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ASSESSMENT OF HEAVY METALS CONTAMINATION IN VEGETABLES AND FRUITS SOLD IN BENIN CITY, EDO STATE, NIGERIA

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ABSTRACT

This study was carried out to determine the levels of heavy metals in some vegetables (Carrot, Cabbage, Cucumber, Lettuce, Green Pea and Water Melon) sold in Benin City, Edo State, Nigeria. The vegetables which originated mostly from the northern part of Nigeria were collected from the point of retail (New Benin Market) over a period of five weeks. The levels of heavy metals present in the vegetables were determined and compared with international standards for maximum allowable limits. The results showed that the average concentrations detected ranged from 154.68 to 304.44, 51.86 to 58.5 and 0.558 to 0.692 mg/kg for iron (Fe), zinc (Zn) and manganese (Mn) respectively. The concentration of iron in Cucumber and Lettuce in the second and fourth week respectively exceeded the maximum permissible limit of 425 mg/kg set by the world health organization (WHO). It was discovered that Cucumber and Lettuce sold in the second and fourth week respectively were not safe for consumption because of their high Iron content. Heavy metal concentration in the vegetables for the other weeks fell within acceptable limits and hence they were safe for consumption. The highest mean levels of iron, zinc and manganese were found in lettuce. This may be due to the use of refuse ash in vegetable production in Jos, Nigeria.

1. INTRODUCTION

Fruits and leafy vegetables are used to increase the quality of soups and also for dietary purposes (Sobukola et al., 2007). They are very nutritional and are useful for maintaining

good health as well as being used for preventive and curative measures for various diseases (D'Mello, 2003).

However, most of these vegetables are irrigated with grey waste water from urban drainages in countries like China and India (Sundaravadivel and Vigneswaran, 2001). In some northern states of Nigeria, grey water contaminated through defecation, urination, contacts with industrial effluents and industrial chemicals are used for irrigation of fruits and vegetable plants. Unfortunately, grey water contains heavy metals and vegetables absorb these metals when it is used for irrigation (Chiroma et al., 2014).

It was reported that farmers around Jos, Nigeria, in a bid to raise the fertility of farm soils for sustainable agricultural production, combined inorganic fertilizers, manure, town refuse ash (Alexander, 1986) and farm waste ash (Phillips-Howard and Kidd, 1991) and used the mixture as manure. Consistent utilization of the town refuse ash has led to health and environmental concerns. It was discovered that in such soils, lettuce crop contained iron in concentrations exceeding the maximum allowable limits recommended by WHO/FAO for human consumption (Pasquini, 2006). There is proof that farms with a history of town refuse ash use have an accumulation of some heavy metals in them (Pasquini, 2006).

Heavy metals have been known to have both positive and negative effects on humans. (Adriano, 1984; Slaveska et al., 1998; Dundar and Saglam, 2004; Colak et al., 2005). Some are key contaminants of food supply and may be considered to be very problematic in our environment while others like iron, zinc and copper are essential for human body physiology (Zaidi et al., 2005). Generally, most heavy metals are not biodegradable. They have long biological half-lives and the tendency to accumulate in the different body organs leading to unwanted side effects (Jarup, 2003). As a result of this, there are increasing concerns by environmentalists to have an accurate database on the levels of these heavy metals in our environment as well as on food crops we consume. However, there are limited literature reports on systematic environmental monitoring for most of the heavy metals in soils and vegetables irrigated with untreated grey waters (Chiroma et al., 2014).

It has been established, that fruits and vegetables grown in some of the northern parts of Nigeria are excessively polluted with heavy metals due to the use of grey water for their irrigation (Chiroma et al, 2014). It has also been discovered that the use of town refuse ash for fertilization in places like Jos, Nigeria has led to human and environmental concerns. Most of the fruits available for sale in Benin City, Edo State, come from these areas. Hence, the aim of this study was to examine the level of some heavy metals in vegetables and fruits sold in Benin City with a view to ascertaining if the levels meet international standards and thus determine if the vegetables are safe for consumption.

2. MATERIALS AND METHODS

2.1. Sample Collection

The vegetables and fruits used in this study were Carrot (*Daucus carota* sativa), Cabbage (*Brassica oleracea* capitata), Lettuce (*Lactuca sativa* capitata), Water Melon (*Citrullus lanatus*), Cucumber (*Cucumis sativus*) and Green Pea (*Pisum sativum*). These materials were obtained from New Benin Market, Benin City, Edo State. Representative samples of the fruits and vegetables were obtained from wholesale vendors who get their supplies from the Northern part of Nigeria. The samples were obtained fresh upon supply from the supplier. The vegetables and fruits were collected in polyethene bags for transport to the laboratory.

2.2. Sample Preparation

The fruit samples were sliced into bits to increase the surface area for drying. The sliced samples were then sun-dried for a period of one week. An amount (0.5 g) of each of the dried fruit samples was weighed into 50 ml platinum crucibles. The crucibles were then placed in a muffle furnace operating at 500 ^{o}C and the samples were allowed to ash for 3 hours. The ashed samples in each crucible were then digested by mixing them with 5 ml of 10% (v/v) nitric acid (HNO_3), 5 ml of 20% (v/v) perchloric Acid ($HClO_4$) and 2 ml of 10% (v/v) sulphuric acid (H_2SO_4) at 100^{o}C on a hot plate for two hours in a fume cupboard. The resulting solution was left to cool for twelve hours and then transferred to 250 ml flasks, after which they were diluted with 88 ml of distilled water to make it up to the 100 ml mark. The content of each flask was filtered with Whatman No. 1 filter paper into appropriate sample bottles and then stored for subsequent analysis.

2.3. Analytical Procedure

The concentration of elements was carried out using an Atomic Absorption Spectrophotometer (AAS Solar 969 Unicam Series).

3. RESULTS AND DISCUSSION

3.1 Heavy Metal Concentration in the Vegetable Samples in Week 1

The results obtained as presented in Table 1 showed that Lead and Chromium were not detected in any of vegetable samples collected during the first week of the study. Hence, they were not included in subsequent investigations since these samples came from the same source. The highest concentration of Iron was observed in lettuce procured from Jos, Nigeria. This was, followed by carrot procured from Jos also. Cucumber had the highest concentration of zinc followed by lettuce. The highest concentration of manganese was observed in cabbage (Table 1). This indicates that there was some level of pollution in the farm soil on which these vegetables were cultivated either through irrigation or other means. It has been established that absorption of heavy metals is relatively higher in the leaves and roots of most vegetables than in other parts (Rasaq et al., 2015). This could explain the high

concentration of Iron in lettuce, cabbage and carrot combined with the fact that leafy vegetables, inherently, have high iron content. (Odhave et al., 2007). The use of town refuse ash in urban vegetable production had also led to heavy metal contamination of farmlands in Jos, Nigeria, causing lettuce from these areas to have very high concentration of Iron (Pasquini, 2006). This further explains the high concentration of iron in lettuce. Watermelon and green pea had relatively low concentrations of heavy metals and it was desired to focus the investigaton on root and leafy vegetables, hence they were not included in subsequent analysis. The concentrations of heavy metals in all the samples analysed were below the maximum permissible limit. This showed that they were safe for consumption.

Table 1: Concentration of metals (mg/kg) in different vegetable samples from new Benin market in week 1

Vegetable/Source	Fe	Mn	Zn	Pb	Cr
			mg/kg		
Carrot (Jos)	203.1	0.35	30.5	ND	ND
Cabbage (Jos)	202.5	0.90	43.2	ND	ND
Cucumber (Jos)	171.5	0.50	60.3	ND	ND
Lettuce (Jos)	228.0	0.71	50.3	ND	ND
Green Pea (Jos)	191.0	0.15	42.8	ND	ND
Water Melon (Jos)	94.5	ND	31.1	ND	ND
MPL WHO	425	500	100	0.3	30

*ND = Not Detected MPL= Maximum permissible level

3.2. Heavy Metal Concentration in the Vegetable Samples in Week 2

Results obtained during the second week of the investigation as presented in Table 2 showed that cucumber had the highest concentration of iron (563.1 mg/kg). This value exceeded the maximum allowable limit as set by the WHO. This implies that there was a high degree of contamination of the farm soil from which cabbage from week 2 was cultivated. This contamination may have been as a result of the use of grey water for irrigation or from the use of town refuse ash for fertilization in Jos, Nigeria. (Pasquini, 2006). Lettuce had the highest concentration of zinc, followed by carrot. Manganese concentration was highest in lettuce. This is as a result of the high potential for heavy metal absorption in leaves and roots of most vegetables (Rasaq et al., 2015) This implies that all the other vegetables except cucumber were safe for consumption.

Table 2: Concentration of metals (mg/kg) in different vegetable samples from new Benin market in week 2

Vegetable/Source	Fe	Mn	Zn
		mg/kg	
Carrot (Jos)	100.5	0.77	73.7
Cabbage (Jos)	146.9	0.60	31.5
Cucumber (Jos)	563.1	0.27	22.3
Lettuce (Jos)	306.8	0.90	85.9
MPL WHO	425	500	100

MPL= Maximum permissible level

3.3. Heavy Metal Concentration in the Vegetable Samples in Week 3

In the third week, cucumber also had the highest concentration of iron, followed by cabbage as shown in Table 3. Carrot had the highest concentration of zinc, followed by lettuce. Cucumber had the highest concentration of manganese. The concentration of heavy metals in all the vegetables fell within acceptable limits indicating that the means of irrigation and fertilization on the farm soils where these vegetables were grown did not cause severe contamination. The change in heavy metal concentration in vegetables between week 2 and week 3 may be due to change in the source of irrigation water. The vegetables may have come from a different farmland in Jos, Nigeria where best practices are employed. This change in level of heavy metals in the vegetables made them all safe for consumption.

Table 3: Concentration of metals (mg/kg) in different vegetable samples from new Benin market in week 3

Vegetable/Source	Fe	Mn	Zn
		mg/kg	
Carrot (Jos)	132.7	0.67	58.7
Cabbage (Jos)	162.4	0.41	41.8
Cucumber (Jos)	179.1	0.86	31.5
Lettuce (Jos)	139.0	0.78	51.2
MPL WHO	425	500	100

MPL= Maximum permissible level

3.4. Heavy Metal Concentration in the Vegetable Samples in Week 4

Lettuce had the highest concentration of iron in the fourth week, followed by cucumber as shown in Table 4. Cabbage had the highest zinc concentration, followed by cucumber. Manganese concentration was highest in carrot. The concentration of iron in lettuce exceeded the maximum allowable limit. Here again, the result indicated that there was a high probability that the farmlands used for cultivating these vegetables were contaminated with heavy metals due to use of urban refuse ash for soil fertilization. As stated earlier, the use of refuse ash for fertilization of lettuce results in high concentration of iron in the vegetable, thereby making it unsafe for consumption (Pasquini, 2006). The use of grey water for irrigation may also produce the same result (Chiroma et al., 2014). Hence all the other vegetables excluding lettuce from week 4 were safe for consumption.

Table 4: Concentration of metals (mg/kg) in different vegetable samples from new Benin market in week 4

Vegetable/Source	Fe	Mn	Zn
		mg/kg	
Carrot (Jos)	230.0	0.59	40.1
Cabbage (Jos)	126.7	0.32	84.4
Cucumber (Jos)	257.6	0.57	77.6
Lettuce (Jos)	581.2	0.35	29.8
MPL WHO	425	500	100

MPL = Maximum permissible level

3.5. Heavy Metal Concentration in the Vegetable Samples in Week 5

In the fifth week, lettuce also had the highest iron concentration, followed by cucumber as shown in Table 5. This may be due to the relatively high concentration of naturally occurring iron in lettuce as it fell within the acceptable limit. Cucumber and carrot available in the market in the fifth week of the investigation came from Kano and Zaria respectively. Cucumber had the highest zinc concentration, followed by lettuce. This may be due to the use of grey water for irrigation of farm soils in Kano, Nigeria (Chiroma et al., 2014). Manganese concentration was highest in cabbage. The concentration of heavy metals in all the vegetables fell within acceptable limits indicating that they were safe for consumption and therefore, all the vegetables were safe for consumption.

Table 5: Concentration of metals (mg/kg) in different vegetable samples from new Benin market in week 5

Vegetable/Source	Fe	Mn	Zn
		mg/kg	
Carrot (Zaria)	191.8	0.85	56.3
Cabbage (Jos)	134.9	0.91	66.9
Cucumber (Kano)	196.9	0.59	81.0
Lettuce (Jos)	267.2	0.72	75.3
MPL WHO	425	500	100

MPL = Maximum permissible level

3.6. Mean Concentration of Metals in the Vegetable Samples within the 5 Weeks Period

The mean concentrations of the metals present in the samples were determined and the results are presented in Table 6. The results showed that lettuce had the highest mean concentration of all the metals investigated. This indicates that leafy vegetables absorb heavy metals from contaminated soils more than other vegetables. This is as a result of the high potential for heavy metal absorption in leaves and roots of most vegetables (Rasaq et al., 2015).

Table 6: Mean Concentration of metals (mg/kg) in different vegetable samples from new Benin market within the 5- weeks period

Vegetable	Fe	Zn	Mn
		mg/kg	
Carrot	171.62	51.86	0.646
Cabbage	154.68	53.56	0.628
Cucumber	273.64	54.54	0.558
Lettuce	304.44	58.5	0.692
MPL WHO	425	100	500

MPL = Maximum Permissible Level

Most of the vegetables and fruits available for sale in New Benin market during the period of the investigation were brought in from Jos, Nigeria on a weekly basis. The exception was in the fifth week when carrot and cucumber were brought in from Zaria and Kano respectively.

4. CONCLUSION

From the study, the following conclusions could be drawn:

- Lead and Chromium were not detected in the vegetables.
- The highest mean levels of iron, zinc and manganese were found in lettuce this may be related to the use of refuse ash in vegetable production in Jos, Nigeria.
- The concentrations of manganese in the vegetables were very minimal.
- The concentration of iron in cucumber and lettuce in the second and fourth week respectively exceeded the maximum permissible limit of 425 mg/kg set by the World Health Organization and therefore unsafe for consumption.
- Most of the vegetables obtained from the market at New Benin had their heavy metal levels below the maximum allowable limit and hence may not constitute a hazard for the consumers. This may be associated with the fact that the vegetables were washed upon arrival from their source of cultivation.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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