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Full Length Research Paper

Copper, selenium and zinc content of canned and non-canned beverages in Nigeria

Orisakwe, O. E.*, Oragwu, C. I., Maduabuchi, J. M. U., Nzegwu, C. N. and Nduka, J. K. C.

College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus, P. M. B. 5001, Nnewi, Anambra State, Nigeria.

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The levels of copper, selenium and zinc in beverages purchased in Nigeria were studied. Fifty samples of these beverages were digested in nitric acid and were analyzed using the Atomic Absorption Spectrophotometer (AAS). The zinc levels ranged from 0.0 - 1.34 mg/L for the canned and 0.01 - 1.11 mg/L for the non-canned beverages. All had zinc levels below the maximum contaminant level (MCL) of 5.0 mg/l set by United States Environmental Protection Agency (US EPA). The selenium levels ranged from 0.24 - 1.67 mg/L for the canned and 0.07 - 1.23 mg/L for non-canned beverages. 20 out of 21 (95%) canned beverages had selenium levels that exceeded the MCL whereas 90% of the non-canned products had selenium levels above the MCL. The copper levels ranged from 0.04 - 3.55 mg/L for the canned and 0.04 - 3.20 mg/L for non-canned beverages. 11 out a total of 21 (52%) canned beverages had copper levels that exceeded the MCL. 45% of the non-canned products had copper levels above the MCL. The mean and median values of copper and selenium exceeded the MCL in the beverages whereas the zinc levels did not exceed the MCL. The calculated amount of copper, selenium and zinc in three beverages were 14.57, 5.96 and 5.31 mg respectively. The worst-case scenario is assumed here to estimate the weekly intakes of Cu, Se and Zn, and results seem to pose some concern. 48 and 92% of the 50 beverages studied in March 2005 in Nigeria failed to meet the US EPA criteria for acceptable copper and selenium levels in consumer products.

Key words: Copper, selenium, zinc, contaminants, beverages, Nigeria.

INTRODUCTION

Human exposure to copper is primarily through food and water intake (US. EPA, 1995; NIPHEP, 1989). Copper is released into the environment primarily through mining, sewage treatment plants, solid minerals, plumbing supplies, (pipes, faucets, braces, and various forms of tubing), and agricultural processes (ATSDR, 1990). Drinking water sources become contaminated with copper primarily because of its use in many different types of plumbing supplies. It is a common component of fungicides and algaecides, and agricultural use of copper for these purposes can result in its presence in soil, ground water and many forms of produce (ATSDR, 1990). Though cop-per is an essential trace element required by the body for normal physiological processes, overexposure to copper containing substances can result in copper toxicity and a wide variety of complications. Young children are at risk of intoxication because of high consumption of drinking water and immature copper metabolism.

Absorption of copper occurs through the lungs, gastrointestinal tract and skin (US. EPA, 1985). The degree to which copper is absorbed in the gastrointestinal tract largely depends upon its chemical state and the presence of other compounds like zinc (U.S. Air Force, 1990). Once absorbed, copper is distributed primarily to the liver, kidneys, spleen, heart, lungs, stomach, intestines, nails, and hair. Individuals with copper toxicity show an abnormally high level of copper in the liver, kidneys, brain, eyes, and bones (ATSDR, 1990).

Selenium is a metal commonly found in rocks and soil. It is used as an ingredient in toning baths in photography, as pigment in manufacturing ruby, pink, orange or red coloured glass etc. Small selenium particles in the air settle

*Corresponding author. E-mail:eorish@aol.com

Table 1. Copper levels (mg/L) in canned beverages.

Products	Copper (mg/L)	Place of manufacture
Sagiko Pink Guava	3.55	Singapore
Top Mlik	3.51	Hamburg, Germany
Peak Milk	3.55	Leeuwarden, Holland
Picnic Soymilk (Maeil)	3.30	Seoul, South Korea
Three Crown Milk	3.21	Lagos, Nigeria
Luna Milk	2.95	Jedda, Saudi Arabia
Sweet Heart Mixed Fruit	2.52	Tianjin, China
Chinchin Malt Milk	2.39	Tianjin, China
Gody's Malta	1.91	"Imported From Germany"
Star Pino Pineapple	1.61	Shariah, United Arab Emirates
Goldquell Multivitamin	1.43	Fruchtsaft, Gmbh, Germany
Holsten Malta	1.22	Hamburg, Germany
Sobela Mixed Fruit Juice	1.12	Tianjin, China
Lino Malt	1.04	Belgium.
Fanta Orange Drink	0.80	Wadeville, South Africa
Coca-Cola (Coke)	0.76	Wadeville, South Africa
Remmy Rankky Orange	0.50	Wuging, Republic Of China
Glorietta Limonade range	0.35	Germany
Star Mango	0.31	Shariah, United Arab Emirates
Original Precious Juice	0.23	Yunlin, Taiwan
Sprite Soft Drink	0.04	Wadeville, South Africa

Range: 0.04 - 3.55 ; Median Value = 1.43; Mean Value = 1.73.
MCL = 1.30 mg/L; Number of beverages with copper level that exceeded the MCL = 11/21 (52.38%).

to the ground or are taken out of the air in rain. Soluble Selenium compounds in agricultural feeds can leave the field in irrigation drainage water. Selenium can collect in animals that live in water containing high levels of it.

Zinc is an essential element for wound healing (repair of tissues like collagen) and fertility. Evaluation of key nutrients, particularly iron, zinc, and calcium in various formulations of fortified processed complementary foods is a key research need. In fortification of products, zinc oxide is the compound most commonly used because it is well absorbed, produces organoleptic changes and is significantly less expensive than other zinc compounds (Lutter and Dewey, 2003).It has been advocated that legislation to check heavy metal exposure be based on genuine scientific evaluation of the available evidence (Gidlow, 2004). Thus, this study is aimed at providing scientific data on the levels of copper, selenium and zinc probably for the first time in beverages and fruit drinks commonly sold in Nigeria.

MATERIALS AND METHODS

Fifty randomly selected beverage and canned beverages (one sample each) purchased in March 2005 in Nigeria were used in the study. The samples were digested in Teflon lab ware that had been cleaned in a high-efficiency particulate air (HEPA) filtered (class 100), trace-metal-clean laboratory to minimize contamination. This protocol involved sequential cleaning of the lab ware in a series of baths in solutions (1 week each) and rinsed (five per solution) in a three-step order namely a detergent solution and de-ionised water rinses, then 6 N HCl (reagent grade) solution and ultra-pure water rinses, finally, 7.5 N HNO_3 (trace metal grade) solution and ultra-pure water rinses. The lab ware was then air dried in a polypropylene laminar air flow-exhausting hood.

Five milliliters of each sample was used. The samples were digested by adding 15 ml of nitric acid and making it up to 50 ml with de-ionised water. This was heated until the solutions were fully digested and reduced to 10 ml. The solutions were allowed to cool and then filtered. Zinc, selenium and copper levels were analyzed using the Unicam Atomic Absorption Spectrophotometer (AAS) Model 929 with air acetylene flame a detection limit of 0.001. Samples were analyzed in duplicates, that is, replicate sub-samples.

The intake using the arithmetic mean according to Parkhurst (1998) was calculated by multiplying contaminant level, that is, chemical element level by amount/volume of beverage. In all the estimated intakes of copper, selenium and zinc, one and half liters were assumed to be the average volume of the beverages and the MCL are for adults.

RESULTS

The samples studied were classified into canned and non-canned products. In combination, 24/50 (48% of total products) had levels above the recommended copper MCL (Tables 1 and 2). The copper levels ranged from 0.04 - 3.55 mg/L for the canned and 0.04 - 3.20 mg/L for

Table 2. Copper levels (mg/l) in non-canned beverages.

Product	Copper (mg/L)	Place of Manufacture
Fine Merit Yorghurt	3.20	***Lagos, Nigeria***
Savana Pineapple	3.12	Onitsha, Nigeria
Mighty Nice Vanilla Low Fat	2.98	***Cape Town, South Africa***
Mighty Nice Chocolate Drink	2.97	Cape Town, South Africa
Vinamilk Yomilk	2.68	Vietnam
Ribena Black Currant	2.55	Ogun State, Nigeria
Lactosoy Milk	2.45	Prachinburi, Thailand
Lucozade Boost	2.40	Ogun State, Nigeria
Campina Yazoo Milk Drink	2.35	Aalter, Belgium
Vitamilk Soymilk	2.14	Thailand
Popcy Flavoured Drink	2.01	Lagos, Nigeria
Shezza Mango	1.64	Karachi, Pakistan
V-Rovers Pineapple Cordial	1.34	Ogidi, Nigeria
Chivita Orange Juice	1.19	Lagos, Nigeria
Vina Orange Afresh	0.99	Lagos, Nigeria
Chelsea Teezer Gin & Pineapple	0.91	Lagos, Nigeria
Grape Joy Of Health	0.88	Cansavay Bay, Hong Kong.
La Casera Orange Drink	0.83	Lagos, Nigeria
Vitavite Orange Drink	0.78	Lagos, Nigeria
Delight Black Currant Drink	0.68	Lagos, Nigeria
La Casera Apple Drink	0.38	Lagos, Nigeria
Tico Orange Cordial	0.34	***Lagos, Nigeria***
V-Rovers Orange Flavoured Drink	0.32	Ogidi, Nigeria
Sam Cream Soda	0.22	Ogun State, Nigeria
5-Alive Citrus Burst Juice	0.21	Lagos, Nigeria
Caprisonne Pineapple Drink	0.16	Lagos, Nigeria
Lucomalt	0.15	Ogun State, Nigeria
Lulu Apple Drink	0.07	Lagos, Nigeria
Marigold Orange	0.04	Malaysia

Range: = 0.04—3.20; Median Value: = 1.19Mean Value: = 1.38
MCL = 1.30 mg/L; Number of beverages with copper level that exceeded the MCL = 13/29 (44.83%)

non-canned beverages. The percent of canned beverages with copper levels that exceeded the MCL was 52 and 45% of the non-canned products had copper levels above the MCL. The mean/median for the canned products were 1.73/1.43 and 1.38/1.19 for the non-canned respectively. Tables 3 and 4 show the levels of selenium in canned and non-canned beverages respectively. The selenium levels ranged from 0.24 - 1.67 mg/L for the canned and 0.07 - 1.23 mg/L for non-canned beverages. The number of canned beverages with selenium level that exceeded the MCL was 20/21 (95%). 90% of the non-canned products had selenium levels above the MCL. The mean, median and standard deviation for the canned products are 0.92, 0.93 and 0.38.The mean, me-dian and standard deviation for the non-canned products are 0.49, 0.53, and 0.39.

The zinc levels ranged from 0.01 - 1.34 mg/L for the canned and 0.01 - 1.11 mg/L for non-canned beverages. All beverages had zinc levels that were below the maximum contaminant level (MCL) of 5.0 mg/L set by US EPA. The mean and median for the canned products are 0.52 and 0.37. The mean and median for the non-canned products is equal, that is, 0.30 (Tables 5 and 6).

The estimated/calculated intakes for copper, selenium and zinc are contained in Table 7. The calculated amount of copper, selenium and zinc in “worst case scenario” of a milk consumer who takes an average weekly volume of 4.5 L (1.5 L of the 3 more contaminated milk) were 14.57, 5.96 and 5.31 mg/L respectively.

DISCUSSION

Intake of beverages with elevated copper concentrations can induce acute epigastric pain, nausea, vomiting, and diarrhea. However copper concentrations at which symptoms appear and the scope of responses observed is not

Table 3. Selenium levels (mg/L) in canned beverages.

Products	Selenium (mg/L)	Place of Manufacture
Sagiko Pink Guava	1.67	Singapore
Picnic Soymilk (Maeil)	1.32	Seoul, South Korea
Chin Chin Malt Milk	1.06	Tianjin, China
Gody’s Malta Drink	1.03	"Imported From Germany"
Luna Milk	1.02	Jedda, Saudi Arabia
Coca Cola (Coke)	1.01	Wadeville, South Africa
Peak Milk	0.98	Leeuwarden, Holland
Top Milk	0.96	Hamburg, Germany
Fanta Orange Drink	0.94	Wadeville, South Africa
Lino Malt	0.93	Belgium.
Sweet Heart Mixed Fruit	0.93	Tianjin, China
Three Crown Milk	0.92	Lagos, Nigeria
Star Pino Pineapple	0.88	Shariah, United Arab Emirates
Goldquell Multivitamin	0.83	Fruchtsaft, Gmbh, Germany
Remmy Rankky Orange	0.75	Wuging, Republic Of China
Sobela Mixed Fruit Juice	0.72	Tianjin, China
Star Mango	0.71	Shariah, United Arab Emirates
Holsten Malta	0.71	Hamburg, Germany
Original Precious Juice	0.26	Yunlin, Taiwan
Glorietta Limonade Orange	0.24	Germany
Sprite Soft Drink	<DL	Wadeville, South Africa

Table 4. Selenium levels (mg/L) in non- canned beverages.

Product	Selenium (mg/L)	Place of manufacture
Mighty Nice Chocolate Drink	1.23	Cape Town, South Africa
Chelsea Teezer Gin/Pineapple	1.09	Lagos, Nigeria
Campina Yazoo Milk Drink	1.08	Aalter, Belgium
Ribena Black Currant	1.08	Ogun State, Nigeria
Lactosoy Soymilk	1.06	Prachinburi, Thailand
Fine-Merit Yoghurt	0.99	Lagos, Nigeria
Savana Pineapple	0.99	Onitsha, Nigeria
Vitamilk Soymilk	0.95	Thailand
Shezza Mango	0.91	Karachi, Pakistan
Mighty Nice Vanila Low Fat	0.89	Cape Town, South Africa
Vinamilk Yomilk	0.88	Vietnam
Chivita Orange Juice	0.80	Lagos, Nigeria
Lucozade Boost	0.64	Ogun State, Nigeria
Vina Orange Afresh	0.62	Lagos, Nigeria
La Casera Apple Drink	0.53	Lagos, Nigeria
La Casera Orange Drink	0.53	Lagos, Nigeria
Tico Orange Cordial	0.41	Lagos, Nigeria
Lucomalt	0.39	Ogun State, Nigeria
Vitavite Orange Drink	0.39	Lagos, Nigeria
Delight Black Currant Drink	0.36	Lagos, Nigeria
Popcy Flavoured Drink	0.27	Lagos, Nigeria
V-Rovers Orange Flavoured Drink	0.24	Ogidi, Nigeria
V-Rovers Pineapple Cordial	0.20	Ogidi, Nigeria
Marigold Orange	0.16	Malaysia
Grape Joy Of Health	0.16	Cansavay Bay, Hong Kong.

Table 4 contd.

Lulu Apple Juice	0.07	Lagos, Nigeria
Sam Cream Soda	<DL	Ogun State, Nigeria
5-Alive Citrus Burst Juice	<DL	Lagos, Nigeria
Caprisonne Pineapple Drink	<DL	Lagos, Nigeria

<DL = value less than detection limit of 0.001.; Range: = 0.07 — 1.23; Median Value: = 0.53
Mean Value: = 0.49; MCL = 0.05 mg/L;
Number of beverages with selenium level that exceeded the MCL = 26/29 (89.66%)

Table 5. Zinc levels (mg/L) in canned beverages.

Products	Zinc (mg/L)	Place of Manufacture
Top Milk	1.34	Hamburg, Germany
Peak Milk	1.27	Leeuwarden, Holland
Picnic Soymilk (Maeil)	1.16	Seoul, South Korea
Three Crown Milk	1.14	Lagos, Nigeria
Sagiko Pink Guava	1.10	Singapore
Luna Milk	1.04	Jedda, Saudi Arabia
Sweet Heart Mixed Fruit	0.84	Tianjin, China
Chin Chin Malt Drink	0.81	Tianjin, China
Original Precious Juice	0.67	Yunlin, Taiwan
Star Pino Pineapple	0.55	Shariah, United Arab Emirates
Sobela Mixed Fruit Juice	0.37	Tianjin, China
Goldquell Multivitamin	0.35	Fruchtsaft, Gmbh, Germany
Fanta Orange Drink	0.27	Wadeville, South Africa
Holsten Malta	0.25	Hamburg, Germany
Lino Malta	0.21	Belgium.
Gody's Malt Drink	0.17	"Imported From Germany"
Remmy Rankky Orange	0.16	Wuging, Republic Of China
Coca-Cola (Coke)	0.16	Wadeville, South Africa
Glorietta Lemonade Orange	0.10	Germany
Star Mango	0.10	Shariah, United Arab Emirates
Sprite Soft Drink	0.01	Wadeville, South Africa

Range = 0.01 - 1.34; Median Value = 0.37
Mean Value = 0.52; MCL = 5.0 mg/L; No beverage had Zn level exceeding the MCL.

Table 6. Zinc levels (mg/L) in non-canned beverages.

Products	Zinc (mg/L)	Place of Manufacture
Fine Merit Yoghurt	1.110	Lagos, Nigeria
Savanna Pineapple	1.100	Onitsha, Nigeria
Mighty Nice Chocolate Drink	1.020	Cape Town, South Africa
Mighty Nice Vanilla Low Fat	0.990	Cape Town, South Africa
Vinamilk Yomilk	0.910	Vietnam
Lactosoy Soymilk	0.810	Prachinburi, Thailand
Campina Yazoo Milk Drink	0.790	Aalter, Belgium
Vitamilk Soymilk	0.720	Thailand
Shezza Mango	0.540	Karachi, Pakistan
V-Rovers Pineapple Cordial	0.480	Ogidi, Nigeria
Lucozade Boost	0.480	Ogun State, Nigeria
Chivita Orange Juice	0.380	Lagos, Nigeria
Chelsea Teezer Gin & Pineapple	0.320	Lagos, Nigeria

Table 6 contd.

Lucomalt	0.300	Ogun State, Nigeria
Vina Orange Afresh	0.300	Lagos, Nigeria
Vitavite Orange Drink	0.270	Lagos, Nigeria
La Casera Orange Drink	0.260	Lagos, Nigeria
Ribena Black Currant Juice	0.240	Ogun State, Nigeria
5 Alive Citrus Burst Juice	0.214	Lagos, Nigeria
Grape Joy Of Health	0.180	Cansavay Bay, Hong Kong.
Tico Orange Cordial	0.100	Lagos, Nigeria
V-Rovers Orange Flavored Drink	0.100	Ogidi, Nigeria
Caprisonne Pineapple Drink	0.081	Lagos, Nigeria
La Casera Apple Drink	0.080	Lagos, Nigeria
Delite Black Currant	0.060	Lagos, Nigeria
Popcy Flavored Drink	0.050	Lagos, Nigeria
Lulu Apple Juice	0.010	Lagos, Nigeria
Sams Cream Soda	0.010	Ogun State, Nigeria
Marigold Orange	<DL	Malaysia

<DL = value less than detection limit of 0.001. ;Range: = 0.01 - 1.11; Median Value: = 0.30, Mean Value: = 0.30,MCL = 5.0 mg/L No beverage had Zn level exceeding the MCL.
Grey background represent beverages of animal origin; bold lines represent threshold MCL values, green background represent beverages of vegetal origin (fruit juices, etc..) and white others not directly derived from living organisms, either animals or vegetables (e.g. coca cola, malt etc).

Table 7. Example of calculating intake.

True Cu intake =	1.5* x 3.55 + 1.5 x 3.48 + 1.5 x 2.68 = 14.57 mg/L Cu
True Se intake =	1.5 x 1.67 + 1.5 x 1.32 + 1.5 x 0.98 = 5.96 mg/L Se
True Zn intake =	1.5 x 1.34 + 1.5 x 1.16 + 1.5 x 1.04 = 5.31 mg/L Zn

*(that is, assumed beverage volume multiplied by heavy metal contaminant level for each of the three products: the volume of the beverage was assumed to be one litre each).

clear (Pizzaro et al., 1999). Copper has been connected to a form of Early Childhood Liver Cirrhosis (ECLC) known as Non-Indian Childhood Cirrhosis (NICC). NICC is similar to Indian Childhood Cirrhosis (ICC), which is attributed to the excessive intake of copper derived from milk and water stored in copper and brass vessels (Zietz, 2003; de Vergara, 1999).

Copper is an essential trace element but higher exposure can induce acute and chronic intoxications in humans. Copper in tap water has caused a series of systemic diseases in Germany in recent years (copper-induced liver cirrhosis). Besides cirrhosis, another type of disease with predominantly gastrointestinal symptoms, has occurred which likewise appeared to be induced by copper in tap water. The German study revealed that the gastrointestinal diseases can be caused by copper concentrations (relatively lower than that given by the German Guidelines for Drinking Water). Copper poisoning must be considered as a possible cause of chronic gastrointesinal diseases in those countries in which copper plumbing is common (Eife et al., 1999). In Sweden about 10% of the children had copper intake above the level recommended by the World Health Organisation (WHO) (Petterson and Rasmussen, 1999). Elsewhere, drinking water has been implicated as the leading source of copper toxicity (de Vergara 1999). Results of this study show that beverages are significant sources of copper exposure to consumers in Nigeria. The copper levels in canned beverages showed a significant variation (p from the levels in non-canned beverages. Those who consume routinely large amounts of such products with copper level greater than the MCL (1.30 mg/L) may be exposed to copper toxicity. Of particular concern is the level in a common beverage like liquid milk. Considering a weekly consumption of 41 L tins of ‘Peak’ branded milk, and the bioavailability of copper from diet being 65 - 70% (Barceloux, 1999), a consumer would absorb 2.26 (that is, 65% of 3.48 being amount of Cu in peak milk) x 4 mg, that is 9.04 mg of copper in a week. In children, the level absorbed will be higher because of their immature copper metabolism [13]. This level in a single dose may not cause acute copper toxicity but can be very harmful considering chronic exposure and bioaccumulation. Thus repeated consumption of these beverages with high copper levels may pose a risk in reduction of total homocysteine and folate which are essential to body metabolism (Tamura and Turnlund, 2004).

Copper level in public water supplies in Nigeria is not controlled. Moreover the high levels of copper in consumer products must have been from water as well from the manufacturing process. The threshold for gastrointestinal symptoms of copper in drinking water has not been precisely established in controlled prospective studies (Pizzaro et al., 2001). A publication suggested that copper concentrations ≥ 3 mg/L, as copper sulfate, in drinking water produce a significant increase in gastrointestinal symptoms but not in diarrhea (Pizzaro et al., 2001). Researchers have assessed whether mean daily intake of copper or maximal concentration of copper in drinking water is related to the incidence of diarrhea and vomiting among young children. A report from Sweden has stated that there were no significant associations between daily intake of copper or maximal concentration of copper in drinking water and the risk of diarrhoea (Petterson et al., 2003). This may not be the case in Nigeria hence-further research is needed along this line of reasoning.

Selenium, an integral part of the enzyme glutathione peroxidase that prevents free radical damage to cells is also responsible for the conversion of thyroxine to iodothyronine in liver microsomes. Hypothyroidism is therefore seen infrequently in selenium-deficient area (Haslet et al., 2002). In a study done in Greenland (2000), the selenium intake by humans was high with whale skin being the dominant source of it in diet (Johansen et al., 2000). This suggests that bioaccumulation in the food chain plays a role in determining the amount of selenium intake by humans through food. Some parts of China also have depleted selenium in their soil and food (Anonymous, 1995). In Denmark, the selenium intake from food has been estimated to be 343 µg/wk with meat, plucks, fish, egg, milk, cheese and cereals as the most important sources. This is close to the recommended intake of 350 µg/wk in Denmark (Anonymous, 1995). A maximum daily safe intake of 400 µg/day, equaling 2800 µg /week has been suggested by Yang et al. (1989).

Selenium is also important in infant's nutrition. The contribution of selenium through human milk to the heavy metal burden of infants is variable and can be influenced by maternal nutritional states (Lutter and Dewey, 2003). In Nigeria, a great number of pregnant and lactating women consume the beverages under study. 82% of the products revealed high levels of selenium above the MCL. Hence, regular consumers are not unexposed to risks of toxicity. On the other hand, for non-breast fed children or children of mothers deficient in this nutrient, a significantly greater proportion of the selenium requirement needs to be met through complementary foods (Lutter and Dewey, 2003).

The daily ration of a fortified complementary food should contain 4 – 5 mg of Zn as described by Rosado (2003). This exceeds the *Recommended Daily Allowance* RDA of 3 mg and is justified because of the lower bioavailability of zinc in diets typical in developing countries (Lutter and Dewey, 2003). All the 50 samples used for this study had their zinc levels below both the RDA and MCL for zinc in food and water respectively. It also appeared that some of the products with higher zinc levels example top milk, peak milk, picnic soymilk, three crown milk and fine merit yoghurt had the zinc level fortified to attain such levels. This however was not precisely indicated on the labels.

The presence of other nutrients and trace elements in food/drinks may affect the bioavailability of zinc. Fortification with mineral salts has the potential risk of reducing the bioavailability of other minerals in the food by either changing their intestinal solubility or by competing for uptake at absorption site (Abrams and Atkinson, 2003). Data on the potential for such mineral-mineral interactions have resulted primarily from studies of single mineral dietary supplements rather than minerals used as fortificants in food. Concern has primarily centered on the effect of calcium and phosphorus on iron and zinc absorption, zinc fortification on copper absorption and iron fortification on zinc absorption [6]. Considering calcium for instance, data are not yet available to support the recommendation on optimal dietary calcium-zinc ratios (Abrams and Atkinson, 2003). Negative effects of typical zinc intakes on copper absorption have not yet been demonstrated (Rosado, 2003), but the addition of conservative amounts of copper to zinc in fortified foods may need to be considered. Fortification of food with iron does not have a negative effect on zinc absorption (Whittaker, 1998). The only exception to this finding is when the Fe and Zn molar ratio is 25:1, a ratio that is highly unlikely to occur in fortified foods (Lutter and Dewey, 2003).

These issues are very important in human nutrition especially in developing countries like Nigeria where there is a lower bioavailability of zinc in staple foods like cereals. For infants and children, breast-feeding status is not important for the nutrients for which human milk makes a small contribution toward total requirement, such as iron and zinc (WHO, 1998). For these nutrients, nearly the entire requirement must be met through complementary foods.

Although the present study has not employed the use of food intake diaries, the calculated/estimated intakes of copper, selenium and zinc using arithmetic mean for a Nigerian taking one and half liters of different beverages, that is the intakes are shown in Table 7. In the present study, the calculated/estimated intakes of these heavy metals are 14.57 mg/L Cu, 5.96 mg/L Se and 5.31 mg/L Zn per week. This estimated intake value may be higher especially in dry seasons. It could be reasoned therefore that if from processed beverages alone, the body burden of these heavy metals in an average Nigerian exceeds that of values obtained in Europe and America, a cumulitive amount from other sources may make it even higher. Taken together we suggest a follow-up study of the blood levels of these heavy metals in the local population especially the highly susceptible groups namely children and pregnant women.

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REFRENCES

US, EPA(1995).Effect of pH,DIC, Orthophosphate and Sulfate on Drinking Water Cupro Solvency.EPA/600/R-95/085.Washington DC:U.S. ENVIRONMENTAL PROTECTION AGENCY, Office of Res and Devt.

NIPHEP, Integrated Criteria Document Copper. Appendix to Report No.758474009.Bilthoven, The Netherlands: National Institute of Public Health and Environmental Protection,1989.

ATSDR (Agency for Toxic Substances and Diseases Registry).1990.Toxicological Profile for Copper. Prepared by Syracuse Research Corporation for ATSDR, U.S.Pub. Health Service under contract. 88-0608-2.ATSDR/TP-90-08.

U.S,EPA (1985).Drinking Water Criteria Document for Copper(Final Draft).EPA 600/X-84/190-1, Cincinnati, OH:U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office.

U.S,Air Force (1990).Copper. In: The Installation Program Toxicology Guide.Vol 5.Wright,Patterson Air Force Base,Ohio.pp.77(1-43).

Lutter CK, Dewey KG (2003).Proposed nutrient composition for fortified complementary foods.J. Nutr. 133:3011S-3020S.

Gidlow DA(2004).Lead toxicity.Occupational Medicine (Lond). 54 (2): 76-81.

Parkhurst DF (1998).Arithmetic versus geometric means for enviromental Concentration data.Environ Sci Technol 32: 92A-98A.

Pizzaro F, Olivares M, Gidi V, Araya M (1999).The gastrointestinal tract and acute effects of copper in drinking water and beverages.Rev Environ Health 14:pp.231-238

Zietz BP, Dieter HH, Lakomek M, Schneider H, KeAyler-Gaedtke B, Dunkelberg H (2003). Epidemiological investigation on chronic copper Toxicity to children exposed via the public drinking water supply. Sci Total Environ. 302(1-3): 127-144.

de Vergara JD, Zietz BP, Schneider HB, Dunkelberg H(1999). Determination of the extent of excessive Copper concentrations in the tap water of households with copper pipes and an assessment of possible health hazards for infants. Eur. J. Med. Res. 4(11):475-82.

Eife R, Weiss M, Barros V,Sigmund B, Gorrip U, Komb D, Wolf W, Kittel J, Schramel P, Reiter K (1999).Chronic Poisoning by Copper in tap water 1:Copper Intoxication with predominantly Gastrointestinal symptoms. Eur. J. Med. Res.(6): 219-23.

Petterson R, Rasmussen F (1999).Daily intake of copper from drinking water among young children in Sweden. Environ Health Perspect. 109(6): 441-6.

Barceloux DG. Copper J, Toxicol, Clin,Toxicol(1999).37(2): 217-30

Tamura T, Turnlund JR (2004). Effect of long-term, high copper intake on the concentrations of plasma homocysteine and B-vitamins in young men. Nutrition 20(9):757-9.

Pizzaro F, Olivares M, Araya M, Gidi V, Uauy R (2001).Gastrointestinal Effects Associated with Soluble and Insoluble Copper in Drinking Water. Environ Health Perspect. 109(9): 949-52.

Petterson R,Rasmussen F,Oskarsson A(2003).Copper in drinking water:not a strong risk factor for diarrhea among young children.A population-Based study from Sweden. Acta. Paedtr. 92(4): 473-80.

Haslet C, Chilvers ER, Boon NA, Colledge NR, Hunter JAA. eds (2002).Davidson's Principles and Practice of Medicine.Edinburgh, Churchill.Livingstone (Elsevier Science Limited).pp.325.

Johansen P, Pars T, Bjerregaard P (2000).Lead, cadmium, mercury, and selenium intake by Greenlanders from local marine food. Sci Total Environ.245:187-194.

Anon(1995).Overvagningssystem for levnedsmidler 1988-1992. Levnedsmiddelstyrelsen, Morkhoj Bygade 19,DK-2860 Soborg, Denmark,Pub.nr.p. 232.

Yang G, Yin S, Zhou L, Gu B, Yan Y, Liu Y(1989). Studies of safe maximal daily dietary Se-intake in a seleniferous area. J. Trace Elem Electrolytes Health Dis 123-130.

Rosado JL(2003).Zinc and copper: proposed fortification levels and recommended zinc compounds. J. Nutr.133:2985S-2989S.

Abrams SA, Atkinson SA (2003).Calcium, magnesium, phosphorus and vitamin D fortification of weaning foods. J.Nutr.133:2994S-2999S.

Whittaker P (1998).Iron and zinc interactions in humans. Am. J. Clin. Nutr. 68: 442S-446S.

WHO(1998).Complementary feeding of young children in developing countries:a review of current scientific knowledge.WHO/NUT/98. 1. Geneva Switzerland.