Asian Journal of Research in Botany

5(2): 42-52, 2021; Article no.AJRIB.65681

Phytochemical Screening, Proximate Compositions and Heavy Metal Concentrations of Four Commonly Sold Vegetables in Some Lagos Markets, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors OSO and AKY designed the study. Authors LMO and OKA performed the statistical analysis. Authors LMO and OKA wrote the first draft of the manuscript. Authors LMO and OKA managed the analyses of the study. Author LMO managed the literature searches. All authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Vinayaka K.S, Kumadvathi First Grade College, India.
Reviewers:
(1) Debi Sharma, ICAR-Indian Institute of Horticultural Research, India.
(2) J. J. Dhruv, Anand Agricultural University, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/65681

Original Research Article

Received 17 December 2020
Accepted 11 February 2021
Published 02 March 2021

ABSTRACT

Leafy vegetables are part of African households and these vegetables are eaten for their nutritive and medicinal uses. Scarcity of the vegetables has increased the demands. However, environmental pollution is a challenge on their safety. *Gongronema latifolium, Piper guineense, Lasianthera africana, Heinsia crinata* vegetables obtained from different markets in Lagos, Nigeria. Phytochemical, proximate and heavy metal analyses of the vegetables were carried out. These four vegetables were shown to be rich in nutrients. They also contained appreciable secondary metabolites- saponins, alkaloid etc. content of which may vary except terpenoids. However, mineral and heavy metal analyses revealed the ranges of K(29.43-68.09 mg/kg), Mg(26.33-28.41 mg/kg), Pb(0.01-0.03 mg/kg), Mn(2.44-21.84 mg/kg), Ag(0.01-0.24 mh/kg), Zn(0.54-1.34 mg/kg), Cd(0.01-0.02 mg/kg), Fe(2.17-3.92 mg/kg), Ni(1.22-1.46 mg/kg) and Na (1.84-4.32 mg/kg) in all the vegetables. These metals are within or below the W.H.O and other known world agencies' permissible limits. Thus, the vegetables are safe for consumption as at the time of this research.

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However, despite the fact that the heavy metals' concentration of the vegetables are within or below permissible limits, variation occurred in metallic compositions of the vegetables. Thus, this may serve as an indicator that the sources or locations in which these vegetables are grown before they are taken to markets should be monitored.

Keywords: Phytochemicals; proximate composition; heavy metals; gongronema latifolium; piper guineense; lasianthera Africana; heinsia crinata.

1. INTRODUCTION

Vegetables are plants whose part or parts are eaten as supporting foods or main dishes and they maybe aromatic, bitter or tasteless[1]. The use of leafy vegetable is part of Africa's cultural heritage and they play vital roles in the customs, traditions and food culture of the African households. Nigeria is endowed with varieties of vegetables and different types are consumed by various ethnic groups for different reasons. These reasons include medicinal, nutritive and so on [2-5]. Sofowora [6] reported that some of these vegetables are used for bones, teeth, blood, muscles, hair and nerve cells. Vegetable constitutes the cheapest and most available sources of proteins, vitamins, minerals and essential amino acids.

Several studies have reported the discovery of different active compounds in plants especially vegetables on the basis of their enthnobotanical information and direct use in patent drug production [7-10]. There are different kinds of vegetables known to man. Thus, vegetables are edible roots, stems, leaves, fruits or seeds. Each group contributes to diet in its own way [11-13]. Examples of vegetables include *Gongronema latifolium, Piper guineense, Lasianthera africana, Heinsia crinata, Amaranthus cruentus,* and many others.

Gongronema latifolium Benth is a climber belonging to the family *Asclepiadaceae*. It is a plant with woody hollow glabrous stems and characterized with greenish yellow flowers [14]. It is commonly found in forests in the tropical Africa. It is propagated by seeds or stem cuttings. *G. latifolium* is commonly referred to as Utazi, Arokeke or Madumaro [15]. *G. latifolium* is used as leafy vegetable and spice for sauces, soups and salads owing to its sharp-bitter and sweet tastes, showing evidence for more phytochemicals such as saponins, alkaloids and so on [16,17]. It is also used for spicing local beer, stems often chewed as chewing sticks and generally for treating diarrhea, cough, diabetes, high blood pressure and many more [18-21].

Piper guineense is a vine belonging to the family *Piperaceae*. It is a plant that climbs up to 13 meter high. *P. guineense* is often found in all West African countries [22-25]. In Nigeria, it is often called Iyere and Uziza [25]. The plant has been reported to contain some organic compounds such as alkaloids, phenols, alcohol and so on [19,26]. *P. guineense* has been reported for use as food spice, treatment of ailments such as epilepsy, rheumatism, stomach aches [19,27]. Also, other potentials such as mulluscillicidal, antibacterial, pisicidiadal, abortifaclent and many others have been reported for *P. guineense* [26,28].

Lasianthera africana is a perennial glabrous shrub of the family *Icacinaceae (Stemonuracea)*. It is a plant whose height may reach 61-136 centimeter and is widely distributed in the tropics of Africa and Asia [29]. It is commonly referred to as *Editan* in Nigeria. *L. africana* have been reported to have four ethno-varieties often distinguished by their tastes, leaf colours and ecological distributions. *L. africana* leaves are often consumed as vegetable in Nigeria. The therapeutic properties such as antacid, analgesic, antispasmodic, laxative, anti-pyretic, anti-malaria and many others have been reported for *L. africana* [30-33].

Heinsia crinata is a scrambling shrub that grows to a height of 8-13 meter and belongs to the family *Rubiaceae*. It is commonly known as Bush Apple. it is often referred as Atama, Tonopoho or Fumbawa in Nigeria. It is often found in the Tropics of Central and West Africa [10]. The plant has been reported for the treatment of various ailments such as hypertension, arthritis, and many other diseases [34-38]. *H. crinata* is a fine palatable soup vegetable eaten popularly in Nigeria.

The continuous demand for vegetables and scarcity of arable lands for farming all over the world especially in Nigeria has been tremendously challenging for farmers. Thus, safety of most vegetables sold in Lagos markets cannot be guaranteed. This is because locations

have been reported to control the quality and quantities of nutrients. Oluwole et al. [11-13,39] reported that human activities and some soil properties have effects on the proximate and metal levels of some leafy vegetables popularly grown in Lagos. It is on this that the study tends to screen for the phytochemical, proximate composition and heavy metals concentration in four vegetables commonly sold in some Lagos markets.

2. MATERIALS AND METHODS

2.1 Collection of Materials

Gongronema latifolium and *Piper guineense* were obtained at Mushin market in Mushin Local Government area, *Heinsia crinata* was obtained from Okokomaiko market in Ojo Local Government area while *Lasianthera africana* was obtained from Oyingbo market in Mainland Local Government area, Lagos State, Nigeria.

2.2 Processing of Plant Materials

Fresh leaves of the vegetables were thoroughly and separately washed with distilled water. Afterwards, they were air dried by exposing the leaves to a constant room temperature at 25°C for 3-4 weeks. The leaves were then grounded into fine powder using dried pestle and mortar.

2.3 Proximate Analysis

The proximate analysis for leafy vegetable samples for moisture, ash, crude fibre and fat were carried out following the standard AOAC methods [40]. Nitrogen was determined by micro-Kjeldahl method as described by Pearson [41] and the percentage nitrogen was converted to crude protein content by multiplying with 6.25. Carbohydrate was determined by difference; that is: %Carbohydrate= 100- %Moiture - %Protein- %Fat- %Mineral. All findings were performed in triplicates.

2.4 Mineral and Heavy Metal Analysis

The mineral and heavy metal content of the leafy vegetable were analysed 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 spectrophotometer (Gallenkamp model, United Kingdom) [42]. All analyses were carried out in triplicates.

2.5 Sample Extraction for Phytochemistry

50 g of each of the powdered vegetable samples were weighed into labeled sample bottles and moistened with 100 ml of 80% methanol. The bottles were covered with lids and the mixture was allowed to stand for 24 hours. The extracts were placed on a water-bath at 45^{o}C to evaporate the methanol. The residues thus obtained were used as crude extract for phytochemical analysis.

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 [42], Mohammed et al. [43] and Adu et al. [44]. 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.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Proximate compositions of four commonly sold vegetable in some Lagos markets

Table 1 shows the proximate analysis of four commonly sold vegetables in some Lagos markets. The results revealed that *Lasianthera africana* and *Piper guineense* contained similar moisture contents; also, *Heinsia crinata* and *Gongronema latifolium* has similar moisture contents. *Piper guineense* showed the highest protein percentage followed *Heinsia crinata* compared to the other vegetables (Table 1). *Lasianthera africana* had higher crude fibre content followed by *Heinsia crinata* and *Piper guineense* respectively. All the four vegetables had similar percentage carbohydrates and crude fat except *Lasianthera africana* (Table 1). *Gongronema latifolium* has the highest dry ash percentage.

3.1.2 Phytochemical analysis of four commonly sold vegetables in some Lagos markets

Table 2 shows the phytochemical screening of four commonly sold vegetables in some Lagos

Table 1. Proximate composition (%) of four commonly sold vegetables in Lagos Markets

Vegetables	Moisture	Protein	Crude fibre	Carbohydrate	Crude fat	Ash
Lasianthera africana						
Mean ± S.D	5.72 ± 0.04	6.67 ± 0.09	10.80 ± 0.05	71.80 ± 0.07	0.17 ± 0.12	4. 74 ± 0.11
Range	5.68 - 5.76	6.57 –6.75	10.84 – 10.93	71.74 -71.87	0.15 – 0.18	4.63 – 4.84
Heinsia crinata						
Mean ± S.D	4.02 ± 0.05	8.53 ± 0.18	6.24 ± 0.45	76. 29 ± 0.30	1.05 ± 0. 03	3.89 ± 0.03
Range	3.97 - 4.05	8.38 – 8.73	5.92 –6.75	75.88 -76.67	1.02 – 1.08	3.86 – 3.92
Gongronema latifolium						
Mean ± S.D	4.05 ± 0.03	6.54 ± 0.31	3.80 ± 0.20	77.63 ± 0.04	1.36 ± 0.03	6.62 ± 0.05
Range	4.01 -4.06	6.29 – 6.89	3.46 – 4.02	77.59 -77.67	1.33 – 1.38	6.58 – 6.67
Piper guineense						
Mean ± S.D	5.20 ± 0.02	10.64 ± 0.09	5.44 ± 0.03	74.60 ± 0.05	0.56 ± 0.02	3.56 ± 0.03
Range	5.18 -5.22	10.53 – 10.71	5.40 – 5.46	74.53 -74.65	0.54 – 0.58	3.52 – 3.61

SD = Standard deviation

Table 2. Phytochemical screening of four commonly sold Vegetables in some Lagos markets

Phytochemicals/ vegetables	*L. africana*	*H. crinata*	*G. latifolium*	*P. guineense*
Tannin	-	+	-	-
Phenol	-	+	-	-
Saponin	+	+	+	+
Flavonoid	+	-	+	+
Terpenoid	-	-	-	-
Cardiac glycoside	+	+	+	+
Steroid	-	-	+	-
Phlobatanin	+	+	-	+
Alkaloid	+	+	+	+
Sugar	+	+	+	+

(+) Present; (-) Absent

markets. The results revealed that tannin and phenol are present in *H. crinata* only. Saponin, cardiac glycosides, alkaloid and sugar are present in all the four vegetables (Table 2). Also, flavonoid is absent in *H. crinata*, while steroids are not detected in both *L. africana* and *H. crinata*. However, Terpenoids are absent in all the four vegetables (Table 2).

3.1.3 Heavy metal analysis of four commonly sold vegetables in some Lagos markets

Table 3 shows the heavy metals concentrations of four commonly sold vegetables in some Lagos markets. The results revealed that the concentration of potassium (K) in *Piper guineense* was higher followed by that of *Gongronema latifolium* and *Lasianthera africana* while *H. crinata* had the least concentration of K metal (Table3). The magnesium (Mg) concentrations of all the vegetables sampled were similar with *H. crinata* showing the least concentration (Table 3). The concentration of lead (Pb) metal in *G. latifolium* is higher than those in other vegetables with *H. crinata* having the least concentration of Pb metal (Table 3). *L. africana* and *G. latifolium* have similar concentration for Manganese (Mn) metal, simultaneously had the highest concentrations while *P. guineense* and *H. crinata* had the least concentration values respectively (Table 3). The concentration of silver (Ag) metal in the four vegetables showed that *P. guineense* and *G. latifolium* had the highest concentration values respectively (Table 3). The concentrations of Zinc (Zn) metal in all the four vegetables sampled were close with *H. crinata* having the least concentration values of Zn metal (Table 3). The cadmium (Cd) concentrations in *G. latifolium*, *L. africana* and *P. guineese* were similar while *H. crinata* had the least (Table 3). More so, the iron (Fe) concentrations in the four vegetables were close with *H. crinata* showing the least concentration (Table 3). Nickel (Ni) concentrations in *H. crinata*, *G. latifolium* and *P. guineense* were similar except for *L. africana* that contained higher concentration (Table 3). However, *L. africana* and *H. crinata* had close values for sodium (Na); *G. latifolium* and *P. guineense* showed similar values for Na (Table 3).

Table 3. Mineral and heavy metal analysis (mg/kg) of four commonly sold vegetables in some Lagos market

Vegetables/Metals	Potassium-K	Magnesium Mg	Lead Pb	Manganese Mn	Silver Ag	Zinc Zn	Cadmium Cd	Iron Fe	Nickel Ni	Sodium Na
Lasianthera africana										1.84± 0.59
Mean ± S.D	38. 20 ±11.08	27.18 ± 0.06	0.25 ±0.01	21.84 ± 0.62	0.24±0.16	1.34± 0.01	0.02± 0.01	3.13 ± 4.41	1.46 ±0.05	1.42- 2. 25
Range	30.18 - 45.85	27.14 - 27.22	0.24 - 0.25	21.40- 22.27	0.13 -1.35	1.33 - 1.35	0.01 - 0.02	0.01 - 6.25	1.36 - 1.56	
Heinsia crinata										
Mean ± S.D	29. 43 ± 1.51	26.33 ± 0.27	0.10 ±0.01	2.44 ± 0.65	0.01± 0.02	0.54± 0.12	0.01± 0.00	2.17 ± 0.32	1.26 ±0.05	1.73± 0. 28
Range	28.36- 30.49	26.14 - 26.52	0.03 - 0.17	1.98- 2.90	0.08 -0.11	0.45 - 0.62	0.00 - 0.02	1.94 - 2.39	1.22- 1. 29	1.42- 2. 25
Gongronema latifolium										
Mean ± S.D	44. 55 ± 0.98	28.03 ± 0.01	0.30 ±0.02	20.11 ± 0.13	0.05± 0.06	1.24± 0.01	0.02± 0.01	3.92 ± 0.04	1.22 ±0.01	3.59±0. 01
Range	43.85- 45.2	28.02 - 28.04	0.23 - 0.39	20.01- 20.20	0.01 -0.09	1.23 - 1.25	0.01 - 0.02	3.89 - 3.95	1.20- 1. 24	3.58- 3. 60
Piper guineense										
Mean ± S.D	68. 09 ± 0.00	28.41 ± 0.23	0.22 ±0.01	4.03 ± 1.65	0.07± 0.08	1.13± 0.21	0.02± 0.01	3.71 ± 0.34	1.25 ±0.01	4.32±0. 02
Range	68.00- 68.18	27.14 - 27.22	0.21 - 0.22	2.86- 5.19	0.01 -0.13	0.92 - 1.34	0.01 - 0.02	3.45 - 3.95	1.24 - 1.26	3.72 - 4.87
Standard Permissible Limit	N. A[h]	N.A[h]	0.30[b] 0.20[g]	500.00[b]	5.00[d]	60.00[e]	0.10[b] 0.03[c]	425.00[b]	1.50[a]	4.00[a] 5.00[f]

S.D= Standard deviation

[a]WHO/FAO (Codex Alimentarius Commission. Joint FAO/WHO [45]) and Indian Standard Awashthi [46]; [b]WHO (Codex Alimentarius Commission, Joint FAO/WHO[47] and codex alimentarius commission [48]; [c]European Union (EU)[49]; [d]WHO/FAO (FAO/ WHO,codex general standard for contamination and toxin in foods, [50]; [e]WHO (codex alimentarius commission[51]; [f]Agency for toxic substance disease registry (ATSDR, [52]); [g]China food hygiene standard, [53]; [h]N.A (None Available for vegetables)

3.2 Discussion

3.2.1 Proximate compositions of four commonly sold vegetables in Lagos markets

Proximate analyses of the four commonly sold vegetables in Lagos markets are shown in Tables 1. The percentage moisture contents of *L. africana, G. latifolium, H. crina and P. gineense* ranged from 4.02% to 5. 72% in the vegetables obtained the markets (Table 1). These percentages are similar to those reported earlier for some leafy vegetables by Oluwole et al. [39]. Also, Onwordi et al. [53] and Oluwole et al [11] had earlier reported higher moisture content in some commonly consumed leafy vegetables in Nigeria. More so, the lower moisture contents in vegetables have been attributed to increase storage life [54]. However, this variation has been attributed to differences in soil compositions, mineralization and ecological factors such as water [11-13,55]. Thus, moderate moisture content has been reported to support the activities of water soluble enzymes and co-enzymes which are needed for metabolism [56]. Crude protein contents of the four vegetables sampled ranges from 6.54-10.04% (Table 1). This result was lower than what was reported by Onwordi et al. [53], Fagboun et al. [57], Asaolu et al. [58] and Oluwole et al. [12,39] in some vegetables such as Bitter leaf (50.64%), Indian Spinach (58.80%), Bush-buck (66.60), Scent leaf (62.71%), *Amaranthus hydridus* (49.02%), *Hibiscus sabdariffa* (46.56%), *Telfairia occidentalis* (61.70%). But the result of this finding was higher than the findings of Oluwole et al. [11]. Thus, foods of plant base that supply the body with more than 12% of protein have been reported to be good source of protein [59,60].

Crude fibre contents of the four sampled vagetables ranged from 3.80-10.84% (Table 1). This conformed to the reported range values (8.50-20.90%) for some Nigerian Vegetables [11-13,61]. However, fibres have reported to aid good health and provision of essential nutrients when consumed in the appropriate combination [62]. Carbohydrate contents in the four vegetables sampled ranged from 71.80-77.63% (Table 1). The value obtained for carbohydrates was above the range of 1.22-57.17% as reported by Sanni and Olaofe [63], Onwordi et al. [53], Asaolu et al. [58]; Oluwole et al. [11,39] for *A. cruentus*, *C. olitorius*, *A. argenta, Vernonia amygdalina, O. gratissimum* and *Hibiscus sabdarifa*. Carbohydrate constitutes a major class of naturally occurring organic compounds which are essential for the maintenance of life and also provide raw materials for many industries [64]. Percentage fat contents for the sampled vegetables (*L. africana, G. latifolium, H. crina and P. gineense)* ranged from 0.17-1.36% in some Lagos markets (Table 1). These values were similar to those reported by Oluwole et al. [39] but were also higher than those reported in some vegetable by Asaolu et al. [58]. However, Oluwole et al. [11] reported higher values in *A. cruentus* and *O. gratissimum* at1. 62% and 3.59% respectively.

Percentage ash content ranged from 3.56-4.74% in all the four vegetables sampled (Table 1) Thus, the ash content obtained are lower to those of *O. gratissimum* reported by Fagboun et al. [57] and *A. hybridus* [55] and also there was lower ash contents of *A. cruentus* (30.88%) and *O. gratissimum* (7.12%) respectively as reported Oluwole et al. [11]. However, Oluwole et al. [39] reported similar values for *T. triangulare* and *A. spinosus*. Ash content is essential in food for its impacts in mineral constituents [65]. However, various differences were observed in the proximate compositions of *L. africana, G. latifolium, H. crina and P. gineense* in the markets. These differences have been reported by Oluwole et al. [11,12,52]; they attributed these variation to abiotic factors such as water, soil mineralization, and so on within and around the locations of cultivation of these vegetables.

3.2.2 Phytochemical compositions of four commonly sold vegetables in Lagos markets

Phytochemical screening of *L. africana, G. latifolium, H. crina and P. gineense* sold in some Lagos markets revealed the presence of some vital secondary metabolites viz: tannin, phenol, saponin, flavonoid, cardiac glycosides, steroid, phlobatanin, alkaloid and sugar except terpenoid (Table 2). However, it was observed that all the vegetables samples showed the presence of Saponin, alkaloid, cardiac glycosides and sugar. Saponin have been reported in some plants with anti-feeder properties in fishes [65]; expectorant and cardio-tonic activities [43]; hypoglycemic and anti-diabetic effects in treating diabetes mellitus [43,44,66]; aid DNA replication and prevent multiplication of cancerous cells [43,66]. Alkaloids are important for numerous biological activities such as anticancer in both human and animal health [67-70]. Sugar or carbohydrates have been reported to have little or no

therapeutic effects but are integral parts in some medicinal ingredients [43,71]. Also, sugar has been used as immuno-modulator with other vaccines [43,72]. However, cardiac glycosides are used for treating congestive heart failure [43,44]. Also, glycosides have been reported for their laxative, diuretic and antiseptic properties [43,73,74].

Flavonoids have been documented in some plants (*L. africana, G. latifolium, H. crina and P. gineense*) to help in detoxification, modifications of cell's reaction to carcinogens, viruses and allergens [18,43,75,76]. Also, some researchers have also reported that flavonoids have anti-microbial activity, anti-inflammatory, antioxidant and antitumour properties which are associated with the power of scavenging free radicals [43,77,78]. Tannin also has been documented for its anti-diarrheal effects Cardiac glycosides are known for congestive heart failure [43,44].

3.2.3 Mineral and heavy metal analyses of four commonly sold vegetables in some Lagos markets

Mineral and heavy metal analyses on *L. africana, G. latifolium, H. crina and P. gineense* commonly sold in some Lagos markets. 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 permissible limits or accepted world standards (Table 3). It further revealed that Lead (Pb), Cadmium (Cd) and Nickel (Ni) were within permissible limits as recommended by WHO and world known standardizing agencies [45-55]. However, the remaining metals are far below the permissible limits. This study agrees with other several studies [39,43,79-82]. All these studies found out that most of the vegetables sold in Lagos and other parts of the world are safe for consumption.

More so, the metals are known for their influence in various body functions based on concentrations. Minerals such as K, Na, Mg, Mn, and Fe play important roles in human health and animal health and diseases have been highlighted [11].

4. CONCLUSION

From the results of this study, it could be concluded that *L. africana, G. latifolium, H. crina and P. gineense* commonly sold in some Lagos markets, Nigeria are very rich in nutrients needed by the body for proper functioning. It's further revealed that the four vegetables contained appreciable secondary metabolites-, saponin, cardiac glycosides alkaloid and many others which vary except terpenoid, which are useful active substances of high medicinal values. More so, the results revealed that the vegetables contained minerals and heavy metals which are within or below the World Health Organization and other known agencies' permissible limits. Thus, the vegetables are safe for consumption as at the time of this research. However, despite the fact that the heavy metals' concentration of the vegetables are within or below permissible limits, variation occurred in metallic compositions of these vegetables. This may serve as an indicator that the sources or areas in which these vegetables were grown before they are taken to markets should be monitored.

ACKNOWLEDGEMENTS

Authors extend gratitude to all members of staff of Departments of Botany and Chemistry, Lagos State University, Ojo, Lagos, Nigeria for their contributions during the time of this research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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