Levels of Selected Heavy Metals in Some Nigerian Vegetables

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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, Cu, 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 (Doughies 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 (Adamoroti, 1996; Smith and Frey, 2004; Bresseler et al., 2004). Acute high-dose lead poisoning has been known to cause haemolytic anaemia 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 micronutrients. Their deficiencies may cause serious functional disorders.

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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 thermostated 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 μg g⁻¹. Iron had the maximum concentration in onions (6.31 μg g⁻¹) and minimum in garlic (1.04 μg g⁻¹). Arsenic was found in onion (6.67 μg g⁻¹). The maximum level of nickel was found in ginger (0.21 μg g⁻¹) and the minimum in onion (0.04 μg g⁻¹). Zinc had the maximum concentration in ginger (4.83 μg g⁻¹) and the minimum concentration in onion (2.10 μg g⁻¹). The maximum concentration of chromium was found in ginger (0.04 μg g⁻¹) and the minimum in onion (<0.01 μg g⁻¹). Cadmium showed maximum concentration in ginger (0.12 μg g⁻¹) and the minimum in onion, which is identical to that of garlic (0.06 μg 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-Mulloidi, 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 μg g⁻¹). Chromium concentration was the same for the two vegetables (<0.01 μg g⁻¹). Zinc content was relatively higher in spinach (5.93 μg g⁻¹) than cabbage (<0.01 μg g⁻¹). But Nickel content was higher in cabbage (0.37 μg g⁻¹) than spinach (0.19 μg g⁻¹). The concentration of lead in spinach (0.13 μg g⁻¹) was higher than that of cabbage (<0.01 μg 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 μg g⁻¹) than that of potatoes (3.78 μg g⁻¹). The lead level appeared to be comparable (<0.01 μg g⁻¹) for both vegetables. Both vegetables did not show detectable levels of arsenic and mercury. Cadmium was only found in carrot (0.12 μg g⁻¹), Nickel content was higher in carrot (0.25 μg g⁻¹) than in the Irish potato (0.03 μg g⁻¹). The Zinc content in carrot was considerably higher (4.03 μg g⁻¹) than that in Irish potato (2.97 μg g⁻¹). The chromium level in carrot was very low (<0.01 μg g⁻¹) compared to that of Irish potato (0.08 μg g⁻¹).
Table 1: Concentration (µg g⁻¹, dry weight) of heavy metals in vegetables (Edible part-Stem)  

<table>
<thead>
<tr>
<th>Name of sample</th>
<th>Fe</th>
<th>Pb</th>
<th>Ni</th>
<th>Zn</th>
<th>Cr</th>
<th>Cd</th>
<th>As</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginger (Zingiber officinale)</td>
<td>2.02±0.50</td>
<td>&lt;0.01±0.00</td>
<td>0.21±0.03</td>
<td>4.83±0.05</td>
<td>0.04±0.01</td>
<td>0.12±0.03</td>
<td>-</td>
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</tr>
<tr>
<td>Garlic (Allium sativum)</td>
<td>1.04±0.04</td>
<td>&lt;0.01±0.00</td>
<td>0.07±0.01</td>
<td>4.00±0.04</td>
<td>0.03±0.02</td>
<td>0.06±0.02</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Onions (Allium cepa)</td>
<td>6.31±0.05</td>
<td>&lt;0.01±0.00</td>
<td>0.04±0.03</td>
<td>2.10±0.04</td>
<td>&lt;0.01±0.01</td>
<td>0.06±0.01</td>
<td>0.67±0.05</td>
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</tr>
<tr>
<td>- Not detected</td>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Name of sample</th>
<th>Fe</th>
<th>Pb</th>
<th>Ni</th>
<th>Zn</th>
<th>Cr</th>
<th>Cd</th>
<th>As</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinach (Spinacea oleracea)</td>
<td>13.97±0.04</td>
<td>0.15±0.05</td>
<td>0.19±0.05</td>
<td>5.93±0.03</td>
<td>&lt;0.01±0.00</td>
<td>0.12±0.04</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cabbage</td>
<td>2.50±0.05</td>
<td>&lt;0.01±0.00</td>
<td>0.37±0.05</td>
<td>&lt;0.01±0.00</td>
<td>0.00±0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>*Carrot</td>
<td>4.04±0.03</td>
<td>&lt;0.01±0.00</td>
<td>0.25±0.01</td>
<td>4.03±0.02</td>
<td>&lt;0.01±0.00</td>
<td>0.12±0.03</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>**French beans</td>
<td>3.99±0.04</td>
<td>&lt;0.01±0.00</td>
<td>0.03±0.01</td>
<td>2.97±0.02</td>
<td>&lt;0.01±0.00</td>
<td>0.06±0.01</td>
<td>-</td>
<td>-</td>
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<tr>
<td>- Not detectable, * Edible part-root, ** Edible part-seed</td>
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Table 3: Concentration (µg g⁻¹, dry weight) of heavy metals in vegetable edible part-fruit  

<table>
<thead>
<tr>
<th>Name of sample</th>
<th>Fe</th>
<th>Pb</th>
<th>Ni</th>
<th>Zn</th>
<th>Cr</th>
<th>Cd</th>
<th>As</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garden eggs (Solanum incanum)</td>
<td>8.28±0.05</td>
<td>&lt;0.01±0.00</td>
<td>0.17±0.03</td>
<td>3.73±0.05</td>
<td>&lt;0.01±0.00</td>
<td>0.09±0.02</td>
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<td>Tomatoes (Lyco-persicum esculentum)</td>
<td>1.98±0.02</td>
<td>&lt;0.01±0.00</td>
<td>0.11±0.02</td>
<td>1.93±0.05</td>
<td>&lt;0.01±0.00</td>
<td>0.05±0.02</td>
<td>5.82±0.03</td>
<td>-</td>
</tr>
<tr>
<td>Okra (Abelmoschus esculentus)</td>
<td>7.25±0.05</td>
<td>0.13±0.05</td>
<td>0.10±0.05</td>
<td>11.56±0.05</td>
<td>&lt;0.01±0.00</td>
<td>-</td>
<td>7.33±0.05</td>
<td>-</td>
</tr>
<tr>
<td>Marrow (Cucurbita pepo)</td>
<td>8.88±0.03</td>
<td>0.13±0.05</td>
<td>0.25±0.05</td>
<td>10.21±0.04</td>
<td>&lt;0.01±0.00</td>
<td>0.06±0.02</td>
<td>8.93±0.01</td>
<td>-</td>
</tr>
<tr>
<td>Green pepper (Capsicum frutescens)</td>
<td>3.16±0.01</td>
<td>0.13±0.05</td>
<td>0.38±0.05</td>
<td>9.82±0.04</td>
<td>0.01±0.00</td>
<td>0.05±0.02</td>
<td>9.30±0.05</td>
<td>-</td>
</tr>
<tr>
<td>- Not detectable</td>
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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 Okra (11.56 µg g⁻¹) and the minimum in tomato (1.93 µg g⁻¹). The lead content of Okra, 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 (*Lycopersicum 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**


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