Trends in

Applied Sciences Research

ISSN 1819-3579

Academic
Journals Inc.

www.academicjournals.com

Trends in Applied Sciences Research 2 (1): 76-79, 2007
ISSN 1819-3579

Levels of Selected Heavy Metals in Some Nigerian Vegetables

Anthony E. Aiwonegbe and Esther U. Ikhuoria
Department of Chemistry, University of Benin, Benin City, Nigeria

Abstract: Heavy metal content of twelve vegetable samples procured from local markets in Benin and Lagos cities is estimated by wet digestion and atomic absorption spectrophotometry. The metals include Fe, As, Pb, Hg, Cd, Cr, Zn and Ni. The results obtained from the study revealed that Fe has the highest concentration in all the vegetable samples with values ranging from 1.040-13.97 μg g^{-1}. Hg was found to be below detection limit in all the samples. The levels of the various heavy metals in the vegetable samples studied were found to be in the order: Fe > Zn> As> Ni> Cd> Cr> Pb> Hg. The overall heavy metal levels in most of the vegetables analysed fell under safe range of concentration with few exceptions.

Key words: Vegetables, heavy metals, human health, toxic, micro-nutrients, malnutrition

INTRODUCTION

Although heavy metals are present in food in very minute quantities the very human existence is due to their role in body metabolism. It has been established that whatever is taken as food might cause metabolic disturbance if it does not contain the permissible upper and lower limits of heavy metals. Thus, both deficiency and excess of essential micro-nutrients (e.g., iron, zinc, chromium, etc.) may produce undesirable effects (Van *et al*., 1989; Konofal *et al*., 2004; Koçak *et al*., 2005).

Effects of toxic metals (cadmium, chromium, lead, nickel, etc.) on human health and their interactions with essential heavy metals (trace elements) may produce serious consequences (Abdulla and Chmielnicka, 1990; Tokusoglu *et al*., 2004). From this viewpoint, metals such as iron, arsenic, lead, mercury, cadmium, chromium and nickel are considered suitable for studying the impact of various foods on human health. Arsenic occurs naturally in food at concentration levels, which are rather essential. However, it can occur as a toxic contaminant of food due to pesticide spray (Doghesiem and Alla, 2004; Lam, 2003). Like wise, lead is toxic and is assimilated through dietary intake up to 25 μg day^{-1} and through inhalation up to 15 μg day^{-1} (Ademoroti, 1996; Smith and Frey, 2004; Bresseler *et al*., 2004). Acute high-dose lead poisoning has been known to cause haemolytic anemia and renal tubular dysfunction as well as subtle behavioural, constitutional and neurocognitive impairments (Katzung, 1998).Cadmium primarily targets the renal and gastrointestinal systems (Griffin, 2004). Renal failure and gastrointestinal irritation are the usual symptoms following a high oral dose intake of cadmium (Muller, 2002).

Chromium is present in human tissues in variable concentrations and its deficiency is characterized by disturbance in glucose, lipid and protein metabolism (Schumacher, 1993). Lately, it has been reported that in patients with acute myocardial infarction, the mean concentration of serum nickel were significantly increased through the period of 1-36 h after the onset of symptoms (Alexander, 2005).

Vegetables are staple part of human meal taken as food in raw and cooked forms. Over the past few decades, there has been a change in the focus of nutritional, health concerns, from malnutrition, to wide spread chronic shortages of micronutients. Their deficiencies may cause serous functional disorders.

Corresponding Author: Esther U. Ikhuoria, Department of Chemistry, University of Benin, Benin City, Nigeria

In view of the importance of the role that heavy metals play in defining the nutritional status of the human body, the present study was initiated to investigate the levels of contamination with heavy metals.

The levels of the above-cited metals were estimated by atomic absorption method in twelve different vegetables abundantly consumed by the local population.

MATERIALS AND METHODS

Twelve vegetable samples were obtained fresh from local markets in Benin City, Nigeria, 2005. The samples were immediately processed for analysis with as much shortest time in between as was practically possible to achieve. About 150 g of each vegetable sample was washed with distilled water and oven-dried overnight at 80°C (Gorsuch, 1970). The dried sample was ground in a mortar until fine powder was obtained. An aliquot of exactly 1.0 g of the powder was weighed and transferred to a 250 mL beaker with an addition of 15 mL of 30% nitric acid (Gorsuch, 1976). The beaker is heated at 50±1°C, using a thermostat water bath, for about 1 h. To the digested sample, distilled water was added to make the volume up to 50.0 mL. The resulting solution was then analyzed using atomic absorption spectrophotometer model AA-670, for the estimation of heavy metal content. The twelve vegetable samples were divided into five groups on the basis of the part consumed; namely, root, stem, leaf, fruit and seed.

RESULTS AND DISCUSSION

Table 1 shows the heavy metal content of vegetables whose edible part is stem. Iron, Nickel, zinc, chromium and cadmium had 100% incidence of occurrence. Mercury was not detected in any of the samples while Lead was generally below 0.01 $\mu g\ g^{-1}$. Iron had the maximum concentration in onions (6.31 $\mu g\ g^{-1}$) and minimum in garlic (1.04 $\mu g\ g^{-1}$). Arsenic was found in onion (6.67 $\mu g\ g^{-1}$). The maximum level of nickel was found in ginger (0.21 $\mu g\ g^{-1}$) and the minimum in onion (0.04 $\mu g\ g^{-1}$). Zinc had the maximum concentration in ginger (4.83 $\mu g\ g^{-1}$ and the minimum concentration in onion (2.10 $\mu g\ g^{-1}$). The maximum concentration of chromium was found in ginger (0.04 $\mu g\ g^{-1}$) and the minimum in onion (<0.01 $\mu g\ g^{-1}$). Cadmium showed maximum concentration in ginger (0.12 $\mu g\ g^{-1}$) and the minimum in onion, which is identical to that of garlic (0.06 $\mu g\ g^{-1}$).

Similar results were obtained in previous studies on some local vegetables from Punjab, Pakistan (Khalid and Jaffar, 1997) and vegetables samples from New Castle (Pless-Mulloli, 2001).

Table 2 gives the concentration levels of heavy metals in spinach and cabbage whose edible part is leaf. Both vegetables did not show detectable levels of Arsenic and mercury. Cadmium was not also detected in cabbage but spinach showed cadmium concentration (0.12 $\mu g\ g^{-1}$). Chromium concentration was the same for the two vegetables (<0.01 $\mu g\ g^{-1}$). Zinc content was relatively higher in spinach (5.93 $\mu g\ g^{-1}$) than cabbage (<0.01 $\mu g\ g^{-1}$). But Nickel content was higher in cabbage (0.37 $\mu g\ g^{-1}$) than spinach (0.19 $\mu g\ g^{-1}$). The concentration of lead in spinach (0.13 $\mu g\ g^{-1}$) was higher than that of cabbage (<0.01 $\mu g\ g^{-1}$). The same table also shows the heavy metal levels of carrot (edible part-root) and Irish potatoes (edible part-seed). The iron content of carrot was higher (4.04 $\mu g\ g^{-1}$) than that of potatoes (3.78 $\mu g\ g^{-1}$). The lead level appeared to be comparable (<0.01 $\mu g\ g^{-1}$) for both vegetables. Both vegetables did not show detectable levels of arsenic and mercury. Cadmium was only found in carrot (0.12 $\mu g\ g^{-1}$). Nickel content was higher in carrot (0.25 $\mu g\ g^{-1}$) than in the Irish potato (0.03 $\mu g\ g^{-1}$). The Zinc content in carrot was considerably higher (4.03 $\mu g\ g^{-1}$) than that in Irish potato (2.97 $\mu g\ g^{-1}$). The chromium level in carrot was very low (<0.01 $\mu g\ g^{-1}$) compared to that of Irish potato (0.08 $\mu g\ g^{-1}$).

Table 1: Concentration (μg g^{-1}, dry weight) of heavy metals in vegetables (Edible part-Stem)

Name of sample	Fe	Pb	Ni	Zn	Cr	Cd	As	Hg
Ginger (*Zingiber officinale*)	2.02±0.50	<0.01±0.00	0.21±0.03	4.83±0.05	0.04±0.01	0.12±0.03	-	-
Garlic (*Allium sativum*)	1.04±0.04	<0.01±0.00	0.07±0.01	4.00±0.04	0.03±0.02	0.06±0.02	-	-
Onions (*Allium cepa*)	6.31±0.05	<0.01±0.00	0.04±0.03	2.10±0.04	<0.01±0.01	0.06±0.01	0.67±0.05	-

-Not detected

Table 2: Concentration (μg g^{-1}, dry weight) of heavy metals in vegetables (Edible part-leaf)

Name of sample	Fe	Pb	Ni	Zn	Cr	Cd	As	Hg
Spinach (*Spinacea oleracea*)	13.97±0.04	0.13±0.05	0.19±0.05	5.93±0.03	<0.01±0.00	0.12±0.04	-	-
Cabbage (*Brassica deracea*)	2.50±0.05	<0.01±0.00	0.37±0.05	<0.01±0.00	<0.01±0.00	-	-	-
*Carrot (*Daucus carota*)	4.04±0.03	<0.01±0.00	0.25±0.01	4.03±0.02	<0.01±0.00	0.12±0.03	-	-
**Irish potatoes (*Solanum tuberosum*)	3.98±0.04	<0.01±0.00	0.03±0.01	2.97±0.02	0.08±0.05	-	-	-

-Not detectable, * Edible part-root, ** Edible part-seed

Table 3: Concentration (μg g^{-1}, dry weight) of heavy metals in vegetable edible part-fruit

Name of sample	Fe	Pb	Ni	Zn	Cr	Cd	As	Hg
Garden eggs (*Solanum incanum*)	8.28±0.05	<0.01±0.00	0.17±0.03	3.73±0.05	<0.01±0.00	0.09±0.02	-	-
Tomatoes (*Lycop-esicum esculentum*)	1.98±0.02	<0.01±0.00	0.11±0.02	1.93±0.05	<0.01±0.00	0.05±0.02	5.82±0.03	-
Okro (*Hibiscus esculentus*)	7.25±0.05	0.13±0.05	0.10±0.05	11.56±0.05	<0.01±0.00	-	7.33±0.05	-
Marrow (*Cucurbita pepo*)	8.88±0.03	0.13±0.05	0.25±0.05	10.21±0.04)	<0.01±0.00	0.06±0.02	8.93±0.01	-
Green pepper (*Capsicum frutescens*)	3.16±0.01	0.13±0.05	0.38±0.05	9.82±0.04	0.01±0.00	0.05±0.02	9.30±0.05	

-Not detectable

Table 3 shows the heavy metal content of vegetables whose edible part is fruit. The values show that the fruits are rich in iron content with a percent incidence of 100%. Its minimum concentration was found in tomato (1.98 μg g^{-1}) and the maximum in marrow (8.88 μg g^{-1}). As with other samples, mercury was below detection limit in all the samples. The chromium content was generally similar for all the vegetable samples (<0.01 μg g^{-1}). The samples are also very rich in zinc, with a 100% incidence of occurrence, it maximum concentration was found in Okro (11.56 μg g^{-1}) and the minimum in tomato (1.93 μg g^{-1}). The lead content of Okro, marrow and green pepper was the same (0.13 μg g^{-1}). Garden egg and tomato also had identical value for lead (<0.01 μg g^{-1}). The percent occurrence of nickel was 100% and maximum nickel was found in green pepper (0.10 μg g^{-1}). Cadmium was present in 80% of the samples with comparable values; the maximum level was found in garden egg (0.09 μg g^{-1}) whereas the minimum was in tomato (0.05 μg g^{-1}). Arsenic had its maximum level in green pepper (9.30 μg g^{-1}) and minimum in tomato (5.82 μg g^{-1}).

Of all the vegetables analyzed, leaf vegetable showed the highest level of iron. Chromium and cadmium content did not appear alarming but arsenic level has exceeded 1 μg g^{-1} in five cases. Nickel level was generally below 1 μg g^{-1} and zinc showed highest level in fruit vegetables. The overall lead content remained below 0.01 μg g^{-1} while mercury was not detected in all the samples analyzed. Almost all the vegetables investigated for heavy metal levels were found acceptable for human consumption (Conor, 1980).

CONCLUSIONS

Vegetables are a very important part of a diet. With increasing health consciousness and the growing number of vegetarians nowadays, vegetable safety is a very important issue. The results from this study show that most of the vegetables analysed fell within safe range with the exception of Tomatoes (*Lycopesicum esculentum*), Okro (*Hibiscus esculentus*), Marrow (*Cucurbita pepo*) and Green pepper (*Capsicum frutescens*). We therefore recommend that further work to assess the heavy metal content of contaminated and uncontaminated soils and the results obtained compared with those of the vegetables grown on such soils.

REFERENCES

Abdulla, M., J. Chmielnicka, 1990. New aspects on the distribution and metabolism of essential trace elements after dietary exposure to toxic metals. Biol. Trace-Element Res., 23: 25-53.

Ademoroti, C.M.A., 1996. Environmental Chemistry and Toxicology. Foludex Press Ltd., Ibadan, Nigeria, pp: 8-10.

Alexander Tse-Yan Lee, 2005. Vegetable-borne poisoning. The Internet J. Toxicol., 2: 1.

Bressler, J., L. Olivi, J.H. Cheong. Y. Kim and D. Bannona, 2004. Divalent metal transporter in lead and cadmium transport. Annual New York Acad. Sci., 1012: 142-152.

Conor, R., 1980. Metal Contamination of Food. Applied Science Publishers Limited, London.

Dogheism, A.M.M. and S.A. Alla, 2004. Pesticide and heavy metal levels in Egyptian leafy vegetables and some aromatic medicinal plants. MetaPress. Food Additives and Contaminants, pp: 323-330.

Gorsuch, T.T., 1970. The Destruction of Organic Matter, Vol. 39, Pergamon Press, New York.

Gorsuch, T.T., 1976. Accuracy in trace analysis; sampling, sample handling and analysis. National Bureau of Standard. Publication No. 422, Washington DC., pp: 491-508.

Griffin, K., 2004. Medical information: Itai-itai-cadmium exposure. Tracker (summer), pp: 13-14.

Katzung, B.G., 1998. Chelators and Heavy Metal Intoxication. Basic and Clinical Pharmacology, 7th Edn., Appleton and Lange. Prentice Hall International, USA., pp: 956-968.

Khalid, M. and M. Jaffar, 1997. Selected trace-metal levels in local vegetables procured from Punjab, Pakistan. J. Chem. Soc. Pak., 19: 49-53.

Koçak, S., O. Tokuşoğlu and S. Aycan, 2005. Some heavy metal and trace essential element detection in canned vegetable foodstuffs by differential pulse polarography (DPP). Electronic J. Environ. Agric. Food Chem., 4: 871-878.

Konofal, E., M. Lecendreux, I. Arnulf and M.C. Mouren, 2004. Iron deficiency in children with attention-deficit/hyperactivity disorder. Arch. Pediatr. Adolesc Med., 158: 1113-1115.

Lam, Y.S., 2003. National environmental protection and evaluation for agricultural pesticide pollution control main laboratories bulletin. State Environmental Protection Administration, China. [www.sepa.gov.cn/eic/]

Muller, P., 2002. Appendix B: Cadmium (Cd) and its Compounds. Ten Carcinogens in Toronto. Tox Probe Inc. Toronto. Canada, pp: 27-B35.

Pless-Mulloli, T. Executive summary: report on the analysis of PCCD/PCDF and heavy metals in vegetable samples from Newcastle allotments: Assessment of the role of the Byker incinerator 2001, University of Newcastle, pp: 1-33.

Schumacher, M., J.L. Domingo, J.M. Llobet and J. Cobella, 1993. Chromium, Copper and Zinc concentrations in edible vegetables grown in Tarragona province, Spain. Ull. Environ. Contam. Toxicol., 50: 514-521.

Smith, L.W. and R.J. Frey, 2004. Health A to Z: Lead poisoning. Lifesteps. [www.lifesteps.com/gm/Atoz/ency/l]

Tokuşoğlu, Ö., Ş. Aycan, S. Akalin, S. Koçak and N. Ersoy, 2004. Simultaneous differential pulse polarographic (DPP) determination of cadmium, lead and copper in milk and dairy products. J. Agric. Food Chem., 52: 1795-1799

Van, D., W.H. Devos,W.H., H. Muys, J.A. Wasstra, 1989. Minerals and trace elements in total diets in the Netherlands. Br. J. Nutr., 61: 9-5.