International Journal of Ecotoxicology and Ecobiology
2022; 7(1): 8-14
http://www.sciencepublishinggroup.com/j/ijee
doi: 10.11648/j.ijee.20220701.12
ISSN: 2575-1727 (Print); ISSN: 2575-1735 (Online)

Assessment of the Heavy Metals' Levels, Phytochemical Profiles, Mineral and Proximate Compositions of Four Commonly Consumed Vegetables in Lagos State, Nigeria

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To cite this article:
Oluwole Surukite Opeolu, Ogun Mautin Lawrence, Adamson Toluwaloju Olamide. Assessment of the Heavy Metals' Levels, Phytochemical Profiles, Mineral and Proximate Compositions of Four Commonly Consumed Vegetables in Lagos State, Nigeria. *International Journal of Ecotoxicology and Ecobiology*. Vol. 7, No. 1, 2022, pp. 8-14. doi: 10.11648/j.ijee.20220701.12

Received: November 11, 2021; **Accepted**: December 1, 2021; **Published**: January 24, 2022

Abstract: Safety of the environments (land, air and water) including plants and animals inhabiting it is a concern for many ecologists nowadays and this is due to human ecosystems' exploration. Thus, this study aimed at assessing the heavy metals' levels, phytochemical profiles, mineral and proximate compositions of four commonly consumed vegetables in Lagos State. Leaves of *Vernonia amygdalina*, *Telfairia occidentalis*, *Gnetum africanum* and *Parquetina nigrescens* were obtained in some major markets in Lagos State; the leaves of the vegetables were subjected to laboratory analysis for the determination of phytochemical, mineral, proximate and heavy metals' concentrations using standard procedures. Data obtained were subjected to analysis of variance (ANOVA). Proximate analysis revealed appreciable amount of protein, carbohydrate, fat, moisture and ash contents in the vegetables. The phytochemical profiling revealed the presence of some vital secondary metabolites viz: tannins, phenols, saponins, flavonoids, cardiac glycosides, steroid, phlobatanin, alkaloid and sugar except terpenoids within the four vegetables sampled. However, it was observed that *T. occidentalis* lack saponins; *P. nigrescens* contain no tannins and phenols while, G. *africanum* show no steroids and phlobatannins. Also, the analysis of metals revealed the range of minerals- K (27.51-68.09mg/100g), Mg (25.68-27.60mg/100g), Mn (0.31-1.06mg/100g), Zn (0.45-1.42mg/100g), Fe (2.20-6.65mg/100g), P (1.10-1.19mg/100g) and Na (1.36-2.15mg/100g) and heavy metals-Pb (0.10-0.28mg/100g), Ag (0.04-0.57mg/100g), Cd (.01-0.90mg/100g), Cu (2.95-3.35mg/100g), Cr (0.075-2.60mg/100g), Co (0.45-0.95mg/100g) and Ni (1.16-2.60mg/100g) and all these elements were within or below the World Health Organization's permissible limits for toxicity. Hence, these four vegetables commonly consumed in Lagos are good and toxic free for consumption and continuous check on the consumed vegetables in Lagos to avoid toxicity since it's a mega city with industrialization is recommended.

Keywords: *Vernonia amygdalina*, *Telfairia occidentalis*, *Gnetum africanum*, *Parquetina nigrescens*, Heavy Metals, Proximate Composition, Minerals, Phytochemicals

1. Introduction

Without any iota of doubt, vegetables are important in the maintenance of good health because of their nutritive and medicinal advantages (benefits). Ijeh *et al.* [1] documented that most veggies consist largely of water, fibre, vitamins and minerals. However, Farombi *et al.* [2] documented that good vegetables are sources of vitamin A and carotene. Vegetables are plants' cultivated for their edible parts or food purposes. They include leaves, stems, roots, fruits, seeds and so on [2]. The growing awareness of vegetables in diets is due to their easy nutrient supply, regulatory, protective and body building materials [3]. Several vegetables have been reported for their richness in various mineral elements (Mg, Ca, Na, Fe and so on) and phytochemical compounds like alkaloids, saponins, cardiac glycosides, tannins and so many others are needed by body for proper development [1-7]. Among these vegetables are *Corchorus olitorius*, *Amaranthus spinosus*, *Amaranthus viridis*, *Telfairia occidentalis*, *Celosia argentea*, *Talinum triangulare*, *Vernonia amygdalina*, *Parguetina nigrescens*,

Gnetum africanum, and many others [5-7].

Vernonia amygdalina Del. is often named as bitter leaf; a shrub that grows up to 1-3meters tall and is indigenous to Africa especially Lagos in Nigeria [8]. It belongs to the family Asteraceae and has a characteristic odour and bitter taste in every part of the plant due to the inherence of some secondary compounds like alkaloids, cardiac glycosides and many others [1, 2]. Bitter leaf is often used as a green veggie or as a condiment in soups. Also, bitter leaf is largely used for its medicinal potentials in treating fever, enema, infertility and many other ailments [1, 2, 9].

Telfairia occidentalis (Hook. F.) is an annual climber with fast growing potential and it's belonging to Cucurbitaceae family. It is commonly referred to as Fluted pumpkin which bears fruits that are heavy and furrowed. It is native to West Africa especially Nigeria [10, 11]. *T. occidentalis* are widely cultivated by it seeds. Fluted pumpkins' leaves are eaten in Nigeria (Lagos) as a green vegetable or main part of soup. The plant contains some anti-nutrients like saponnin, phytic acid, tannin and so on [10, 12] and proximate such as protein, vitamins, minerals [11, 13]. Fluted pumpkin leaves have also been reported to be rich in iron and minerals used in blood purification [3, 11].

Gnetumafricanum (Welw.) is a dioeciously forest perennial liana which grows up to 10m long and belonging to the family Gnetaceae [14]. It is commonly found in Nigeria and some other parts of Africa (West and Central) [15]. *G. africanum* is usually referred to as *Enu, Okazi*and*Afang* in Nigeria but known as *Koko* and *Nkoko*in both French and Portuguese respectively. *G. africanum* have been reported to contain some minerals- calcium, iron, magnesium, thiamine and carotene [16]) and some secondary compounds like tannins, oxalate and many others [4, 16]. The leaves are primarily used as food but its medicinal potentialshave also been documented. These medicinal potentials include treatment of sore throat, enlarged spleen, catarrh, nausea and as an antidote against arrow poison [14, 15].

Parquetina nigrescens (Afzel.) is a twine (herbaceous and perennial) which grows up to 7-8meter in length and is an Apocyanaceae family. *P. nigrescens* is usually seen growing on ant hills across the African religions [17]. It is commonly referred to as *Ewe Ogbon* in Nigeria among the Yorubas. *P. nigrescens* has been found to contain carotenoids, cardiac glycosides, alkaloids and so on [17, 18]. *P. nigrescens* leaves are usually consumed as vegetable in soups but leaves, bark, latex and roots have been reported for use in ethno-medicine for treating several diseases like diarrhea, skin lesion, menstrual disorder and many others [18, -20].

However, population explosion and poor waste management have increased the loss of arable lands and its consequence discharge of toxic, biodegradable and non-biodegradable wastes on lands [21]. These wastes contain some heavy metals that are poisonous to the body if taken by animals and human at certain concentration above the permissible limits. Yasser *et al.* [22] reported that heavy metals such as copper, zinc and lead are poisonous to the body if consumed above limits. More so, [6, 23] reported the buildup of heavy metals in some vegetables harvested on the roadsides and dumpsites in Lagos State.

Thus, this research was laid out to monitor the level of heavy metals, phytochemical status, mineral and proximate compositions of *V. amygdalina*, *T. occidentalis*, *P. nigrescens* and *G. africanum* in relation to their safety for consumption. Hence, threshold demand for vegetables in Lagos state, Nigeria has resulted in cultivation and harvesting of vegetables from unsafe places such as roadsides and dumpsites.

2. Materials and Methods

2.1. Collection of Materials

Vernonia amygdalina and *Telfairia occidentalis* were obtained at Tejuosho market in Surulere Local Government area, *Gnetum africanum* leaves were obtained at Akwa-Ibom Park, Ojuelegba in Yaba Local Government area while *Parquetina nigrescens* leaves were obtained at Oyingbo market in Mainland Local Government area, Lagos State, Nigeria.

2.2. Processing of Plant Materials

Fresh leaves of *Vernonia amygdalina, Telfairia occidentalis, Gnetum africanum* and *Parquetina nigrescens* were carefully and independently washed with water to remove dust. This was followed by air drying of the leaves at a steady temperature of 25°C for 3-4 weeks. The leaves were then milled to produce powder using electric grinder.

2.3. Proximate Analysis

The Analysis of proximate compositions of sampled vegetables was done to determine the moisture, ash, crude fibre and fat contents using AOAC methods [24]. Nitrogen was estimated using micro-Kjeldahl method as reported by Pearson [25] and the percentage nitrogen was converted to crude protein content by multiplying with 6.25. Carbohydrate was estimated by difference; that is: % Carbohydrate=100 - % Moiture - %Protein- %Fat- %Mineral. All findings were performed in triplicates.

2.4. Mineral and Heavy Metal Analysis

Mineral and Heavy Metal Analysis The mineral and heavy metal contents of the leafy vegetables were analyzed using the solution obtained by drying the samples at 55°C and dissolving the ash in distilled deionized water in flask. All the metals (K, Mg, Pb, Mn, Ag, Zn, Cd, Fe, Ni and Na) were analysed using atomic absorption and flame emission spectrophotometers (Gallenkamp model, United Kingdom) [26]. All analyses were carried out in triplicates.

2.5. Sample Extraction for Phytochemistry

Fifty grams (50g) each of the powdered leave samples was weighed into labeled sample bottles and moistened with 100ml of 80% methanol. The bottles were covered with coverlids and the mixture was allowed to stand for 24 hours. The extracts were placed on a water-bath at 45^{o}C to dry off the methanol. Thus, residues were kept as crude extract for

phytochemical analysis. This was done for all the vegetable samples.

2.6. Qualitative Screening of Phytochemicals

The qualitative screening of phytochemicals for each of the vegetables was evaluated according to the standard methods previously reported by AOAC [26], Mohammed et al. [27], Ojewumi and Dedeke [28] and Oluwole *et al*. [7]. Vegetables were screened for total flavonoids, tannins, phenols, saponins, terpenoids, cardiac glycosides, steroids, phlobatanins, alkaloids and sugar. These phytochemicals were only screened for their presence or absence in the vegetables.

2.7. Statistical Analysis

The data collected from the analyses of various parameters was analyzed using the mean and standard deviation; the means were compared using analysis of variance (ANOVA) with the aid of the software SPSS 2007 version 20. Least Significance Difference test (LSD) was done using Duncan's Multiple Range Test at the 95% probability level.

3. Results

3.1. Proximate Compositions of Four Commonly Consumed Vegetable in Lagos

Table 1 shows the proximate compositions of four commonly consumed vegetables in Lagos, Nigeria. The results revealed that percentage moisture (6.80%) and crude protein (10.91%) contents *in P. nigrescens* is highly significant (P≤0.05) than those in other vegetables (Table 1). *V. amygdalina* contained the highest percentage of crude fibre (9.86%). *G. africanum* is significantly (P≤0.05) the highest in carbohydrate content compared to other vegetables. *V. amygdalina* and *P. nigrescens* are significantly (P≤0.05) the highest in crude fat (0.99%) and ash (4.88%) contents respectively compared to other vegetables (Table 1).

3.2. Phytochemical Screening of Four Vegetables Commonly Consumed in Lagos

Table 2 shows the qualitative phytochemical compositions of four vegetables commonly consumed in Lagos, Nigeria. The results revealed that tannins and phenols are present in *V. amygdalina, T. occidentalis* and *G. africanum* but absent in *P. nigrescens* (Table 2). Flavonoids, Cardiac glycosides, alkaloids and sugar are present in all the four vegetables. Saponin is absent in *T. occidentalis* while Steroids and Phlobatanins are absent in *G. africanum*. However, Terpenoids are absent in all the vegetables (Table 2).

3.3. Minerals and Heavy Metal Analyses of Four Vegetables Commonly Consumed in Lagos

Table 3 shows the mineral and heavy metals' compositions of four vegetables commonly consumed in Lagos. The results revealed that potassium (K) content in *T. occidentalis* is the most highly significant (P≤0.05) across the sampled vegetables with *P. nigrescens*having the least significant values for K (Table 3). Lead (Pb) contents in T. occidentalis and P. nigrescens are not significantly different from each other, as well as the Pb contents in *V. amygdalina* and *G. africanum*. However, the manganese contents in the four vegetables are insignificantly (P≤0.05) different from each other (Table 3).

More so, the silver (Ag), zinc (Zn) and cadmium (Cd) contents in the four vegetables are insignificantly (P≤0.05) different from each other with *T. occidentalis* showing the highest values for Ag and Cd; and *V. amygdalina* for Zn respectively. The iron (Fe) and Magnesium (Mg) contents in T. occidentalis has the values but insignificantly (P≤0.05) different from other vegetables (Table 3). Nickel contents of *P. nigrescens* are highly significantly (P≤0.05) different from other vegetables. Sodium and copper contents are insignificantly different from each other across the vegetables (Table 3).

Moreover, the phosphorus contents in *V. amygdalina* and *G. africanum* are significantly (P≤0.05) different from others across the vegetables; the chromium values in V. amygdalina are significantly (P≤0.05) different from others across the vegetables, while cobalt values in *T. occidentalis* are significantly (P≤0.05) different for others across the vegetables (Table 3).

Table 1. *Proximate compositions of Four Commonly Consumed Vegetables in Lagos.*

Vegetables	Moisture	Protein	Crude Fibre	Carbohydrate	Crude Fat	Ash
V. amygdalina						
Mean ± S.D	5.09±0.03^{b}	8.67±0.13^{c}	9.86±0.14^{a}	71.20±0.19^{a}	0.99±0.07^{a}	4.19±0.02^{a}
Range	5.06 - 5.12	8.55 - 8.80	9.73 - 10.01	71.05 - 71.41	0.93 - 1.06	4.17 – 4.21
T.occidentalis						
Mean ± S.D	2.60±0.03^{c}	9.76±0.09^{b}	8.94±0.18^{bd}	74.46±0.08^{b}	0.63±0.03^{b}	3.60±0.04^{b}
Range	2.58 - 2.63	9.68 – 9.86	8.81 - 9.14	74.37 -74.53	0.60 – 0.65	3.57 – 3.64
P. nigrescens						
Mean ± S.D	6.80±0.06^{a}	10.91±0.11^{a}	9.28±0.07^{c}	67.51±0.18^{c}	0.62±0.01^{bc}	4.88±0.05^{c}
Range	6.75 -6.87	10.81–11.03	9.21 – 9.35	67.35 - 67.71	0.61 – 0.63	4.83 – 4.93
G. africanum						
Mean ± S.D	2.03±0.02^{d}	7.80±0.07^{d}	9.03±0.21^{bcd}	77.63±0.12^{d}	0.21±0.02^{d}	3.31±0.03^{d}
Range	2.01 -2.05	10.53-10.71	8.86 – 9.26	77.49 -77.72	0.19– 0.23	3.28 – 3.34

SD=Standard deviation; Means ± S.D (%) in the same column that do not have similar alphabets at P≤0.05 are significantly different according to one-way Analysis of Variance (ANOVA-1).

Table 2. *Phytochemical Screening of four vegetables commonly consumed in Lagos.*

Parameters	*V. amygdalina*	*T.occidentalis*	*P. nigrescens*	*G. africanum*
Tannins	+	+	-	+
Phenols	+	+	-	+
Saponins	+	-	+	+
Flavonoids	+	+	+	+
Terpenoids	-	-	-	-
Cardiac Glycosides	+	+	+	+
Steroids	+	+	+	-
Phlobatannin	+	+	+	-
Alkaloids	+	+	+	+
Sugar	+	+	+	+

Present (+); Absent (-).

Table 3. *Mineral and Heavy Metals' Compositions of Four Vegetables Commonly Consumed in Lagos.*

Parameters	*V. amygdalina* (*mg/100g*)	*T. occidentalis* (*mg/100g*)	*P. nigrescens* (mg/*100g*)	*G. africanum* (*mg/100g*)	*WHO [29] Permissible Limit (mg/100g)*
K (Potassium)					
Mean ± S.D	48.29±27.27^{a}	68.09±0.00^{d}	27.51±1.15^{b}	27.78±0.46^{bc}	N.A
Range	29.01 - 67.58	68.08 - 68.10	26.70 -28.70	27.45 - 28.10	
Pb (Lead)					0.30
Mean ± S.D	0.25±0.05^{ac}	0.10±0.01^{a}	0.16±0.05^{ac}	0.28±0.02^{cd}	
Range	0.22 - 0.29	0.09 - 0.11	0.13 - 0.19	0.27 - 0.29	
Mn (Manganese)					
Mean ± S.D	0.31±0.05^{abcd}	1.06±0.01^{abcd}	0.50±0.06^{abcd}	0.64±0.01^{abcd}	500.00
Range	0.28 - 0.34	1.05 - 1.07	0.46 - 0.54	0.60 - 0.69	
Ag (Silver)					
Mean ± S.D	0.04±0.03^{abcd}	0.57±0.05^{abd}	0.28±0.01^{ad}	0.26±0.08^{abcd}	5.00
Range	0.02 - 0.06	0.54 - 0.61	0.27 - 0.29	0.20 - 0.32	
Zn (Zinc))					
Mean ± S.D	1.42±0.17^{abcd}	0.88±0.01^{abd}	0.83±0.09^{acd}	0.45±0.01^{abcd}	60.00e
Range	1.29 - 1.54	0.88 - 0.89	0.77 - 0.89	0.44 - 0.45	
Cd (Cadmium)					0.10
Mean ± S.D	0.02±0.00^{bc}	0.90±0.00^{acd}	0.01±0.00^{ab}	0.02±0.00^{b}	
Range	0.01 - 0.03	0.00 - 0.00	0.00 - 0.02	0.01 - 0.02	
Fe (Iron)					
Mean ± S.D	3.76±0.53^{abd}	6.65±0.01^{acd}	4.54±0.47^{bd}	2.20±0.07^{abcd}	425.00
Range	3.39 - 4.13	6.56 - 6.74	4.20 - 4.88	2.15 - 2.24	
Mg (Magnesium)					
Mean ± S.D	26.69±0.35^{bd}	27.60±0.01^{acd}	25.68±0.30^{bd}	26.84±0.01^{abc}	N.A
Range	25.94 - 26.44	27.59 - 27.60	25.47-25.89	26.83 - 26.85	
Ni (Nickel)					
Mean ± S.D	1.30±0.02^{cb}	1.24±0.02^{cb}	2.60±0.0^{d}	1.16±0.03^{abc}	1.50
Range	1.28 - 1.31	1.22 - 1.25	2.58 - 2.63	1.14 - 1.18	
Na (Sodium)					4.00
Mean ± S.D	2.10±0.23^{bd}	1.36±0.01^{acd}	2.15±0.32^{bd}	1.87±0.15^{d}	
Range	1.93 - 2.26	1.35 - 1.36	1.92 - 2.37	1.77 - 1.98	
Cu (Copper)					10
Mean ± S.D	3.35±0.03^{ab}	2.95±0.03^{bd}	3.05±0.05^{ab}	2.95±0.02^{bd}	
Range	2.58 - 4.12	2.38 - 3.52	2.58 - 3.53	2.58 - 3.32	
P (Phosphorus) Mean ±S.D	1.15±0.03^{c}	1.55±0.01^{ab}	1.10±0.03^{c}	1.95±0.03^{bd}	NA
Range	1.08 - 1.22	1.42 - 1.68	0.58 - 1.62	1.68 - 2.22	
Cr (Chromium)					2.00
Mean ± S.D	2.60±0.03^{a}	0.75±0.02^{bc}	0.80±0.01^{bc}	0.75±0.02^{bc}	
Range	2.58 - 2.63	0.58 - 0.92	0.48 - 1.12	0.58 - 0.92	
Co (Cobalt)					
Mean ± S.D	0.95±0.03^{ab}	0.45±0.01^{c}	0.80±0.02^{abc}	0.60±0.01^{abc}	
Range	0.58 - 1.32	0.38 - 0.52	0.58 - 1.02	0.38 - 0.82	

SD=Standard deviation; Means ± S.D (%) in the same column that do not have similar alphabets at P≤0.05 are significantly different according to one-way Analysis of Variance (ANOVA-1); NA=None Available.

4. Discussion

4.1. Proximate Compositions of Four Vegetables Commonly Consumed in Lagos

Proximate analyses of four vegetables commonly consumed in Lagos as shown in Table 1. Percentage moisture contents ranged between 2.03-6.80% in all the vegetables (*V. amygdalina, T. occidentalis, P. nigrescens and G. africanum*). These percentages were close to those investigated by Hussain*et al*. [30] and Oluwole *et al*. [6, 7]. But, Odoh *et al*. [31], Oluwole*et al*. [5] and Chatepa and Masamba [32] had previously reported increase in the moisture contents for some vegetables in Nigeria and Malawi. These reductions in moisture have been attributed to increase in shelf life of the vegetables. Crude protein contents ranged between 7.80-10.91% in for vegetables. These percentages agreed with those reported by Oluwole *et al*. [7] but were lower than those reported by Odoh *et al.* [31] and Chatepa and Masamba [32] for some commonly consumed vegetables Africa. Thus, plant based proteins are reported to supply up to 12% body proteins [33]. Crude fibre contents recorded ranged from 8.94-9.86% in all the four vegetables studied. This value was close to those reported by Oluwole *et al*. [7] but was below those documented by Odoh *et al*. [31], Oluwole et al. [5] and Chatepa and Masamba [32] for some African vegetables. Crude fibres havebeen documented to aid human wellbeing if consumed appropriately. However, carbohydrate contents in the four vegetables ranged from 67.51-77.63%. These values conform to the findings of Hussain *et al*. [30] and Oluwole *et al.* [7] but were above those documented by Odoh *et al*. [31]. Carbohydrates are one of the essential energy sources in diet and as much as 60% may be provided [34]. Crude fat contents of the four vegetables ranged from 0.21-0.99%. These valuesare close to the values documented for some Nigeria vegetables [7, 34] but the values were lower than those investigated in earlier researches [30-32]. Vegetable fats are said to be rich in basic unsaturated fatty acids which are considered to be significant in human diet and health. Crude ash contents recorded for the four vegetables ranged from 3.31-4.88%. These values were close to the values documented by Odoh *et al*. [31] and Oluwole *et al.* [7]. Ash content is essential in food for its supportive role in mineral constituents of the body.

4.2. Phytochemical Compositions of Four Commonly Consumed Vegetables in Lagos

Qualitative phytochemical screening of *V. amygdalina, T. occidentalis, P. nigrescens and G. africanum* commonly consumed in Lagos revealed the presence of somevital secondary metabolites viz: tannins, phenols, saponins, flavonoids, cardiac glycosides, steroid, phlobatanin, alkaloid and sugar except terpenoids (Table 2). However, it was observed that *T. occidentalis* lacksaponins; *P. nigrescens* contain no tannins and phenols while, G. *africanum* shows no presence of steroids and phlobatannins. This finding was similar to findings of Oluwole*et al*. [7] when they reported similar metabolites in some vegetables commonly sold in Lagos markets. Also, Khan *et al* [35], Adu *et al*. [4] and Huzafa*et al.* [36] reported the presence of similar metabolites in *Incarvil leaemodi* and *Piper guineense.* These phytochemicals such as tannins, phenols, saponins, flavonoids, cardiac glycosides, steroid, phlobatanin, alkaloid and many others have been reported for protection against diseases by contributing along with antioxidants, vitamins and enzymes, thus improving the total human defense system. It is further suggested that these plants have antispasmodic, anti-diabetic properties and anti-tumor activities and are due to the presence of certain specific metabolites and carbohydrates which add up to plants' leaves medicinal abilities [28].

4.3. Mineral and Heavy Metal Analyses of Four Vegetables Commonly Consumed in Some Lagos

Mineral and heavy metal analyses on *V. amygdalina, T. occidentalis, P. nigrescens and G. africanum* commonly consumed in Lagos were carried out. The study revealed the presence of minerals (K, Mg, Mn, Zn, Fe and Na) and heavy metals (Pb, Ag, Cd and Ni) were within or below the World Health Organisation's [29] permissible limit or accepted world standards (Table 3). It further revealed that Lead (Pb), Cadmium (Cd) Cobalt (Co) Phosphorus (P) and Nickel (Ni) were within permissible limits as recommended by World Health Organization. This study conformsto other several studies [4, 6, 7, 23, 31, 37-39]. All these studies found out that most of the vegetables consumed in Lagos and other parts of the world are safe for consumption. However, the minerals are known for their effects on various human body metabolisms based on concentrations.

5. Conclusion

From the findings of the study, it could be deduced that the four vegetables (*V. amygdalina, T. occidentalis, P. nigrescens and G. africanum*) commonly consumed in Lagos are rich in proximate and mineral nutrients needed by the body for normal and effective functioning. It also revealed the inherence of some essential metabolites- saponins, cardiac glycosides alkaloids and many others which vary except terpenoid, which shows their medicinal potentials in correcting some ailments. More so, the results further revealed that the four vegetables contained minerals and heavy metals which are within or below the World health Organization's permissible limits for toxicity. Hence, these four vegetables commonly consumed in Lagos are good and toxic free for consumption. However, this study recommends continuous check on the consumed vegetables in Lagos to avoid toxicity since it's a mega city with industrialization.

Acknowledgements

Authors sincerely acknowledge the authorities of Lagos

State University, Ojo, Nigeria for providing the laboratory facilities. This research did not receive any funding from any agencies either in the public and commercial sectors.

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