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Assessment of Heavy Metals in Edible Fruits Sold in Selected Markets in Ihiala Local Government Area, Anambra State

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Abstract: This study assessed the concentration of heavy metals in edible fruits sold in selected markets in Ihiala Local Government Area, Anambra State. Despite the nutritional benefits obtained from fruit consumption, the presence of heavy metals accompanying it from the environment draws scientific concerns affecting the human health. The multi-stage and random sampling techniques were used in dividing the area into three with three markets. Ninety-five fruit sellers participated in the study. The instruments used for data collection were field observation, questionnaire and laboratory analysis. Twelve fruit samples of banana, watermelon, apple and pineapple, four from three markets were collected. Also, three samples of unripe banana fruits were collected, to compare the percentage increase in the concentration of arsenic that might be arising from the use of calcium carbide. ANOVA was used for data analysis. Results revealed that the concentrations of Zn, Ni, Cu, Pb and Cr in all fruits were within WHO/FAO's acceptable limits of heavy metals in fruits. Whilst As and Fe were above the limit. Results also indicated an increase in the concentration of As in ripe banana compared with unripe one. Findings showed that 80% of the respondents were not aware of the health implication of consuming of CaC2 ripen fruits. There was no significant relationship between the concentration of Zn, Ni, Cu, Pb and Cr in fruits sold in markets and human health risks as the F_{cal} value of the metals was less than F_{crit} at ($P<0.05$) level of significance. However, there was a significant relationship between the concentrations of As and Fe and human health risk as F_{cal} was greater than F_{crit} at ($P>0.05$) level of significance, which shows the serious human health risk associated with As and Fe toxicity.

Keywords: *Anambra, Calcium carbide, Edible fruits, Heavy metals, Human health*

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1. Introduction

Food safety is a major public concern worldwide. During the past decades, the increasing demands for food safety have stimulated research regarding the risk associated with the consumption of food products contaminated by heavy metals, pesticides and/or toxins (D'Mello, 2003; Aydinalp and Marinova, 2012). According to Mintah, Eliason, Nsiah, Baah, Hagan and Ofosu (2012), a fruit is the edible and fleshy seed-associated structures of certain plants, which could be sweet such as apples, oranges, grapes, strawberries, watermelon and bananas or non-sweet such as lemon and olives in their raw forms. Benefits obtainable from consumption of fruits are greater life span (Bellavia, Larsson, Bottai, Wolk and Orsini 2013), improved mental health (Conner, Brookie, Carr, Mainvil and Vissers 2017), better cardiovascular health (Oyebode, Gordon-Dseagu, Walker and Mindell 2014), reduced risks of some cancers (Boffetta, Couto, Wichmann, Ferrari, Trichopoulos and Bueno-de-Mesquita, 2010) and weight management (Rolls, Ello-Martin and Tohill, 2014) among others. In the USA, lower risk of obesity was observed among healthy middle-aged women who consumed fruits (He, Hu, Colditz, Manson, Willett and Liu, 2004). Specifically, fruits contain sufficient potassium, which is needed to reduce the effect of bone loss and occurrence of kidney stones (Mintah et al 2012).

Despite the nutritional benefits obtain from fruit consumption, the presence of heavy metals accompanying it from the environment draws scientific concerns as these affect human health (Koleayo, Kelechi, Olutunde and Olapeju, 2017; Adewale, Makinde, Kusemiju and

Obembe, 2022). Heavy metal contents in fruits can be toxic when they exceed the recommended health levels or when they bio-accumulate in the body over a long period (Orisakwe, Nduka, Amadi, Dike and Bede, 2012). Heavy metals are not biodegradable, have long biological half-lives and have the potential for accumulation in the different body organs leading to unwanted effects (Singh, Sharma, Agrawal and Marshall, 2010). Most heavy metals are extremely toxic and because of their solubility in water, contamination may readily reach toxic levels (Arora, Kiran, Rani, Rani, Kaur and Mittal, 2008). Food chain contamination is one of the most important pathways for the entry of these toxic pollutants into the human body (Wang, Chen, Chai, Yang, Huang and Zheng, 2011; Harmanescu, Alda, Bordean, Gogoasa and Gergen, 2011). Other than water and soil, foods may also be contaminated with trace metals due to increased usage of chemicals, sprays, preservatives, industrialization, mining activities and fertilizers, (Ali, Ayub, Nabi, Ali, Malek and Seyedeh, 2015).

According to United Nations-Habitat (2004), the root causes of these problems are generally held to be the rapid pace of urbanization, land use changes, industrialization, unregulated application of chemical fertilizers, pesticides, herbicides and other synthetic chemicals for farming especially in developing countries with extremely high populations. Advancement in technology has challenged the integrity of the environment with discharge of effluents containing heavy metals (Fulekar, Singh and Bhaduri, 2009). Prabhat, Sang, Ming, Yiu and Ki-Hyun (2019) reported that wastewater, treated effluent and sludge contaminated with heavy metals have frequently been used as low-cost sources of irrigation in parts of Asia and Africa, which has caused food quality and hence health to deteriorate. They further stated that both highly populated countries (e.g., India and China) and underdeveloped countries (e.g., Nigeria and Zambia) have soil crop subsystems affected by wastewater irrigation and sludge amendment patterns, with food safety and ecotoxicology consequences. Likewise in India, long-term wastewater irrigation has been shown to contaminate food crops with heavy metals (concomitantly changing the physiology and biochemistry of crop plants) and pose health hazards (Ghosh, Bhatt and Agrawal, 2012; Chabukdhara, Munjal, Nema, Gupta and Kaushal, 2016).

Additionally, other root causes of fruit contamination by heavy metals have been identified to be artificial ripening agents, used to accelerate ripening process in fruits (Igbinaduwa, Omotoso, Aikpitanyi and Uwaezuoke, 2018). Fruit ripening is a natural process in which fruits go through various physical and chemical changes and gradually become sweet, colored, soft and palatable (Prasanna, Prabha and Tharanathan, 2007). With the advancement of science and technology, increase in human population and the rapid development of fruit trade, artificial ripening has become essential and as such various methods like the use of ethanol, methanol, acetylene gas, potassium sulfate, oxytocin, ethylene glycol, ethephon, carbon monoxide and calcium carbide have been developed to artificially stimulate this ripening process, mostly to meet the high demand of consumers (Gandhi, Sharma and Bhatnagar, 2016).

In many developing countries like Nigeria, the most commonly used chemical for artificial ripening is calcium carbide (Siddiqui and Dhua, 2010). According to them, calcium carbide is indiscriminately used in preference to other recommended practices of inducing ripening because it is readily available and also very much affordable. Consumption of carbide ripened fruits has been reported to be extremely hazardous for health (Orisakwe et al 2012). This is because acetylene, generated from carbide reduces oxygen supply to the brain (Dhembare, 2013). In the long term, it may produce mood disturbance and loss of memory (Mohammad, 2012). Industrial grade Carbide is also known to contain a lot of other chemical impurities such as arsenic and phosphorous (Igbinaduwa et al, 2018) which is dangerous. For example, long term arsenic toxicity leads to multi-system disease and the most serious consequence is malignancy (Hossain, Akhtar and Anwar, 2015).

In spite of the nutritional value of consuming fruits, their consumption has been linked with some health diseases arising from elevated levels of heavy metals and that is why metal contamination of food is one of the most significant aspects of food quality assurance (Ramesh, Ram, Narasimha, Rajya, and Kafila, 2019). However, no research known to the researchers has made efforts to assess the concentration of these heavy metals in edible fruits sold in markets in the study area, hence this study.

2. Materials and methods

Ihiala Local Government Area is one of the local government areas in Anambra State, Nigeria. It is located in the southern part of Anambra State. It lies approximately between latitude 5º48′00″N and 5º′55″12N and between longitude 6º48′60″E and 6º5′20″E and covers an area of 8.6 square kilometer. It is located 48km north of Owerri and 40km south of Onitsha. It is bounded by Ogbaru Local Government Area in the west, Ekwusigo and Nnewi South Local Government Area in the north and Imo State in the south and west (Egboka and Okpoko, 1999). The study area is made up of autonomous communities as follows: Ihiala (headquarters), Okija, Ubuluisuzor, Iseke, Orusumogho, Mbosi, Azia, and Uli. Figure 1 is a map of Nigeria, showing Anambra State and figure 2 is the map of Anambra State showing the study area.

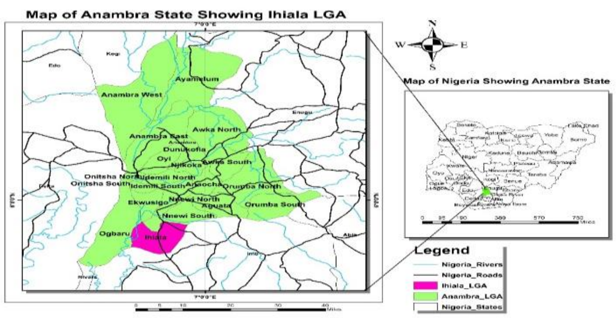

Figure 1: Location of Ihiala Local Government Area in the Map of Anambra
Source: JEOSpatial Services, Awka, Anambra State (2020)

The study area consists of two easily distinguishable geologic formations: the Ogwashi-Asaba Formation (Oligocene–Miocene) and the Benin Formation. Geologically, the area lies on 6,000m deep sedimentary rocks with altitude of 142m (Obichukwu, 2014). These sedimentary rocks comprise of ancient Cretaceous Deltas which are somewhat to that of the Niger Delta with Nkporo Shale, the Mamu formation and the Ajali Sandstones. The soils of Ihiala Local Government Area are derived from the underlying Sandstones and Shale units. The soils are well drained and weakly consolidated in most part of the study area (Ndukwe, Francis, Kelechi, Chiamaka, Raphael and Amos, 2013). The area is made up of plain lands and hills. To the west lies the alluvial plains and the east lays the Awka-Orlu uplands with elevation ranging from 30-80m (Iwena, 2010).

The study area is drained by Orashi River and its tributaries, the Awgbu and Omai rivers all in the northern part (okija) and Akazi and Abanze rivers in the central part (Ihiala), there is also Atamili and Enyinja rivers in the Southern part (Uli). The Orashi and Akazi Rivers are the major rivers in this area (Wikipedia, 2020). Ihiala Local Government Area is located within the rainforest belt. The typical rainforest vegetation has almost disappeared giving rise to derived savannah, vegetation of shrubs and bushes because of rapid agricultural development. The tree species found in the area include oil palm, pear, bread fruit, bamboo, orange, pineapple and mango (Wikipedia, 2020).

According to 1991 population census, the population of Ihiala Local Government Area was 188,060 people. The population of the study area was projected using Dudley Kirkt Theory of Population (1996) formula to 2006. The result of the arithmetic showed that Ihiala LGA population was 284572 people in 2006. The same population projection formula but at 3.2% approved annual population growth rate by National Population Commission in 2006, the population of Ihiala LGA is 442,282 people in 2020.

Primary and secondary sources were made use of in this research. Primary data came mainly from respondent's answers to questionnaires and analysis of fruits samples. Primary data were generated from three towns: Ihiala, Okija and Uli as shown in Figure 2. Secondary data came from textbooks, journals, newspapers, bulletins, conference/seminar papers and technical reports that were found to be very relevant to the study.

A multi-stage sampling technique was used in selecting the sample for the study. The 8 towns of the study area shown in figure 2.1 was zoned into three: north, central and south. This forms the first stage (primary) sampling units. Then, one town was chosen at random from each of the zones (Okija, Ihiala and Uli) and this constitutes the second stage (secondary) sampling units. This was followed by the selection of one market at random from each of the three sampled towns. The markets were Nkwobo, Nkwo-Ogbe and Eke Agba-agba market from Okija, Ihiala and Uli respectively. The last stage was the selection of 12 fruit samples, 4 from each of the three markets. Also, three samples of unripe banana fruits were collected one from each of the three markets, without giving any preference to a particular location. This constituted the sampling frame. Figure 2.1 is the Base Map of Ihiala Local Government Area showing the locations where each of the fruit samples was taken from the field.

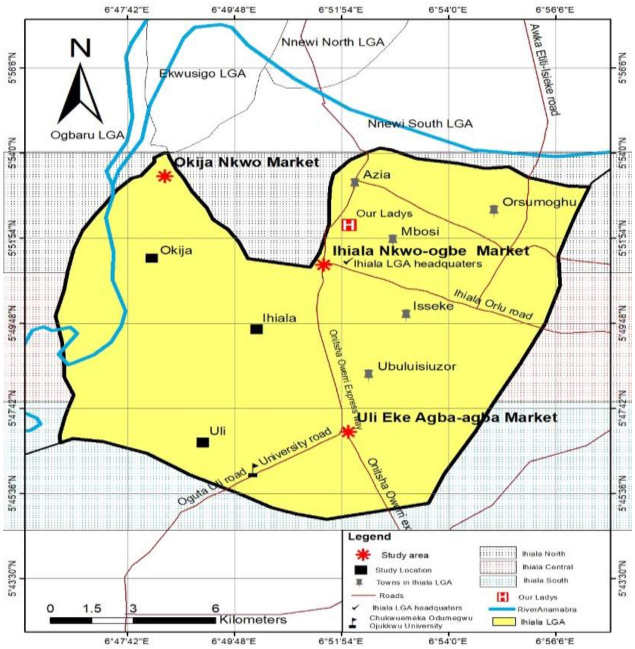

Figure 2: Base Map of Ihiala Local Government Area showing fruits sample locations

Source: Splendour GIS Services, Awka, Anambra State (2020)

The methods used in generating data and information for the studies are observation, questionnaire and laboratory analysis. The researchers observed that majority of the fruits were not properly packaged as the fruits were displayed on the ground, wheelbarrow and on the table along roadsides exposing the them to dust, dirt and large amount of depositions of atmospheric emissions from vehicles. The researchers also observed that most fruit sellers position their tables beside gutters and these gutters are not properly cleaned and if by mistakenly the fruits fall inside the gutter, they will become contaminated if not properly cleaned. Also, the researchers observed that most fruit sellers hawk fruits especially bananas along major high ways and these fruits were not properly packaged thereby exposing them dust, dirt and different levels of atmospheric pollution. In addition to this, the researchers observed that during the process of hawking, some fruits fall the ground and are picked up without being washed properly and placed back on the tray, thereby introducing dirt and other forms of contamination to the fruits.

Questionnaires were administered to selected fruit sellers of banana, apple, watermelon, and pineapple. Closed-ended questions were asked so as to get information. The sample size was determined through head count of all the fruit sellers in the study area. A total of 105 fruit sellers were counted, 30 in Okija, 50 in Ihiala and 25 in Uli and as such, 105 questionnaires were administered. However, only 95 questionnaires were filled and returned. The questionnaires administered were the structured type in which the respondents were provided with alternative answers from which they will select their answers depending on the way the questions were structured. One-way Analysis of Variance (ANOVA) at significant level of 0.05 was used to test the research hypothesis.

3. Results and discussion

The findings of the study revealed that a large proportion of the fruit sellers are engaged in the sales of banana (43%). This is followed by watermelon (19%), apple (17%), pineapple (10%), orange (7%) and pawpaw (4%). The prevalence of banana among the fruits could be attributed to its favourable growth within this region (tropical region) and because they could easily be planted by individuals without much inputs and expertise compared to the other fruits. The findings of this study agree with that of Ibeawuchi et al (2015) who posits that banana, pineapple, pawpaw, citrus constitute the common fruits grown in Nigeria. In a related study by Maduwanthi and Marapeman (2019), they stated that banana is one of the mostly consumed fruits in the world. The data is presented in Figure 3.1.

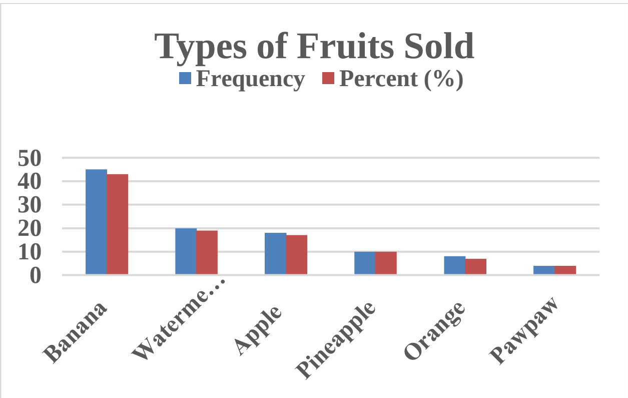

Figure 3.1: Types of Fruits Sold

It is a common practice to sprinkle water on fruits, cover them to facilitate ripening. The findings of the study revealed that 99% used water, 1% use calcium carbide and nobody used kerosene and detergent to accelerate ripening in fruits. Employing water to facilitate ripening has been reported by Burden, Doris, Lomaniec, Marinasky and Pesis (2008). According to them, fruits such as banana, when stored in low humidity facilitate ripening but when humidity is increased, the ripening becomes slower. The data is presented in Figure 3.2.

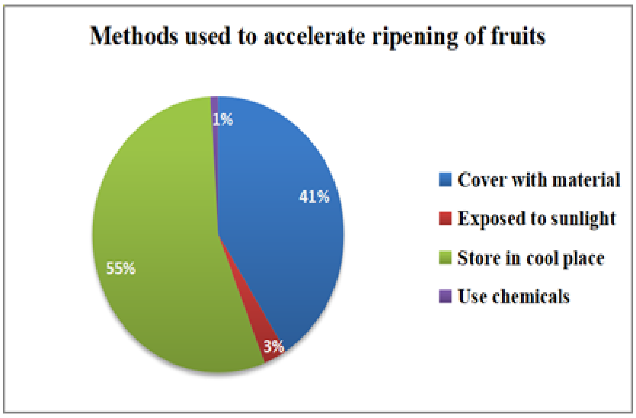

Figure 3.2: Methods used to accelerate ripening of fruits

The study also reveals that 20% of the respondents were aware that calcium carbide (CaC_2) is harmful to human health while 80% were not aware about the health effect of eating calcium carbide ripened fruits. For those fruit sellers who were aware, they claim that consumption of CaC_2 causes abdominal disorder. The data is presented in figure 3.3.

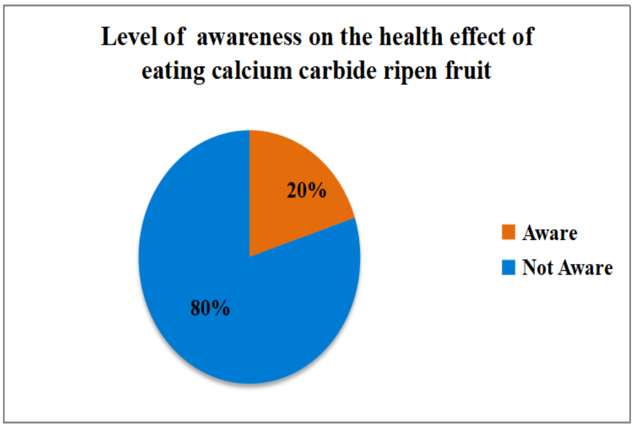

Figure 3.3: Level of awareness on the health effect of eating calcium carbide ripen fruits

The level of awareness on the health implications of consuming CaC_2 ripened fruits was contrary to a study by Ramesh et al (2019) in India who reported that 74.7% of respondent were aware that fruits ripened with CaC_2 has health implications. The health implications associated to consuming CaC_2 ripen fruits have been documented. According to Jindal, Tarsem, Agrawal, Nitika and Sangwan (2013) in their study on accidental poisoning with calcium carbide, they reported that high exposure to arsenic cause a buildup of fluids in lungs with early symptoms of vomiting, diarrhea, burning sensation in chest and abdomen, thirst, weakness, difficulty in swallowing, irritation or burning in the eyes and skin, permanent eye damage, ulcer on the skin, sore throat, cough and shortness of breath.

3.1. Fruit sample percentage compliance with WHO/FAO standard

The percentage compliance with regulatory standard was performed for the sampled fruits from the selected markets in the study area. The WHO/FAO guideline values for maximum permissible limit was used for comparative compliance and the nearer the percentage value obtained is to 0%, the higher the toxicity and dangerous the parameter is and vice-versa. The findings revealed that the concentration of Zinc, Nickel, Copper, Lead and Chromium in all fruits sampled falls within the WHO/FAO acceptable level of heavy metals in fruits, except for Arsenic (As) and Iron (Fe) which concentration falls above WHO/FAO acceptable standard. The data is presented in Table 3.1 and figure 3.4.

Table 3.1: Fruit Sample Percentage Compliance with WHO/FAO Standard

Parameters	Mean	WHO/FAO MPL (mg/kg)	% Compliance	Decision
Zinc	0.038917	0.300	87%	Acceptable
Nickel	0.042750	0.500	91%	,,
Copper	0.040000	0.500	92%	,,
Lead	0.003333	0.100	96%	,,
Chromium	0.003917	0.050	92%	,,
Arsenic	0.004833	0.003	0.0%	Not acceptable
Iron	1.914750	0.800	0.0%	Not acceptable

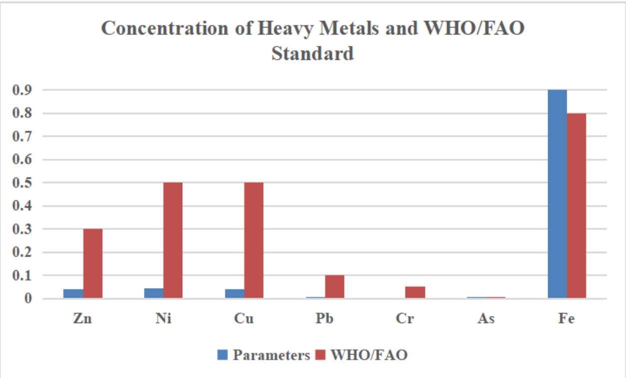

Figure 3.4: Variation between the concentration of heavy metals in fruits and WHO/FAO Standard

The higher concentration of iron beyond acceptable limit could be attributed to the application of biosolid manures and fertilizers to the soil. Study by Shinichi, Kazunori, Hiroyuki, Shingo, Tetsuo and Kazuyuki, (2005) reveals that the application of biosolid manures (livestock manures) on arable soil may be contaminated by heavy metals such as iron derived from additives in the animal feeds used to enhance livestock growth. According to them, the constant application of numerous biosolids (e.g., livestock manures, composts and municipal sewage sludge to land inadvertently leads to the accumulation of heavy metals such as Fe, Cu, Ni, Zn and so forth, in the soil and if repeatedly applied to restricted areas of land, can cause considerable buildup of these metals in the soil in the long run and subsequent accumulation in plants. According to a joint report by FAO/WHO on food standards programme on contaminants in foods (2018), iron occurs as a natural constituent of all foods of plant and animal origin, however, excess iron intake may result in siderosis (deposition of iron in tissue) in liver, pancreas, adrenals, thyroid, pituitary and heart which can result in liver cirrhosis, adrenal insufficiency, heart failure or diabetes. In their study on on iron metabolism and toxicity, Papanikolaoua and Pantopoulosb (2015) reported that iron is an essential nutrient with limited bioavailability but when present in excess, iron poses a threat to cells and tissues. According to them, iron's toxicity is largely based on its ability to catalyze the generation of radicals, which attack and damage cellular macro molecules and promote cell death and tissue injury.

3.2. Statistical analysis

One-way analysis of variance (ANOVA) was used to determine the variation of these heavy metals in fruits. Scheffe's post hoc test was used to determine which fruits statistically differ in the concentration of these heavy metals at $p<0.05$. From Table 3.2, 3.3, 3.4, 3.5 and 3.6 the analysis reveals that there is no significant difference ($p>0.05$) in the concentration of Zinc (Zn) in all these fruits. For the concentration of Nickel (Ni) in these fruits, there is a significant difference ($p<0.05$) between ripe banana and apple. All other fruits have no significant difference in these metals ($p>0.05$). Furthermore, there is no significant difference in the concentration of Cu, Pb and Cr between these fruits. For Arsenic (As), its concentration varies significantly between ripe banana and other fruits (watermelon, apple and pineapple) at ($p>0.05$).

Furthermore, there is no significant difference in the concentration of Iron (Fe) between these fruits (p>0.05).

Table 3.2: One-Sample T Test

	Test Value = 0					
					95% Confidence Interval of the Difference	
Parameters	**T**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Lower**	**Upper**
Concentration of Zn in fruits	8.710	11	.000	0.038917	0.02908	.04875
Concentration of Ni in fruits	5.436	11	.000	0.042750	0.02544	.06006
Concentration of Cu in fruits	5.421	11	.000	0.040000	0.02376	.05624
Concentration of Pb in fruits	1.334	11	.209	0.003333	-0.00217	.00883
Concentration of Cr in fruits	1.452	11	.175	0.003917	-0.00202	.00986
Concentration of As in fruits	1.682	11	.121	0.004833	-0.00149	.01116
Concentration of Fe in fruits	4.224	11	.001	1.914750	0.91708	2.91242

Table 3.3: Multiple Comparison of Concentration of Metals in Fruits

Concentration of Heavy Metals	**Types of fruit (i)**	**Types of fruits (j)**	**Mean (i*j)± Std Error**	**Significance**
Concentration of Zn in fruits	Ripe banana	Watermelon	0.02667±0.00922	P>0.05
		Apple	0.02967±0.00922	P>0.05
		Pineapple	0.02133±0.00922	P>0.05
Concentration of Ni in fruits	Ripe banana	Watermelon	0.04700±0.01530	P>0.05
		Apple	0.05466*±0.01530	P<0.05
		Pineapple	0.02733±0.01530	P>0.05
Concentration of Cu in fruits	Ripe banana	Watermelon	0.02667±0.02059	P>0.05
		Apple	0.01533±0.02059	P>0.05
		Pineapple	-0.0073±0.02059	P>0.05
Concentration of Pb in fruits	Ripe banana	Watermelon	-0.0100±0.00730	P>0.05
		Apple	-0.0023±0.00730	P>0.05
		Pineapple	-0.0100±0.00730	P>0.05
Concentration of Cr in fruits	Ripe banana	Watermelon	0.00633±0.00798	P>0.05
		Apple	0.00633±0.00798	P>0.05
		Pineapple	-0.00300±0.00798	P>0.05
Concentration of As in fruits	Ripe banana	Watermelon	0.01933*±0.00455	P<0.05
		Apple	0.01933*±0.00455	P<0.05
		Pineapple	0.01933*±0.00455	P<0.05
Concentration of Fe in fruits	Ripe banana	Watermelon	2.41600±1.22303	P>0.05
		Apple	0.85900±1.22303	P>0.05
		Pineapple	1.36867±1.22303	P>0.05

Table 3.4: Multiple Comparison of Concentration of Metals in Fruits

Concentration of Heavy Metals	**Types of fruit(I)**	**Types of fruits (j)**	**Mean (i*j)± Std Error**	**Significance**

Concentration of Zn in fruits	Watermelon	Ripe banana	-0.02667±0.00922	P>0.05
		Apple	0.00300±0.00922	P>0.05
		Pineapple	-0.00533±0.00922	P>0.05
Concentration of Ni in fruits	Watermelon	Ripe banana	-0.04700±0.01530	P>0.05
		Apple	0.00767±0.01530	P>0.05
		Pineapple	-0.01967±0.01530	P>0.05
Concentration of Cu in fruits	Watermelon	Ripe banana	-0.02667±0.02059	P>0.05
		Apple	-0.01133±0.02059	P>0.05
		Pineapple	-0.03400±0.02059	P>0.05
Concentration of Pb in fruits	Watermelon	Ripe banana	-0.00100±0.00729	P>0.05
		Apple	-0.00233±0.00729	P>0.05
		Pineapple	-0.01000±0.00729	P>0.05
Concentration of Cr in fruits	Watermelon	Ripe banana	0.00633±0.00798	P>0.05
		Apple	0.00000±0.00798	P>0.05
		Pineapple	-0.00933±0.00798	P>0.05
Concentration of As In fruits	Watermelon	Ripe banana	-0.01933*±0.00455	P<0.05
		Apple	0.00000±0.00455	P>0.05
		Pineapple	0.00000±0.00455	P>0.05
Concentration of Fe in fruits	Watermelon	Ripe banana	-2.41600±1.22303	P>0.05
		Apple	-1.55700±1.22303	P>0.05
		Pineapple	-1.04733±1.22303	P>0.05

Table 3.5: Multiple Comparison of Concentration of Metals in Fruits

Concentration of Heavy Metals	Types of fruit (i)	Types of fruits (j)	Mean (i*j)± Std Error	Significance
Concentration of Zn in fruits	Apple	Ripe banana	-0.02967±0.00922	P>0.05
		Watermelon	-0.00300±0.00922	P>0.05
		Pineapple	-0.00833±0.00922	P>0.05
Concentration of Ni in fruits	Apple	Ripe banana	-0.05467±0.01530	P>0.05
		Watermelon	-0.00767±0.01530	P>0.05
		Pineapple	-0.02733±0.01530	P>0.05
Concentration of Cu in fruits	Apple	Ripe banana	-0.01533±0.02059	P>0.05
		Watermelon	0.01133±0.02059	P>0.05
		Pineapple	-0.02267±0.02059	P>0.05
Concentration of Pb in fruits	Apple	Ripe banana	0.00233±0.00729	P>0.05
		Watermelon	0.00133±0.00729	P>0.05
		Pineapple	-0.00767±0.00729	P>0.05
Concentration of Cr in fruits	Apple	Ripe banana	-0.00633±0.00798	P>0.05
		Watermelon	0.00000±0.00798	P>0.05
		Pineapple	-0.09333±0.00798	P>0.05
Concentration of As In fruits	Apple	Ripe banana	-0.01933*±0.00455	P<0.05
		Watermelon	0.00000±0.00455	P>0.05
		Pineapple	0.00000±0.00455	P>0.05
Concentration of Fe in fruits	Apple	Ripe banana	-0.85900±1.233023	P>0.05
		Watermelon	1.55700±1.22303	P>0.05
		Pineapple	0.50967±1.22303	P>0.05

Table 3.6: Multiple Comparison of Concentration of Metals in Fruits

Concentration of Heavy Metals	Types of fruit(I)	Types of fruits (j)	Mean (i*j)± Std Error	Significance
Concentration of Zn in fruits	Pineapple	Ripe banana	-0.02133±0.00922	P>0.05
		Watermelon Apple	0.00533±0.09220	P>0.05
			0.00833±0.00922	P>0.05
Concentration of Ni in fruits	Pineapple	Ripe banana	-0.02733±0.15301	P>0.05
		Watermelon Apple	0.19667±0.015301	P>0.05
			0.027333±0.01530	P>0.05
Concentration of Cu in	Pineapple	Ripe banana	0.00733±0.02059	P>0.05

fruits		Watermelon Apple	0.03400±0.02059	P>0.05
			0.022667±0.02059	P>0.05
Concentration of Pb in fruits	Pineapple	Ripe banana	0.01000±0.007295	P>0.05
		Watermelon Apple	0.00900±0.007295	P>0.05
			0.007667±0.00729	P>0.05
Concentration of Cr in fruits	Pineapple	Ripe banana	0.00300±0.007976	P>0.05
		Watermelon Apple	0.00933±0.007976	P>0.05
			0.00933±0.007976	P>0.05
Concentration of As In fruits	Pineapple	Ripe banana	-0.01933*±0.00455	P<0.05
		Watermelon Apple	0.00000±0.004552	P>0.05
			0.00000±0.004552	P>0.05
Concentration of Fe in fruits	Pineapple	Ripe banana	-1.36867±1.22303	P>0.05
		Watermelon Apple	1.04733±1.223028	P>0.05
			0.050967±1.223028	P>0.05

3.3. Fruit sample percentage compliance with WHO/FAO Standard

A further analysis on the difference in the concentration of As in ripe and unripe banana reveals that there is no significant difference (p>0.05) in the concentration of As in the two fruits (Table 3.7). However, there is an increasing proportion in the concentration of As from unripe banana to ripe banana (Table 3.8). This increasing proportion of As in ripe banana could be attributed to the application of CaC2 to facilitate ripening of the fruit. The use of CaC2 to facilitate ripening is a common practice by fruit sellers (Fattah et al, 2010). Studies have shown that As constitute an impurity in the elemental composition of CaC2 (Igbinaduwa et al 2018). Yong-Chul, et al (2016) maintained that As concentration that exceeds 0.003mg/kg in fruits could cause cancer and other health implications. It is important to understand the concentration of this metal (As) and other heavy metals in fruit in view of protecting human health. The mean concentration in ripe and unripe banana is presented in figure 3.5.

Table 3.7: Independent Samples Test

Concentration		Levene's Test for Equality of Variances: F	Sig.	t-test for Equality of Means: t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	Upper
Concentration of As in type of banana	Equal variances assumed	4.228	.109	1.164	4	.309	.008000	.006872	-.011079	.027079
	Equal variances not assumed			1.164	2.547	.342	.008000	.006872	-.016243	.032243

Table 3.8: Percentage Increase in Arsenic Concentration

Location	Unripe banana	Ripe banana	% increase in As
Nkwobo Market, Okija	0.008	0.011	37.5
Nkwo-Ogbe Market,Ihiala	0.010	0.015	50
Eke Agba-agba Market,Uli	0.016	0.032	100

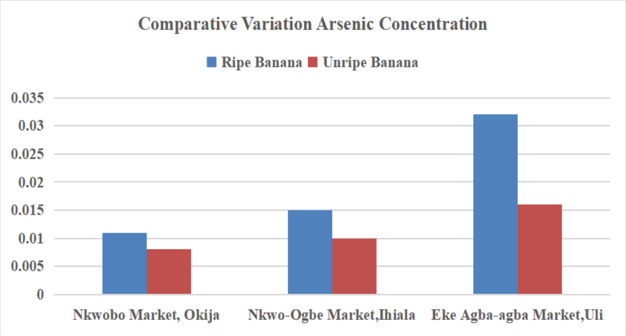

Figure 3.5: Comparative Variation in Arsenic Concentration in Ripe and Unripe Banana Samples

This increasing proportion of As in ripe banana could be attributed to the application of CaC2 to facilitate ripening of the fruit. The use of CaC2 to facilitate ripening is a common practice by fruit sellers (Fattah et al, 2010). Studies have shown that As constitute an impurity in the elemental composition of CaC2 (Igbinaduwa et al 2018). Yong-Chul, et al (2016) maintained that As concentration that exceeds 0.003mg/kg in fruits could cause cancer and other health implications. According to them, even at low concentrations arsenic ingestion causes multi-system adverse health effects such as skin manifestation, vascular disease including arteriosclerosis, renal disease, neurological effects, cardiovascular disease, chronic lung disease, cerebrovascular disease, reproductive effects and cancers of skin, lungs, liver, kidney and bladder. Arsenic contamination has also been reported to be responsible for spontaneous abortion, stillbirth and infant mortality (Himeno, 2017). It is therefore important to educate the public/fruit sellers on the health implications in a view to secure human health, reduce expenses on medical visits and strengthens the productivity of an economy.

4. Conclusion

The high level of arsenic and iron concentration obtained from the result of the study points to conclusion that the use of biosolid manures (livestock and compost manures), fertilizers by farmers and the use of artificial ripening agent (calcium carbide) by fruit sellers contributed to the increase in As and Fe concentrations in the sampled fruits in the study area. The implication of this is that the intake of arsenic and iron may have serious health implications because environmental contaminants, food safety and security, and human health are inextricably linked. On the other hand, although the daily intake of zinc, nickel, copper, chromium, lead in fresh fruits may not constitute a health hazard for consumers because the values of the sampled fruits were below the recommended daily intake of these metals by WHO/FAO. However, these amounts can be hazardous if the fruits are taken in large quantities.

From the findings of the study, the following recommendations were made:

1. Public education targeted on farmers, buyers and sellers of fruits on the health risks associated with the consumption of calcium carbide treated fruits IS necessary and the adaptation of natural and safe ripening practice.
2. Biosolids (livestock and compost manures) should be tested to ascertain the concentration of heavy metals and properly treated before subsequent application to soil in view of removing life threatening heavy metals.
3. The use of fertilizers and pesticides on farm land should not exceed recommended application dosages by manufacturers and also farmers should be educated not to apply at rate against its recommended quantity.
4. Government and concerned health authorities should prohibits the use of any poisonous chemical like calcium carbide, kerosene, acetylene or toxic colour/flavour in fruits that may cause harm to human health.
5. Yearly monitoring program for heavy metals in foodstuffs should be conducted by the government and concerned health authorities in order to prevent food contamination and ensure human health safety.
6. Finally, further research should be carried out in the study area, especially as it relates to food contamination and public health.

References

Adewale, P. S., Makinde, S. C. O., Kusemiju, V. O., & Obembe, O. O. (2022). Determination of Heavy Metals Concentration in Soil and Leafy Vegetables in Urban Expressway and Peri-urban Road Farms of Lagos State, Nigeria. *Journal of Sustainability and Environmental Management,* 1(2), 241–246.

Ali, E, Ayub, E.F., Nabi, S., Ali, M.L., Malek, A., and Seyedeh, S.S. (2015). Assessment of some Heavy Metals in Fruits and Vegetables Collected from Markets in Urmia, Iran. *Natural Journal of Current Science*, 2250-1770.

Arora, M., Kiran, B., Rani, S., Rani, A., Kaur, B., and Mittal, N. (2008). Heavy Metal Accumulation in Vegetables Irrigated with Water from different Sources. *Food Chemistry*, 111(4): 811-815.

Aydinalp, C., and Marinova, S. (2012). Concentration of Cu and Zn in Some Fruits and Vegetables Grown in North Western Turkey. *Bulgaria Journal of Agricultural Science,* 18(5):749–751.

Bellavia, A., Larsson, S.C., Bottai, M., Wolk, A., and Orsini, N. (2013). Fruit and Vegetable Consumption and all-cause Mortality: A Dose-Response Analysis. *The American Journal of Clinical Nutrition*, 98 (2),454-459.

Boffetta, P., Couto, E., Wichmann, J., Ferrari, P., Trichopoulos, D., Bueno-de-Mesquita, H.B. (2010). Fruit and Vegetable Intake and Overall, Cancer Risk in the European Prospective Investigation into Cancer and Nutrition (EPIC). *Journal of the National Cancer Institute*, 102(8),529-537.

Burdon, J.N., Doris, S., Lonaniec, .E., Marinasky, R., and Pesis, .E. (2008). The Post-Harvest Ripening of

Water Stressed Banana Fruits. *Journal of Horticultural Science*, 69 (5):799-804.

Chabukdhara, M., Munjal, A., Nema, A.K., Gupta,S.K., and Kaushal, R.K. (2016).Heavy Metal Contamination in Vegetables Grown around Peri-Urban and Urban-Industrial Clusters in Ghaziabad, India. *Human Ecological Risk Assessment*, 22(3), 736–752.

Conner, T.S., Brookie, K.L., Carr, A.C., Mainvil, L.A., and Vissers, M.C.M. (2017). Let them Eat Fruit! The Effect of Fruit and Vegetable Consumption on Psychological Well-Being in Young Adults: A Randomized Controlled Trial. *Journal Pone*, 12(2):171-206.

D'Mello, J.P.F. (2003). Food Safety: Contaminants and Toxins. Wallingford Oxon, UK, Cambridge: CABI Publishing, 480–482.

Dhembare, A.J. (2013). The Bitter Truth about Fruits with Reference to Artificial Ripeners. *Archives of Applied Science Research*, 5(5), 45-54.

Dudley, K. (1996). A New Demographic Transition, Rapid Population Growth, Consequences and Policy Implications. *International Journal of Academic Sciences*, 8-12.

Egboka, B.C.E., and Okpoko, E.I. (1999). Conjunctive uses of Water Resources and Management in Anambra State, Nigeria. *Natural and Applied Science Journal*, 9(2), 620-633.

Fattah, S.A., and Ali, M.Y. (2010). Carbide Ripened Fruits- A Recent Health Hazard. *Faridpur Medical College Journal*, 5(2),37.

Fulekar, M., Singh, A., and Bhaduri, A.M. (2009). Genetic Engineering Strategies for Enhancing Phytoremediation of Heavy Metals. *African Journal of Biotechnology*, 8,529–535.

Gandhi, S., Sharma, M., Bhatnagar, B. (2016). Comparative Study on the Ripening Ability of Banana by Artificial Ripening Agent (Calcium Carbide) and Natural Ripening Agents. *Indian Journal of Nutrition*, 3(1),127.

Ghosh, A.K., Bhatt, M.A., and Agrawal, H.P. (2012). Effect of Long-Term Application of Treated Sewage Water on Heavy Metal Accumulation in Vegetables Grown in Northern India. *Environment Monitoring Assessment*, 184,1025–1036.

Harmanescu, M., Alda, L.M, Bordean, D.M., Gogoasa, I., and Gergen, I. (2011). Heavy Metals Health Risk Assessment for Population via Consumption of Vegetables Grown in Old Mining Area; A Case Study: Banat County.

He, K.F.B., Hu, G.A., Colditz, J.E., Manson, W.C., and Willett, S. L. (2004). Changes in Intake of Fruits and Vegetables in Relation to Risk of Obesity and Weight Gain among Middle-Aged Women. *International Journal of Obesity*, 28,1569-1574.

Himeno, S. (2017). Versatile Health Effects of Arsenic in Humans. *Environ Toxicol Pharmacol*, 22,81–90.

Hossain, M.F., Akhtar, S., & Anwar, M. (2015). Health Hazards Posed by the Consumption of Artificially Ripened Fruits. *International Food Research Journal*, 22(5), 1755–1760.

Ibeawuchi, I.I., Okoli, N.A., Alagba, A.A., Ofor, M.O., Emma-Okafor, L.C., Peter-Onoh, C.A., and Obiefuna, J.C. (2015). Fruits and Vegetable Crop Production in Nigeria: The Gains, Challenges and the Way Forward. *Journal of Biology, Agriculture and Healthcare*, 5(2), 2224-3208.

Igbinaduwa, P., Omotoso, A.E., Aikpitanyi, R., and Uwaezuoke, C.E. (2018). Toxic Levels of Arsenic and Phosphorous found in some commonly Consumed Fruits Sold in the Market in Benin City. *European Journal of Pure and Applied Chemistry*, 4(1),1-6.

Iwena, C.U., (2010). Essential Geography for Senior Secondary School. University Press, Ibadan, Nigeria. 7th Edition.

Jindal, M., Tarsem, R., Agrawal, T., Nitika, S., and Sangwan, S. (2013). Accidental Poisoning with Calcium Carbide. *Journal of Clinical Toxicology*, 3(2),1–2.

Koleayo, O.O., Kelechi, L.N., Olutunde, O.B., and Olapeju, A.A. (2017). Nutritional Composition and Heavy Metal Content of Selected Fruits in Nigeria, *Journal of Agriculture and Environment for International Development*, 11 (1),123-139.

Maduwanthi, S. D. T., and Marapana, R. A. U. (2019). Induced Ripening Agents and Their Effect on Fruit Quality of Banana: Review. *International Journal of Food Science*, 3,1-8.

Mintah, B.K., Eliason, A.E., Nsiah, M., Baah, E.M., Hagan, E., and Ofosu, D.B. (2012). Consumption of Fruits among Students: A Case of Public University in Ghana. *African Journal of Food, Agriculture, Nutrition and Development*, 12(2),5979-5993.

Mohammad, A. (2012). Review on Physico-Chemical Properties and toxic Effect of Fruit-Ripening Agent Calcium Carbide. *Africa Health Research Organization Publishes*, 5(3),150-156.

Ndukwe, C., Francis, O., Kelechi, N., Chiamaka, I., Raphael, N., and Amos, U. (2013). The Role of Surveying and Mapping in Erosion Management and Control: Case of Omagba Erosion Site, Onitsha Anambra State, Nigeria. *Journal of Environment and Earth Science*, 3(11),129-137.

Obichukwu, O. (2014), Geoelectric Investigation of Groundwater Potential in Ihiala. Unpublished MSc. Thesis Nnamdi Azikiwe University, Awka Anambra State, Nigeira.

Orisakwe, O.E., Nduka, J.K., Amadi, C.N., Dike, D.O., Bede, O. (2012). Heavy Metals Health Risk Assessment for Population via Consumption of Food Crops and Fruits in Owerri, South Eastern, Nigeria.

Oyebode, O., Gordon, D.V., Walker, A., and Mindell, J.S. (2014). Fruit and Vegetable Consumption and All-Cause, Cancer and CVD Mortality: Analysis of Health Survey for England data. *Journal of Epidemiology and Community Health*, 6(2),223-228.

Papanikolaoua, G., and Pantopoulos, K. (2015). Iron Metabolism and Toxicity: Review. *Toxicology and Applied Pharmacology*, 202,199– 211.

Prabhat, K.R., Sang, S.L., Ming, Z., Yiu, F.T., and Ki-Hyun, K. (2019). Heavy Metals in Food Crops: Health Risks, Fate, Mechanisms, and Management: A Review. *Environment International*, 125,365–385.

Prasanna, V., Prabha, T. N., and Tharanathan, R.N. (2007). Fruit Ripening Phenomena–An Overview. *Critical Reviews in Food Science and Nutrition*, 47(1),1–19.

Press-Ustinov, A. (2011). Knows and Unknowns on Burden of Disease due to Chemicals: A Systematic Review. *Journal of Environmental Health*, 2,10-9.

Ramesh, D.B., Ram, D.K.V., Narasimha, R., Rajya, M.L., and Kafila, T.S. (2019). Awareness on Calcium Carbide Ripened Fruits and Recommendations for Toxic Free Artificial Ripening of Fruits. *Inter Journal of Engineering and Advanced Technology*, 9(2),2779 –2783.

Rolls, B.J., Ello-Martin, J.A., and Tohill, B.C. (2014). What can Intervention Studies tell us about the Relationship between Fruit and Vegetable Consumption and Weight Management? *Nutrition Review*, 62(1),1-17.

Shinichi, O., Kazunori, S., Hiroyuki, S., Shingo, U., Tetsuo, A., and Kazuyuki, I. (2005). Accumulation of Zinc and Copper in an Arable Field after Animal Manure Application. Soil Sci. Plant Nutr., 51(6): 801 -808.

Siddiqui, M.W., and Dhua, R. S. (2010). Eating Artificially Ripened Fruits is Harmful. *Journal of Current Science*, 99 (12),1664–1668.

Singh, A., Sharma, R.K., Agrawal, M., and Marshall F.M. (2010). Risk Assessment of Heavy Metal Toxicity through contaminated Vegetables from Wastewater Irrigated Area of Varanasi, India.

United Nations-Habitat. (2004). The State of the World's Cities: Globalization and Urban Culture. UN-HABITAT, Human Settlements Programme, Nairobi.

Wang, Z., Chen, J., Chai, L., Yang, Z., Huang, S., and Zheng, Y. (2011). Environmental Impact and site-Specific Human Health Risks of Chromium in the Vicinity of a Ferro-alloy Manufactory. *China Journal of Hazard Mater*, 190,980-985.

World Health Organization (WHO). (2015). Health topics: Environmental Health, 2015.

Yong-Chul, J., Yashoda, S., and Hwidong, K. (2016). Source, Distribution, Toxicity and Remediation of Arsenic in the Environment – A Review. *International Journal of Applied Environmental Sciences*, 11(2), 559-581.

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