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Levels of Essential Elements and Anions in Vegetables from Organic Matter Impacted Farm in Uyo, Nigeria

Godwin Asukwo Ebong[*], Helen Solomon Etuk

Department of Chemistry, University of Uyo, Uyo, Nigeria

Email address:

g_ebong@yahoo.com (G. A. Ebong), goddyebong2010@gmail.com (G. A. Ebong), helenetuk.etuk@yahoo.com (H. S. Etuk)
[*]Corresponding author

Abstract: Fresh leaves of vegetables widely utilized for their nutritional and medicinal benefits in Nigeria namely: *Telfairia occidentalis, Heinsia crinata, Vernonia amygdelina, Lasienthera africana, Talinum triangulare* and *Gnetum africana were* obtained from an organic matter impacted farm in Uyo, Nigeria. These samples were treated following standard analytical procedures and analysed using atomic absorption spectrophotometric methods for the concentrations of Fe, Cu, Zn, NO_2^-, NO_3^- and PO_4^{3-}. Results obtained indicated the following ranges (μgg^{-1}): 171.10 – 406.66; 5.16 – 6.81; 8.00 – 10.86; 88.40 – 243.32; 110.40 - 343.25 and 163.60 – 422.00 for Fe, Cu, Zn, NO_2^-, NO_3^- and PO_4^{3-} respectively. This study revealed that, *Telfairia occidentalis* has high potential of accumulating iron; *Gnetum africana* has the ability of absorbing more Cu and Zn; *Talinum triangulare* is capable of absorbing high NO_2^- and NO_3^- while *Lasienthera africana* has potential of absorbing more PO_4^{3-} from the soil. However, the concentrations of all the parameters determined except nitrite in *Talinum triangulare* were within their safe limits recommended by WHO. This research work has also established that, the application of organic manure in agricultural soils is recommended provided the soil and sources of organic matter are not polluted.

Keywords: Vegetables, Organic Matter, Nigeria, Essential Elements, Anions and Pollutants

1. Introduction

Anthropogenic activities aimed at improving the quality of life on earth have adversely affected the concentration of chemical substances in soil higher than their natural levels; thereby making them toxic to plants grown on them and subsequently creating serious problems along the food chain. Studies have shown that leafy vegetables have the potential of accumulating very high concentrations of metals and other toxic chemicals from contaminated soil and transferring same into the food chain [1, 2, 3]. The roles of leafy vegetables in nutrition and traditional medicine in Nigeria are enormous [4, 5, 6]. Consequently, most people in developing countries of the world depend on leafy vegetables as a source of mineral elements and as antidote to their health challenges thereby increasing the population of those consuming vegetables. Phosphate, nitrate and nitrite are natural components of soil and vegetables as a consequence of elemental cycles; though their levels in vegetables are greatly influenced by vegetable

type, source, condition of cultivation and storage [7]. It has also been reported that, the application of fertilizers and other agrochemicals for improved output has elevated concentrations of metals and anions in vegetables grown on them [8, 9, 10]. Notwithstanding the intensive application of agrochemicals and extensive utilization of leafy vegetables, the quality of soils on which they are grown on and levels of toxic chemicals accumulated in them are not given the much attention deserved. Accordingly, consumption of vegetables grown on contaminated soils may result in accumulation of metals, anions and other toxic chemicals, thereby creating associated health consequences along the food chain [11, 12, 13]. It is therefore imperative to assess the quality of vegetables widely consumed by the populace to forestall impending disaster that may arise as reported by Xian [14]. This study aimed at evaluating the concentration of anions and essential elements in leafy vegetables obtained from a farm in Uyo, Akwa Ibom state which has been exposed to intensive applications of organic manure. Results obtained from this study will expose the suitability or otherwise of

vegetables and health implications associated with the consumption of vegetables from studied farm and other farm exposed to organic manure.

2. Materials and Methods

Sample Collection and Treatment

Matured and leaves of *Telfeiria occidentalis, Heinsia crinata, Gnetum africana, Lasienthera africana, Veronia amygdalina* and *Talinum triangulare* were randomly collected from a farm in Itiam village in Uyo, Akwa Ibom State, Nigeria. Fresh leaves of the studied vegetables were obtained using stainless steel knife following the methods of Radojevic and Bashkin [15]. Samples collected were washed first with tap water and later with distilled water to remove debris deposited on them. Vegetable samples obtained were oven dried at 104˚C for 24 hours, ground and sieved.

3. Sample Digestion and Trace Metal Analysis

1g of each sieved vegetable sample in an acid-washed porcelain crucible was placed in a muffle furnace for four (4) hours at 500°C. The crucible was later removed from the furnace and cooled. 10 ml of 6M HCl was added covered and heated on a steam bath for 15 minute, then I ml of HNO_3 added and evaporated to dryness. For complete dissolution of samples, 5 ml of 6M HCl and 10ml of distilled water were finally added and the mixture heated on a steam bath. The mixture was cooled and filtered into a 50ml volumetric flask and made up to mark with distilled water (15). Concentrations of iron, copper and zinc in studied vegetables were determined using atomic absorption spectrophotometer (Pye Unicam SPQ) model.

4. Determination of Nitrate and Nitrite

For the determination of nitrate and nitrite, to 1g of each fresh vegetable sample in a 100 ml flask, 50 ml of distilled water was added, shaken for 30 minutes. The mixture was filtered into another 100 ml volumetric flask and made to mark with distilled water [15]. Concentrations of nitrate and nitrite were determined using grating spectrophotometer SE

2343 model.

5. Determination of Phosphate

Concentration of phosphate in each of the vegetable samples was determined by cutting the vegetables into small pieces and air-dried for three (3) days; ground and sieved. 1g of each of the sieved samples was weighed into acid-washed porcelain crucibles. To each crucible, 5ml of 20% (w/v) magnesium acetate was added and evaporated to dryness. These crucibles were transferred into a muffle furnace at 500°C for four (4) hours, removed and cooled. 10ml of 6M HCl was then added to each of the crucible and heated on a steam bath for 15 minutes. The content of each crucible was transferred into evaporating dish, 1ml of Conc. HNO_3 added and heated for 1 hour. 1ml of 6M HCl was added to the mixture, shaken then 10ml of distilled water added and heated on a steam bath. The content of the evaporating dish was cooled, filtered into a 50ml volumetric flask and made to mark with distilled water [15]. Phosphate levels in studied vegetables were determined using grating spectrophotometer SE 2343 model.

6. Statistical Analysis

IBM SPSS Statistics 20 model was employed for the analysis of mean, standard deviation, kurtosis and Pearson correlation coefficients.

7. Quality Assurance

To guarantee the reliability, accuracy and reproducibility of our findings, standard analytical techniques were employed and reagents used were of high percentage purity. Precautions were taken to minimized or if possible eliminate errors that would have accompanied the procedures.

8. Results and Discussion

Results for the concentration of iron, copper, zinc, nitrate, nitrite and phosphate in the different vegetables studied are shown in Table 1. Table 2 gives the correlation coefficients of trace metals and anions in studied vegetables.

Table 1. *Concentration (µgg^{-1}) of essential micro elements and anions in vegetables commonly consumed in Akwa Ibom State, Nigeria.*

SAMPLE	Fe	Cu	Zn	NO_2^-	NO_3^-	PO_4^{3-}
Telfairia occidentalis	406.66	5.16	8.00	88.40	110.40	171.60
Heinsia crinata	171.10	5.63	8.58	158.00	231.20	201.60
Vernonia amygdelina	206.66	5.80	9.16	200.00	298.80	304.80
Lasienthera africana	373.32	5.57	9.14	212.40	292.40	422.00
Talinum triangulare	351.10	6.15	8.53	243.32	343.25	401.20
Gnetum africana	217.76	6.81	10.86	91.00	124.47	163.60
Minimum	171.10	5.16	8.00	88.40	110.40	163.60
Maximum	406.66	6.81	10.86	243.32	343.25	422.00
Mean	287.77	5.85	9.05	165.52	233.43	277.47
Standard Deviation	100.56	0.57	0.99	64.80	96.77	115.65
Kurtosis	-2.68	1.02	2.65	-1.92	-1.89	-2.34

* Mean of three determinations.

Iron is essential for synthesis of chlorophyll and responsible for the production of some respiratory related enzymes in plants. Deficiency of iron in plants may result in chlorosis of leaves and stunted growth [16]. However, high content in plant can cause bronzing and stippling of leaves. Concentrations of iron in leafy vegetables studied ranged between 171.10μgg[-1] and 406.66μgg[-1]. The highest level of iron was recorded in *Telfairia occidentalis* while *Heinsia crinata* indicated the lowest concentration of iron. The mean concentration of iron recorded for all the studied vegetables (287.77±100.56μgg[-1]) is lower than 425.00mgkg[-1] stipulated by FAO/WHO [17]. Consequently, application of organic manure may not have elevated concentration of iron to a level higher than that desired by vegetables grown there. Thus, these vegetables could be good supplement for iron in human body. The level of iron in studied vegetables is much higher than 0.21 – 3.54mg/kg reported in vegetables from Northern part of Nigeria by Akan *et al*. [8]. Nevertheless, the range (73.30 – 516.30μgg[-1]) recorded in vegetables from Saudi Arabia by Ali and Al-Qahtani [18] is higher than that reported in this study. Concentrations of iron in the different vegetables studied followed platykurtic distribution since the kurtosis is less than zero (-2.68).

Copper is required for proper plant growth though at very low concentration however; higher levels of copper have been reported in vegetables. Copper concentrations in studied vegetables varied between 5.16μgg[-1] in Telfairia occidentalis and 6.81μgg[-1] obtained in Gnetum Africana. The obtained range is higher than 1.220 – 5.220μg/g reported for copper in vegetables from middle belt of Nigeria by Raphael and Adebayo [11] but lower than 22.19 – 76.50mg/kg obtained by Demirezen and Ahmet [19] in leafy vegetables from Turkey. The mean copper concentration obtained (5.85±0.57μgg[-1]) is below 73.00mg/kg recommended for leafy vegetables by FAO/WHO [17]. This study has shown that, organic matter applied to improve plant yield may not have polluted the soil environment with copper. However, copper concentrations in studied vegetables could have been essential for normal enzymatic activities and plant growth as reported by Raven *et al*. [20]. Consumption of these vegetables may have been a good source of copper for human. Copper concentration varied from one vegetable to the other and recorded a kurtosis value of 1.02 which is a leptokurtic distribution.

Zinc concentrations in studied vegetables varied between 8.00μgg[-1] and 10.8μgg[-1]; the highest concentration was recorded in *Gnetum africana* while zinc concentration in *Telfairia occidentalis* was the lowest obtained. This range is consistent with that reported by Rapheal and Adebayo [11] in vegetables from Makurdi but higher than 0.11 – 1.44 mgkg[-1] obtained in vegetables from Maiduguri, Nigeria. However, this range is lower than 21.54 – 35.54μgg[-1] reported by Ali and Al-Qahtani [18] in vegetables from Saudi Arabia. The mean concentration of zinc (9.05±0.99μgg[-1]) is much lower than 99.40mgkg[-1] stipulated for leafy vegetables by FAO/WHO [17]. This study therefore revealed that, farm

inputs applied may not have impacted negatively on the level of zinc in studied vegetables. Consequently, concentrations of zinc in the studied vegetables could be functional for their growth and normal enzymatic activities as indicated by Hafeez *et al*. [21]. Zinc indicated a leptokurtic distribution pattern in vegetables studied with kurtosis value of 2.65.

Nitrite concentrations in studied vegetables varied from 88.40μg/g reported in *Telfairia occidentalis* to 243.32μgg[-1] obtained in *Talinum triangulare*. This range is higher than 8.18 -199.42μgg[-1] obtained in samples from Borno State, Nigeria by Uwah *et al*. [22]. The range is also dissimilar with 33.00 – 478.00μgg[-1] reported in Kano, Nigeria by Akan *et al*. [23]. The high nitrite in studied vegetables may be attributed to excessive application of nitrate fertilizers and organic manure to improve their yield and high nitrate content in the area [24, 25]. This is in agreement with the report by Santamaria *et al*. [26] that leafy vegetables contain high level of nitrite. The mean concentration of nitrite in all studied vegetables except *Telfairia occidentalis* and *Gnetum Africana* were above 100.00mgkg[-1] recommended for leafy vegetables by WHO [27]. This has shown that, organic matter applied to improve plant yield may have increased the nitrite level substantially. Consequently, prolong consumption of these vegetables may result in infantile methemoglobinemia in young children; headache, dizziness, vomiting and diarrhea in adults [28, 29]. The variation of nitrite concentrations from one vegetable to the other followed a platykurtic distribution as indicated by kurtosis value of -1.92.

Nitrate is natural component of the environment as a consequence of nitrogen fixation however; the concentration in plants has been greatly elevated by the modern farming practices. Concentrations of nitrate in studied vegetables ranged between 110.40μgg[-1] recorded in *Telfairia occidentalis* and 343.25μgg[-1] obtained in *Talinum triangulare*. This is above 110.00 – 178.00 μgg[-1] reported by Akan *et al*. [30] in vegetables from Kano, Nigeria but lower than 91.00 – 3428.00μgg[-1] obtained in vegetables from Turkey by Mor *et al*. [31]. Generally, the mean obtained (233.43±96.77μgg[-1]) is within the limit of 2500mgkg[-1] recommended for leafy vegetables by WHO [27]. Organic materials in the farm could have contributed nitrate level that may not pose a problem to those consuming vegetables obtained from the studied farm. Consequently, concentrations of nitrate in studied vegetables could be essential for tissue development [32]. Variations of nitrate concentrations among studied vegetables followed a platykurtic distribution with kurtosis value of -1.89.

Phosphate in studied vegetables varied from 163.60μgg[-1] in *Gnetum africana* to 422.00μgg[-1] obtained in *Lasienthera africana*. This is higher than 2.897 – 3.342 mgkg[-1] and 32.00 – 73.00μgg[-1] reported in Kenya by Wamalwa *et al*. [33] and in vegetables from Kano, Nigeria by Akan *et al*. [30] respectively. The high phosphate levels in studied vegetables could be attributed to the application of organic manure in the farm and the nature of the parent material from which the soil was formed [34, 35]. Nevertheless, the mean phosphate

level obtained ($277.47\pm115.65\mu gg^{-1}$) is lower than 5000 $mgkg^{-1}$ stipulated by WHO [27] for leafy vegetables. Consequently, phosphate in studied vegetables could be essential for normal plant photosynthetic, growth and reproductive processes [34]. Accordingly, phosphate level contributed by organic matter applied to the farm has not reached the nuisance level. Consumption of vegetables with the reported phosphate concentrations aid in the formation of bones and teeth, kidney functioning, muscle contraction, normal heartbeat and nerve signaling in human [35]. However, bioaccumulation of phosphate in the underlying soil should be avoided to forestall incidences such as hyperphoshatemia, hypocalcaemia, osteoporosis and soft tissues calcinosis in consumers of vegetables grown on the soil [36, 37]. Results obtained for phosphate concentrations in studied vegetables followed a platykurtic distribution as indicated by Kurtosis value of -2.34.

9. Correlation Studies of Parameters Determined in Studied Vegetables

Table 2. *Pearson correlation coefficients among parameters in studied vegetables.*

	Fe	Cu	Zn	NO_2^-	NO_3^-	PO_4^{3-}
Fe	1.000					
Cu	-0.435	1.000				
Zn	-0.464	0.846*	1.000			
NO_2^-	0.094	-0.044	-0.259	1.000		
NO_3^-	-0.001	-0.022	-0.233	0.995*	1.000	
PO_4^{3-}	0.382	-0.074	-0.188	0.922*	0.885*	1.000

*Significant at $P < 0.01$

Weak negative correlations were recorded for the pairs Fe-Cu and Fe-Zn with r values of -0.435 and -0.464 respectively at 99% confidence limit. This study indicated that, there was no linear association at $P < 0.01$ between the following pairs: Fe-NO_2^- and Fe-NO_3^- with r values of 0.094 and -0.001 respectively. However, iron indicated a weak positive correlation with phosphate at $P < 0.01$ with correlation coefficient of 0.382. Consequently, the parameters determined in studied vegetables may have emanated from different sources and their chemical properties may be different from that of iron [38, 39]. Copper exhibited no linear relationship with nitrite, nitrate and phosphate at $P < 0.01$ wth r values of -0.044; -0.022 and -0.074 respectively. Thus, these properties may have originated from sources different from copper in the studied vegetables. Nevertheless, strong positive correlation was recorded for the relationship between copper and zinc indicating that these metals may have originated from a common source in the studied vegetables. The common source of copper and zinc may be attributed to organic manure in the farm as reported by Shayler *et al*. [40]. Zinc indicated no linear association with nitrite, nitrate and phosphate at $P < 0.01$ with correlation coefficients of -0.259; -0.233 and -0.188 respectively. Hence, these parameters originated from sources different from zinc. Nitrite correlated perfectly and positively with nitrate at $P <$

0.01 with r = 0.995. nitrite also exhibited strong positive association with phosphate in studied vegetables at $P < 0.01$ (r = 0.922). Thus, organic manure applied to the farm may have resulted in the accumulation of nitrite, nitrate and phosphate in studied vegetables [41]. Results obtained in Table 2 also revealed that, nitrate correlated positively and significantly with phosphate at $P < 0.01$ with r = 0.885. This corroborated with the findings by Masime *et al*. [41] that, application of organic manure in a farmland could attribute to high levels of nitrate and phosphate in plants grown on the farm.

10. Conclusion

This study has exposed the quality of vegetables obtained from the farm investigated and has also shown that, the application of organic manure to our farms may not pose any seroius health or environmental threat. However, the soil quality and source of organic manure may affect the quality of vegetables hence, periodic quality assessment of vegetables is encouraged. A comparison of our results with the ones from mechanized farms has shown that, inorganic fertilizers and other agrochemicals can affect the quality of vegetables from such farms. Mechanized farming may introduced serious environmental and health problems to our society if not properly managed and controlled.

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