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Research Article

DETERMINATION OF THE LEVEL OF SOME TRACE AND HEAVY METALS IN SOME SOFT DRINKS OF ETHIOPIA

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Abstract

Levels of nickel, cadmium, chromium, lead, manganese and copper were measured in six brands of soft drinks commonly consumed in Harar, Ethiopia using flame atomic absorption spectrometry (FAAS). The Mineral contents obtained using FAAS has a considerable concentration difference among the six soft drinks ($p > 0.05$). The measured concentration of Cr were statistically different for each of the 6 groups of soft drinks under this studies ($p > 0.05$). In Pepsi-Cola, Mirinda and Ambo flavor soft drinks; Pb, Cr and Cu levels were significantly higher than those concentrations determined for Mn, Ni and Cd. Contrarily, the level of Ni and Cd concentrations were lower while their concentration occurs in the range of permissible value of international and national standards. In general, our experimental result indicates that Ni, Cd, Pd, Mn, and Cu levels found in all soft drink samples were within the acceptable values. From all studied elements, Cr concentrations determined in soft drinks were statistically higher. Therefore, we suggested that health authorities and soft drink producing companies should pay more attention to the sources of these metals in soft drinks.

Keywords: Copper, chromium, lead, manganese, cadmium, nickel, soft drinks

Introduction

Heavy metals can be toxic to living things at certain levels. Lead and cadmium toxicity is well documented and is recognized as a major environmental and health risk throughout the globe although they occur naturally, they come from many different sources: some mining industries, burning of fossil fuels, like coal, burning garbage or tobacco, and even forest fires, release heavy metals into the environment. Heavy metals can be absorbed by plants, wildlife and people through the food they eat (TFC 2002).

They can also be absorbed through water and breathing. Some heavy metals can become more concentrated when animals (predators) use other animals for food (prey) as part of the food chain. This is called biomagnifications. Some metals, such as iron, chromium and copper, are needed in small quantities to keep people and animals healthy. Problems can occur with these metals if the body receives too much of them. Heavy metals such as lead and mercury are never desirable in any amount.

Once inside our bodies different metals can build up in different body parts, including the kidney, liver and spleen. 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 human's well-being (Alrmalli *et al*. 2005). 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 letharg (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).The presence of metallic impurities in soft drinks can constitute health hazards to the public (Onianwa et al., 1999; Bakare-Odunola, 2005; Krepcio et al., 2005). Environmental pollution is the main cause for these heavy metals 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 fertilizers and pesticides, and sewage sludge or irrigation with residual waters is among the causes of contamination of raw foodstuffs (Demirözü & Saldamli, 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). Because of their high toxicity, arsenic, lead and cadmium need to be quantified in food and beverages (Barbaste *et al*. 2003). The consumption of sugar-sweetened soft drinks is associated with obesity, dental caries, and low nutrient levels. Experimental studies tend to support a causal role for sugar-sweetened soft drinks in these ailments, though this is challenged by other researchers. "Sugar-sweetened" includes drinks that use high-fructose corn syrup, as well as those using sucrose.

Many soft drinks contain ingredients that are themselves sources of concern: caffeine is linked to anxiety and sleep disruption when consumed in excess, and some critics question the health effects of added sugars and artificial sweeteners. Sodium benzoate has been investigated by researchers at University of Sheffield as a possible cause of DNA damage and hyperactivity (Valko, 2005). Other substances have negative health effects, but are present in such small quantities that they are unlikely to pose any substantial health risk provided that the beverages are consumed only in moderation. It remains possible that the correlation is due to a third factor: people who lead unhealthy lifestyles might consume more soft drinks. If so, then the association between soft drink consumption and weight gain could reflect the consequences of an unhealthy lifestyle rather than the consequences of consuming soft drinks.

Experimental evidence is needed to definitively establish the causal role of soft drink consumption. Reviews of the experimental evidence suggest that soft drink consumption does cause weight gain, but the effect is often small except for overweight individuals. http://en.wikipedia.org/wiki/Soft_drink – cite _note-Gibson_.282008.29-18 Many of these experiments examined the influence of sugar-sweetened soft drinks on weight gain in children and adolescents (Bakare ,2005). Generally, any effect of heavy metals toxicity should be considered with regards of their maximum contaminant level goal (MCLG) and maximum contaminant level (MCL).

Maximum contaminant level goal (MCLG) is the level of a contaminant in drinking water below which there is no known or expected risk to health and maximum contaminant level (MCL) is the highest level of a contaminant that is allowed in drinking water. The MCL in milligram per liter of those heavy metals studied in this analysis were shown in the table below. (United States Environmental Protection Agency, 2009, United States Environmental Protection Agency last updated on Wednesday, may 09, 2012, World Health Organization, 2007).

Table 1: MCL of metallic ion

Metallic ion	MCL(mg/L)
Copper	1.3
Chromium	0.05
Cadmium	0.005
Manganese	0.05
Nickel	0.02
Lead	0.015

Materials and Methods

Samples collection technique

Six different samples of soft drink beverages such as Coca - Cola, Fanta, Sprit, Pepsi-Cola, Mirinda and Ambo flavor were collected from Harar, Ethiopian market in this study. The samples were digested using nitric acid for analysis. All chemicals and reagents used of analytical grade. Nitric acid, deionized water and salts of metals were used to prepare stock and standard solutions for the calibration curve plot.

Soft drink samples were randomly selected for analysis and determination of toxic metal ions concentration using the atomic absorption spectrophotometer (AAS).

Instrumentation

AAS instruments (Brucker VGP210; USA) consisting of a hallow cathode lamp, slit width of 0.7nm and air-acetylene flame was used for this work. The samples were analyzed for heavy metals namely; chromium winch was analyzed at wave length of 357.87nm, nickel at 232.00nm, cadmium at 228.8nm, lead at 283.31nm and copper at 324.75nm.

Sample treatment

The nitric acid 5M of 10 ml, was added to 25 ml of the sample (soft drink) to remove organic material by decomposing them into carbon dioxide (CO_2); and also to convert the metals present into soluble forms according to the equation:

$$(CH_2)_n + 2HNO_3 \rightarrow nCO_2 + 2NO + 2H_2O$$

The mixture was evaporated on a hot plate in a fume cupboard until the brown fumes disappears leaving white fumes.

50 ml of distilled water was added and this was concentrated by evaporation on a hot plate to 25 ml. Subsequently, 25 ml deionized water was added to make up to 50 ml. This was then ready for AAS analysis (AOAC, 2003).

Standard Solutions preparation

A stock standard solution, 1000 ppm, of the metal ion was prepared in 500 mL of volumetric flask by dividing the molar mass of the compound containing the element by the molar mass of the element. The weight obtained was equivalent to 0.5 g of the metal ion. This weight (which is equivalent to 0.5 g of the metal) was dissolved in 500 ml to give 1000 ppm. The conversion of mass of metals in a given volume to ppm, which is a unit of concentration is based up on that, one gram in 1000 ml is 1000 ppm and one milligram in 1000 ml is one ppm. Serial dilutions were made to prepare a series of standard solution from a stock solution of each metal and the absorbance of these solutions was obtained using the FAAS. The calibration graph was plotted and the regression equations were obtained. Blank was determined by using deionized water.

Sample analysis

Calibration curve was made by using AAS equipped with appropriate filter for each metal ion by measuring the absorbance of series standard solution of metal ions followed by measuring the absorbance of the samples (AOAC, 2003)[3]. The concentrations of the digested soft drink samples were derived from the regression equation and the samples were analyzed in triplicates.

Data treatment

Difference between treatment means in all batch adsorption studies will be done by using analysis of variance (ANOVA) and for comparison of the means of the treatments, the Fisher's least significant difference (LSD) test used at $P = 0.05$ significance level.

Results and Discussion

For this study six soft drinks available in Harar market were obtained from Coca Cola company(Coca-Cola, Sprite and Fanta), Moha soft drink industry (Pepsi and Mirinda), and Ambo beverage industry (Ambo flavor). An analytical estimation test was performed for six elements and the result summarized in Table 3. The regression equation and coefficient of determination (R) for the calibration plots are shown in Table 2 and there was no detectable metal ion in the distilled water which was used as a blank control. The maximum concentration of Cr according to international or national standards of heavy metals in soft drink is 0.05ppm. However, the concentration of chromium (Cr) obtained in Coca-Cola, Fanta, Sprite samples were 0.145 ± 0.0226, 0.1133 ± 0.0265 and 0.1830 ± 0.0559 ppm respectively. Our data revealed in Table 3, for nickel and cadmium were non-detectable metals. In addition, manganese showed non-detectable level in 70% of the samples while copper was non-detectable only in Coca-Cola, Fanta and Sprite. Comparing the results within each class it is clear that Cr concentration in the samples under investigation is higher in all soft drinks.

Table 2: Regression data for the calibration plot

Parameters	Cu	Mn	Pb	Cr	Ni	Cd
Regression equation	y = 0.0817x +0.0329	y = 0.0995x +0.0067	y = 0.00107x +0.0003	y = 0.0273x +0.0013	y = 0.0229x +0.0060	y = 0.2099x +0.0445
Coefficient of determination (R)	0.9971	0.9974	0.9796	0.9870	0.9981	0.97794

*y=absorbance measurements (A),x=concentration(mg/L)

Table 3: Average concentration of detectable metal ions in soft drink samples in ppm (mg/L)

Sample	Cu^{2+}	Mn^{2+}	Pb^{2+}	Cr^{2+}	Ni^{2+}	Cd^{2+}
Coca-Cola	ND	ND	ND	$^{a}0.145 \pm 0.0226$	ND	ND
Fanta	ND	$^{a}0.0165 \pm 0.0056$	$^{a}0.0035 \pm 0.0198$	$^{b}0.1133 \pm 0.0265$	ND	ND
Sprite	ND	$^{a}0.0397 \pm 0.0058$	$^{a}0.0041 \pm 0.0376$	$^{b}0.1830 \pm 0.0559$	ND	ND
Pepsi-Cola	$^{a}0.1346 \pm 0.026$	ND	$^{a}0.0067 \pm 0.0542$	$^{b}0.0233 \pm 0.0028$	ND	ND
Mirinda	$^{b}0.0613 \pm 0.0203$	ND	$^{a}0.0079 \pm 0.0543$	$^{a}0.0300 \pm 0.0092$	ND	ND
Ambo flavor	$^{b}0.0360 \pm 0.0087$	ND	$^{b}0.0039 \pm 0.0520$	$^{a}0.0313 \pm 0.0145$	ND	ND

Means in the same column between letter aa are not significantly different ($P > 0.05$)
Means in the same column between letter bb and ab are significantly different ($P > 0.05$).

The overall mean concentration of lead is 0.0079 ± 0.0543 mg/L in Mirinda, 0.003526 ± 0.0198 mg/L and 0.0039 ± 0.0520 mg/L in Fanta and Ambo flavor respectively; for copper metal the highest concentration present in Pepsi-Cola were 0.1346 ± 0.026 mg/L and 0.0360 ± 0.0087 mg/L obtained as the minimum concentration in Ambo flavor. Similarly, for chromium 0.1830 ± 0.0559 mg/L was observed as the highest concentration in Sprite followed by 0.0233 ± 0.0028 mg/L, the lowest concentration in Pepsi-Cola. In a contrary, both nickel and cadmium were below the detection limits in all of the soft drinks. Based on the mean (n =3) concentrations (Table 2), the level of heavy metal contents were arranged in the following increasing order: Cr>Mn>Pb for Fanta; Cr >Mn>Pb for Sprite; Cu >Cr>Pb for Pepsi-Cola and Cu>Cr> Pb for Mirinda and Ambo flavor. Some of the soft drink products in this study were found to contain high concentration of heavy metals, particularly Cr and Cu which showed a wide variation among the samples significantly.

Conclusion

In this study, the level of copper, manganese and lead present in all soft drinks were in the range of permissible values. However, 50% of samples contained Cu and Mn and 83.3% of soft drinks contained lead. Similarly, all samples contained Cr, whereas, both Ni and Cd were non-detectable in this research studies. In addition chromium metal ion present in 67% of samples (i.e. Coca-Cola, Fanta, Sprite and Ambo flavor) were above MCL value. In conclusion, all Cu, Mn, Ni and Cd are below their MCL, that stated by United State Environmental Protection Agency and WHO (WHO 2007).

Therefore, agencies and soft drink producing companies should handle this issue urgently to safe guard the health of the people. Heavy metal contamination in soft drinks has been an important factor thus; facility modernization and quality manufacturing are required to prevent heavy metal contamination in soft drinks to the consumers.

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