Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2018, 5(12):90-101**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Comparative Proximate, Nutrient Density, Minerals and Trace Metals Composition of Vegetables from Abattoir Wastes Impacted Soils

Emmanuel U. Dan, Kokoette Raymond, Matthew U. Okon

[1]Department of Chemistry, University of Uyo, Uyo. Akwa Ibom State, Nigeria
[2]Department of Microbiology, University of Uyo, Akwa Ibom State, Nigeria

Abstract Proximate, mineral elements, trace metals and nutrient densities of five edible vegetables (*Gnetnum africana, Pterocarpus mildbraedi, Gongronema latifolium, Heinsia crinata, Ocimum gratissimum)* obtained from abattoir wastes impacted soils in Akwa Ibom State, Southern Nigeria, were investigated and compared using standard analytical protocols. Studied vegetables from all abattoir soils and control showed variations in proximate (moisture and ash content, crude lipid, protein and fibre, carbohydrate and energy values) and mineral elements (Na, K, Ca, Mg and P) contents. Trace metals (Fe, Zn, Cd, Pb, and Cu) results indicated higher levels in vegetables from all the abattoir soils studied than in their corresponding controls though were within permissible limit by World Health Organization for plants except for Fe. Nutrient densities result indicated that the studied vegetables recorded values greater than 100% for the minerals except for K. The results of nutrient densities obtained reveal that all the studied vegetables can serve as sources of mineral element supplements.

Keywords proximate; trace metals, composition, nutrient density, abattoir wastes

Introduction

Man has benefitted greatly from the consumption of vegetables as a source of nutrient such as vitamins, mineral elements and protein than any other plant. In Nigeria, consumption of vegetables cut across all the population from young to the aged. The wide acceptance of this category of plant as common food stem significantly from the fact that it is cheap, readily available throughout the seasons of the year, and its highly nutritious [1]. Apart from the use of vegetables as food, vegetables have been reported to have huge medicinal values such as in the treatment of diabetics [2], piles and high blood pressure [3], constipation and stomach disorder [4], conjunctivitis, convulsions and rheumatic pains [5], low blood cholesterol level and breast cancer [6] and others. Due to its high demands by the Nigerian populace, these plants are being cultivated all year round in almost every environment (land) including dumpsite soils. The planting of vegetables in soils within dumpsite soils is a common practice especially with several reports by researchers about the richness of dumpsite soils in plant nutrients. In Akwa Ibom State, Southern Nigeria, vegetables are also planted in soils around abattoirs or slaughter houses by local farmers who lives around these vicinities. These vegetables are usually harvested and are consumed within and outside the State. This practice is suspected to be dangerous especially with several reports available on the negative effects of abattoir wastes discharged into soil environment. These include increasing soil trace metals level, excessive soil nutrients, sulphides, mercaptan and organic acid, toxins, and alteration of physicochemical properties of soils [7-9]. Although there are many reports on proximate compositions and trace metals levels of some leafy vegetables in Akwa Ibom State, there is no report on those planted on soils laden with abattoir wastes. Therefore, this paper seeks to assess the impact of abattoir wastes on the distribution of trace metals, mineral elements and proximate compositions of leafy vegetables planted on soils impacted with abattoir wastes within Akwa Ibom State, Southern Nigeria. The findings obtained in this research work shall be useful in providing information on the safety in terms of consumption of these common vegetables especially as regards to it trace metals loads and others.

Materials and Methods

Scientific, English, Ibibio names and brief description of five (5) edible vegetables used in this study are presented in Table 1

Table 1: Scientific, English, Ibibio names and description of vegetables studied

Scientific Names	English Names	Ibibio	Brief description of vegetable
Gnetnum africanum	-	Afang	Is a perennial plant that grows 10 m long, with thick papery – like leaves growing in groups of three. The leaves may also grow about 8 cm long, and at maturity the vine will produce small cone-like reproductive structure [10].
Pterocarpus mildbraedi	-	Mkpaefere	Is an evergreen or semi deciduous tree with small, rounded crown; and can grow 15 – 25 m tall. The long straight bowl can be up to 60 cm in diameter [11].
Gongronema latifolium	-	Utasi	Is a climbing shrub with broad, heart – shaped leave that has a characteristics sharp, bitter and slightly sweet taste especially when eaten fresh. The tree can grow 10 – 20 m tall and the stem are usually very soft and hairy [11].
Heinsia crinata	-	Atama	Is a scrambling shrub up to 3 m. leaves opposite, elliptic to ovate, hairless and small domatia below. Mostly found in riverine fringes and thickets in sandy soil with up to 1100 m altitude range [10]
Ocimum gratissimum	African basil	Green	Erect herb or soft shrub up to 2 m. Leave opposite, ovate – lanceolate, variously pubescent on both surfaces, gland dotted below [11].

Samples collection and Pre-treatment

Fresh samples of five vegetables each were obtained from soil around three (3) abattoir waste sites namely Calabar –Itu (Cal – Itu), Itam (Itam) and Abak (Abak) in Akwa Ibom State, Southern Nigeria. For each abattoir locations, five vegetables each were also obtained from a soil 2000 meters from abattoir wastes site and used as Control. The collected samples were labeled and separately wrapped with polyethylene bags, before being taken to Botany and Ecological Studies Department, University of Uyo, Uyo, Akwa Ibom State for authentication. Prior to analysis, 1.00 g each of the samples and Control were washed with de-ionised water chopped into small pieces with knife and then dried in an oven for 3h at 105°C. The resulting samples were then ground into fine powder using electrical blender (model - 231STK). The obtained powder samples were then stored in a polyethylene bag, put in an air tight container for further analysis.

Determination of proximate composition

All determinations were done in triplicate and values obtained were expressed as mean ± standard error of mean (Mean ± SEM). Moisture and ash contents, crude lipids, protein and fibre, carbohydrate and energy content of the samples and Control were the proximate carried out in this study. Moisture and ash contents of the samples were determined using gravimetric methods (method 14:004) described in details by [12]. Crude fibre and lipid were determined using the method of AOAC, while carbohydrate content of the samples was done according to the method of Adedeye [1]. Crude protein and fibre contents were done by determining Kjeldahl's nitrogen content of the vegetables and subsequent conversion to crude protein by multiplying the obtained values with a factor of 5.3, acid base digestion method described in details elsewhere [12, 2] respectively. Energy content was calculated using the equation below and calculated as kilocalories per 100 g [13].

$$Energy\left(\frac{kcal}{100}g\right) = (Crude\ lipid\ \times 8) + (Crude\ protein \times 2) + \ (CHO\ \times 4)$$

Where CHO = Carbohydrate contents of the vegetable studied

Determination of mineral and trace metals content

Minerals determined in this study included Na, K, Ca, Mg and P, while trace metals were Fe, Zn, Cd, Pb and Cu. Prior to the determination of these elements in the vegetable samples, 1.00 g of ground powder samples were digested with aqua regia (3moles HCl : 1mole HNO_3) solutions as described by Dimpe *et al* [14]. Filtrate obtained after acid digestion procedures was then used for the determination of Fe, Zn, Cd, Pb, Cu and Mg by atomization using Agilent 710 Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES). Determination of Na, K, Ca and P was done using flame emission spectrophotometer (Model 381&391).

Evaluation of nutrient densities of studied vegetables

Nutrient densities of vegetables from the three abattoir soils and their Control were calculated using the equation (1) below

$$Nutrient\ Density = \frac{(Np)/\,(Ep)}{(Nr)/(Er)} \qquad \text{--------------------- (1)}$$

$$Where\ Np = Nutrient\ level\ in\ studied\ sample;Ep = Ideal\ energy\ supplied\ by\ the\ sample;Nr = Ideal\ number\ of\ calories\ of\ vegetable\ per\ 100\ g\ ;\ Er = Recommended\ energy\ intake\ of\ the\ nutrient$$

Ideal calories of all the vegetables used in this studied were taken to be in the class of vegetables that provides 25 calories of energy to the body per 100 gram (United State Department of Agriculture database 2016). Recommended energy intake for adults (19 – 50) years was taken to be 2500 kcal; while RDA (mg) for Na, K, Ca, Mg and P were 500, 2000, 1200, 350 and 800 respectively. The results were expressed in percent (%).

Results and Discussion

Proximate composition of vegetables

Results for proximate composition of vegetables obtained from abattoir wastes impacted soils within Akwa Ibom State are presented in Tables 2 - 4. The results indicated differences in proximate composition of the five edible vegetables studied. *Gongronema latifolium* from Cal-Itu abattoir soil recorded highest (64.53%) value in moisture content and least (32.19%) in *Heinsia crinata* from Abak abattoir soil. Generally, it was also observed that moisture contents in all the five vegetables from each abattoir soil were higher than those from the Control soils of each abattoir. Results of moisture content for vegetables obtained in this study are higher than those earlier reported for some Nigerian vegetables like *A. cruentus* (23.57 %), *C. olitorius* (15.58,) *and C. argenta* (30.90 %) respectively reported by Onwordi *et al*.,[15]. The variations in the moisture content within each abattoir soil observed in this study may be attributed to the frequency of abattoir wastes that are discharge to the soils, ecological factors and physicochemical properties of the abattoir soils.

Table 2: Proximate composition (%) of vegetables from Cal - Itu abattoir soil and Control

Proximate	MC	AC	CL	CHO	CP	CF
Vegetables						
Ga	43.12 ±1.80	7.25 ± 0.29	4.67 ± 0.02	23.12 ±1.21	10.67 ±0.08	8.94 ±0.05
Pm	52.18 ±0.38	8.73 ±0.12	3.02 ±0.04	18.87 ±1.08	14.56 ±0.02	6.67 ±0.01
Gl	64.53 ±0.21	5.21 ±0.32	2.09 ±0.02	14.32 ±0.76	11.04 ±1.01	11.12±0.03
Hc	38.83 ±1.02	10.65 ±0.03	6.12 ±0.04	9.54 ±0.56	18.25 ±0.00	6.26 ±0.14
Og	51.05 ± 1.06	6.84 ±0.27	7.54 ±0.01	10.21 ±0.21	15.11 ±0.03	7.07 ±0.05

Control						
Ga	38.24 ± 0.04	2.83 ± 0.10	3.12 ±0.02	20.39 ±0.32	11.03 ±0.01	9.04 ±0.03
Pm	46.32 ±0.03	4.13 ±0.06	2.18 ±0.02	12.84 ±0.06	12.56 ±0.01	7.21 ±0.02
Gl	55.02 ±0.04	2.84 ±0.02	2.34 ±0.04	8.43 ±0.02	16.23 ±0.03	8.44 ±0.03
Hc	32.08 ±0.01	6.09 ±0.03	8.32 ±0.03	11.63 ±1.03	14.25 ±0.07	7.01 ±0.05
Og	44.43 ±0.06	2.53 ±0.00	1.83 ±0.00	10.17 ±0.34	13.15 ±0.04	7.37 ±0.01

*Ga – *Gnetnum africana*; Pm – *Pterocarpus mildbraedi*; Gl - *Gongronema latifolium; Hc – Heinsia crinata; Og - Ocimum gratissimum;* MC – Moisture content; AC – Ash content; CL – Crude lipids; CHO – Carbohydrate; CP – Crude protein; CF – Crude fibre

Table 3: Proximate composition (%) of vegetables from Itam abattoir soil and Control

Proximate	MC	AC	CL	CHO	CP	CF
Vegetables						
Ga	46.23 ± 0.07	6.35 ±0.00	6.13 ±0.22	20.04 ±1.12	9.03 ±0.09	9.54 ± 1.03
Pm	55.03 ±0.05	8.23 ±0.01	4.83 ±0.31	16.32 ±1.05	13.43 ±0.01	7.03 ±0.42
Gl	58.91 ±0.04	6.71 ±0.05	6.06 ±0.12	11.80 ±0.32	11.45 ±0.03	10.34 ±0.25
Hc	40.03 ±0.01	11.04 ±0.03	3.65 ± 0.06	26.32 ±0.65	17.85 ±0.04	6.78 ±0.08
Og	53.89 ±0.06	7.85 ±0.12	4.06 ±0.15	14.76 ±0.26	17.91 ±0.12	10.01 ±0.04
Control						
Ga	38.85 ±0.40	3.03 ±0.02	4.10 ±0.07	12.85 ±0.06	8.05 ± 1.03	9.42 ±0.04
Pm	51.06 ±0.10	1.56 ±1.03	2.08 ±0.05	8.98 ±0.08	12.83 ±0.02	6.14 ±1.01
Gl	53.14 ±1.10	4.01 ±0.32	3.18 ±0.05	6.93 ±0.05	10.12 ±0.05	12.12 ±0.03
Hc	37.03 ±0.00	5.89 ±1.05	6.11 ±0.10	22.05 ±0.01	15.32 ±0.06	6.21 ±0.03
Og	46.04 ±0.03	2.43 ±0.22	3.00 ±0.02	15.07 ±0.13	18.37 ±0.03	8.57 ±0.01

*Ga – *Gnetnum africana*; Pm – *Pterocarpus mildbraedi*; Gl - *Gongronema latifolium; Hc – Heinsia crinata; Og - Ocimum gratissimum;* MC – Moisture content; AC – Ash content; CL – Crude lipids; CHO – Carbohydrate; CP – Crude protein; CF – Crude fibre

Table 4: Proximate composition (%) of vegetables from Abak abattoir soil and Control

Proximate	MC	AC	CL	CHO	CP	CF
Vegetables						
Ga	37.65 ± 1.02	8.94 ±0.38	4.74 ±0.03	18.85 ±0.42	8.45 ±0.15	7.83 ±0.30
Pm	48.11 ±0.52	9.52 ±0.24	2.04 ±0.03	18.03 ±0.21	12.34 ±0.08	7.65 ±0.42
Gl	53.09 ±1.21	6.93 ±1.03	8.13 ±0.01	8.47 ±0.02	10.26 ±0.11	9.53 ±0.12
Hc	32.19 ±1.07	10.04 ±0.30	1.86 ±0.02	15.90 ±0.11	16.53 ±0.04	7.75 ±0.08
Og	38.54 ±2.00	8.54 ±0.21	2.82 ±0.00	9.63 ±0.05	14.63 ±0.00	10.51 ±0.03
Control						
Ga	40.25 ±0.08	3.30 ±0.01	2.43 ±0.02	7.84 ±0.04	6.36 ±0.03	8.65 ±0.03
Pm	45.13 ±0.06	2.34 ±0.03	3.82 ±0.01	4.07 ±0.00	10.61 ±0.04	6.48 ±0.22
Gl	55.10 ±0.01	1.96 ±0.01	1.65 ±0.03	6.06 ±0.01	11.11 ±0.01	8.62 ±0.32
Hc	36.23 ±0.07	4.42 ±0.01	8.05 ±0.03	14.32 ±0.02	15.43 ±0.00	9.72 ±0.31
Og	36.19 ±0.07	2.93 ±0.02	1.36 ±0.01	10.47 ±0.19	16.36 ±0.02	11.87 ±0.04

*Ga – *Gnetnum africana*; Pm – *Pterocarpus mildbraedi*; Gl - *Gongronema latifolium; Hc – Heinsia crinata; Og - Ocimum gratissimum;* MC – Moisture content; AC – Ash content; CL – Crude lipids; CHO – Carbohydrate; CP – Crude protein; CF – Crude fibre

Results for ash content indicated a total range of 5.21 – 10.89% for all the five vegetables from the three abattoir soils with highest (10.89) value obtained in *Heinsia crinata* from Itam abattoir soil and least (5.21) obtained in *Gongronema latifolium* from Cal-Itu abattoir soil. Ranges for ash content of vegetables obtained in this study is consistent though with slight difference with 5.49 – 16.05% reported by Dan *et al.*,[16] for selected vegetable grown in Akwa Ibom State. Ash content has been reported as a measure of the non-volatile inorganic constituents remaining after ashing [17]. The ash content is generally recognized as a measure of quality for the assessment of the functional properties of foods

Crude lipid and protein contents of vegetables from the abattoir soils indicated ranges of 1.86 – 8.13 % and 8.45 – 18.25% respectively. From the results, *Gongronema latifolium* from Abak abattoir soil recorded highest crude lipid, while *Heinsia crinata* from Abak again recorded the least value. In the case of vegetables from the Control soils, range for crude lipid was 1.36 – 8.32% with *Heinsia crinata* from Cal – Itu recording highest (8.32%), while *Ocimum gratissimum* from Abak had the least (1.32%). For the crude protein for vegetables from Control soils, the range was 6.36 -18.37% with *Ocimum gratissimum* obtained from Itam recording highest and least in *Gnetnum africana* from Abak Control soil. Range for Crude lipid recorded in vegetables obtained in this study are higher than 1.01 – 3.24% previously reported by Ooi *et al.,* [5], but lower than 16.45 – 24.02% reported by Yahaya *et al.*,[2] in their previous studies. For protein, the reported range obtained agrees with the report of Ooi et al., 2012, but higher than 4.89 – 5.22% previously reported by Eze *et al.,* [18] for common vegetables from Abuja metropolis, Nigeria.

Ranges for CHO contents of all vegetables from the abattoir and Control soils were 8.47 – 26.32% and 4.07 – 22.05% respectively. Highest CHO content was found in *Heinsia crinata* obtained from Itam abattoir soil, while the least was found in *Gongronema latifolium* from Abak abattoir soil. For the control, *Heinsia crinata* from Itam abattoir soil recorded highest content of *CHO, and Pterocarpus mildbraedi* from Abak recorded the lowest. Range for CHO contents in vegetables obtained in this study are similar to those previously reported by Kokoette *et al.*, [12]; Adepoju *et al.*, [19] and Iheanacho *et al.*,[20] in their respective studies though slightly different. The slight difference may be as a result of the location, soil, variety, maturity and the cultural practices adopted during planting [21]. Results presented in Tables 2 – 4, also reveal that crude fibre content of the vegetables ranged from 6.78 – 11.12% with *Gongronema latifolium* recording the highest (11.12) and the least (6.78) % obtained in *Heinsia crinata* from Cal - Itu abattoir soil. Fibre in human diet helps to prevent over absorption of water and the formation of hard stools which can result in constipation. Besides, fibre lowers the body cholesterol level, thus reducing the risk of cardiovascular diseases [22, 23].

Table 5: Energy content (kcal/100g) of vegetables from abattoir and Control soils

Vegetables	***Gnetnum africana***	***Pterocarpus mildbraedi***	***Gongronema latifolium***	***Heinsia crinata***	***Ocimum gratissimum***
Abattoir soils					
Cal-Itu	151.80 ±0.03	128.76 ±1.07	96.08 ± 1.12	123.62 ± 0.33	131.38 ± 2.01
Itam	147.26 ±0.04	130.78 ±0.54	118.58 ±0.56	170.18 ±0.42	127.34 ± 0.41
Abak	130.22 ±0.01	113.12 ±0.35	119.44 ±1.00	111.54 ± 0.11	90.34 ± 0.06
Control soils					
Cal-Itu	128.58 ± 0.01	93.92 ±1.08	84.90 ± 0.46	141.58 ± 0.10	81.62 ± 0.77
Itam	100.30 ± 0.03	78.22 ± 0.73	73.40 ± 0.55	167.72 ± 1.00	121.02 ± 0.43
Abak	63.52 ± 0.23	68.06 ± 0.06	59.66 ± 0.19	152.54 ± 2.00	85.42 ± 0.68

Results in Table 5 reveal the energy content (kcal/100 g) of five vegetables from three abattoir soils and their corresponding control soils. From the result, energy content of the entire vegetables were found to ranged from 90.34 – 170 kcal/100g with *Heinsia crinata* from Itam abattoir soil recording the highest energy content (170.18) of all the vegetable studied, while *Ocimum gratissimum* from Abak had the lowest (90.34) energy content. For vegetables obtained from the Control soils, energy content ranged from 59.66 – 167.72 kcal/100g with *Heinsia crinata from* Itam Control soil recorded highest (167.72) energy content , while *Gongronema latifolium* from Abak control soil recorded the lowest (59.66). For the abattoir soils, all the vegetables recorded energy contents greater than 100% except *Gongronema latifolium* from Cal-Itu and *Ocimum gratissimum* from Abak abattoir soils. The results also reveals that all the vegetables from each of the abattoir soil recorded higher energy contents than were obtained in vegetables from their control soils except for *Heinsia crinata*. *Heinsia crinata* from control soils (Cal – Itu, Itam and Abak) recorded higher energy content than *Heinsia crinata* from the abattoir sites. Ranges for energy contents in vegetable obtained in this study is lower than 319.00 – 363.00 kcal/100g and 214 – 325 kcal/100g reported by Yahaya *et al.*,[2] and Kokoette *et al.*, [12] in their respective studies, but higher than 21.39 – 27.70 kcal/100g reported by Adeyeye *et al.*, [1]. The reason for these disparities may be due to differences in fat and protein contents of the vegetable samples used for analysis; which may differ in many respect like age of the vegetable, organic matter content and pH of soil where the vegetable is planted, growth and morpho-physiological differences [1]. However, the low energy content of vegetables obtained in this study further validates the fact that leafy vegetables in Nigeria are low in energy content. This finding is not surprising as many people especially the obese and diabetics always prefer using these vegetables as food since they contain low carbohydrate (low sugar).

Mineral composition of vegetables from abattoir and control soils

Out of the sixteen (16) essential minerals needed in varied quantities by the human body, Na, K, Ca, Mg and P are the five (5) most important of them. Results in Tables 6 - 8 below represent levels of Na, K, Ca, Mg and P in five different edible vegetables obtained from three (3) different abattoir soils and Control.

Table 6: Dietary mineral composition of edible vegetables from Cal -Itu abattoir soil and Control

Minerals	Na	K	Ca	Mg	P
Vegetables					
Gnetnum africana	58.76 ± 0.02	18.56 ±0.03	107.98 ±1.80	201.86 ±2.10	10.09 ±0.05
Pterocarpus mildbraedi	42.13 ±0.01	23.64 ±0.03	87.90 ±1.03	286.12 ±1.63	12.45 ±0.05
Gongronema latifolium	70.17 ±0.21	14.73 ±0.01	129.45 ±1.00	198.65 ±2.12	8.78 ±0.01
Heinsia crinata	49.74 ±0.11	8.89 ±0.02	74.87 ±0.67	212.32 ±1.59	16.13 ±0.02
Ocimum gratissimum	63.32 ±0.07	10.06 ±0.10	113.43 ±0.46	147.46 ±1.05	18.45 ±0.01
Control					
Gnetnum africana	48.23 ± 0.02	11.90 ±0.03	86.76 ±1.29	210.11 ±3.21	6.11 ± 0.02
Pterocarpus mildbraedi	36.54 ±0.01	16.84 ±0.02	90.50 ±1.03	248.32 ±2.83	4.56 ±0.01
Gongronema latifolium	63.53 ±0.02	10.56 ±0.02	118.43 ±2.32	167.04 ±1.82	6.16 ±0.01
Heinsia crinata	53.34 ±0.02	8.13 ±0.01	70.34 ±0.47	182.06 ±1.64	11.18 ±0.05
Ocimum gratissimum	51.19 ±0.12	7.05 ±0.03	95.32 ±0.22	124.26 ±1.20	10.05 ±0.01

* Values are mean ± SEM calculated as mg/100 g dry weight analyzed individually in triplicate

Table 7: Dietary mineral composition of vegetables from Itam abattoir soil and Control

Minerals	Na	K	Ca	Mg	P
Vegetables					
Gnetnum africana	42.98 ±1.22	12.65 ±0.04	98.32 ±1.93	163.98 ±1.00	6.37 ±0.03
Pterocarpus mildbraedi	37.45 ±1.04	27.82 ±0.04	63.19 ±2.01	195.32 ±2.00	8.66 ±0.04
Gongronema latifolium	61.14 ±0.34	10.73 ±0.02	119.46 ±3.26	152.82 ±0.84	9.42 ±0.01
Heinsia crinata	62.78 ±0.21	10.08 ±0.00	83.13 ±0.86	129.14 ±1.14	10.87 ±0.01
Ocimum gratissimum	57.89 ±0.80	6.17 ±0.01	126.92 ±1.09	168.67 ±0.89	9.73 ±0.02
Control					
Gnetnum africana	39.97 ±0.20	8.46 ± 0.00	76.09 ±0.05	126.96 ±3.07	4.11 ±0.01
Pterocarpus mildbraedi	28.46 ±0.23	11.83 ±0.03	54.62 ±0.04	148.42 ±1.95	4.03 ±0.01
Gongronema latifolium	58.14 ±0.11	5.57 ±0.02	106.32 ±0.01	98.03 ±2.11	6.48 ±0.00
Heinsia crinata	47.93 ±0.09	6.06 ±0.03	63.21 ±0.01	67.89 ±0.86	2.94 ±0.02
Ocimum gratissimum	38.64 ±0.02	9.42 ±0.02	111.06 ±0.04	117.52 ±2.43	3.90 ±0.05

* Values are mean ± SEM calculated as mg/100 g dry weight analyzed individually in triplicate

Table 8: Dietary mineral composition of vegetables from Abak abattoir and Control soils

Minerals	Na	K	Ca	Mg	P
Vegetables					
Gnetnum africana	37.32 ±1.02	9.96 ±0.06	74.86 ±1.40	174.97 ± 2.11	5.90 ± 0.00
Pterocarpus mildbraedi	39.41 ±1.13	18.05 ±0.08	65.08 ±1.54	185.09 ± 1.98	8.53 ±0.03
Gongronema latifolium	53.65 ±0.79	6.93 ±0.06	100.67 ±0.65	109.65 ± 1.06	9.32 ±0.05
Heinsia crinata	50.03 ±1.00	12.11 ±0.04	54.03 ±1.02	201.80 ± 2.32	11.05 ±0.05
Ocimum gratissimum	28.36 ±0.86	3.94 ±0.08	97.94 ±1.00	124.87 ± 0.66	8.93 ±0.01

Control					
Gnetnum africana	28.16 ± 0.20	6.21 ± 0.03	81.26 ± 1.03	143.88 ± 2.11	5.13 ± 0.03
Pterocarpus mildbraedi	24.92 ± 0.31	10.76 ± 0.03	70.43 ± 1.21	121.76 ± 3.04	6.25 ± 0.02
Gongronema latifolium	36.29 ± 0.09	3.55 ± 0.01	76.91 ± 1.34	118.95 ± 1.31	13.21±0.02
Heinsia crinata	41.94 ±0.18	8.23 ± 0.07	48.45 ± 2.12	164.64 ± 1.09	7.26 ± 0.01
Ocimum gratissimum	31.13 ± 1.01	1.83 ± 0.06	69.36 ±1.04	106.32 ± 1.00	4.20 ±0.01

*Values are mean ± SEM calculated as mg/100 g dry weight analyzed individually in triplicate

Results (mg/100 g DW) for Na level in the entire five vegetables from the three abattoir soils indicated ranges of 28.36 – 70.17 and 24.92 – 63.53 for the Control. The results also indicated that *Gongronema latifolium* from Cal-Itu abattoir soil recorded the highest level (70.17) of Na, while *Ocimum gratissimum* from Abak abattoir soil recorded the lowest levels (28.36) of Na. Also, it was observed that vegetables from the studied abattoir soils recorded higher levels of Na than those obtained from the control soils except for *Heinsia crinata* from Cal - Itu and *Ocimum gratissimum* from Abak abattoir soils. Ranges of Na in vegetables from the three abattoir soils obtained in this study agrees with 10.50 – 64.60 mg/100g DW reported for vegetables from Owerri, Imo State, by Iheanacho *et al.*, [20]. However, obtained ranges are lower than 98.0 – 170.0 mg/100gDW reported by Yahaya *et al.*, [2] for some selected vegetables from Minna, Niger State, Northern Nigeria.

For K, obtained ranges indicated 3.94 – 27.82 mg/100 g DW for all the vegetables from the three abattoir soils, and 3.55 – 16.84 mg/100 g DW for the Control soils. *Pterocarpus mildbraedi* from Itam recorded highest level (27.82) of K, while the lowest (3.94) was recorded by *Ocimum gratissimum* from Abak abattoir soil. Also, vegetables from the three abattoir soils were found to record higher levels of K than was obtained for vegetables from the Control soil soils except for *Ocimum gratissimum* obtained from Itam abattoir soil. Ranges of K obtained in this study are consistent with 3.40 – 11.05 mg/100 g DW reported by Iheanacho *et al* (2009), 9.70 – 10.08 mg/100 g DW reported by Inyang [24] for vegetables in their respective studies, but inconsistent with 2168 – 3748 mg/100 g DW reported by Fasuyi [25]. The variations in the levels of Na and K obtained in this study with those reported in literature may be as a results of differences in the percentage of clay in soils where these vegetables were obtained, soil pH , among other factors [26]. Na and K are responsible for regulating water content and electrolyte balance in the human body with daily requirement of 1600 mg/day Na and 3500 mg/day K for adults.

Levels of Ca and Mg in all the vegetables from the abattoir and Control soils were found to vary in abundance. Results for Ca and Mg in vegetables from all the abattoir soils studied indicated the following ranges; 54.03 – 119.46 mg/100 g DW Ca and 109.65 – 286.12 mg/100 g DW Mg, while for the Control were 48.45 – 118.43 mg/100 g DW Ca and 67.89 – 248.32 mg/100 g DW Mg. The results indicated that *Gongronema latifolium* from Itam abattoir soil was the highest (119.46) accumulator of Ca, while *Heinsia crinata* from Abak abattoir soil was the least accumulator (54.03).

In the case of Mg, *Pterocarpus mildbraedi* from Cal-Itu was the highest accumulator (286.12), while the least (109.65) was *Gongronema latifolium* from Abak abattoir soil. Results in Tables 6 – 8 also indicated that levels of Ca and Mg in all the vegetables studied from the three abattoir soils were higher than those obtained from Control soils except for *Gnetnum africana*, *Pterocarpus mildbraedi* from Abak and *Pterocarpus mildbraedi from Cal-Itu* abattoir soils. Ranges obtained for Ca and Mg in vegetables from abattoir soils in this study are higher than 13.60 – 28.80 mg/100 g DW Ca and 3.60 – 13.68 mg/100 g DW Mg reported by Iheanacho *et al.*,[20]; 31.50 – 39.30 mg/100 g DW Ca and 13.62 – 40.60 mg/100 g DW Mg reported by Mohd *et al*., [27], but lower than 387.01 – 519.21 mg/100 g DW Ca and 237.86 – 425.24 mg/100 g DW Mg reported by Yahaya *et al.*, [2]. Although there are no limits to the quantities of Ca and Mg in food, it has been reported that the reference Ca and Mg intakes are about 1000 and 300 mg/day. Ca and Mg plays vital roles in the human body and are said to be involved in bone and teeth formation, activation of many enzymes and functioning of muscles and nerves.

For P, the ranges were 5.90 – 18.45 mg/100 g DW for vegetables from abattoir soils, and 2.94 – 13.21 mg/100 g DW for those from the Control soils. The results indicated that *Ocimum gratissimum* from Cal – Itu abattoir soil recorded higher P than other vegetables, while *Gnetnum africana* from Abak was found to be the least accumulator of P. Like other minerals investigated in this study, levels of P in vegetables from the abattoir soils were higher than those obtained from the control soils except for *Gongronema latifolium* obtained from Abak abattoir soil as shown in Table 8.

Trace metals levels in Vegetables in abattoir soils

Results of trace metals levels in five (5) vegetables obtained from three (3) abattoir soils and Control sites within Akwa Ibom State, Southern Nigeria are presented in Tables 9 – 11. From the result presented, there were variations in the concentration of trace metals among the vegetables from the three different abattoir soils studied.

Table 9: Trace metals levels in edible vegetables from Cal – Itu abattoir soil and Control

Trace metals	Fe	Zn	Cd	Pb	Cu
Vegetables					
Gnetnum africana	18.32 ± 0.22	2.28 ±0.01	0.10 ± 0.00	0.05 ±0.01	3.04 ± 0.05
Pterocarpus mildbraedi	5.63 ±0.01	1.42 ±0.08	0.05 ± 0.01	0.03 ±0.00	1.16 ± 0.01
Gongronema latifolium	4.91 ± 0.03	0.84 ± 0.01	0.03 ± 0.01	0.07 ±0.01	0.43 ±0.00
Heinsia crinata	11.21 ± 0.16	1.14 ± 0.00	0.04 ± 0.00	0.09 ±0.00	0.82 ±0.01
Ocimum gratissimum	9.40 ± 0.08	3.64 ± 0.04	0.06 ± 0.00	0.02 ±0.00	0.37 ±0.00
Control					
Gnetnum Africana	2.54 ±0.06	0.48 ±0.02	0.002 ±0.000	0.004 ±0.000	0.21 ±0.01
Pterocarpus mildbraedi	1.81 ±0.01	0.23 ±0.00	0.003 ±0.000	0.002 ±0.000	0.16 ±0.00
Gongronema latifolium	1.23 ±0.02	0.11 ±0.00	0.001 ±0.000	0.006 ±0.001	0.09 ±0.00
Heinsia crinata	5.15 ± 0.07	0.31 ±0.01	0.005 ±0.001	0.003 ±0.000	0.20 ±0.02
Ocimum gratissimum	4.63 ± 0.03	0.12 ±0.01	0.008 ±0.001	0.002 ±0.000	0.24 ±0.01

* Values are mean ± SEM calculated as mg/kg analyzed individually in triplicate

Table 10: Trace metals levels in vegetables from Itam abattoir soil and Control

Trace metals	Fe	Zn	Cd	Pb	Cu
Vegetables					
Gnetnum africana	14.24 ± 2.10	1.04 ±0.01	0.04 ±0.00	0.03 ±0.00	1.07 ±0.03
Pterocarpus mildbraedi	18.16 ± 1.06	1.13 ±0.01	0.08 ±0.01	0.05 ±0.00	1.32 ±0.01
Gongronema latifolium	6.73 ±0.20	0.94 ±0.03	0.13 ±0.02	0.11 ±0.01	0.73 ±0.01
Heinsia crinata	9.62 ±1.12	0.73 ±0.02	0.05 ±0.00	0.10 ±0.00	0.27 ±0.02
Ocimum gratissimum	6.04 ±0.60	1.06 ±0.00	0.16 ±0.00	0.07 ±0.01	0.48 ±0.01
Control					
Gnetnum africana	5.32 ±0.10	0.31 ±0.01	0.002 ±0.000	0.006 ±0.001	0.12 ±0.01
Pterocarpus mildbraedi	3.81 ±0.34	0.26 ±0.02	0.001 ±0.000	0.002 ±0.000	0.18 ±0.03
Gongronema latifolium	4.11 ±0.19	0.17 ±0.00	0.001 ±0.000	0.001 ±0.000	0.10 ±0.00
Heinsia crinata	2.34 ±0.03	0.19 ±0.00	0.003 ±0.000	0.005 ±0.000	0.06 ±0.00
Ocimum gratissimum	6.12 ±0.08	0.24 ±0.01	0.001 ±0.000	0.003 ±0.001	0.15 ±0.02

* Values are mean ± SEM calculated as mg/kg analyzed individually in triplicate

Table 11: Trace metals levels in vegetables from Abak abattoir soil and Control

Trace metals	Fe	Zn	Cd	Pb	Cu
Vegetables					
Gnetnum africana	4.07 ±0.18	0.82 ±0.01	0.04 ±0.00	0.02 ±0.00	0.48 ±0.04
Pterocarpus mildbraedi	12.16 ±1.36	1.02 ±0.03	0.02 ±0.00	0.07 ±0.02	0.36 ±0.01
Gongronema latifolium	8.10 ±0.92	0.43 ±0.00	0.01 ±0.00	0.03 ±0.00	1.04 ±0.04
Heinsia crinata	7.41 ±0.21	0.96 ±0.00	0.06 ±0.01	0.09 ±0.02	0.74 ±0.10
Ocimum gratissimum	6.23 ±0.02	1.64 ±0.01	0.08 ±0.01	0.03 ±0.01	0.66 ±0.13
Control					
Gnetnum africana	1.04 ±0.01	0.48 ±0.02	ND	ND	0.03 ±0.00
Pterocarpus mildbraedi	1.21 ±0.02	0.35 ±0.00	0.001 ±0.000	0.001 ±0.000	0.05 ±0.01
Gongronema latifolium	0.95 ±0.02	0.22 ±0.01	ND	0.001 ±0.000	0.02 ±0.00
Heinsia crinata	0.73 ±0.00	0.40 ±0.01	ND	ND	0.08 ±0.02
Ocimum gratissimum	0.64 ±0.01	0.32 ±0.00	ND	ND	0.04 ±0.01

* Values are mean ± SEM calculated as mg/kg analyzed individually in triplicate ND – Not detected

Results for the levels of trace metals (Fe, Zn, Cd, Pb and Cu) in five different vegetables from three abattoir soils and Control are presented in Tables 9 - 11. Ranges for each of the trace metals in all the five vegetables from all the abattoir soils studied were 4.07 – 18.32 mg/kg Fe, 0.43 – 2.28 mg/kg Zn, 0.01 – 0.16 mg/kg Cd, 0.02 – 0.11 mg/kg Pb and 0.27 – 3.04 mg/kg Cu. For the vegetables obtained from the Control soils, ranges were 0.64 – 6.12 mg/kg Fe, 0.11 – 0.48 mg/kg Zn, ND – 0.008 mg/kg Cd, ND – 0.006 mg/kg Pb and 0.02 – 0.24 mg/kg Cu. For vegetables obtained from Cal – Itu abattoir soil, *Gnetnum africana* showed a good accumulator of Fe (18.32 mg/kg), Cd (0.10 mg/kg) and Cu (3.04 mg/kg); while, *Ocimum gratissimum* was for Zn (3.64 mg/kg) and *Heinsia crinata* showed a good accumulator of Pb. For vegetables obtained from the Control soil around Cal –Itu abattoir site, *Heinsia crinata* accumulated more Fe (5.15 mg/kg) followed by *Ocimum gratissimum. Gnetnum africana* indicated highest accumulator of Zn and Cu, *Ocimum gratissimum* and *Gongronema latifolium* accumulated more of Cd and Pb respectively.
Vegetables obtained from Itam abattoir soil indicated that *Pterocarpus mildbraedi* showed a good accumulator of Fe (18.16 mg/kg), Zn (1.13 mg/kg) and Cu (1.32 mg/kg); while, *Ocimum gratissimum* was for Cd (0.16 mg/kg) and *Gongronema latifolium* showed a good accumulator of Pb (0.11 mg/kg). Also, vegetables obtained from Abak abattoir soil indicated that *Pterocarpus mildbraedi* showed a good accumulator of Fe (12.16 mg/kg), *Ocimum gratissimum* for Zn (1.64 mg/kg) and Cd (0.08); *Heinsia crinata* for Pb (0.09 mg/kg) and *Gongronema latifolium* showed a good accumulator of Cu (1.04 mg/kg). Results presented in Table 9 – 11, also indicated that the levels of each trace metals in vegetables from all the abattoir soils were higher than the level obtained from their respective Control soil. Cd was not detected in *Gongronema latifolium, Heinsia crinata*, Pb recorded a non detectable level in *Gnetnum africana, Heinsia crinata*, and *Ocimum gratissimum* for vegetables obtained from Control soil from Abak. Varied levels of trace metals in plants including vegetables in Nigeria have been reported by different authors [28, 29, 30, 16] and the levels of trace metal uptake by plants are affected by several factors such as plant species, physiology of the plant, environmental factors and others [31, 32]. However, the results of trace elements obtained in this study are within the acceptable limit for Cu (3 – 15mg/kg); Pb (1 – 5 mg/kg), Zn (1 – 50 mg/kg); Cd (1 – 5mg/kg); Cr (1 – 10 mg/kg) stipulated by the World Health Organization for plant. In general, the results of trace metal levels in vegetables from all the abattoir soils indicated that none of the vegetables studied were identified as hyper accumulator since all the vegetables accumulated less than 1000 mg/kg of any of the studied trace metals.

Nutrient Density profile of vegetables from abattoir and control soils

Nutrient density (ND) determination expressed in percent for all the vegetables obtained from abattoir and control soils were carried out and the results are presented in Table 12 – 14.

Table 12: Nutrient density (%) of vegetables from Cal -Itu abattoir soil and Control

Minerals	Na	K	Ca	Mg	P
Vegetables					
Ga	1175.20 ± 0.83	92.80 ± 0.36	899.83 ± 1.11	5767.43 ± 1.02	126.12 ± 0.02
Pm	842.60 ± 0.21	118.20 ± 0.34	732.50 ± 2.01	8174.85 ± 1.21	155.63 ± 0.00
Gl	1403.40 ± 0.67	73.65 ± 0.21	1078.75 ± 1.02	5675.70 ± 0.04	109.75 ± 0.08
Hc	994.80 ± 1.03	44.45 ± 0.11	623.91 ± 0.14	6066.29 ± 0.06	201.63 ± 0.35
Og	1266.40 ± 1.00	50.30 ± 0.20	945.25 ± 0.31	4213.13 ± 0.21	230.63 ± 0.42
Control					
Ga	964.60 ± 0.02	59.50 ± 1.00	723.00 ± 0.06	6003.14 ± 12.03	76.38 ± 0.32
Pm	730.80 ± 0.20	84.20 ± 0.43	754.16 ± 0.00	7094.85 ± 9.10	57.00 ± 0.31
Gl	1270.61 ± 0.04	52.80 ± 0.13	986.91 ± 0.01	4772.57 ± 1.03	77.01 ± 0.03
Hc	1066.80 ± 0.22	40.65 ± 0.24	586.16 ± 1.11	5201.71 ± 3.08	139.75 ± 0.54
Og	1023.00 ± 0.03	35.25 ± 0.05	794.33 ± 0.37	3550.29 ± 2.32	125.62 ± 0.11

* Ga – *Gnetnum africana*; Pm – *Pterocarpus mildbraedi*; Gl - *Gongronema latifolium; Hc – Heinsia crinata; Og - Ocimum gratissimum*.

Table 13: Nutrient density (%) of vegetables from Itam abattoir soil and Control

Minerals	Na	K	Ca	Mg	P
Vegetables					
Ga	859.60 ± 5.10	63.25 ± 1.01	819.33 ± 2.61	4685.14 ± 1.03	79.63 ± 0.87
Pm	749.00 ± 2.92	135.10 ± 2.13	526.58 ± 1. 64	5580.57 ± 2.91	108.25 ± 1.11
Gl	1222.80 ± 0.67	53.65 ± 2.07	995.51 ± 2.00	4366.29 ± 4.95	117.75 ± 2.43
Hc	1255.61 ± 3.91	50.40 ± 1.46	692.75 ± 3.00	3689.71 ± 3.87	135.86 ± 4.25
Og	1157.80 ± 2.04	30.85 ± 3.21	1057.66 ± 2.04	4819.14 ± 1.36	121.63 ± 3.01
Control					
Ga	794.40 ± 0.21	42.30 ± 0.03	634.08 ± 0.20	3627.43 ± 3.09	51.38 ± 0.05
Pm	569.20 ± 0.00	59.15 ± 0.06	455.16 ± 0.03	4240.57 ± 1.18	50.37 ± 0.06
Gl	1162.80 ± 0.06	27.85 ± 0.02	886.00 ± 0.13	2800.85 ± 0.86	81.00 ± 0.02
Hc	958.60 ± 0.84	30.31 ± 0.32	526.75 ± 0.42	1939.71 ± 1.02	36.75 ± 0.03
Og	772.80 ± 1.10	47.10 ± 0.05	925.50 ± 1.87	3357.71 ± 1.00	48.75 ± 0.03

***** Ga – *Gnetnum africana*; Pm – *Pterocarpus mildbraedi*; Gl - *Gongronema latifolium; Hc – Heinsia crinata; Og - Ocimum gratissimum*

Table 14: Nutrient density (%) of vegetables from Abak abattoir soil and Control

Minerals	Na	K	Ca	Mg	P
Vegetables					
Ga	746.40 ± 0.04	49.80 ± 0.01	623.83 ± 1.02	4999.14 ± 5.00	73.75 ± 0.12
Pm	788.20 ± 0.02	90.25 ± 0.03	542.33 ± 1.32	5288.28 ± 2.03	106.63 ± 0.43
Gl	1073.00 ± 0.01	34.65 ± 0.21	838.91 ± 1.54	3132.86 ± 3.15	116.50 ± 0.21
Hc	1006.60 ± 0.32	60.55 ± 0.08	450.25 ± 1.03	5765.71 ± 2.09	138.13 ± 0.22
Og	567.20 ± 0.10	19.70 ± 0.03	816.17 ± 1.62	3567.73 ± 1.18	111.63 ± 0.31
Control					
Ga	563.20 ± 0.04	31.05 ± 0.06	677.17 ± 1.11	4110.86 ± 1.76	64.13 ± 0.04
Pm	498.40 ± 0.00	53.80 ± 0.19	586.91 ± 2.13	3478.86 ± 4.71	78.12 ± 0.05
Gl	725.80 ± 0.03	17.75 ± 0.03	640.91 ± 0.53	3398.57 ± 0.69	165.13 ± 1.07
Hc	838.80 ± 1.03	41.15 ± 0.23	403.75 ± 0.59	4704.06 ± 1.43	90.75 ± 0.38
Og	622.60 ± 2.10	9.15 ± 0.11	578.00 ± 1.04	3037.71 ± 1.00	52.50 ± 0.11

***** Ga – *Gnetnum africana*; Pm – *Pterocarpus mildbraedi*; Gl - *Gongronema latifolium; Hc – Heinsia crinata; Og - Ocimum gratissimum*

Nutrient density of food refers to the amount of nutrients (mineral elements) in a food compared to the amount of calories [33]. Nutrient dense foods have more nutrients per calorie than foods that are not nutrient dense, and usually contain vitamins, mineral, complex carbohydrate, lean protein and healthy fat. From the results, the following ranges were obtained for all the vegetables from the abattoir soils: 567.20 – 1403.40% Na, 30.85 – 135.10% K, 450.25 – 1078.75% Ca, 3132.86 – 8174.85% Mg and 73.75 – 230.63% P. For control, ranges were 563.20 – 1270.61% Na, 17.75 – 84.20% K, 403.75 – 986.91% Ca, 1939.71 – 7094.85% Mg, and 48.75 – 139.75% P. For both abattoir and Control soils, all the vegetables recorded highest nutrient density for Mg, while that of K, was the lowest for all the vegetables studied. Also, all the vegetables from abattoir soils recorded nutrient densities greater than 100% for all the mineral elements except for K that recorded ND < 100% (*Pterocarpus mildbraedi* from Cal- Itu and Itam abattoir soils). The results of ND > 100% recorded by these vegetables for all the mineral elements (Na, Ca, Mg and K) obtained in this study, is an indication that the studied vegetables can serve as source of mineral element supplements. Higher ND (>100%) for vegetables have also been reported by Yahaya *et al.* [2] and Omale *et al.*, [34] from common edible vegetables from Minna, Northern Nigeria and Ile-Ife, South-western Nigeria respectively.

Conclusion

The results obtained in this study have shown significant variations in proximate, mineral and trace metals, and nutrient density of five different vegetable commonly consumed in Akwa Ibom State. Also, the results have showed that vegetables from the studied abattoir soils contained appreciable amounts of crude lipid, protein, fibre, CHO and energy in addition to some mineral elements. Results of trace metals analysis of the vegetables indicated that they were present in low concentrations that were within the permissible limits for plants. This means that the vegetables studied may not be harmful and is not likely to produce any undesirable health effects if consumed. Nutrient densities greater than 100% obtained for all the vegetables from the abattoir soils shows that the vegetables can serve as additional source of mineral elements to the human body when consumed. This study therefore concludes that vegetables grown in abattoir impacted soils are richer in mineral elements and other proximate.

References

[1]. Adeyeye, A., Olufunmilayo, D., Ayodele, G., & Akinwumi, A. (2014). Evaluation of the Nutritional Composition of Some less Common Edible Leafy Vegetables in Nigeria. American Journal of Food Science and Nutrition. 5 (1): 26-31.

[2]. Yahaya, A., Suleiman, I., Rahmatallah, A., Alawode, B., & Usman, B. (2014). Nutrient Content of Selected Edible Leafy Vegetables. American Journal of Applied Chemistry, 2(3): 42-45.

[3]. Okafor, J. O. (1983). Horticultural Promising Indigenous Wild Plant Species of the Nigeria Forest Zone. Hort 123:165-176.

[4]. Bako, S. P., Luka, S. A., Bealo, E. B.; Aula, J. (2002). Ethanobotany and Nutrient Content of *Gnetum africana* in Nigeria. SCITECH Publishers, USA. 79-84.

[5]. Ooi, D. J., Shahid, I., & Maznah, I. (2012). Proximate Composition, Nutritional Attributes and Mineral Composition of *Peperomia pellucida* L. (Ketumpangan Air) Grown in Malaysia. Molecules, 17, 11139-11145.

[6]. Mosango, D.M (2008). *Peperomia pellucida* (L.) Kunth. In *Prota 11(1): Medicinal Plants/Plantes médicinales 1*; Schmelzer, G.H., Gurib-Fakim, A., Eds.; PROTA: Wageningen, The Netherlands,

[7]. Magaji, J. Y., & Chup, C.D. (2012). The Effects of Abattoir Waste on Water Quality in Gwagwalada-Abuja, Nigeria. Ethiopian Journal of Environmental Studies and Management, 54, 542 -549.

[8]. Nwachukwu, M. I., Akinde, S. B., Udujih, O. S. & Nwachukwu, I. O. (2011). Effect of Abattoir Wastes on the Population of Proteolytic and Lipolytic Bacteria in a Recipient Water Body (Otamiri River). Global Research Journal of Science, 1, 40 - 42

[9]. Mohammed, S., & Musa, J. J. (2012). Impact of Abattoir Effluent on River Landzu, Bida, Nigeria. Journal of Chemical, Biological and Physical Sciences, *2*(1), 132-136.

[10]. Mialoundama, F. (1993). Nutritional and socio-economic value of Gnetum leaves in Central African Forest. Parthenon Publishing Group, Carnforth, United Kingdom. pp 171-182.

[11]. Aletor, M. V., & Adeogun, O. A. (1995). Nutrient and anti-nutrient components of some tropical leafy vegetables, Food Chemistry, 53: 375 – 389.

[12]. Kokoette, R., Emmanuel, D**.**, & Uwemedimo, E., (2018). Comparative phyto-chemistry and trace metal level in leaf, seed and flowers of *Moringa oleifera* sourced from Akwa Ibom State. Chemical Science International Journal, 23(4): 1-10

[13]. Emmanuel I.A., & Folasade O.O. (2011). Chemical composition and functional properties of leaf protein concentrates of *Amaranthus hybridus* and *Telfairia occidentalis.* Agri. And Bio. J. of North Ameri, 2(3): 499-511.

[14]. Dimpe, K.M., Ngila, J. C., & Nomnogono, P. N. (2015). Evaluation of sample preparation methods for the detection of total metal content using inductively coupled plasma optical emission spectrometry (ICP-OES) in wastewater and sludge. Journal of Physical Chemical Earth, 76, 34 – 43

[15]. Onwordi, C., Ogungbade, A., & Wusu, A. (2009). The Proximate and Mineral Composition of Three Leafy Vegetables Commonly Consumed in Lagos, Nigeria. African Journal of Pure and Applied Chemistry, 3(6): 102- 107

[16]. Dan, E, U., Udo, U. E., and Ituen, E. B (2013). Comparative assessment of proximate and heavy metals composition in some selected vegetable leaves sourced from three major markets in Akwa Ibom State, Southern Nigeria. Aust. J. Basic and Appl. Sci., 7(8): 676 – 682

[17]. Ifon, E.T. & Bassir, O. (1979). The Nutritive Value of some Nigerian Leafy Green Vegetables, Vitamin and Mineral contents. Food Chemistry, 4(4): 263-267.

[18]. Eze, O. C., Tukura, B. W., Atolaiye, B. O., Opaluwa, O. D., & Ubani, K I (2018). Proximate composition and health risk evaluation of vegetables grown at a waste-water irrigated site in FCT, Abuja, Nigeria. Int. J. Adv. Sci. Res and Eng, 4(5): 10-22

[19]. Adepoju O. T. & Oyewole E. O. (2008). Nutritional importance and micronutrient potentials of two non– conventional indigenous green vegetables from Nigeria. Agric. J. 3(5): 362-365.

[20]. Iheanacho K., & Ubebani A. C. (2009). Nutritional composition of some leafy vegetables consumed in Imo State, Nigeria. J. Appl. Sci. Environ. Manage. 13 (3): 35-38.

[21]. Adeleke, R.O., & Abiodun, O.A. (2010). Chemical Composition of three traditional vegetables in Nigeria. *Pakistan Journal of Nutrition,* 9 (9): 658-860.

[22]. Rankin, W.M., Hilreth, E. M., Lake, B., & Waterworth, M. (1976). Foods and Nutrition, 12th edition, Clarke, Doble and Brendon Ltd, Plymonth, 140-143.

[23]. Rumeza, H., Zafar, I., Mudassar, S., & Masooma, R. (2006). Use of Vegetables as Nutritional Food: Role in Human Health. J. Agric. Biochem. Sci., 1: 18-20.

[24]. Inyang, U. E (2016). Nutrient content of four lesser-known leafy vegetables consumed by Efik and Ibibio people in Nigeria. Nigerian Journal of Basic and Applied Science, 24(1):1-5

[25]. Fasuyi, A. O. (2010). Nutritional potential of some tropical vegetables meal: Chemical characterization and functional properties. African Journal of Biotechnology, 5(1): 49 -53

[26]. Taiz, L (1997). Plant physiology, 2nd ed. Sinuaer Associate, Sunderland, Massachusetts. Pp. 24 – 35.

[27]. Mohd A. M., Idris, M. B. & Abdulrasheed, A. (2016). The mineral composition and proximate analysis of T. occidentalis (Fluted Pumpkin) leaves consumed in Kano metropolis, northern Nigeria. Am. Chem. Sci. J. 10 (1): 1-4.

[28]. Arora, M., Kiran, B., & Reni, S. (2008). Heavy metal accumulation in vegetables irrigated with water from different sources. Food Chem, 111:27 -36

[29]. Asaolu S. S., Adefemi O. S., Oyakilome I. G., Ajibulu K. E. & Asaolu M. F. (2012). Proximate and mineral composition of Nigerian leafy vegetables. J. Food Res. 1 (3): 214-218.

[30]. Ebong, G., Etuk, H., & Johnson, A. (2007). Heavy metals accumulation by *Talinum triangulare* grown on Waste Dumpsites in Uyo Metropolis, Akwa Ibom State, Nigeria. Journal of Applied Sciences, 7(10): 1404- 1409.

[31]. Oluyemi, E. A., Feuyit, G., Oyekunle, J. A. O., & Ogunfowokan, A. O. (2008), *Int. J.* Environmental Science and Technology, 2: 5, 89 – 96.

[32]. Cui, J., Zhu, Y., Chen, D., & Qui, Y (2004). Transfer of metals from near a smelter in Nanning, China. *Env Int.*, 30: 785 -791

[33]. Adams I. (2011). Focus on Nutrient Dense Foods and Beverages. European Journal of Food Science and Tech., 23(4): 12 -24

[34]. Omale, J. & Ugwu C. E. (2011). Comparative studies on the protein and mineral composition of some selected Nigerian vegetables. Afri. J. Fd. Sci. 5 (1): 22-25.