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Assessments of the Levels of Heavy Metals in Some Selected Tropical Fruits

[*1]Bala, M. and [2]Bashar, J. B.

Abstract

Heavy metals are important environmental pollutants that can cause serious damage to all forms of life. They can find their way into the food chain causing serious health disorders. This study was undertaken to assess the concentrations of heavy metals (Pb, Mn, Cd, Zn, Mo, Co, Cr, Ni, Fe and Cu) in the pulps and peels of pineapple, shea-fruit, mango, water melon and avocado pear, using Atomic Absorption Spectrophotometric method. The results of the analysis revealed the mean concentrations of individual heavy metal contents in various segments of the fruits. Levels of Cd in the peel of shea fruit (0.041 ± 0.01 mg/kg) and the pulp and peel of mango (0.41 ± 0) are found to exceed the established permissible limits of heavy metal in foods. Furthermore, with the exception of water melon in the sampled fruits, the concentrations of Mo above the permissible limits have been found in the peel of pineapple (0.44±0 mg/kg), the pulp and peel of shea-fruit (0.87±0 mg/kg and 0.44 ± 0.01 mg/kg, respectively),pulp and peel of mango (0.44 ± 0.01 mg/kg and 0.44 ± 0 respectively) and the peel of avocado pear (0.42 ± 0.02 mg/kg). In a similar trend, high level of Pb has been found in the peel of avocado pear (0.64 ± 0.06 mg/kg). However, except for Cd, Mo and Pb all the metals assessed in

*[*1]Bala, M. and [2]Bashar, J. B.*
[1] Department of Biochemistry, Faculty of Basic Medical Sciences, Bayero University Kano.
[2]Federal Institute of Industrial Research, Kano Zonal Office, Kano.
**Corresponding author; balamukhtar@yahoo.com*

this study are within the acceptable limits. Similarly, significant differences ($p<0.05$) exists between the peel and pulp of fruits analyzed. High levels of heavy metals in fruits/foods has undesirable side effect on the overall well-being of the populace.

Keywords: *Heavy metals, Pollutants, Food chain, Peel, Pulp, Fruits.*

Introduction

Heavy metals poisoning has widely gained attention as a result of a number of researches conducted on their effect at various levels of life (Duruibe *et al.,* 2007). Heavy metals enter human body through food, water, air or absorption through the skin (Galadima *et al.,* 2010). Plants take up heavy metals by absorption from airborne deposits on the part exposed to polluted air environment as well as contaminated soils through root systems (Elbagermi *et al.,* 2012). Similarly, the absorption capacity of heavy metals depends upon the nature of plants and some of them have greater potential to accumulate higher concentrations than others (Anita *et al.,* 2010). These metals can accumulates in the shoot and roots of plants at low, medium or high levels (Verma and Dubey, 2003; Adeyeye, 2005). Also, the heavy metals contamination of fruits may occur due to their irrigation with contaminated water (Al Jassir *et al.,*2005). 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, plants protection agents and fertilizers which could be adsorbed through leaf blades (Sobukola *et al.,* 2008). The excessive content of these metals in food is associated with etiology of a number of diseases, especially with cardiovascular, kidney, nervous as well as bone diseases. (Jarup, 2003; Radwan and Salama, 2006). Severe exposure of Cd may result in pulmonary effects such as emphysema, bronchiolitis and alveolitis (McLaughlin *et al.,* 2006). Renal effects may also result due to sub-chronic inhalation of Cd (EU, 2002; Young 2005).

Humans are encouraged to consume more fruits and vegetables, which are good sources of nutrients that are beneficial to their health such as vitamins, minerals, fiber and various anti-oxidants (Crentsil *et al.,* 2011). Unfortunately, these foodstuffs contain both essential and toxic metals over a wide range of concentrations (Radwan and Salama, 2006). It has been observed that most of the mean ingestion of heavy metals in food is due to plant origin (Crentsil *et al.,* 2011). In view of the above, this study was conducted to assess the level of heavy metals in some selected tropical fruits.

Materials and Methods

Chemicals and reagents

The chemicals and reagents used in the study were of analytical grade.

Sample Collection

Fresh samples of pineapple *(Ananas comosus)*, shea-fruit *(Vitellaria paradoxa)*, mango *(Mangifera indica)*, water melon *(Citrus lanatus var)* and avocado pear *(Persia americana)* were purchased from three market outlets in Kano. Samples were also identified by taxonomist, selected, labeled and analyzed under standard laboratory procedures.

Sample Preparation and Preservation

After collection of the fruits from the market and selection, the fresh samples were initially washed with tap water (to remove dusts and dirt) and rinsed with de-ionized water. The samples were sliced to separate the pulp and peel and dried in a fresh airfor five days, and then in microwave oven at 65^{0}C until constant weights were obtained. The samples were pulverized using pestle and mortar, sieved and stored in plastic containers prior to laboratory analysis.

Sample Digestion

Five gram (5 g) each of the pulverized samples wasput into a 100 ml beaker and 20 ml mixture of HNO_3: HCl in the ratio 1:1 were added. The content was digested at 190^{0}C in a fume hood until a clear white smoke appeared. After cooling, the solution was filtered using a Whatman filter paper into a 50 ml volumetric flask and then made up to a final volume with distilled water.

Determination of Heavy Metals by Atomic Absorption Spectrophotometry

Heavy metals of interest were analyzed using Atomic Absorption Spectrophotometer (BUCK Scientific, 210 VGP) under standard operating conditions of the AAS machine.

Statistical analysis

Statistical analyses were carried out using Student t-test at ($p<0.05$) to compare the significant difference between the pulp and peel of the sampled fruits.

Results and Discussion

The results of heavy metals contents in pulps and peels of fruits are presented in the table. Nickel has not been detected in any of the studied samples.

The resultsshow that lead was only detected in the peel of water melon (0.09 ±0.01 mg/kg) and avocado pear (0.64 ± 0.06mg/kg). The peels of water melon and avocado pear have significantly ($p<0.05$) higher level of lead than their corresponding pulps. The maximum tolerable limit of lead in fruits is 0.3 mg/kg (WHO, 2010). This indicates that the concentration of lead in the peel of avocado pear is above the permissible limit. Deteriorated lead-based paints, and resulting dust and soil contamination are the primary sources of environmental lead exposure (CDC, 2009). Moreover, it has been reported that lead has no known biological function in human or mammalian organisms (ATSDR 2007) and is harmful even at low concentration when ingested (Zeid, 2010).

Levels of manganese were obtained in all fruits except in mango (Table 1). The levels of manganese in all the samples were significantly ($p<0.05$) higher in the peel than their corresponding pulp. The established maximum tolerable limits of manganese in fruits are 10.38 mg/kg (ATSDR, 2000). The values obtained in this study are therefore, within the permissible limits. Manganese is required for the formation of bone and cartilage and in urea cycle (Sandstorm *et al.*, 1986). Chronic inhalation of high level of Mn has been associated with a neurodegenerative disorder characterized by both central nervous system abnormalities andneuropsychiatric disturbances (Santamaria, 2008).

Mean concentrations of cadmium in samples of fruit is shown in the table. Cadmium was only detected in shea-fruit (peel) and mango (peel and pulp). In both the two samples, peels have significantly ($p<0.05$) higher level than pulp. These values are above the permissible limits (0.2 mg/kg) established by JECFA (FAO/WHO, 2007) indicating that the fruits are polluted by cadmium. The presence of cadmium may be attributed to its level in the soil due to fertilizer application and selective uptake by plants where they are grown (Cheng *et al.,* 2002). Skeletal and renal effects are sensitive marker of cadmium exposure (ATSDR, 2012). Cadmium pose a great health risk to humans even at low concentrations in the body (Saturag *et al.,* 2000), and because the body has limited capacity to respond to cadmium exposure as the metal cannot undergo metabolic degradation to less toxic substances and excreted, the target organs for cadmium toxicity in animals includes liver, kidney, lungs, testes, prostate, heart, skeletal system, nervous and immune systems (Jarup *et al.*, 1998; Saturag *et al.*, 2000).

Similarly, zinc was detected in all the fruits with peels having significantly ($p<0.05$) higher level than pulp (Table). The order of accumulation in peels and pulps are shea-fruit>avocado pear>water melon>pineapple>mango. The maximum tolerable limit of zinc is 60 mg/kg (FAO/WHO, 2007). Values obtained in present study are within the acceptable limits of zinc in fruits. Zinc is an essential component of a large number of enzymes (>300) participating in the synthesis and degradation of proteins, lipids, carbohydrates and nucleic acids as well as the metabolism of other micronutrients (FAO/WHO, 2001; Geissler and Powers, 2005). However, elevated levels of dietary Zn can have a negative effect on Cu balance, which is exploited therapeutically to "de-copper" in Wilson disease patients (EMEA, 2007).

Molybdenum contents have been found in all fruits with the exception of water melon (Table 1). A concentration of molybdenum (0.44 ± 0 mg/kg) was found in the peel of pineapple alone. Similarly, shea-fruit peel (0.87 ± 0 mg/kg) had significantly higher ($p<0.05$) level than pulp (0.43 ± 0.02 mg/kg). However, no significant ($p>0.05$)

difference was observed between the pulp and peel of mango. No molybdenum content was detected in the pulp of avocado pear but the peel had significantly higher ($p<0.05$) level. The maximum tolerable limit of molybdenum in fruits established by the Institute of Medicine is 0.05 mg/kg (IOM, 2001). This indicated that the values obtained for molybdenum in this study exceeded the permissible limits.

For cobalt, it is only detected in the peel of pineapple (Table). The values are within the permissible limit of 0.1 mg/kg (EPA, 2000). Absence of cobalt in most of the sampled fruits could also be attributed the nature of soil and distance from other sources of pollution (Kalagbor *et al.,* 2014). Also, levels of cobalt have not been detected in orange, African mango and guava (Table). Prolong exposure to high levels of cobalt as a metal, fumes or dust has been reported to cause respiratory disease with symptoms ranging from cough to permanent disability and even death (Dorsit *et al.,* 1970). Likewise, chromium was only detected in thepeels of shea-fruit, mango and avocado pear (Table 1). The maximum permissible limit of chromium in fruits is 1.5 mg/kg (FAO/WHO, 2010). The results obtained in present study showed that the sampled fruits are within the permissible limits.

Iron is important in the diet especially for pregnant and nursing mothers as well as infants (Mohammed and Sharif, 2011). The table shows the concentration of iron in samples of fruit. Iron contents have been found in all the studied segments of fruits. In this study, pineapple peel had the highest iron content followed by water melon, avocado pear, shea-fruit and then mango (Table 1). Iron content of pineapple, shea-fruit, water melon and avocado pear is significantly ($p<0.05$) higher than those of their corresponding values in pulp. For mango, nosignificant difference ($p>0.05$) was observed between the pulp and peel. The maximum acceptable limits of iron in fruits are 56 mg/kg (FAO/WHO, 2003). Therefore, the values obtained in this study are therefore within the acceptable limits of iron in fruits. Iron plays important role in oxygen binding in hemoglobin and acting as important catalytic centre in many enzymes for example the cytochrome (Geissler and Powers, 2005). Iron toxicity is evident, particularly in respect of fatalities in children associated with ingestion of adult Fe supplements (EMEA, 2007).

Copper is an essential micronutrient necessary for hematologic and neurologic system (Tan *et al.,* 2006). The table shows the concentration of copper in the studied fruits. Copper was only detected in the peels of shea-fruit, mango and water melon (Table 1). The maximum tolerable limit of copper in fruits is 40 mg/g (FAO/WHO, 2001). Therefore, values obtained in this work are within the acceptable limits. Copper can also produce adverse effects in the liver, gastrointestinal tract and kidney for humans and animals upon ingestion of toxic doses (Araya *et al.*, 2003).

Conclusion

The results obtained in this study showed that among the ten heavy metals assessed only Cd and Mo have been found to exceed the maximum permissible limits in some of the studied segments of fruits, particularly the peels. Meanwhile, the use of fruits peels in the formulation of animal feeds is currently increasing due to their nutritional compositions. However, this is not without problems because at certain points some of these fruits are polluted by toxic substances which upon ingestion, bioaccumulates in animals and humans causing various health disorders. Therefore, necessary measures have to be taken to ensure that pollution of fruits and vegetables are reduced to minimal but their consumption should be sustained and encouraged.

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Table 1: Heavy metal content in Pulp and Peel of fruits (mg kg^{-1} dry weight)

Samples	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Zn
P_1	ND	ND	ND	ND	3.29 ± 0.01^a	0.84 ± 0^a	ND	ND	ND	0.36 ± 0.01^a
P_2	ND	0.05 ± 0.01^a	ND	ND	4.13 ± 0.06^a	1.69 ± 0.01^a	0.44 ± 0	ND	ND	0.73 ± 0.02^a
SF_1	ND	ND	ND	ND	0.83 ± 0.02^b	0.86 ± 0.03^b	0.43 ± 0.02^a	ND	ND	0.36 ± 0^b
SF_2	0.41 ± 0.01^a	ND	0.47 ± 0	1.54 ± 0.04^a	2.46 ± 0^b	1.68 ± 0^b	0.87 ± 0^a	ND	ND	1.06 ± 0.01^b
M_1	0.41 ± 0^b	ND	ND	ND	1.64 ± 0	ND	0.44 ± 0.01	ND	ND	0.34 ± 0.03^c
M_2	0.82 ± 0.01^b	ND	0.47 ± 0	1.54 ± 0.04^b	1.64 ± 0	ND	0.44 ± 0	ND	ND	0.72 ± 0.01^c
W_1	ND	ND	ND	ND	2.47 ± 0.02^c	0.46 ± 0.02^c	ND	ND	ND	0.37 ± 0.02^d
W_2	ND	ND	ND	1.56 ± 0^c	3.27 ± 0.02^c	0.84 ± 0^c	ND	ND	0.09 ± 0.01^a	0.73 ± 0.02^d
AP_1	ND	ND	ND	ND	1.63 ± 0.02^d	0.73 ± 0.04^d	ND	ND	ND	0.5 ± 0.02^e
AP_2	ND	ND	0.49 ± 0.02^a	ND	2.19 ± 0.02^d	1.63 ± 0.04^d	0.42 ± 0.02^b	ND	0.64 ± 0.06^b	1.05 ± 0.03^e
MLs	0.2 mg/kg[1]	0.1 mg/kg[2]	1.5 mg/kg[3]	40 mg/kg[4]	56 mg/d[5]	10.38 mg/kg[6]	0.05 mg/kg[7]	1.1 mg/kg[8]	0.3 mg/kg[9]	60 mg/kg[1]

Values are mean ± standard deviation of triplicate results. Figures followed by the same superscript in the same column are statistically significant ($p<0.05$). ND=Not Detected, B_1=Banana Pulp, B_2=Banana Peel, PP_1=Pawpaw Pulp, PP_2=Pawpaw Peel, O_1=Orange Pulp, O_2=Orange Peel, G_1=Guava Pulp, G_2=Guava Peel, AM_1=African mango Pulp, AM_2=African mango Peel. MLs= Maximum Limits, Superscript 1= FAO/WHO, (2007), 2= (EPA, 2000), 3= FAO/WHO (2010), 4= FAO/WHO, (2001), 5= FAO/WHO JECFA, (2003), 6= ATSDR, (2000), 7= (IOM, 2001), 8= EPA, (2001), 9= (WHO, 2010).