Scientific Research and Essays Vol. 5(8), pp. 813-818, 18 April, 2010
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 © 2010 Academic Journals

Full Length Research Paper

Lead levels in some edible vegetables in Lagos, Nigeria

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Accepted 17 February, 2010

This study was carried out to investigate the level of lead in six edible vegetables from two popular markets and farms in Lagos metropolis. Total acid leaching digestion method was employed and determination of the lead was done by atomic absorption spectrophotometry (AAS). All the vegetables were analyzed in the forms in which they are normally consumed. The concentration of lead obtained ranged from 0.00 mg/kg ± 0.022 at Mushin –7.5 mg/kg ± 0.080 at Yaba for *Celosia argentea*; 0.00 mg/kg ± 0.002 at Mushin – 4.76 mg/kg ± 0.047 at Yaba for *Amaranthus hybridus*; 1.16 mg/kg ± 0.039 at Oba farm – 3.96 mg/kg ± 0.151 at Yaba for *Telfaria occidentalis*; 0.00 mg/kg ± 0.015 at Yaba – 9.820 mg/kg ± 0.036 at Idi-Araba for *Vernonia amygdalina;* 0.00 mg/kg ± 0.091 at Mushin – 3.99 mg/kg ± 0.173 at Oba farm for *Talinum triangulare*; 1.02 mg/kg ± 0.049 at Oba farm – 9.22mg/kg ± 0.088 at Mushin for *Lactuca sativa*. The mean concentrations of the metal were 3.01, 1.93, 3.00, 3.61, 2.26 and 3.76 mg/kg, respectively. Lead was detected in 80% of all analyzed vegetables with an overall mean concentration of 2.78 mg/kg, which is regarded as relatively high. This may be attributed to the proximity of farms and markets to roadsides, where there are vehicular emissions. Going by the tolerable weekly intake of 25 µg/kg.bw/wk for lead (an equivalence of 1.5 mg/person/week assuming a body weight of 60 kg), it can be concluded that, some Lagos residents may be prone to lead toxicity, considering the fact that, these vegetables are regarded as highly nutritious foods and are largely consumed in Nigeria.

Key words: Lead, vegetable, AAS, toxicity.

INTRODUCTION

For several years now, lead has been the intense focus of environmental health research and this is understandable, considering the perennial effect of lead toxicity (Ogunsola, 1994; Anetor, 1997; Cobb, 2000; Okoronkwo, 2005). It is therefore, imperative to decipher whether vegetables, fruits and food crops are safe for human consumption. There have been several reports on lead contamination in Nigeria (Ogunsola, 1994; Nriagu et al., 1996; Anetor, 1997; Sridhar et al., 2000; Cobb, 2000; Okoronkwo, 2005) and this pollution spans across the water, soil and air environments (Ogunsola et al., 1995; Fakayode et al., 2003; Nwoko et al., 2002). The source of lead in water is mostly from the drainage and surface runoffs (Sridhar, 2000) in addition to effluent discharges from industries, which contribute to the lead levels in the final recipients such as rivers, streams or wells. (Ayodele, 1996). Lead levels in soil and air vary according to the location and nearness to lead based activities and vehicular density. The sources of food contamination have often been traced to fumes from car exhausts (Fakayode and Owolabi, 2003; Agbo, 1997; Sridhar et al., 2000). All these sources of pollution invariably contribute to food contamination.

Lead persists in the environment once it is introduced. Plants which are able to concentrate lead (Sridhar, 1998; Nwoko and Egunjobi, 2002) accumulate it in their roots and foliage (Anikwe and Nwobodo, 2002; Amusan et al., 1999). Okoronkwo et al. (2005) reported the levels of lead present in the soil from an abandoned waste dump in Umuahia, South-eastern Nigeria with mean concentrations of 111.75 ± 17.78 and 76.63 ± 19.94 mg/kg, respectively. It is also not uncommon to find vegetable farms being irrigated with sewage water, and vegetables grown in these farms have also been shown to have high concentrations of lead and other heavy metals, with large concentrations in the roots and foliage (Chiroma et al.,

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2003).Other studies have revealed that, lead does not readily accumulate in the fruiting part of vegetable and fruit crops (e.g. corn beans, squash, tomatoes, straw, berries, apples); higher concentrations are most likely to be found in leafy vegetables (e.g. lettuce) and on the surface of root crops (Rosen, 2002). Generally, lead contaminations occur in vegetables grown on contaminated soils (Bakare et al., 2004).

Lead poisoning is a global reality, and fortunately is not a very common clinical diagnosis yet in Nigeria except for few occupational exposures (Anetor et al., 1999). The national campaign for the promotion of a green environment is therefore a very timely one. Children are known to be most susceptible to toxicity and ingestion is their most common source of exposure (Goyer, 1996). They often develop toxic levels from their hand-to-mouth activity when they come in contact with contaminated soil, or by actually eating contaminated food, and even more undeservedly by mother-to-fetus mobilization through placental barriers from infected mothers (Silbergeld, 1991; Gulson et al., 1997). Chronic lead poisoning is a common problem in children that occurs when small amount of lead are ingested over a longer period. Symptoms include learning disabilities, reduced I.Q. hyperactivity, mental retardation, slowed growth, hearing loss and headaches (Goyer, 1993).

Lead is recognized as a cause of secondary porphyria resulting, from heme biosynthesis inhibition, and characterized by elevated levels of blood δ-aminolevulinic acid (ALA), zinc protoporphyrin (ZPP), urinary ALA and coproporphyrin (CPU) (Daniell et al., 1997). The result of these biochemical aberrations is the development of cutaneous lesions and/or photosensitivity, acute neuro-visceral attacks, or all of these.

Biological markers of heme biosynthesis inhibition can reveal the effects of lead at various stages in the heme biosynthesis pathway. Lead inhibits the second enzyme in the pathway, aminolevulinic acid dehydratase (ALAD), which synthesizes porphobilinogen from ALA (Bernard and Lauwerys, 1987). Decreased ALAD activity results in an increase of free ALA, the presence of which is postulated as one mechanism for the neurotoxic effects of lead (Moore and Goldberg, 1987). The action of lead at this point in the heme biosynthesis pathway is estimated by measuring the activity of ALAD in blood or the concentration of ALA in blood or urine. The formation of protoporphyrinogen IX from coproporphyrinogen III is inhibited by lead, resulting in an increase in coproporphyrin. Inactivation of coproporphyrinogen oxidase or impaired transport of coproporphyrinogen into mitochondria may underlie this effect (Woods, 1995).

In this study, the level of lead in six vegetables from two popular markets and farms in Lagos metropolis were determined using total acid leaching digestion method, and lead levels analyzed by atomic absorption spectrophotometry (AAS). The vegetables analyzed include: *Celosia argentea*; *Amaranthus hybridus*; *Telfaria occidentalis*; *Vernonia amygdalina; Talinum triangulare* and *Lactuca sativa*.

MATERIALS AND METHODS

Sampling

Five edible vegetables namely: *T. occidentalis* (ugwu), *T. triangulare* (water leaf), *A. hybridus* (tete), *V. amygdelina* (bitterleaf) and *L. sativa* (lettuce) were studied for their lead concentrations. The vegetables were selected from two different vegetable farms and markets in Lagos: Oba farm, Idi-Araba farm, Yaba market and Mushin market. The population of the different sampling sites was noted. The samples from the farm were carefully uprooted, and rinsed slightly with tap water. In the same way, the samples purchased from roadside markets were rinsed. All samples were then air-dried for 10 min, packaged in polythene bags, and labeled for AAS analysis.

Vernonia treatment

The *Vernonia* selected during sampling were divided into two designated as treated and untreated.

Treated Vernonia

These samples were cut into small pieces, and the leaves were vigorously washed thrice with 10 M NaCl for about two minutes, and properly rinsed. This same procedure was repeated until the bitter taste of the leaves had been removed. The leaves were then packaged and labeled for AAS analysis.

Untreated Vernonia

These samples were rinsed slightly with tap water, air-dried for about 10 min, packaged, and labeled for AAS analysis.

Sample digestion

Five grams of the air-dried samples was weighed, and placed in a quartz beaker, and gently heated on a hot plate. Heating was then continued until enough water was driven off for partial carbonization to occur. The beaker was then placed in an electric furnace and heated at 555°C for 1 h to ash. The sample was then removed and allowed to cool.

A ratio 1:1 mixture of HNO_3/H_2O was prepared and about 5 ml of the mixture was added to the ashed sample, and warmed slightly for about five minutes. The mixture was then filtered for AAS measurement using Whatman filter papers.

Preparation of stock standard

In order to prepare the stock standard solution, 1.299 g of $PbNO_3$ (Merck, Germany) was dissolved by using 5% HNO_3 (Merck, Germany) after that, it was decanted into a 1000 ml volumetric flask with 5% HNO_3 and volume was made to mark by 5% HNO_3 solution.

Serial dilution of stock standard

The stock standard solution was serially diluted to concentrations of 10, 1.0 and 0.5 ppm. These different standard solutions were used

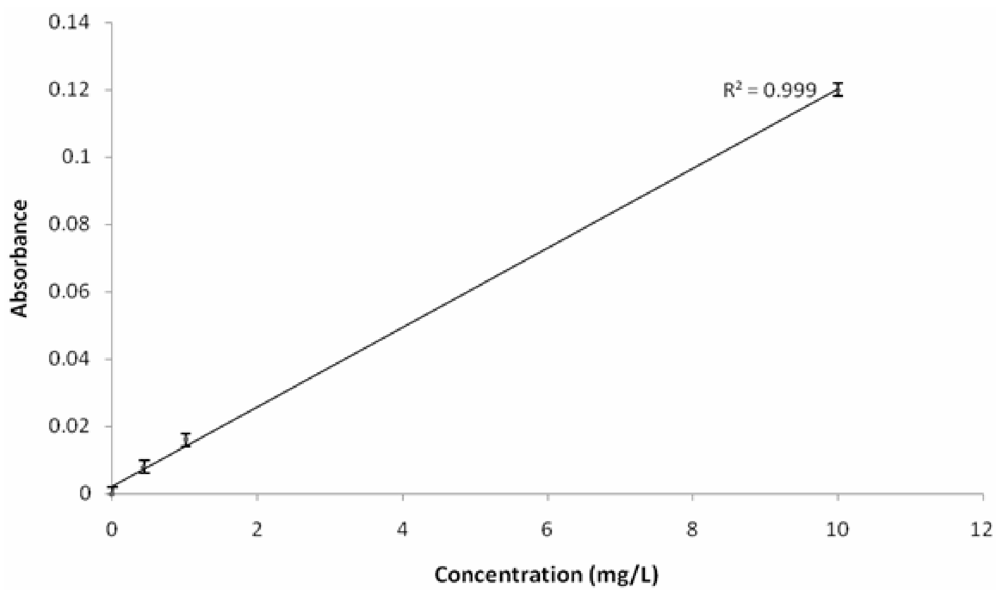

Figure 1. Calibration curve of lead generated by the AAS.

Table 1. Lead distribution in six vegetables from Lagos markets and farms.

Different locations in Lagos	*Celosia* (mg/kg)	*Talinum* (mg/kg)	*Amaranthus* (mg/kg)	*Telfaria* (mg/kg)	*Vernonia* (mg/kg)	*Lactuca* (mg/kg)
Yaba	7.46 ± 0.080	2.78 ± 0.049	4.76 ± 0.047	3.96 ± 0.151	0.00 ± 0.015	NIL
Mushin	0.00 ± 0.022	0.00 ± 0.091	0.00 ± 0.002	3.89 ± 0.002	3.60 ± 0.223	9.22 ± 0.088
Idi-Araba	1.41 ± 0.107	NIL	1.84 ± 0.022	NIL	9.82 ± 0.036	1.04 ± 0.032
Oba farm	3.17 ± 0.032	3.99 ± 0.173	1.11 ± 0.002	1.16 ± 0.039	1.00 ± 0.032	1.02 ± 0.049

to generate a suitable curve, which was used to calibrate the instrument.

Lead determination

Atomic absorption spectrophotometer, A-Analyst 200 was employed in the determination of the metal. All the operational conditions in the instrumentation manual e.g. slit width, current of lamps, beam balancing, and the wavelength of maximum absorption were followed.

Generation of calibration curve

After the serial dilution of the stock standard, the different calibrants were fed into the AAS as standard samples. These were used by the AAS to generate a suitable calibration curve (Figure 1). The samples were then run in triplicates and mean values were calculated.

RESULTS AND DISCUSSION

The results revealed the presence of lead in 80% of these edible vegetables (Figure 2). Table 1 is the lead distribution in six vegetables from Lagos markets and farms above. The mean lead concentrations were 3.01, 1.93, 3.00, 3.61, 2.26, and 3.76 mg/kg for *Celosia, Amaranthus, Telfaria, Vernonia, Talinum and Lactuca*, respectively. The overall mean concentration was 2.78 mg/kg.

Lead is present in the air in the form of lead dust and automobile exhausts are known to contribute significantly to atmospheric lead (Agbo, 1997). Results from this study revealed that, the amount of lead in vegetables appears to be greater in places with higher vehicular traffic. Yaba market which seems to have the highest traffic has an average vegetable lead of 4.7 mg/kg, as compared with Oba farm with average lead of 1.91 mg/kg. The proximity of farms to the roadside is known to affect the amount of lead in soil (Fakayode and Owolabi, 2003) and consequently, the uptake by plants. This probably accounts for the lower lead level in vegetables in Oba farm, considering that the farm is about 50 m away from the roads.

Although, there is no data to fully explain the higher levels of lead in vegetables from Yaba market, one could

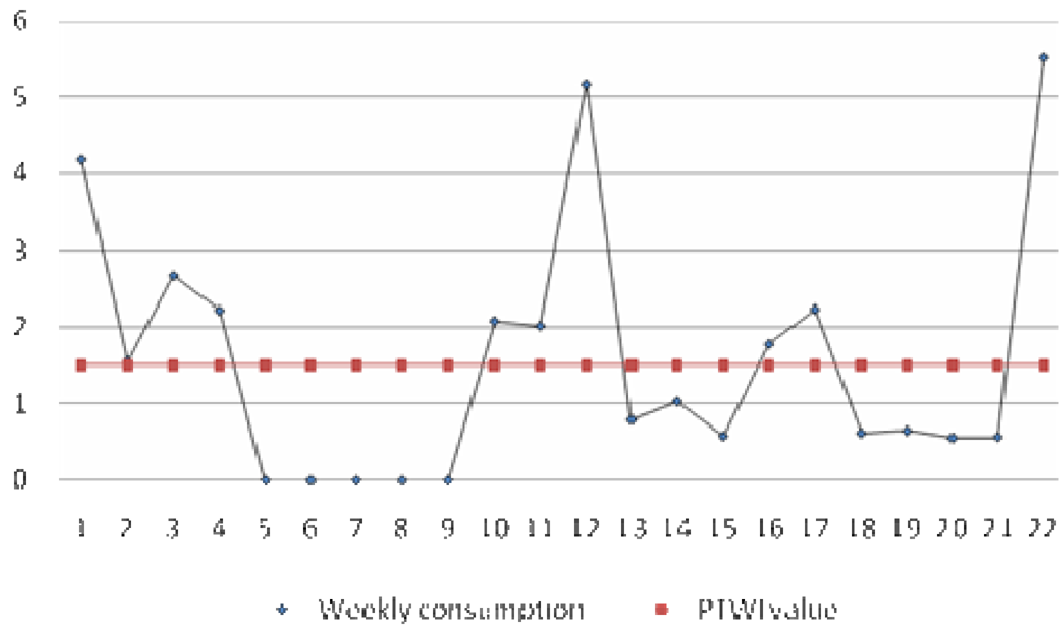

Figure 2. Comparison of PTWI standards with analyzed samples, assuming a daily consumption of 80 g.

Table 2. Mean lead concentration of six edible vegetables and their sources from Lagos, Nigeria.

Vegetable	Mean conc. (mg/kg)
Celosia	3.01 ± 2.80
Amaranthus	1.93 ± 1.76
Telfaria	3.00 ± 2.00
Vernonia	3.61 ± 3.82
Talinum	2.26 ± 1.68
Lactuca	3.76 ± 3.86

Table 3. Total mean lead concentrations of six edible vegetables based on farm.

Market/farm	Mean conc.
Yaba	4.74±2.73
Mushin	2.79±3.64
Idi-Araba	3.53±3.94
Oba farm	1.91±1.32

suggest that, due to the proximity of the market to the roadside, emitted lead from car exhausts get deposited on the exposed vegetables. By extension, one could therefore, infer that the lead in vegetables could be superficial (on the leaf surface) or non-superficial (on the foliage). This is probably considering the lower level of lead determined in washed *Telfaria*. A similar result was reported with *Telfaria* (Akinola and Ekiyoyo, 2006), and it was concluded that heavy metals in this vegetable might be superficial.

However, this does not explain the trend of lead in vegetables from Mushin market, where traffic is equally high. *Celosia, Talinum, and Amaranthus* vegetables from Mushin have no trace of lead (Table 1) unlike *Telfaria, Vernonia* and *Lactuca* from the same roadside market. This is most probably due to the way these vegetables were packaged in sacks, in such a way that, they were not exposed to atmospheric lead. In addition, these vegetables were transported from Abeokuta, (approximately 130 km from Lagos), and were probably less contaminated with lead.

Treated *Vernonia* were found to contain no lead as compared with untreated samples with an average lead of 3.61 mg/kg (Table 2). This perhaps, could be attributed to the vigorous way in which the leaves are washed in order to remove the bitter taste.

Lettuce was found with the highest mean concentration of lead (Table 2). This suggests that, lettuce has the ability to translocate and accumulate more lead in foliage than some other vegetables. This observation conforms to previous reports on lettuce (Cobb et al., 2000).

Lead pollution has been shown to be commensurate with population/vehicular density, and this somehow explains why Lagos residents are prone to lead toxicity. A high lead contamination was reported in 72 various pre-pared food samples from high, medium, and low density areas in Lagos metropolis, and lead contamination was found to be greatest in samples from high density areas (Sridhar and Leslie, 1997). In another study, among Nigerian traffic wardens, it was found that the mean blood lead level in Lagos wardens was 18.1 ± 6.4 µg/dl, which was significantly higher than the level of 10.2 ± 2.7 µg/dl in Ife (a less populated city in Nigeria) wardens (Ogunsola et al., 1994).

Nriagu (1992) capped this in his work when he reported dust lead levels of about 5 µg/m^3 in Lagos metropolis. He further estimated that, about 10 - 30% of the children in Africa might be suffering from lead poisoning.

IMPLICATIONS OF RESULTS

Provisional tolerable week intake (PTWI)

Provisional tolerable weekly intakes (PTWI) are upper limits set by the FAO/WHO expert committee on food additives. (WHO, 1995) These standards are recommended for substances such as heavy metals, which are contaminants in food and are known to bioaccummulate in animals and humans. Certain criteria are used in setting these limits.

In the case of lead, it is often human epidemiological information, obtained from occupationally exposed individuals. From these studies, a "No Observable Effect Level" (NOEL) is established, which is the highest dose level that produces no observable toxic effect in the most sensitive test species, and is expressed in milligrams per kilogram of body weight per week (mg/kg.bw/wk). PTWIs have been set for cadmium, lead, mercury and tin and the term "provisional" is used in order to emphasize the paucity of saftety data on contaminants (WHO, 1995).

The level of PTWIs is continually being re-evaluated. The first upper limit set for lead by the committee was 50 µg.bw/wk, an equivalent of 3 mg/person/wk, assuming a body weight of 60 kg. This was reconfirmed by the committee at its 22nd meeting (WHO, 1995). In this meeting, the committee assessed the risk posed by lead to the health of infants and children and established a PTWI of 25 µg/kg bw for this population group.

The committee again re-evaluated lead at its 41st meeting when the previous PTWI of 50 µg/kg.bw for adults was withdrawn and the existing PTWI of 25 µg/kg bw for infants and children was reconfirmed and extended to people in all age groups. The review of the health effects of lead at the 41st meeting was based on a recent assessment of inorganic lead performed by an international programme on chemical safety (IPCS) task group, published as an environmental health criteria monograph (WHO, 1995).

Results from this study showed a slight elevation of lead in the vegetables. Based on values of lead in the six different vegetables, if a daily intake of 80 g is assumed to be consumed, the weekly intakes would exceed the tolerable limits recommended. Considering Yaba market, with lead concentration of 7.46 mg/kg in *Celosia*. Assuming a daily consumption of 80 g,

$$\text{mass of lead consumed per week} \equiv \frac{80 \times 7.46 \times 7}{1000} \equiv 4.18 \text{ mg/person/wk.}$$

Conclusion

Experimental results from this study show some elevated levels of lead in these edible vegetables sampled from Yaba market, Mushin, Oba farm, and Idi-araba farm. Of the twenty-two samples analyzed, 80% were found to contain lead. Assuming a daily consumption of 80 g/person, about 50% of these consumers would be exceeding the tolerable limit, which will pose a public health threat especially to the Nigerian population residing in Lagos

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