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Trace heavy metals composition of some Nigerian beverages and food drinks

P.C. Onianwa*, I.G. Adetola, C.M.A. Iwegbue, M.F. Ojo, O.O. Tella

Department of Chemistry, University of Ibadan, Ibadan, Nigeria

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Abstract

Several beverages and food drinks available in the market in Nigeria were analysed for their contents of the heavy metals, cadmium, cobalt, chromium, copper, iron, nickel, lead and zinc. The beverage types were grouped into tea, cocoa-based, coffee, cereal-based, dairy products, fruit juices, malt drinks, carbonated soft drinks and wines (non-alcoholic). The levels of the various metals were generally low, and within statutory safe limits. The levels compare well with those reported for similar beverages from some other parts of the world.

1. Introduction

The importance of food composition data in nutrition planning and provision of basic research data for epidemiological studies have been highlighted by Bruce and Bergstrom (1983) and Holden, Schubert and Wolf (1987). The quantity and quality of data available is, however, recognised to be severely limited (Bressani, 1983).

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 (Schroeder, 1973; Somer, 1974; Underwood, 1971; WHO, 1973). The compositions of various metals in different food types of various countries have been the subject of many studies (Cortes Toro, Das, Fardy, Bin & Parr, 1994; Drury & Hammond, 1979; Jorhem & Sundstroem, 1993; Tanaka, Ikebe, Tanaka & Kunita, 1974). Such data are not readily available for most foods of less-developed countries, such as Nigeria, where food composition data are primarily on proximate composition and other nutrients (US Department of Health, Education, & Welfare, 1967).

The present study focusses on heavy metal contents of beverages and some food drinks. As is the case in Nigeria and many other countries, such beverage foods and drinks make up a significant proportion of daily food intake. Musche (1976) reports that, in Germany, beverages contribute 43, 36 and 31% of the total lead, cadmium and mercury, respectively, in the diet. Similar data are available from other countries (Grimanis, Vassilaki-Grimani & Kanias, 1981; Horiguchi, Teramoto, Kurono, & Ninoomiya, 1978; Zurlo & Griffin, 1973). A recorded survey of beverages in Nigeria (Dada, Aiyesimoju, & Ajayi, 1982) was limited to the determination of calcium, magnesium, copper, zinc and iron contents of a few brands of cocoa-based beverages. The present study provides a more detailed determination of the contents of cadmium, cobalt, chromium, copper, iron, nickel, lead and zinc in various classes and brands of beverages in the Nigerian market.

2. Materials and methods

The beverages were grouped into nine classes: tea, coffee, cereal-based, cocoa-based, dairy products, fruit juices, malt drinks, carbonated soft drinks and wines (non-alcoholic). These included ready-to-drink liquids, and some food solids which are easily and usually processed into refreshment beverage drinks by dissolution or extraction with cold or hot water. The tea, coffee, cocoa-based, cereal-based and some dairy-based products were examined as the solids.

Five types (or brands in some cases) of each class of beverage or food drink (Table 1) were obtained from local markets in Ibadan, Nigeria. The selections were specially made to reflect the popular types consumed by the different income groups.

* Corresponding author. Tel.: +234-22-8102461; fax: +234-22-8103043; e-mail: library@kdl.ui.edu.ng

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Samples were processed for analysis by the dry-ashing or wet oxidation methods, or a combination of both (Crosby, 1977). Solid samples were dry-ashed in a muffle furnace at 550°C, and the ash dissolved in 1 M AnalaR grade nitric acid. Liquid samples were heated to dryness with a little concentrated nitric acid in an evaporating dish on a regulated hot-plate. The caked caramelous mass formed in most cases was then ashed in the same dish inside a furnace, and the ash also dissolved with 1 M nitric acid. The sample solutions were subsequently analysed for the metals using an air-acetylene flame atomic absorption spectrophotometer (Buck Scientific 200A model) by the standard calibration technique.

Appropriate quality assurance procedures and precautions were carried out to ensure reliability of the results. Samples were generally carefully handled to avoid contamination. Glassware was properly cleaned, and the reagents (nitric acid and distilled water) were of analytical grade. Reagent blank determinations were used to correct the instrument readings. Calibration standards were made by dilution of the high purity commercial BDH metal standards for atomic absorption analysis. A recovery test of the total analytical procedure was carried out for some of the metals in selected samples by spiking analysed samples with aliquots of metal standards and then reanalysing the samples. Acceptable recoveries of 90 and 92% were obtained for lead and cadmium, respectively.

3. Results and discussion

The mean (±standard deviation) and range of the concentrations of the metals in the various classes of beverages analysed are given in Tables 2 and 3 respectively. For any given metal, a very significant difference (deduced from analysis of variance) was observed in the levels among the various classes of beverages. The levels were generally much lower (about ten-fold) in the liquid materials (fruit juices, malt drinks, carbonated soft drinks, wines and some dairy products) than in the solid materials (tea, cocoa-based, coffee, cereal-based and some dairy products). This is due to the very high water contents of the liquid samples. Levels of a given metal in a specific class of beverage did not appear to vary markedly among the brands.

The levels of the toxic metals, cadmium and lead, were generally low, being much less than or just about 0.5 ppm in almost all samples. Nickel levels, on the other hand, were higher than the corresponding levels of cadmium and lead in each sample. However, apart from the tea samples with average nickel levels of 1.8 ± 1.6 ppm, average nickel levels for even the solid samples

Table 1
Classes and brands of beverages and food drinks used for the study

Class of beverage	Type or brand
Tea[a]	Lipton, Sorrel, Prime, Fine Bru, All Time
Cocoa[a]	Bournvita, Milo, Pronto, Balovita, Fatty Choco
Coffee[a]	Bongo, Owl, Nidocafe, Nescafe, Maxwell
Cereal-based[a]	Millet Ogi, Corn Ogi, Kunu, Custard, Mumu
Dairy-based	Carnco*, Cow Bell*, Banana Yoghurt, Mini Yoghurt, Peak
Fruit juice	Ribena, Lucozade, Fuma Pineapple Juice, Tan Orange Juice, Guava Juice
Malt Drink	Maltina, Lucomalt, Malta Guiness, Amstel Malta, Vitamalt
Carbonated drink	Sprite, Coca Cola, Gold Spot, Pepsi Cola, Tandy
Wine (non-alcoholic)	Evagos, Bacchus, Afa, Dutchess, Apul

[a] Solid samples; others are ready-to-drink liquids.

Table 2
Mean levels (±S.D) of heavy metals in the beverages (ppm)

Class	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Tea[a]	0.13 ± 0.08	5.6 ± 10.0	1.1 ± 1.4	10.7 ± 2.6	124 ± 82	1.8 ± 1.6	0.50 ± 0.50	20.0 ± 2.9
Cocoa[a]	0.21 ± 0.13	2.6 ± 3.3	2.1 ± 1.5	5.8 ± 2.5	125 ± 120	0.50 ± 0.82	0.31 ± 0.32	19.1 ± 6.9
Coffee[a]	0.14 ± 0.11	5.6 ± 5.8	2.9 ± 2.5	4.8 ± 3.7	51 ± 70	0.9 ± 1.1	0.30 ± 0.34	10.7 ± 4.2
Cereal[a]	0.14 ± 0.11	1.7 ± 3.3	1.2 ± 1.8	1.4 ± 1.5	14.4 ± 2.7	0.11 ± 0.18	0.14 ± 0.15	11.4 ± 9.3
Dairy (powder)[a]	0.15 ± 0.0	8.1 ± 3.2	2.7 ± 3.2	1.56 ± 0.84	20.7 ± 5.8	1.19 ± 0.05	0.06 ± 0.03	18.3 ± 4.5
Dairy (ready drink)	0.006 ± 0.003	0.09 ± 0.05	0.01 ± 0.01	0.33 ± 0.31	6.8 ± 7.2	0.05 ± 0.03	0.11 ± 0.08	1.54 ± 1.2
Fruit juice	0.003 ± 0.003	0.15 ± 0.14	0.01 ± 0.01	0.52 ± 0.60	2.1 ± 2.5	0.05 ± 0.05	0.06 ± 0.08	0.46 ± 0.58
Malt	0.002 ± 0.001	0.09 ± 0.12	0.05 ± 0.05	0.33 ± 0.44	1.3 ± 0.7	0.03 ± 0.03	0.05 ± 0.02	0.19 ± 0.10
Carbonated Soft	0.002 ± 0.005	0.25 ± 0.03	0.05 ± 0.04	0.10 ± 0.10	0.37 ± 0.20	0.006 ± 0.005	0.04 ± 0.01	0.15 ± 0.03
Non-alcoholic wine	0.002 ± 0.001	0.17 ± 0.17	0.09 ± 0.13	0.15 ± 0.12	5.53 ± 6.24	0.02 ± 0.03	0.08 ± 0.11	0.81 ± 0.80

[a] Solid samples.

were generally less than 1 ppm. Levels of the essential metals, cobalt, chromium, copper, iron and zinc, were much higher in the samples than those of the non-essential metals. Zinc and iron levels were the highest, reflecting the normal composition expected for plant-derived products, which most of the samples are.

The levels of the various metals are mostly below the safe limits specified for specific beverages and cereal-based foods by the Nigerian local food standards (Table 4) which are essentially adopted from international food standards. Only the levels of iron in a few cases exceed the limits.

Table 5 gives the estimates of the doses of the metals which may be derived from the ingestion of 1 l quantities of the beverage drinks. The values for the solid materials are estimated from the mean concentrations in the solid sample and the estimated weight/volume beverage concentrations of the formulations (Table 5) through which these beverages are usually consumed. The estimated doses of each metal derived from the solution of the solid samples do not differ significantly from those of the ready-to-drink samples. Only for lead and copper are the amounts noticed to be generally higher in the ready-to-drink samples than in the solids. It should be noted, however, that the estimates for the solution of the solid samples do not take into account the possible contributions of the metals from the water, which is used for making such solutions.

Table 3
Range of concentrations of heavy metals in the beverages (ppm)

Class	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Tea[a]	0.056–0.28	0.10–26.1	0.010–3.60	6.78–13.4	12.5–201	0.040–3.55	0.16–1.32	16.6–24.2
Cocoa[a]	0.056–0.42	0.42–8.41	0.060–4.12	2.24–9.07	34.4–336	0.040–1.95	0.080–0.88	7.56–24.3
Coffee[a]	0.020–0.31	0.10–14.2	0.89–6.98	2.13–9.41	6.30–174	0.040–2.58	0.090–0.91	3.73–14.0
Cereal[a]	0.005–0.26	0.003–7.56	0.010–3.97	0.14–3.88	11.0–18.0	0.040–0.44	0.080–0.40	1.15–24.6
Dairy (powder)[a]	0.14–0.16	5.84–10.3	0.39–4.93	0.96–2.16	16.6–24.8	1.15–1.22	0.04–0.08	15.1–21.5
Dairy (ready drink)	0.004–0.009	0.03–0.12	0.005–0.03	0.07–0.67	1.68–15.1	0.04–0.09	0.03–0.18	0.39–2.75
Fruit juice	0.003–0.007	0.003–0.32	0.001–0.030	0.001–1.02	0.56–6.35	0.001–0.10	0.003–0.19	0.020–1.10
Malt	0.002–0.006	0.003–0.30	0.001–0.11	0.070–1.11	0.56–2.36	0.020–0.080	0.030–0.070	0.12–0.38
Carbonated soft	0.001–0.002	0.20–0.27	0.001–0.090	0.20–0.40	0.16–0.67	0.001–0.010	0.020–0.050	0.050–0.18
Non-alcoholic wine	0.001–0.004	0.003–0.35	0.001–0.32	0.001–0.27	0.97–15.5	0.001–0.080	0.003–0.28	0.23–1.96

[a] Solid samples.

Table 4
Nigerian standards[a] for some metals in some beverages (ppm)[b]

Beverage type	Pb	Cu	Fe	Zn
Wines	0.20	2.0	1.0	NS[c]
Soft drinks	0.20	2.0	1.0	NS
Fruit juices	0.30	5.0	5.0	5.0
Malt drinks	0.20	2.0	1.0	NS
Cocoa beverages[d]	1.0	20.0	40.0	NS

[a] Excerpted from several guidelines of the Standards Organisation of Nigeria (SON).
[b] No limits specified for Cd, Co, Cr and Ni.
[c] NS—not specified.

Table 5
Estimated dose of heavy metals from 1 l volumes of the beverages

Beverages	Typical drink formulation	Dose (μg) from 1 l of drink							
		Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Tea	7.5 g per litre	0.98	42	8.3	80	930	14	3.8	150
Cocoa	50 g per litre	11	130	105	290	6250	25	15	955
Coffee	15 g per litre	2.1	84	44	72	765	14	4.5	161
Cereal	50 g per litre	7.0	85	60	70	720	5.5	7.0	570
Dairy(powder)	25 g per litre	3.8	203	68	39	518	30	1.5	458
Dairy (ready drink)	Ready-to-drink	6.0	90	14	330	6820	50	110	1540
Fruit juice	Ready-to-drink	3.0	150	10	520	2100	50	60	460
Malt drink	Ready-to-drink	2.0	90	50	330	1300	30	50	190
Carbonated drink	Ready-to-drink	2.0	250	50	100	370	6.0	40	150
Wine	Ready-to-drink	2.0	170	90	150	5530	20	80	810

Table 6
Levels of heavy metals in some beverages in some other parts of the world (ppm)

Country	Reference	Class	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Canada	Adriano (1984)	Dairy products	0.005	–	0.11	–	–	0.09	0.04	5.1
		Beverage drinks	0.003	–	0.07	–	–	0.22	0.01	–
Czechoslovakia	Gajduskova (1972)	Cereals	–	–	–	–	–	–	–	11.9–53.5
		Carbonated drinks	–	–	–	–	–	–	–	0.1–1.05
		Tea, coffee	–	–	–	–	–	–	–	0.5–75.0
East Asia (general)	Wu Leung & Butrum (1972)	Carbonated drinks	–	–	–	–	–	–	–	3.0–8.0
		Coffee	–	–	–	–	–	–	–	50.0–60.0
		Wine	–	–	–	–	–	–	–	1.0
		Tea	–	–	–	–	–	–	–	189–316
		Cocoa beverage	–	–	–	–	–	–	–	14.0–21.0
Egypt	Hussein and Bruggeman (1997)	Yoghurt drink	–	–	–	–	–	–	–	30.5
Greece	Grimanis et al. (1981)	Wines	–	–	–	0.03–0.4	–	–	–	–
India	Sattar, Ahmad and Khan (1993)	Tea	0.41–0.91	6.5–9.2	–	–	–	–	2.2–5.2	14.5–25.2
	Bhutani, Joshi and Chopra (1989)	Wines	–	–	–	0.92	114	–	–	–
Italy	Clemente, Cigna Rossi and Santaroni (1980)	Dairy products	–	–	–	–	–	0.09	–	–
		Beverages	–	–	–	–	–	0.22	–	–
	Paolo & Maurizio (1978)	Fruit juice	–	–	–	0.87–0.97	–	–	0.10–0.80	0.41
		Malt drink	–	–	–	0.10	–	–	0.38	0.86
		Carbonated drinks	–	–	–	0.08	–	–	1.04	0.58
		Wine	–	–	–	0.21	–	–	0.69	0.32
Japan	Tanaka et al. (1974)	Tea	–	–	–	24–38	–	–	0.6–1.8	–
	Qi, Furuya and Goshishi (1987)	Tea	–	1.35	–	–	–	5.7	–	–
	Sakae, Tarema and Siradan (1989)	Tea	–	–	–	22–26	121–141	–	–	–
Nigeria	Dada et al. (1982)	Cocoa beverages	–	–	–	0.01–1.2	< 10.0	–	–	1.2–8.2
Not specified	Schroeder (1973)	Dairy products	0.27	0.12	0.10	1.76	–	–	–	8.6
		Wine	0.07	0.01	–	0.44	–	–	–	0.2
		Tea	0.001–2.5	–	–	–	–	–	–	0.24–36.4
	Underwood (1971)	Coffee	–	0.93	–	–	–	–	–	–
	Al-Swaidan (1988)	Fruit juice	–	–	–	–	4.5–8.3	–	0.2–0.3	–
Poland	Pogorzelski, Markiewicz and Zegarska (1987)	Dairy products	0.05–0.06	–	–	–	–	–	0.05–0.06	–
	Bulinski, Kot, Bloniarz and Koktysz (1986)	Dairy products	–	–	–	–	–	–	0.091	38.2
Spain	Troncosogonzalez and Guzman (1989)	Wines	–	–	–	1.35	8.44	–	0.55	7.9
	Contreraslopez, Llanaza and Santamaria (1987)	Fruit juice	–	–	–	5.0	15.0	–	0.15	5.0

Such contribution from water is already incorporated in the concentrations reported for the ready-to drink liquid samples.

The levels of these heavy metals in similar beverages in some other parts of the world are given in Table 6. Comparison with levels in the Nigerian beverages reveals that the levels are generally comparable, with a few minor exceptions. Nigerian tea appears to contain high levels of metals such as cobalt, copper, iron and nickel. This trend is similar to the case with tea from Japan and India. Copper levels are higher in Japanese tea (22–38 ppm) than in Nigeria tea (10.7 ± 2.6 ppm). Tea leaves appear to be generally associated with high levels of minerals (Kajita, 1963).

Overall, the study shows that the levels of the eight heavy metals studied are generally within safe limits, and compare well with levels in similar foods from other parts of the world. The data here obtained will be valuable in complementing available food composition data, and estimating dietary intakes of heavy metals in Nigeria.

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