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Full Length Research paper

Heavy metal levels of some fruits and leafy vegetables from selected markets in Lagos, Nigeria

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Heavy metal levels in sixteen different fruits and leafy vegetables from selected markets in Lagos, Nigeria were determined using atomic absorption spectrometry. The results showed that the levels of Lead, Cadmium, Copper, Zinc, Cobalt and Nickel ranged from 0.072±0.06 to 0.128±0.03; 0.003±0.01 to 0.005±0.01; 0.002±0.00 to 0.015±0.02; 0.039±0.01 to 0.082±0.01; 0.014±0.01 to 0.026±0.01 and 0.070±0.07 to 0.137±0.05 mg/kg, respectively, for the fruits. The levels of Lead, Cadmium, Copper, Zinc, Cobalt and Nickel for the leafy vegetables respectively ranged from 0.09±0.01 to 0.21±0.06; 0.03±0.01 to 0.09±0.00; 0.02±0.00 to 0.07±0.00; 0.01±0.00 to 0.10±0.00; 0.02±0.00 to 0.36±0.00 and 0.05±0.04 to 0.24±0.01 mg/kg. Values obtained are comparable with those available in the literature and within tolerable limits of some regulatory authorities.

Key words: Fruits, leafy vegetables, heavy metals, atomic absorption spectrometry.

INTRODUCTION

Fruits and leafy vegetables are widely used for culinary purposes. They are used to increase the quality of soups (leafy vegetables) and also for there dietary purposes (Sobukola et al., 2007). They are made up of chiefly cellulose, hemi-cellulose and pectin substances that give them their texture and firmness (Sobukola and Dairo, 2007). Fresh fruits and vegetables are of great importance in the diet because of the presence of vitamins and mineral salts. In addition, they contain water, calcium, iron, sulphur and potash (Sobukola et al., 2007). They are very important protective food and useful for the maintenance of health and the prevention and treatment of various diseases (D'Mello, 2003). However, these plants contain both essential and toxic metals over a wide range of concentrations (Radwan and Salama, 2006).

Heavy metals have been reported to have positive and negative roles in human life (Adriano, 1984; Slaveska et al., 1998; Divrikli et al., 2003; Dundar and Saglam, 2004; Colak et al., 2005; Oktan et al., 2005). Some like cadmium, lead and mercury are major contaminants of food supply and may be considered the most important problem to our environment while others like iron, zinc and copper are essential for biochemical reactions in the body (Zaidi et al., 2005). Generally, most heavy metals are not biodegradable, have long biological half-lives and have the potential for accumulation in the different body organs leading to unwanted side effects (Jarup, 2003; Sathawara et al., 2004). There is a strong link between micronutrient nutrition of plants, animals and humans and the uptake and impact of contaminants in these organisms (De Leonardis et al., 2000; Yuzbasi et al., 2003; Baslar et al., 2005; Yaman et al., 2005). The content of essential elements in plants is conditional, the content being affected by the characteristics of the soil and the ability of plants to selectively accumulate some metals (Divrikli et al., 2006).

Additional sources of heavy metals for plants are: rainfall in atmospheric polluted areas, traffic density, use of oil or fossil fuels, for heating, atmospheric dusts, plant protection agents and fertilizers which could be adsorbed

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Table 1. Mean levels (mg/kg) of Pb, Cd and Cu in some selected fruits and leafy vegetables from Lagos, Nigeria.

Fruits	MC.	Lead		Cadmium		Copper	
	(%)	Mean	Range	Mean	Range	Mean	Range
Watermelon	92.4	0.108 ± 0.03	0.008 - 0.121	0.004 ± 0.00	0.003 - 0.005	0.004 ± 0.00	0.002 - 0.006
Pineapple	84.7	0.128 ± 0.03	0.016 - 0.120	0.004 ± 0.00	0.004 - 0.005	0.015± 0.02	0.003 - 0.008
Orange	85.4	0.106 ± 0.01	0.107 - 0.113	0.005 ± 0.00	0.004 - 0.006	0.002 ± 0.00	0.001 - 0.003
Tangerine	86.1	0.097± 0.00	0.090 - 0.103	0.005 ± 0.00	0.004 - 0.006	0.003 ± 0.00	0.003 - 0.004
Grape	87.4	0.092 ± 0.00	0.089 - 0.098	0.005 ± 0.00	0.004 - 0.006	0.003 ± 0.00	0.002 - 0.061
Banana	77.2	0.118 ± 0.07	0.108 - 0.176	0.005 ± 0.00	0.004 - 0.006	0.009 ± 0.01	0.007 - 0.035
Pawpaw	78.2	0.072 ± 0.06	0.021- 0.108	0.003 ± 0.00	0.001- 0.006	0.003 ± 0.00	0.003 - 0.004
Apple	86.2	0.112 ± 0.03	0.094 - 0.135	0.004 ± 0.00	0.003 - 0.006	0.003 ± 0.00	0.003 - 0.005
Leafy vegetables							
Indian Basil	84.3	0.09 ± 0.01	0.09 - 0.11	0.025 ± 0.01	0.015 - 0.030	0.017 ± 0.01	0.012 - 0.020
Fluted pumpkin plant	82.1	0.21 ± 0.06	0.15 - 0.27	0.090 ± 0.00	0.089 - 0.010	0.022 ± 0.00	0.021- 0.020
Gboma plant	86.2	0.16 ± 0.00	0.15 - 0.16	0.060 ± 0.00	0.058 - 0.060	0.022 ± 0.00	0.017 - 0.020
Plumed cockscomb	83.2	0.17± 0.01	0.16 - 0.18	0.070 ± 0.00	0.007 - 0.071	0.019 ± 0.00	0.017- 0.020
Jews mallow	83.3	0.10 ± 0.03	0.07 - 0.13	0.040 ± 0.00	0.038 - 0.040	0.013 ± 0.00	0.009 - 0.012
Bitter leaf	83.3	0.14 ± 0.02	0.12 - 0.16	0.060 ± 0.00	0.06 - 0.061	0.022 ± 0.00	0.018 - 0.020
Water leaf	96.3	0.18 ± 0.00	0.17 - 0.18	0.080 ± 0.00	0.078 - 0.08	0.019 ± 0.00	0.017 - 0.020
Cabbage	82.7	0.13 ± 0.04	0.09 - 0.17	0.060 ± 0.00	0.06 - 0.061	0.070 ± 0.00	0.068 - 0.070

M.C. (%) is the moisture content of the samples before analysis.

through leaf blades (Kovacheva et al., 2000; Lozak et al., 2002; Atrouse et al., 2004; Sobukola et al., 2008). These plant materials could also be contaminated from various sources including trace metals as farmers wash them with waste water before bringing them into the market (Divrikli et al., 2006). Some of these elements are toxic to humans even at a very low level. Excessive content of Pb and Cd metals in food is associated with etiology of a number of diseases especially with cardiovascular, kidney, nervous as well as bone diseases (WHO, 1992, 1995; Steenland and Boffetta, 2000; Jarup, 2003). They have also been implicated in causing carcinogenesis, mutagenesis and teratogenesis (IARC, 1993; Pitot and Dragan, 1996). Copper toxicity induces iron deficiency, lipid peroxidation and destruction of membranes (Zaidi et al., 2005). High level of Nickel may also result in Zn or Fe deficiency as well as enzymic malfunctioning (Jarup, 2003).

Based on persistent nature and cumulative behaviour as well as the probability of potential toxicity effects of heavy metals as a result of consumption of leafy vegetables and fruits, there is need to test and analyze these food items to ensure that the levels of these trace elements meet the agreed international requirements. This is particularly important for farm products from this part of the world where only limited data on heavy metal contents of such highly consumed agricultural materials are available. This study therefore, presents data on the levels of Pb, Cd, Zn, Cu, Co and Ni) in some selected fruits and leafy vegetables in West Africa's most popular mega city, Lagos, Nigeria.

MATERIALS AND METHODS

Sampling, sample preparation and treatment

A total of 288 samples consisting of eight different fruits and leafy vegetables each were purchased from three major markets in Lagos, Nigeria during 2006. In each market, three vendors were identified and samples collected twice from each at different times. Edible portions of the samples were used for analysis while bruised or rotten samples were removed. The leafy vegetables include bitter leaf (*Vernonia amygdalina*), water leaf (*Talimum triangulare*), Indian basil (*Ocimum viride*), fluted pumpkin plant (*Felfarin occidentalis*), Gboma plant (*Solanum aethiopicum)*, plumbed cockscomb (*Celosia argentea*), Jews mallow (*Cochorus olitorus*) and Cabbage (*Brassica oleoracae* L.). The selected fruits include orange (*Citrus sinesis*), tangerine (*Citrus reticulata*), grape fruit (*Citrus paradisis*), banana (*Musa paradasiaca*), pawpaw (*Carica papaya*), watermelon (*Citrullus lunatus*), pineapple (*Anana comosus*) and apple (*Malus domestica*). The samples were stored in polythene bags until analysis under refrigeration condition (<10℃).

Leafy vegetables were washed and cut to simulate the human intake conditions, while the fruits were washed and peeled. Samples for analysis were then dried using the oven dry method at 105℃ for 24 h (AOAC, 1990) to obtain the moisture content. A mixer grinder was used to powder the samples while preventing over heating.

About 1.0 g of the samples were weighed and digested in a mixture of 5 ml of HCl, 2 ml of conc. H_2SO_4 and 20 ml of conc HNO_3

Table 2. Mean levels (mg/kg) of Zn, Co and Ni of some selected fruits and leafy vegetables from Lagos, Nigeria.

Fruits	Zinc		Cobalt		Nickel	
	Mean	Range	Mean	Range	Mean	Range
Watermelon	0.047± 0.02	0.039 - 0.062	0.021± 0.00	0.021- 0.023	0.139 ± 0.01	0.114 - 0.125
Pineapple	0.050 ± 0.04	0.029 - 0.084	0.022 ± 0.00	0.022 - 0.024	0.134 ± 0.01	0.121 - 0.127
Orange	0.039 ± 0.01	0.039 - 0.043	0.027 ± 0.02	0.026 - 0.030	0.120 ± 0.00	0.125 - 0.127
Tangerine	0.082 ± 0.01	0.041 - 0.163	0.022 ± 0.00	0.018 - 0.021	0.132 ± 0.00	0.087 - 0.122
Grape	0.073 ± 0.09	0.035 - 0.046	0.025 ± 0.00	0.020 - 0.025	0.105 ± 0.01	0.105 - 0.124
Banana	0.046 ± 0.02	0.035 - 0.062	0.019 ± 0.00	0.019 - 0.033	0.126 ± 0.00	0.083 - 0.119
Pawpaw	0.045 ± 0.02	0.031 - 0.056	0.023 ± 0.00	0.023 - 0.024	0.114 ± 0.00	0.013 - 0.070
Apple	0.045 ± 0.01	0.045 - 0.551	0.020 ± 0.00	0.014 - 0.021	0.116 ± 0.03	0.120 - 0.176
Leafy vegetables						
Indian Basil	0.030 ± 0.00	0.020 - 0.040	0.015 ± 0.00	0.015 - 0.016	0.060 ± 0.01	0.055 - 0.06
Fluted pumpkin plant	0.100 ± 0.00	0.100 - 0.102	0.046 ± 0.00	0.041 - 0.050	0.240 ± 0.01	0.23 - 0.25
Gboma plant	0.120 ± 0.01	0.110 - 0.210	0.036 ± 0.02	0.020 - 0.051	0.183 ± 0.01	0.17 - 0.18
Plumed cockscomb	0.130 ± 0.01	0.126 - 0.130	0.036 ± 0.00	0.035 - 0.037	0.180 ± 0.01	0.12 - 0.20
Jews mallow	0.064 ± 0.04	0.060 - 0.080	0.024 ± 0.00	0.023 - 0.025	0.050 ± 0.04	0.01 - 0.10
Bitter leaf	0.011± 0.00	0.010 - 0.012	0.030 ± 0.00	0.026 - 0.030	0.015 ± 0.03	0.12 - 0.16
Water leaf	0.070 ± 0.01	0.070 - 0.073	0.040± 0.00	0.041 - 0.042	0.190 ± 0.07	0.12 - 0.26
Cabbage	0.050 ± 0.01	0.032 - 0.064	0.040 ± 0.00	0.038 - 0.042	0.160 ± 0.03	0.13 - 0.19

in a conical flask under a fume hood. The content was mixed and heated gently at 180 - 220°C for about 30 min on a hot plate. The content was continuously heated until dense white fumes appear. It was then finally heated strongly for about 30 min and then allowed to cool before making up to the mark in 50 ml volumetric flask. All reagents used were of analytical grade and the Atomic Absorption Spectrophotometer, model Buck 210, VGR, USA was used to determine Pb, Cd, Cu, Zn, Co and Ni in the digested solution.

RESULTS AND DISCUSSION

Tables 1 and 2 show the concentrations of heavy metals investigated in fruits and leafy vegetables commonly consumed in Lagos, Nigeria. The values are given as mean ± SD and the results are means of three replicates. The heavy metal levels determined were based on plants dry weight. Levels of cadmium and copper were observed to be the lowest for the samples while the levels of nickel and lead were the highest. Heavy metals affect the nutritive values of agricultural materials and also have deleterious effect on human beings. National and international regulations on food quality set the maximum permissible levels of toxic metals in human food; hence an increasingly important aspect of food quality should be to control the concentrations of heavy metals in food (Radwan and Salama, 2006; Sobukola et al., 2008).

The results of the analysis showed that the levels of Pb in all samples were between 0.072 mg/kg in pawpaw and 0.21 mg/kg in fluted pumpkin plant with range of 0.021 - 0.108 and 0.15 - 0.27, respectively. The highest levels of Pb in fruits were observed in pineapple, banana, apple and watermelon and in leafy vegetables. Highest contents were observed from fluted pumpkin plant, water leaf, plumed cocks comb and gboma plant in that order. Pb being a serious cumulative body poison enters into the body system through air, water and food and cannot be removed by washing fruits and vegetables (Divrikli et al., 2003). The high levels of Pb in some of these plants may probably be attributed to pollutants in irrigation water, farm soil or due to pollution from the highways traffic (Qui et al., 2000). The level of Pb reported in this study is comparable to those reported for apple (0.19 and 0.76 mg/kg); watermelon (0.30 mg/kg); orange (0.15 mg/kg) and banana (0.02 mg/kg) by Radwan and Salama (2006) and Parvean et al. (2003).

Cadmium is a non-essential element in foods and natural waters and it accumulates principally in the kidneys and liver (Divrikli et al., 2006). Various sources of environmental contamination have been implicated for its presence in foods (Adriano, 1984). In all the samples analyzed, its level was observed to be very low varying between 0.003 and 0.09 mg/kg; lowest in pawpaw and highest in fluted pumpkin plant. Various values have been previously reported for fruits and leafy vegetables which include 0.05, 0.14 and 0.003 mg/kg for apple by Radwan and Salama (2006), Parveen et al. (2003) and Karavoltsos et al. (2002), respectively; watermelon (0.02 and 0.0004 mg/kg); orange (0.04 and 0.0009 mg/kg) and banana (0.02 and 0.001 mg/kg) by Radwan and Salama (2006) and Karavoltsos et al. (2002), respectively. However, Radwan and Salama (2006) and Karavoltos et al. (2002) also reported Cd values of 0.02 and

0.0004 mg/kg for watermelon, 0.04 and 0.0009 mg/kg for orange as well as 0.02 and 0.001 mg/kg for banana. Similarly, Divrikli et al. (2006) have recently reported 0.002 mg/kg as cadmium level in Indian basil as compared with 0.025 mg/kg in this study.

Copper is an essential micronutrient which functions as a biocatalysts, required for body pigmentation in addition to iron, maintain a healthy central nervous system, prevents anaemia and interrelated with the function of Zn and Fe in the body (Akinyele and Osibanjo, 1982). However, most plants contain the amount of copper which is inadequate for normal growth which is usually ensured through artificial or organic fertilizers (Itanna, 2002). In this study, the concentrations of Cu in all the tested samples varied between 0.002 and 0.07 mg/kg; with orange having the lowest and cabbage having the highest. The results obtained here were observed to be lower compared to other published results. Radwan and Salama (2006), Onianwa et al. (2001) and Parveen et al. (2003) have reported 1.47, 0.25 and 0.25 mg/kg for apple, respectively. Furthermore, 1.22 and 2.13 mg/kg; 1.27 and 2.13 mg/kg and 2.51 and 0.95 mg/kg have been reported for the concentration of Cu in watermelon, orange and banana by Radwan and Salama (2006) and Onianwa et al. (2001), respectively. Also, Divrikli et al. (2006) and Ozcan (2004) have earlier reported Cu contents of 0.02 and 0.0081 mg/kg, respectively for Indian Basil.

One of the most important metals for normal growth and development in human beings is Zinc (Divrikli et al., 2006). Its deficiency may be due to inadequate dietary intake, impaired absorption, excessive excretion or inherited defects in zinc metabolism (Colak et al., 2005; Narin et al., 2005). Zinc deficiency due to consumption of plant foods that have inhibitory components for Zn absorption is of growing concern in developing countries. The deficiencies in these countries have been attributed to high consumption of bread made without yeast (Divrikli et al., 2006). Concentration of Zn in the samples reported in this study varied between 0.03 and 0.13 mg/kg with the lowest in Indian Basil and the highest in plumed cockscomb. Available literature have shown that the level of Zn in apple are 1.36, 0.16 and 2.05 mg/kg (Radwan and Salama, 2006; Onianwa et al., 2001 and Parveen et al., 2001). Radwan and Salama (2006) and Onianwe et al. (2001) have also reported Zn levels of 5.35 and 7.40 mg/kg; 2.38 and 2.20 mg/kg; as well as 5.59 and 1.50 mg/kg for watermelon, orange and banana, respectively. However, 0.011 and 0.014 mg/kg were reported for Indian basil by Divrikli et al. (2006) and Ozcan (2004) respectively.

Cobalt has little direct activity on its own in the body as it is an integral component of vitamin B_{12} and as such its effects, sources and uses are very similar to that of vitamin B_{12}. It is involved in preventing and treating pernicious anaemia and also helps in red blood cell production. Co also supports normal nervous system functions (Sobukola et al., 2008). Very little information has been reported on its concentrations in food materials. However, for this study, its level varied between 0.015 and 0.046 mg/kg with the lowest in Indian Basil and the highest observed in fluted pumpkin plant with range values of 0.015 - 0.016 mg/kg and 0.041 - 0.050 mg/kg, respectively.

Nickel also plays some role in body functions including enzyme functions. It occurs naturally more in plants than in animal flesh. It activates some enzyme systems in trace amount but its toxicity at higher levels is more prominent (Divrikli et al., 2006). The Ni levels in the samples tested varied between 0.05 and 0.24 mg/kg with the lowest observed in Jews mallow and highest observed in fluted pumpkin plant with range contents of 0.01 - 0.1 to 0.23 and 0.25, respectively. However, Ni level of 0.067 mg/kg for Indian Basil have been reported by Divrikli et al. (2006) which is within the range of values obtained from this study.

Conclusion

The results obtained in this work on concentration of heavy metals of some selected common fruits and leafy vegetables compared well with similar samples from other published works. Generally, the levels of heavy metals were observed to be lower than those of previous published works and those given by various authorities except the level of Cd in fluted pumpkin, plant, plumed cockscomb and water leaf. The values of heavy metals presented in this work from fruits and leafy vegetables obtained from Lagos, Nigeria can be valuable in the food composition tables for Nigerians and the West African sub-region.

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