harmful metals that have aroused considerable concern (CABRERA *et al.* 1995). Atmospheric contamination, the excessive use of fertilisers and pesticides, and sewage sludge or irrigation with residual waters is among the causes of contamination of raw foodstuffs (DEMİRÖZÜ & SALDAMLİ 2002). As a result of the soil, atmosphere, underground and surface water pollution, our foods and beverages are getting contaminated with heavy metals (KREJPCIO *et al.* 2005).

Pb and Cd toxicity is well documented and is recognised as a major environmental health risk throughout the world. Lead affects humans and animals of all ages, however, the effects of lead are most serious in young children. Cadmium is a toxic and carcinogenic element (KREJPCIO *et al.* 2005; RUBIO *et al.* 2006). Because of their high toxicity, arsenic,

lead and cadmium need to be quantified in food and beverages (BARBASTE *et al.* 2003). Cadmium intake in relatively high amounts can be detrimental to human health. Over a long period of intake, cadmium may accumulate in the kidney and liver and, because of its long biological half life, may lead to kidney damage (MADUABUCHI *et al.* 2006).

Heavy metals composition of foods is of interest because of their essential or toxic nature. For example, iron, zinc, copper, chromium, cobalt, and manganese are essential, while lead, cadmium, nickel, and mercury are toxic at certain levels (ONIANWA *et al.* 1999). Arsenic is a highly toxic element and its presence in food composites is a matter of concern to the humans well-being (AL RMALLI *et al.* 2005). After acute and chronic exposures, it causes a variety of adverse health effects to humans such as dermal changes, respiratory, pulmonary, cardiovascular, gastrointestinal, hemato-

logical, hepatic, renal, neurological, developmental, reproductive, immunologic, genotoxic, mutagenic, and carcinogenic effects (MANDAL & SUZUKI 2002). Copper is one of the essential trace elements. The deficiency of this element is manifested by impaired haematopoiesis, bone metabolism, disorders of the digestive, cardiovascular, and nervous systems. Sporadically, copper intoxications are described. The acute exposure to copper containing dust is manifested by metal fume fever (KŘÍŽEK *et al.* 1997). Zinc deficiency, resulting from poor diet, alcoholism, and malabsorption, causes dwarfism, hypogonadism, and dermatitis, while the toxicity of zinc due to excessive intake may lead to electrolyte imbalance, nausea, anaemia, and lethargy (ONIONWA *et al.* 2001).

Diet is the major source of heavy metals exposure; therefore, it is important to monitor the dietary intake of these heavy metals to quantify them. According to the Turkish Food Codex (TFC), the maximum contaminant levels of arsenic, copper, zinc, cadmium, and lead may not exceed 0.1, 2, 2, 0.01, and 0.1 mg/kg (ppm), respectively, in soft drinks (TFC 2002).

Our aim was to determine the levels of arsenic, copper, zinc, cadmium, and lead levels in canned soft drinks of ten different trademarks sold in Turkey, and to evaluate whether or not the heavy metal levels complied with the TFC values.

MATERIALS AND METHODS

Total number of 104 samples, used of ten different trademarks, were investigated for the heavy metals presence in canned soft drinks (carbonated drinks) collected from several regions in Turkey, that is the Ankara, Sakarya, Denizli, Burdur, Yozgat, Ordu, Van, Kilis, Bolu, and Adana regions. All of the samples originated from Turkey.

Multi element standards (arsenic, cadmium, copper, lead, zinc) were purchased from High-Purity Standards Cat No. QCS-26. All reagents were of analytical grade.

ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry) methods were used for the quantitative analysis of heavy metals in all samples. To determine the heavy metals levels, AOAC methods were used (AOAC 1986, 2003; JORHEM 1993).

Briefly, a 30 ml soft drink sample was allowed to rest for 24 h and thereby its gases evaporated. Subsequently, to 5 g of the sample 5 ml HNO₃ 65% was added. A microwave furnace was used for the digestion and dissolution of the experi-

mental samples. In this method, the samples were dissolved at 190°C and 400 psi pressure in Mars 5 apparatus (Vessel Type XKP 1500, CEM, Matthews, USA). After further 20 min processing, the samples were put into 25 ml polyethylene flasks which were made up with deionised water. The 1% HNO₃ solution was passed through the apparatus and it was then cleaned.

The heavy metals were analysed by Inductively Coupled Plasma-Optical Emission Spectrometry (Varian Vista-MPX CCD Simultaneous Spectrophotometer, Murgave-Victoria, Australia). The calibration curves were constructed using a series of dilutions containing different levels of heavy metals.

The reading was made at the emission wavelengths for arsenic, copper, zinc, cadmium, and lead of 228.812 nm, 223.009 nm, 334.502 nm, 228.802 nm, and 220.353 nm, respectively.

The results were evaluated according to One Way ANOVA test, and for the comparison of the heavy metal values and TFC limit values One-Sample *t*-test was used (DANIEL 1991).

RESULTS AND DISCUSSION

The detection limits for arsenic, copper, zinc, cadmium, and lead were 9.5 µg/l, 0.45 µg/l, 0.10 µg/l, 0.32 µg/l, and 0.75 µg/l, respectively. The technique was found to be repeatable, similar results having been obtained when the same operator used the same equipment.

The levels of arsenic, copper, zinc, cadmium, and lead in soft drink samples were determined. All analyses were repeated three times for each sample. The respective values are shown in Table 1.

In the soft drink samples, the mean values determined were with arsenic 0.037 ± 0.002 mg/kg, copper 0.070 ± 0.009 mg/kg, zinc 0.143 ± 0.012 mg/kg, cadmium 0.005 ± 0.0003 mg/kg, and lead 0.029 ± 0.002 mg/kg, respectively. The maximum and minimum mean levels found were 0.111–0.001, 0.770–0.004, 0.90–0.009, 0.011–0.0001, and 0.091 to 0.004 for arsenic, copper, zinc, cadmium, and lead, respectively.

The results of the analyses were evaluated following the guidelines of the Turkish Food Codex. Table 1 shows that the difference between the mean level of arsenic in the samples and the TFC values (0.1 mg/kg) are statistically significant ($P < 0.001$). Furthermore, the difference between the mean levels of copper and zinc in the samples and the TFC

Table 1. The levels of heavy metals in soft drinks ($\bar{x} \pm SE$ in mg/kg)

Sample	<i>n</i>	Arsenic	Copper	Zinc	Cadmium	Lead
A	13	0.033 ± 0.006**	0.114 ± 0.057**	0.134 ± 0.020**	0.006 ± 0.001**	0.026 ± 0.005**
B	10	0.029 ± 0.008**	0.071 ± 0.021**	0.078 ± 0.015**	0.007 ± 0.001*	0.028 ± 0.005**
C	10	0.035 ± 0.008**	0.043 ± 0.020**	0.225 ± 0.082**	0.006 ± 0.001**	0.030 ± 0.006**
D	10	0.045 ± 0.011**	0.031 ± 0.008**	0.119 ± 0.027**	0.005 ± 0.001**	0.033 ± 0.006**
E	11	0.043 ± 0.005**	0.066 ± 0.016**	0.139 ± 0.017**	0.004 ± 0.001**	0.030 ± 0.005**
F	10	0.042 ± 0.007**	0.125 ± 0.029**	0.235 ± 0.047**	0.004 ± 0.001**	0.034 ± 0.009**
G	10	0.030 ± 0.008**	0.063 ± 0.012**	0.138 ± 0.017**	0.004 ± 0.001**	0.035 ± 0.006**
H	10	0.042 ± 0.007**	0.048 ± 0.011**	0.142 ± 0.031**	0.006 ± 0.001**	0.024 ± 0.007**
I	10	0.041 ± 0.007**	0.047 ± 0.016**	0.099 ± 0.015**	0.005 ± 0.001**	0.023 ± 0.004**
K	10	0.029 ± 0.003**	0.074 ± 0.018**	0.120 ± 0.031**	0.005 ± 0.001**	0.024 ± 0.004**
Total	104	0.037 ± 0.002**	0.070 ± 0.009**	0.143 ± 0.012**	0.005 ± 0.0003**	0.029 ± 0.002**

* $P < 0.01$ – the difference between the mean Cd level determined in the samples of B firm and the TFC values

** $P < 0.001$ – the difference between the mean Ar, Cu, Zn, Cd, Pb levels determined in all samples and the TFC values

values (2 mg/kg) are also statistically significant ($P < 0.001$). In addition to this, the cadmium values in the samples of firm B and other firm samples are also significant, with $P < 0.01$ and $P < 0.001$, respectively. The difference between the mean level of lead in the soft drink samples and the TFC value (0.1 mg/kg) are statistically significant ($P < 0.001$).

Our data revealed that the arsenic, copper, zinc, cadmium, and lead levels found in all of the soft drink samples were within the Turkish Food Codex standard values. The occurrence of heavy metals in water and several foods has been investigated in Turkey (BAYHAN & YENTÜR 1989; ÖKTEM BAYHAN *et al.* 2004). Our research is important in view of its being the first study of the soft drinks in Turkey.

In several countries, similar studies were previously reported concerning heavy metals as is the case in the current study (MAFF 1998; ONIANWA *et al.* 1999; ASHRAF *et al.* 2000; KREJPCIO *et al.* 2005; MADUABUCHI *et al.* 2006). KREJPCIO *et al.* (2005) reported lead, cadmium, copper, and zinc levels as 0.020–0.46 mg/l, 0.004–0.060 mg/l, 0.047–1.840 mg/l, and 0.063–3.39 mg/l, respectively, in a total of 66 fruit juice samples examined in Poland. These lead and cadmium levels in fruit juice samples were found to resemble those found in our research. Moreover, copper and zinc levels of this study were higher than those in our study. MADUABUCHI *et al.* (2006) reported cadmium levels as 0.003–0.081 mg/l in canned drinks and 0.006–0.071 mg/l in non-canned drinks. These cadmium contents are higher in comparison with those in our study. Also in this research, the lead

levels were 0.002–0.0073 mg/l in canned drinks and 0.092 mg/l in non-canned drinks. These lead levels were lower than those in our research.

ONIANWA *et al.* (2001) reported cadmium, copper, lead, and zinc levels as 0.002 ± 0.005 ppm, 0.10 ± 0.10 ppm, 0.04 ± 0.01 ppm, 0.15 ± 0.03 ppm, respectively, in carbonated soft drinks in Nigeria. At the same time, they reported cadmium, copper, lead, and zinc levels of 0.003 ± 0.003 ppm, 0.52 ± 0.60 ppm, 0.06 ± 0.08 ppm, and 0.46 ± 0.58 ppm in fruit juice, respectively. These results are similar to ours.

The research performed in England revealed that the heavy metal levels in the non-alcoholic beverage samples were within the standard. In this study lead, arsenic, and cadmium contents were determined as 0.02–0.05 mg/kg, < 0.1 mg/kg, and 0.0004–0.001 mg/kg, respectively, in non-alcoholic beverage samples from totally 100 samples (MAFF 1998). These cadmium and lead contamination rates in the samples were found to be higher than were our results. ASHRAF *et al.* (2000) reported arsenic levels as 0.837 mg/l in 34 soft drinks in Pakistan. These findings showed higher rates in comparison with our study.

Metals are present in foods (including drinks) either naturally or as a result of human activities such as agricultural practices, industrial emissions, car exhausts, or contamination during manufacture. Food and beverage contamination may also occur due to raw materials and water used.

The application of agricultural wastes should be made at a rate which exceeds their levels in water.

Heavy metal contamination in foods and drinks has been an important topic. Facility modernisation and quality manufacturing are required to prevent heavy metal contamination in drinks and thus the possible health hazards to the consumer.

A long-term and/or excessive consumption of foods containing heavy metals above the tolerance levels, has a hazardous impact on human health. Because soft drinks are widely consumed, they contribute a large fraction to the heavy metals intake and, therefore, strict control of these elements is advisable.

For this reason, the steps in all processes must be monitored for preventing the contamination by heavy metals.

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Corresponding author:

Prof. GÜLDEREN YENTÜR, Gazi University Faculty of Pharmacy Department of Food Analyses, 06330 Etiler Ankara, Turkey
tel.: + 90 312 202 32 00, e-mail: yentur@gazi.edu.tr