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Trace metal levels in fruit juices and carbonated beverages in Nigeria

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Abstract Trace metal levels in selected fruit juices and carbonated beverages purchased in Lagos, Nigeria were determined using atomic absorption spectrophotometer (Unicam model 969) equipped with SOLAAR 32 windows software. Fruit juices analysed were grape, pineapple, apple, orange, lemon juices and their brand names were used. Some carbonated drinks were also evaluated for metal levels. Trace metals investigated were Cr, Cu, Pb, Mn, Ni, Zn, Sn, Fe, Cd and Co. Trace metal contents of fruit juices were found to be more than the metallic contents of carbonated beverages. Pb level in the fruit juices ranged from 0.08 to 0.57 mg/l but was not detected in the carbonated drinks. Concentrations of Pb in lemon juice and Mn in pineapple juice were relatively high. Cd and Co were not detected in the selected juices and beverages. Additionally, Pb, Cu, Cr and Fe were not detected in canned beverages but were present in bottled beverages. However, the metal levels of selected fruit juices and carbonated beverages were within permissible levels except for Mn in pineapple juice and Pb in lemon juice.

Keywords Carbonated beverages · Fruit juices · Nigeria · Trace metals

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Introduction

Many Nigerians drink fruit juices and carbonated beverages. The increasing intake of these drinks by a sizeable population in the country is largely attributed to the increase in fast food restaurants and snack bars, the growing preference for non-alcoholic drinks due to religious beliefs, increase in prices of alcoholic drinks and preference for imported goods by most Nigerians. The gastrointestinal tract of humans is exposed to various environmental pollutants including trace metals that contaminate food and water and may have toxic effects on the body. Studies indicate that some metals act as catalysts in the oxidative reactions of biological macromolecules, hence the toxicities associated with these metals might be due to oxidative tissue damage (Ercal et al. 2001).

Reasons could be advanced for the toxicity of trace metals in humans. For instance, the metabolism of the toxic metal may be similar to metabolically related essential ones. Such is the case with effects of Pb and Ca in the central nervous system and Pb, Fe and Zn in heme metabolism. Human cells that are involved in the transport of metals such as gastro-intestinal, liver or renal tubular cells are particularly susceptible to toxicity (Jarup 2003). Factors such as age, diet, interactions and exposure to other toxic metals influence the toxicity levels of metals in humans (Peakall and Burger 2003). Children and the elderly are believed to be more susceptible to toxicity from metallic exposure. Trace metals are present in foods in amounts below 50 ppm and have some toxicological or nutritional significance. While some inorganic elements such as Na, K, Ca, P are essential for man, elements like Pb, Cd, Hg, As are found to cause deleterious effects even in low levels of 10–50 ppm. Although Fe, Cu, Zn are found to be necessary in certain quantities in foods, the same elements can cause ill effects when consumed at higher levels. Hence, determination of both major and trace levels of metal contents in food is important for both food safety and nutritional considerations (Ministry of Health and Family Welfare 2005). Trace metals are classified into three classes based on their effects on life. The essential nutritive metals are Co, Cu, Fe, I, Mn and Zn. However, elements such as Cu and Zn have emetic action when ingested in higher amounts. The non-nutritive non-toxic metals which are not harmful when present in amounts not exceeding 100 ppm include Al, B, Cr, Ni and Sn. However, the increasing chromium intake calls for concern. Nigerian consumers may be exposed to higher levels considering the relative contribution of the element to the diet by beverages alone (Maduabuchi et al. 2007). The non-nutritive toxic metals which are known to have deleterious effects even at amounts below 100 ppm are As, Sb, Cd, F, Pb, Hg and Se (Ministry of Health and Family Welfare 2005). For example, arsenic exposure induces cardiovascular diseases, developmental abnormalities, neurologic and neurobehavioral disorders, diabetes, hearing loss, hematologic disorders and various types of cancer (Tchounwou et al. 2004).

Utilization of trace metals by humans influence the potential for health effects through environmental transport and by altering the biochemical form of the element (WHO 1992). Naturally, metals are redistributed in the environment by both geologic and biologic cycles (Goyer and Thomas 2001). Rain water dissolves rocks and ores and physically transports material to streams and rivers, adding and deleting from adjacent soil and eventually to the ocean to be precipitated as sediment or taken up in the rain water to be relocated elsewhere on earth (Forner and Wittman 1993). The biologic cycles include bioconcentration by plants and animals and incorporation into food cycles.

Food is a major source of human exposure to metals. Potential sources of human exposure include consumer products and industrial waste as well as the working environment. Cumulative poisoning due to ingestion of food containing metals such as lead and arsenic over a long period do occur. Some metals have detrimental effects on the quality or nutritive value of food. For example, copper causes off-flavour in milk and dairy products and tend to destroy vitamin C in fruit products. It is known that fruit juices and carbonated beverages contain trace metals. Therefore, the trace metal contribution of juices and beverages cannot be neglected (Onianwa et al. 2000). Less attention appears to be given to determination of trace metals in fruit juices and carbonated beverages. This investigation aims at determining trace metal content in imported fruit juices packaged in pouches and carbonated

Table 1 Trace metal content (ppm) of fruit juices

Fruit type	Cr	Cu	Pb	Mn	Ni	Zn	Sn	Cd	Co
Grape	0.08	ND	0.08	0.80	0.20	0.39	1.80	ND	ND
Pineapple	ND	ND	0.09	15.00	0.29	0.90	0.45	ND	ND
Apple	ND	0.26	0.08	0.53	0.02	0.17	1.90	ND	ND
Orange	ND	0.02	0.08	0.45	0.06	0.19	0.59	ND	ND
Lemon	0.05	ND	0.57	0.23	0.02	0.93	1.85	ND	ND

Table 2 Trace metal content (ppm) of carbonated beverages in glass containers

Beverage type	Cu	Mn	Ni	Zn	Sn	Fe	Cd	Co
$Beverage_1$	0.08	0.01	0.02	0.07	0.02	0.62	ND	ND
$Beverage_2$	0.19	0.01	0.02	0.02	0.02	0.44	ND	ND
$Beverage_3$	0.29	0.01	0.02	0.05	0.02	0.67	ND	ND
$Beverage_4$	0.14	0.01	0.02	0.02	0.02	0.21	ND	ND
$Beverage_5$	0.33	0.01	0.02	0.15	0.02	0.49	ND	ND

beverages in cans and glass bottles in Nigeria. The study serves as a guide in avoiding bio-accumulation of heavy metals in human system considering the peculiarity of environmental pollution being experienced in industrial and urban centres of Nigeria.

Materials and methods

The fruit juice samples were purchased in Lagos at Oke Arin, Oyingbo, Apongbon and Ikeja markets. Bottled (glass) and canned samples of the same brand of carbonated drinks were obtained and analysed. The brand names of the imported fruit juices were labelled $brand_1$, $brand_2$, $brand_3$, $brand_4$ and $brand_5$ respectively. The carbonated beverage samples analysed were similarly labelled $beverage_1$, $beverage_2$, $beverage_3$, $beverage_4$ and $beverage_5$. Trace metal levels in selected fruit juices and carbonated beverages were determined using atomic absorption spectrophotometer (Unicam model 969) equipped with SOLAAR 32 windows software. A multi-metal standard solution of nine (9) metals was prepared to give the following concentrations: Cu 1.0 ppm, Zn 0.2 ppm, Ni 0.2 ppm, Cr 0.2 ppm, Mn 0.05 ppm, Pd 0.5 ppm, Cd 0.5 ppm, Co 0.2 ppm, Sn 0.2 ppm.

In fruit juices, large particles were first removed by centrifuging and interference from sugar was compensated for by using standard method of additions. Fruit juices were centrifuged for 15 min at 4,500 rpm to obtain pulp free liquid. Aliquots 0, 1, 2 and 3 ml of the multi-metal standard solution were added to 100 ml volumetric flasks containing 3, 2, 1 and 0 ml of distilled water respectively and diluted to 100 ml with clear juice. The prepared samples were aspirated directly into the atomic absorption spectrophotometer. Carbonated beverages were analysed after the removal of carbon (IV) oxide by aeration. Four 100 ml aliquot of carbonated drinks were pipetted into 250 ml beakers containing 0, 1, 2 and 3 ml of multi-metal standard solution respectively. After heating on a hot plate until the volume was reduced to 75 ml, the samples were cooled and diluted to 100 ml and the prepared samples were aspirated directly into the spectrophotometer.

Results and discussion

Levels of Pb, Cd, Cu and Zn less than 0.05, 0.05, 0.30–1.10 and 1.30–8.6 mg/l have been reported (Food and Drug Directorate 1990). Concentrations up to 2.10 and 150 mg/l for Mn and Sn respectively have been found in citrus juices. In this study, trace metal content of selected fruit juices, carbonated beverages in glass containers and cans are highlighted in Tables 1, 2 and 3. Trace metal levels of fruit juices were higher than metallic levels of carbonated beverages which were comparatively low. This implies that it is relatively safer to consume carbonated beverages compared

Table 3 Trace metal content (ppm) of carbonated beverages in cans

Beverage type	Cu	Mn	Ni	Zn	Sn	Fe	Cd	Co
$Beverage_1$	ND	0.01	0.02	3.30	0.02	ND	ND	ND
$Beverage_2$	ND	0.01	0.02	0.08	0.02	ND	ND	ND
$Beverage_3$	ND	0.01	0.02	0.08	0.02	ND	ND	ND
$Beverage_4$	ND	0.01	0.02	2.05	0.02	ND	ND	ND
$Beverage_5$	ND	0.01	0.02	6.80	0.02	ND	ND	ND

to fruit juices. Cd and Co were not detected in all selected juices and beverages and Pb was not detected in the carbonated drinks. Concentrations of Pb in lemon juice and Mn in pineapple juice were relatively high. This relatively high concentration of Pb in lemon juices and Mn in pineapple juice indicates the need for a more detailed study of these juices. Zn contents of canned beverages were much higher than that found in glass bottled beverages. Pb, Cu, Cr and Fe were not detected in canned beverages but were detected in glass containing beverages. Bio-accumulation of trace metals do have serious health implications in human beings. For example, high level of Pb has been reported to be responsible for anemia and affect central nervous system, causing mental retardness and convulsion in childhood (Ademoroti 1996). High level of Mn causes psychiatric disorder including difficulty in walking, speech and compulsive behavior such as running, fighting and singing. However, the metal levels of selected fruit juices and carbonated beverages were within the permissible limits stipulated by Standard Organization of Nigeria and Codex Alimentarius (IARC 1987) except for manganese (15.00 ppm) in pineapple juice and lead (0.57 ppm) in lemon juice.

References

Ademoroti, C. M. A. (1996). Environmental chemistry and toxicology (pp. 171–204). Ibadan: Foludex Press.

Ercal, N., Gurer-Orhan, H., & Aykin-Burns, N. (2001). Toxic metals and oxidative stress part I: Mechanisms involved in metal-induced oxidative damage. *Current Topics in Medical Mycology, 1*(16), 529–539.

Food and Drug Directorate (1990). *Heavy metal determination in food drinks*. Ottawa, Canada: Department of National Health and Welfare.

Forner, U. A., & Wittman, G. W. (1993). *Metal pollution in aquatic environment* (p. 486). Berlin: Springer.

Goyer, R. A., & Thomas, W. C. (2001). In *Casarett and Doull's toxicology. The basic science of poisons* (p. 1236). McHrawHill.

IARC (1987). *Overall evaluations of carcinogenicity*. International Agency for Research on Cancer.

Jarup, L. (2003). Hazards of heavy metal contamination. *British Medical Bulletin, 68*, 167–182.

Maduabuchi, J. U., Adigba, E. O., Nzegwu, C. N., Oragwu, C. I., Okonkwo, I. P., & Orisakwe, O. E. (2007). Arsenic and chromium in canned and non-canned beverages in Nigeria: A potential public health concern. *International Journal of Environmental and Research Public Health, 4*(1), 28–33.

Ministry of Health and Family Welfare (2005). *Manual of methods of analysis of metals. Lab. Manual 9*. New Delhi: Government of India.

Onianwa, P. C., Lawal, J. A., Ogunkeye, A. A., & Orejimi, B. M. (2000). Cadmium and nickel composition of Nigerian foods. *Journal of Food Composition and Analysis, 13*, 961.

Peakall, D., & Burger, J. (2003). Methodologies for assessing exposure to metals: Speciation, bioavailability of metals, and ecological host factors. *Ecotoxicology and Environmental Safety, 56*(1), 110–121.

Tchounwou, P. B., Centeno, J. A., & Patlolla, A. K. (2004). Arsenic toxicity, mutagenesis, and carcinogenesis—a health risk assessment and management approach. *Molecular and Cellular Biochemistry, 255*(1–2), 47–55.

WHO (1992). Our planet, our health. Report of the WHO Commission on Health and Environment.