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Assessment of the Proximate Compositions and Heavy Metals' Profiles of *Talinum triangulare* L., *Corchorus olitorius* L. and *Solanum macrocarpon* L. Harvested from Some Farmlands, Roadsides and Markets in Badagry Division of Lagos State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The growing concern over the safety of vegetables consumed in some areas of Lagos due to increased discharge of pollutants that cannot be overlooked was the basis for this research. Thus, this study aimed at assessing the proximate compositions and heavy metals' profiles of *Talinum triangulare, Corchorus olitorius and Solanum macrocarpon* harvested from some farmlands, roadsides and markets in Badagry division of Lagos State. Leaves of *Talinum triangulare, Corchorus olitorius* and *Solanum macrocarpon* were obtained from farmlands, roadsides and markets in different local government areas in Badagry division of Lagos State. Proximate and heavy metals' analyses were done using standard analytical procedures. Proximate analyses of the three vegetables showed that the vegetables contained moisture, carbohydrate, lipid, crude fibre, fat, and ash at very appreciable quantities. Also, the results of the heavy metals' analyses revealed the range of Pb(0.01-0.03 mg/kg), Cd(0.01-0.07mg/kg), Fe(1.83-3.78 mg/kg), Cu(0.05-0.23 mg/kg), Mn(0.01-1.06 mg/kg), Zn(0.08-1.01 mg/kg) for farmlands; Pb(0.01-1.06 mg/kg), Cd(0.01-0.07 mg/kg), Fe(1.00-3.30 mg/kg), Cu(0.01-1.03 mg/kg), Mn(0.01-1.06 mg/kg), Zn(0.86-1.08 mg/kg) for roadsides and P(0.01-0.02mg/kg); Cd(0.01-0.04 mg/kg), Fe(1.78-3.02 mg/kg),

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Cu(0.01-0.08 mg/kg), Mn(0.02-0.12 mg/kg), Zn (0.01-2.01 mg/kg) for markets among the three vegetables in three the local government areas of Badagry division. However, chromium was not detected in the vegetables for all the locations. These metals were below or within WHO permissible limits except for lead and cadmium which were higher in some vegetables from Ojo roadsides and farmlands; lead in Amuwo-Odofin roadsides and Badagry farmlands respectively. It could be inferred from this study that vegetables across the three locations are rich sources of nutrients irrespective of specific points of collections. However, vegetables from roadsides had the highest overall heavy metal concentrations compared to those from farmland and markets and this could be linked to pollution by vehicular emission among others in the study areas. Thus, regular monitoring of the vegetables should be encouraged to checkmate possible health hazards from consumption of these vegetables.

Keywords: Heavy metals; proximate composition; Talinum triangulare; Corchorus olitorius; Solanum macrocarpon; farmlands; roadsides and markets.

1. INTRODUCTION

Life expectancy in Nigeria is higher among rural dwellers than those in urban areas. The reason for this is the dependability of rural dwellers on nature while most of the people in cities feed mostly on synthesized products rather than natural produce [1]. Macronutrients such as carbohydrates, lipids, fats and proteins are important parts of the human diet and are necessary for nourishment [2]. Most of the plant parts like leaves, stem, fruit, seeds and roots are made of these macronutrients, especially proteins [3]. Selection of plants for nutritive value, systematic classification and nutrient improvement programs depend upon quality and quantity of protein in seeds [4]. Moisture, ash and fibers have also been reported as important for human well-being [5]. Leafy vegetables that are rich in nutrients are bountifully grown in different regions of world, especially in Nigeria to meet up with dietary and medicinal requirement [6]. Green leafy vegetables make up the critical components of human diet in West Africa [7,8]. Vegetables are regarded as essential source of vitamins, minerals, and fiber which are crucial for human nutrition and wellbeing [9]. Balkair and Ashraf [10] predicted that the popularity of leafy vegetable among farmers in urban areas will continue to increase as a result of the ready market provided by the teaming population.

Nevertheless, there is a concern over vegetable consumption in the urban areas due to possible contamination believed to be caused by the usage of contaminated urban streams for irrigation. Previous findings have shown that urban effluent contains high concentration of heavy metals, which readily build-up in vegetables hence posing a health risk to consumers [11]. Industrial processes such as municipal sewage and solid waste disposal, vehicular traffic, pesticide use, and inappropriate use of fertilizers contribute to increased concentration of heavy metals in the environment [12]. Heavy metals affect contaminated foods adversely, which in turn affect human wellbeing and can drain a significant part of the fundamental supplements in the body [13].

The consequence of vehicular pollution materializes on the physiological facet of plants [14,15]. Absorption of heavy metals modifies the pH of soil which in turn affects anatomical, physiological and reproductive features of plants [16,17]. The reproductive parts of plants are negatively affected by automobile’s emission [18]. Growth of seedlings and germination of roadside vegetation are strongly affected by heavy metal pollution [19] Wu et al. [20] reported that excessive lead toxicity reduces germination rate of seeds. During production, transportation and marketing, heavy metals from industries and vehicles could be deposited on vegetables. It was reported by Al-Jassir et al. [21] that high levels of heavy metals in vegetables sold in the markets at Riyadh city in Saudi Arabia is as a result of atmospheric deposition. Later, Sharma et al. [22,23] also reported that atmospheric deposition significantly shoot-up the levels of heavy metals contamination in vegetables sold in the markets of Varanasi, India. Continuous consumption of unsafe concentrations of heavy metals via foodstuffs could lead to the chronic accumulation of heavy metals in the kidney and liver of humans which disrupt numerous biochemical processes and lead to cardiovascular, nervous, kidney and bone diseases [24,25].

However, it is a common practice in Lagos among farmers to cultivate vegetables along roadsides because of limited arable farmland, high population and easy accessibility to the consumers. Thus, this study aimed at evaluating the proximate composition and heavy metal contents of *Talinum triangulare, Corchorus olitorius and Solanum macrocarpon* collected from farmlands, roadsides and markets in Badagry division of Lagos State, Nigeria.

2. MATERIALS AND METHODS

2.1 Sample Collection

Samples of *Talinum triangulare*, *Corchorus olitorius* and *Solanum macrocarpon* were handpicked from three different Local Government areas in Badagry Division, Lagos State, Nigeria. Specific points of collection are roadside, farmland and marketplace in Ojo L.GA; roadside, farmland and market place in Amuwo-Odofin L.G.A. and roadside, farmland and market place in Badagry L.G.A (Fig. 1). They were collected and placed in polythene bags which were labeled according to the plant type, and location. They were taken to the laboratory for preparation and analysis.

2.2 Sample Preparation for Heavy Metal Analysis

The collected samples were separated and cleaned first with tap water followed by distilled water to eliminate suspended particles. Samples were cut into smaller pieces with a knife and the samples were put in different crucibles and ash in a furnace at 650°C for two hours. A quantity of the ash (0.4 g) from each plant sample was weighed separately into a beaker. To each sample, 3 mL of concentrated HCl and 1 mL of concentrated HNO_3 were added, and heated on a hot plate at 100°C for 10 minutes to destroy any oxidizable materials and carbonates. The solutions were topped with deionized water to the 30 ml mark and filtered using a Whatman filter paper. The filtrate was analyzed for the presence of heavy metals.

2.3 Preparation of Vegetable for Proximate Composition Evaluation

Leaves of these vegetables were collected freshly from different locations. The vegetables were washed with distilled water and thinly sliced, and then treated with chlorine concentrated solution. These samples were oven dried at temperature of 30°C for 24 hours. The samples were grounded with a blender and stored in air-tight container. Each sample (100g) was weighed and extracted with methanol which was used for the proximate composition.

2.4 Proximate Analysis

The proximate analysis for leafy vegetable samples for moisture, ash, crude fibre and fat were carried out following the standard methods of AOAC [26]. Nitrogen was determined by micro-kjeldahi method as described by Pearson [27] and the percentage nitrogen was converted to crude protein by multiplying by 6.25. Carbohydrate was determined by difference. All findings were performed in triplicates.

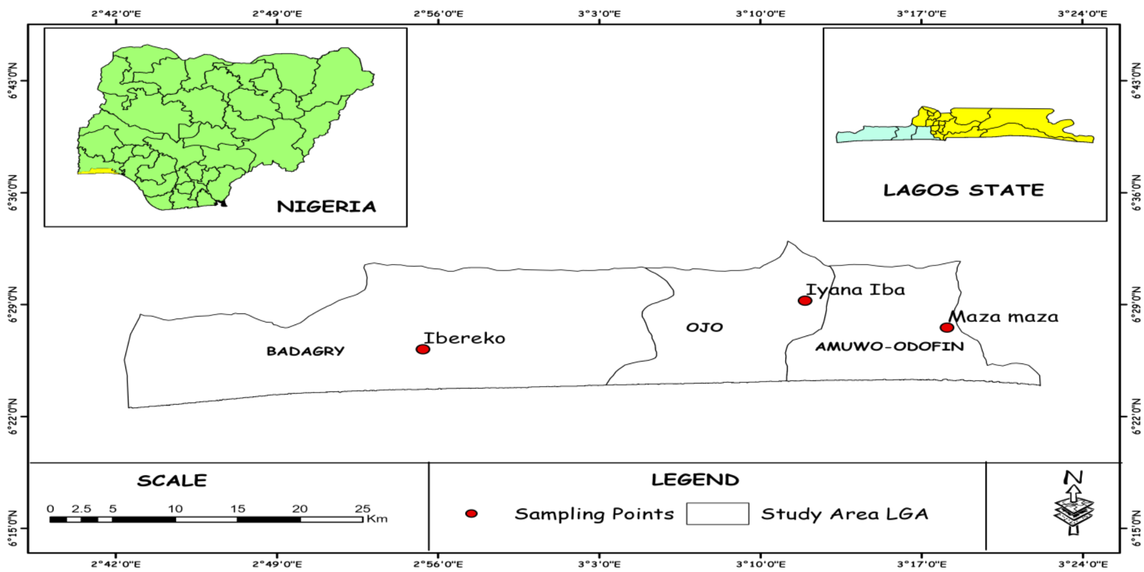

Fig. 1. Map of Lagos State, Nigeria showing sample locations

2.5 Heavy Metal Analysis

The heavy metal constituents of the leafy vegetable were analyzed using the solution obtained by dry ashing the samples at 55°C and dissolving the ash in distilled deionized water in flask. All the metals were analysed using atomic absorption spectrophotometer (Buck Scientific Model 200A) as described by AOAC [28].

2.6 Statistical Analysis

All the data collected were in triplicates and these were subjected to univariate statistical analysis using mean ± standard deviation.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Proximate analysis of vegetables collected from different locations in Ojo L.G.A

Table 1 shows the proximate analysis of vegetables collected from three different locations in Ojo Local Government Area. The result revealed that *Solanum macrocarpon* collected from roadsidehas the highest moisture contents while *Talinum triangulare* collected from the roadside had the least moisture contents (Table 1).The percentage protein contents of *Solanum macrocarpon* collected at the roadside had the highest values while *Corchorus olitorius* and *Solanum macrocarpon* collected from farmland had similar values. The crude fibre contents of *Talinum triangulare* collected in both roadside and farmland had similar values while *Talinum triangulare* from the market had least values for crude fibres (Table 1). The carbohydrate contents of *Talinum triangulare* collected at the market had the highest values while, *Solanum macrocarpon* and *Corchorus olitorius* from the roadside had similar carbohydrate contents (Table 1). The crude fat content of *Talinum triangulare* collected at the market had the highest values, while *Talinum triangulare* from the roadside had the lowest value. *Corchorus olitorius* from the roadside had the highest ash content with *Talinum triangulare* samples collected from the roadside had the least (Table 1).

3.1.2 Proximate Analysis of Vegetables Collected from different Locations in Amuwo-Odofin L.G.A

Table 2 shows the proximate analysis of vegetables collected from three different locations in Amuwo-Odofin Local Government Area. The result showed that *Solanum macrocarpon* and *Corchorus olitorius* collected from roadside has the highest moisture contents while *Talinum triangulare* collected from the roadside had the least moisture contents (Table 2). The percentage protein contents of *Talinum triangulare* collected from the market had the highest values while *Talinum triangulare* obtained from farmland had least value. The crude fibre contents of *Corchorus olitorius and Solanum macrocarpon* collected at the farmland had similar values while *Talinum triangulare* from the market and roadside had least values for crude fibres (Table 2). The carbohydrate contents of *Talinum triangulare* collected from the market had the highest values while *Solanum macrocarpon* and *Corchorus olitorius* from the roadside had similar carbohydrate contents (Table 2). The crude fat content of *Solanum macrocarpon* and *Corchorus olitorius* collected at the roadside had the highest values, while *Talinum triangulare* from the roadside had the lowest value. All vegetables from the roadside had similar ash content while *Talinum triangulare* samples collected from the farmland had the least (Table 2).

3.1.3 Proximate Analysis of Vegetables Collected from different Locations in Badagry L.G.A

Table 3 shows the proximate analysis of vegetables collected from three different locations in Badagry Local Government Area. The result showed that *Solanum macrocarpon* and *Corchorus olitorius* collected from roadside has the highest moisture contents while *Talinum triangulare* collected from the farmland had the least moisture contents (Table 3).The percentage protein contents of *Talinum triangulare* collected from the market had the highest values while *Talinum triangulare* obtained from farmland had least value. The crude fibre contents of *Corchorus olitorius and Solanum macrocarpon* collected at the farmland had similar values while *Talinum triangulare* from the roadside had least value for crude fibres (Table 3). The carbohydrate contents of *Talinum triangulare* collected from the market had the highest values while *Solanum macrocarpon* and *Corchorus olitorius* from the market had similar carbohydrate contents (Table 3). The crude fat content of *Talinum triangulare* collected at the farmland had the highest values, while *Solanum macrocarpon* and *Corchorus olitorius* from the market had the lowest value. *Solanum* *macrocarpon* and *Corchorus olitorius* from the roadside had similar ash content while *Talinum triangulare* samples collected from the market had the least (Table 3).

3.1.4 Heavy metal concentration analysis of vegetables collected from different locations in Ojo local government area

Table 4 shows the heavy metal concentrations analysis of vegetablescollected from three differentlocations in Ojo Local Government. The result showed that the *Talinum triangulare* collected from farmland had the highest Manganese (Mn) contents while, *Corchorus olitorius* and *Solanum macrocarpon* collected from farmland had the least Mn contents (Table 4). Also, the Copper (Cu) concentrations in *Talinum triangulare* obtained from the farmland has the highest concentration while, *Talinum triangulare* from the roadside had least mean Cu concentration (Table 4). Almost all the vegetables had similar mean Zinc (Zn) concentration values with the exception of *Talinum triangulare* from the farmland which was significantly lower than the rest (Table 4).Highest Lead (Pb) concentration was recorded in *Talinum triangulare* from the roadside while it was not detected in *Corchorus olitorius* and *Solanum macrocarpon* from the farmland and roadside. Iron (Fe) concentrations in *Corchorus olitorius and Solanum macrocarpon* from farmland were similar but *Talinum triangulare* from the roadside had the least Fe concentration. Highest cadmium (Cd) concentration was detected in *Talinum triangulare* collected from the farmland with cadmium concentration of majority of these vegetables being below detection limit. Chromium (Cr) was not detected in any of the vegetables across the locations.

3.1.5 Heavy metal concentration analysis of vegetables collected from different locations in Amuwo-Odofin L.G.A.

Table 5 shows the heavy metal concentrations analyses of vegetables collected from three different locations in Amuwo-Odofin Local Government. The result showed that the *Talinum triangulare*collected from roadside had the highest Manganese (Mn) content while, *Corchorus olitorius* and *Solanum macrocarpon* collected from farmland had the least Mn contents along with *Talinum triangulare* from the market (Table 5). Also, the Copper (Cu) concentrations in *Talinum triangulare* obtained from the roadside has the highest concentration while, *Corchorus olitorius* and *Solanum macrocarpon* from the roadside had least mean Cu concentration (Table 5). Almost all the vegetables had similar mean Zinc (Zn) concentration values with the exception of *Talinum triangulare* from the roadside which was significantly higher than the rest (Table 5). Highest Lead (Pb) concentration was recorded in *Talinum triangulare* from the roadside while it was not detected in *Corchorus olitorius* and *Solanum macrocarpon* from the market. Iron (Fe) concentrations in *Corchorus olitorius and Solanum macrocarpon* from farmland were similar but *Talinum triangulare* from the roadside had the least Fe concentration. Cadmium (Cd) concentrations in all the vegetables studied were similar but not detected in *Talinum triangulare* from farmland, *Corchorus olitorius* and *Solanum macrocarpon* from roadside. Chromium (Cr) was not detected in any of the vegetables across the locations (Table 5).

3.1.6 Heavy metal concentration analysis of vegetables collected from different locations in Badagry L.G.A.

Table 6 shows the heavy metal concentrations analyses of vegetables collected from three different locations in Badagry Local Government. The result showed that the *Talinum triangulare*collected from roadside had the highest Manganese (Mn) content while, *Corchorus olitorius* and *Solanum macrocarpon* collected from farmland had the least Mn contents along with *Talinum triangulare* from the market (Table 6). Also, the Copper (Cu) concentrations in *Talinum triangulare* obtained from the roadside has the highest concentration while, *Corchorus olitorius* and *Solanum macrocarpon*from the roadside and *Talinum triangulare* from the market had least mean Cu concentration (Table 6). Zinc (Zn) concentration values was highest in *Talinum triangulare* collected from roadside and lowest in *Corchorus olitorius* and *Solanummacrocarpon* obtained from the market (Table 6). Highest Lead (Pb) concentration was recorded in *Talinum triangulare* from the farmland while it was not detected in any of the market samples. Iron (Fe) concentrations in *Corchorus olitorius and Solanum macrocarpon* from farmland were similar but *Talinum triangulare* from the roadside had the least Fe concentration.Cadmium (Cd) concentrationsin all the vegetables studied were similar but not detected in *Corchorus olitorius and Solanum macrocarpon* from roadside.Chromium (Cr) was not detected in any of the vegetables across the locations (Table 6).

Table 1. Proximate composition (%) of vegetables collected from different locations in Ojo L.G.A.

Vegetable	Location		Carbohydrate (%)	Crude protein (%)	Crude fat (%)	Moisture (%)	Ash (%)	Crude fibre (%)
Corchorus olitorius	Farmland	Mean ±S.D	31.62 ± 0.18	5.91 ± 0.03	0.89 ± 0.05	56.27 ± 0.12	2.30 ± 0.07	3.02 ± 0.06
	Market	Mean ±S.D	30.33 ± 0.73	6.75 ± 0.14	0.79 ± 0.00	56.60 ± 0.11	2.71 ± 0.02	2.84 ±0.71
	Roadside	Mean ±S.D	30.13 ± 0.27	7.00 ± 0.07	0.93 ± 0.01	56.79 ± 0.09	2.88 ± 0.05	2.27 ± 0.32
Talinum triangulare	Farmland	Mean ±S.D	33.61±0.38	6.09 ± 0.08	0.90±0.01	51.38±0.13	2.06 ± 0.84	5.09 ± 3.21
	Market	Mean ±S.D	40.65± 0.56	6.70 ± 0.01	1.02 ± 1.00	55.65±0.74	1.86±0.99	1.41 ± 0.09
	Roadside	Mean ±S.D	36.73±0.11	6.75 ± 0.45	0.02 ± 1.10	42.70± 0.25	1.07 ± 1.05	5.09 ± 3.21
Solanum macrocarpon	Farmland	Mean ±S.D	31.62 ± 0.09	5.91 ± 0.02	0.89 ± 0.04	56.27 ± 0.09	2.30 ± 0.05	3.02 ± 0.04
	Market	Mean ±S.D	30.33 ± 0.52	6.75 ± 0.10	0.79 ± 0.01	56.60 ± 0.07	2.71 ± 0.02	2.84 ± 0.51
	Roadside	Mean ±S.D	30.13 ± 0.19	7.00 ± 0.05	0.93 ± 0.02	56.79 ± 0.06	2.88 ± 0.04	2.27 ± 0.23

S.D= Standard Deviation

Table 2. Proximate composition (%) of vegetables collected from different locations in Amuwo-Odofin L.G.A

Vegetable	Location		Carbohydrate (%)	Crude protein (%)	Crude fat (%)	Moisture (%)	Ash (%)	Crude fibre (%)
Corchorus olitorius	Farmland	Mean ±S.D	30.31 ± 0.10	5.31 ±0.03	1.02 ± 0.06	55.78 ± 0.12	2.21 ± 0.05	5.39 ± 0.21
	Market	Mean ±S.D	29.68 ± 0.05	5.95 ±0.13	0.93 ± 0.01	56.11 ±0.11	2.65 ±0.04	4.70 ± 0.02
	Roadside	Mean ±S.D	30.04 ± 0.10	6.18 ± 0.06	1.09 ±0.03	56.30 ±0.08	2.80 ±0.09	3.60 ± 0.20
Talinum triangulare	Farmland	Mean ±S.D	32.58±0.56	5.09 ± 0.05	0.76 ±0.26	50.30±0.56	1.11 ± 0.96	5.02 ± 2.64
	Market	Mean ±S.D	46.46± 0.35	6.39 ± 0.08	2.11 ± 0.05	56.20±0.75	1.86 ± 0.99	1.02±1.00
	Roadside	Mean ±S.D	37.09± 0.23	6.30 ±0.21	0.05 ± 1.48	39.89 ±0.16	2.80 ± 0.06	1.02 ± 0.06
Solanum macrocarpon	Farmland	Mean ±S.D	30.31 ± 0.07	5.31 ± 0.02	1.02 ± 0.05	55.78 ± 0.09	2.21 ± 0.04	5.39 ± 0.15
	Market	Mean ±S.D	29.68 ± 0.04	5.95 ± 0.09	0.93 ± 0.01	56.11 ± 0.08	2.65 ± 0.03	4.70 ± 0.02
	Roadside	Mean ±S.D	30.04 ± 0.07	6.18 ± 0.05	1.09 ± 0.02	56.30 ± 0.06	2.80 ± 0.06	3.60 ± 0.14

S.D= Standard Deviation

Table 3. Proximate composition (%) of vegetables collected from different locations in Badagry L. G. A.

Vegetable	Location		Carbohydrate (%)	Crude protein (%)	Crude fat (%)	Moisture (%)	Ash (%)	Crude fibre (%)
Corchorus olitorius	Farmland	Mean ± S.D	29.56 ± 0.12	5.63 ±0.03	0.99 ±0.06	58.01 ± 0.12	2.15 ± 0.07	3.68 ±0.04
	Market	Mean ± S.D	28.34 ±0.68	6.31 ± 0.13	0.89 ±0.01	58.35 ± 0.11	2.53 ± 0.02	3.59 ±0.68
	Roadside	Mean ± S.D	28.84 ± 0.33	6.55 ± 0.06	1.05 ± 0.01	58.55 ± 0.08	2.69 ± 0.04	2.34 ± 0.29
Talinum triangulare	Farmland	Mean ± S.D	49.40± 0.17	5.04 ±0.06	4.18 ±0.61	35.65± 0.74	0.43 ±0.07	1.10 ± 0.57
	Market	Mean ± S.D	54.90± 0.36	7.68±0.04	2.97±0.08	42.86± 0.72	0.19 ± 0.01	1.80± 0.06
	Roadside	Mean ± S.D	38.70± 0.12	6.11 ± 0.10	5.01 ± 1.00	36.86± 0.21	1.05 ± 0.03	1.05 ± 0.06
Solanum macrocarpon	Farmland	Mean ± S.D	29.56 ± 0.09	5.63 ± 0.02	0.99 ± 0.04	50.01 ± 0.09	2.15 ± 0.05	3.68 ± 0.03
	Market	Mean ± S.D	28.34 ± 0.48	6.31 ± 0.10	0.89 ± 0.01	58.35 ± 0.08	2.53 ± 0.02	3.59 ± 0.48
	Roadside	Mean ± S.D	28.84 ± 0.24	6.55 ± 0.05	1.05 ± 0.01	58.55 ± 0.06	2.68 ± 0.03	2.34 ± 0.21

S.D= Standard Deviation

Table 4. Heavy metal contents (mg/100g) of vegetables collected from different locations In Ojo L.G.A.

Vegetable	Location	Lead	Cadmium	Iron	Copper	Manganese	Zinc	Chromium
Corchorus olitorius	Farmland	ND	0.07±0.01	3.78±0.18	0.14±0.01	0.03±0.00	1.01±0.01	ND
	Market	ND	ND	3.02±0.13	0.08±0.01	0.12±0.01	1.00±0.00	ND
	Roadside	0.02±0.00	ND	2.93±0.07	0.04±0.00	0.13±0.00	1.00±0.02	ND
Talinum triangulare	Farmland	0.03±0.00	ND	2.00±0.05	0.23±0.01	1.06±1.08	0.08±0.01	ND
	Market	0.02±0.00	0.01±0.00	1.78±0.18	0.04±0.00	0.11±0.01	1.41±0.01	ND
	Roadside	1.06±1.01	1.03±3.078	1.03±3.08	0.01±0.07	0.10±1.08	1.08±0.07	ND
Solanum macrocarpon	Farmland	ND	0.07±0.01	3.78±0.13	0.13±0.01	0.03±0.00	1.01±0.00	ND
	Market	ND	ND	3.02±0.09	0.08±0.00	0.12±0.01	1.00±0.00	ND
	Roadside	0.02±0.00	ND	2.93± 0.05	0.03±0.00	0.13±0.00	1.00±0.02	ND
FAO/WHO limits [29]		**0.30**	**0.02**	**450**	**40**	**500**	**60**	**5**

Table 5. Heavy metal contents (mg/100g) of vegetables collected from different locations in Amuwo-Odofin L.G.A

Vegetable	Location	Lead	Cadmium	Iron	Copper	Manganese	Zinc	Chromium
Corchorus olitorius	Farmland	0.01±0.01	0.01±0.00	3.30±0.16	0.12±0.01	0.02±0.00	0.89±0.01	ND
	Market	ND	0.01±0.00	2.69±0.03	0.07±0.00	0.11±0.01	0.89±0.03	ND
	Roadside	0.02±0.00	ND	2.56±0.06	0.03±0.00	0.11±0.00	0.86±0.02	ND
Talinum triangulare	Farmland	0.01±0.03	ND	1.83±0.07	0.07±0.00	0.02±0.003	0.99±0.03	ND
	Market	ND	0.00±0.00	2.56±0.06	0.08±0.01	0.02±0.00	0.89±0.03	ND
	Roadside	1.04±1.01	0.01±0.01	1.00±0.08	1.03±0.07	1.06±1.08	1.07±0.07	ND
Solanum macrocarpon	Farmland	0.01±0.00	0.01±0.00	3.30±0.11	0.12±0.01	0.02±0.00	0.88±0.00	ND
	Market	ND	0.04±0.03	2.69±0.02	0.07±0.00	0.11±0.01	0.89±0.02	ND
	Roadside	0.02±0.00	ND	2.56±0.00	0.03± 0.00	0.11±0.00	0.87±0.01	ND
FAO/WHO limits [29]		**0.30**	**0.02**	**450**	**40**	**500**	**60**	**5**

Table 6. Heavy metal contents (mg/100g) of vegetables collected from different locations in Badagry L.G.A.

Vegetable	Location	Lead	Cadmium	Iron	Copper	Manganese	Zinc	Chromium
Corchorus olitorius	Farmland	0.01±0.00	0.01±0.00	3.27±0.52	0.12±0.03	0.02±0.00	0.88±0.19	ND
	Market	ND	0.01±0.00	2.79±0.43	0.07±0.01	0.11±0.02	0.93±0.10	ND
	Roadside	0.02±0.00	ND	2.63±0.34	0.03±0.00	0.12±0.02	0.90±0.16	ND
Talinum triangulare	Farmland	1.06±1.01	0.01±0.00	2.01±0.12	0.05±0.00	0.12±0.01	1.01±0.01	ND
	Market	0.01±0.01	0.01±0.00	2.63±0.34	0.03±0.00	0.02±0.01	2.01±0.00	ND
	Roadside	ND	0.01±0.01	1.02±0.01	1.03±0.07	1.01±0.00	1.05±0.03	ND
Solanum macrocarpon	Farmland	0.01±0.00	0.01±0.00	3.27±0.36	0.12±0.02	0.02±0.00	0.88±0.13	ND
	Market	ND	0.01±0.00	2.79±0.30	0.08± 0.01	0.11±0.02	0.92±0.07	ND
	Roadside	0.02±0.00	ND	2.63±0.24	0.03±0.00	0.12±0.01	0.90±0.11	ND
FAO/WHO limits [29]		**0.30**	**0.02**	**450**	**40**	**500**	**60**	**5**

3.2 Discussion

3.2.1 Proximate analyses of vegetables across the three sampled locations

The proximate analyses of the three vegetables obtained from three different locations are shown in Tables 1-3. The moisture content of the vegetables collected from different farmlands across the three locations ranges from 35.65% to 58.01%. For vegetables collected from markets, the moisture content ranges from42.86% to 58.35% while it ranges from 36.86% to 58.55% for those collected from roadsides. These values are higher than those reported for three leafy vegetables commonly consumed in Lagos [30]. The variations in the moisture content can be attributed to different seasons of harvesting in addition to other ecological factors peculiar to the study areas [31]. The carbohydrate composition varies from 29.56% to 49.40% among samples collected from farmlands across the three locations. Vegetables collected from markets have values ranging from 28.34% to 54.90% but roadsides collected values are within 28.84% to 38.70%. The carbohydrate content of vegetables in this study is within the values reported by Idoko et al. [32]. It is generally known that in humans, carbohydrate are utilize as major sources of biological energy through their oxidation in the cells. They also function as organic precursors for the biosynthesis of many cell components [31]. The protein content varies from 5.04 – 6.09% in vegetables collected from different farmlands across the locations. For samples collected from different markets, values of protein composition range from 5.95% to 7.68%. Market samples have values ranging from 6.19- 7.00%. This result is lower than what was reported by Oluwole et al. [33]. Plant foods that supply the body with more than 12% of their caloric value from protein have been reported to be good source of protein [34]. This shows that samples from this study are not rich sources of protein. The crude fat ranges from 0.76% - 4.18%, 0.79% - 2.97% and 0.02% - 5.01% in vegetables collected from farmlands, markets and roadsides respectively. The crude fat content in vegetables across the three sampled areas is quite higher than the values reported by Hodson et al. [30]. Lipids (fat) are major energy yielder in human nutrition, ranking close behind carbohydrate. Lipids are essential carbon sources for the biosynthesis of cholesterol and other steroids. The provision of essential fatty acids by plant triacylglycerol is also well known and documented [35]. The low lipid sources observed in the vegetable leaves make them good for human health [36]. The crude fibre results ranges from 1.10%to 5.39% in vegetables collected from farmlands across the three locations. The crude fibre content for samples collected from markets varies between1.02% to 4.70% while it ranges from 1.02%- 0.09% for vegetables collected from roadsides. The fibre content in these vegetables are higher compared to the values reported by Taiga et al. [37]. Dietary fibre helps to lower serum cholesterol level, risk of coronary heart diseases, constipation and diabetes [38]. The percentage ash content ranged from 0.43-2.30, 0.19 - 2.21 and 1.05 – 2.88 in vegetables collected from farmlands, markets and roadsides respectively across the three locations. The ash content is lower in the vegetables used in this study than those reported in Oluwole et al. [33]. The total ash content has been reported as a measure of the nonvolatile inorganic constituents remaining after ashing [39].

3.2.2 Heavy metals analysis of vegetables across the three Sampled Locations

The heavy metal analyses of the three vegetables obtained from the three different locations are shown in Tables 4-6. The study revealed that cadmium concentrations in the three vegetables were above the WHO / FAO permissible limit of 0.02 mg/kg [29] and one reported by Oluwole et al. [33]. Lente et al. [40] also reported cadmium values below detection limit of 0.006 mg/kg in vegetables grown in long-term wastewater irrigated urban farming sites in Accra. Cadmium is obviously becoming an increasing health concern in agriculture as it has been linked with damage of kidneys, bones and its probable carcinogenic nature [41]. In addition, Guerra et al. [42] noted that cadmium is very dangerous as it can be taken up through the alimentary tract; penetrate through placenta during pregnancy, and damage membranes and the DNA. It was said by same author that once cadmium is in the human body, it may persist in the metabolism from 16 to 33 years, and is connected to many health issues including renal damages and abnormal urinary excretion of proteins. Reduction in bone calcium concentration and increment in urinary excretion of calcium has also been associated with Cd exposure that can cause death [43].

This study revealed that Chronium level in the various vegetables might not pose health risk to consumers as they were below detectable limit.

Chromium is essential for insulin activity and deoxyribonucleic acid transcription in living organism particularly human beings. However, an intake less than 0.02 mg per day could lessen cellular responses to insulin [44].

Lead has been reported to have toxic effects on organs like kidneys, liver, lung and spleen which result to different biochemical defects. It exhibits neuropathology when adults are exposed occupationally or accidentally to excessive levels. There is a relationship between lead in the human body and the increase of blood pressure of adults [45]. This study showed that the lead concentrations in three vegetables across different locations were above the WHO / FAO permissible limit of 0.30 mg/kg [29]. Similar studies conducted by Oluwole et al. [33] showed concentration of Pb with mean range of 0.00-0.008 mg/kg. Suruchi and Pankaj [41] also reported 2.652 mg/kg of Pb in some vegetables.

Manganese concentration of the vegetables in this study were well below WHO/FAO permissible limit of 500 mg/kg [29] which means there is a likelihood of anthropogenic input on the vegetables in these locations.

Iron levels in vegetables collected for this study were below the WHO/FAO permissible limit of 450 mg/kg [29] and ones reported by Monu et al. [46]. According to Codex [47], excess ingestion of Fe can result in deposition of iron in tissues (siderosis) in adrenals, liver, pancreas, thyroid, pituitary among others in human.

Zinc concentrations in the three vegetables were below the WHO/FAO permissible limit of 60 mg/kg [29]. Zinc concentration in this study is below concentration reported in similar study conducted by Singh et al. [48] but similar to zinc concentration reported by Oluwole et al. [33]. Zinc is known to be an essential mineral as a result of its exceptional biological and public health significance [49]. However, excessive ingestion can have adverse effects on human health [50]. According to Harmanescu et al. [51], Zn can reduce immune function and the levels of high-density lipoproteins. In the developing world, its deficiency affects about two billion people and is related with many diseases [52]. It also causes growth retardation, delayed sexual maturation, infection susceptibility, and diarrhea in children and is responsible for about 800,000 children death worldwide per year [49].

Copper concentrations in this study were below the WHO / FAO permissible limit of 40 mg/kg [29] and is well within values reported by Oluwole et al. [33]. This suggests that Cu concentrations in the various vegetables across the locations are safe for consumption. Copper is important for humans as a trace dietary mineral. Nevertheless, excess consumption of Cu can lead to adverse effects on human health [50]. For example, excess Cu concentration can result to acute intestine and stomach aches, and liver damage [50].

A closer look at the results showed that vegetables obtained from roadsides across the three locations have the highest heavy metal concentrations than those collected from farmlands and markets. This is quite relatable as they are exposed to various forms of pollution such as vehicular emission, oil spillage and many others.

4. CONCLUSION

It could be inferred from this study that vegetables across the three locations are rich sources of nutrients irrespective of specific points of collections through the results of the proximate analysis. It could also be concluded from the present study that Cd and Pb concentrations in all the vegetables were above the permissible limits set by FAO/WHO for human consumption. The levels of other heavy metals like Fe, Zn, Co and Mn fall below the permissible limit with Cr not even detected in any of the vegetables. However, vegetables collected from roadsides had the highest overall heavy metal concentrations compared to those collected from farmlands and markets. This could be attributed to pollution by vehicular emission, indiscriminate dumping of wastes among others in the study areas which promote increase in the level of toxic metals in vegetables. Thus, regular monitoring of heavy metal contamination of vegetables in farmlands, roadsides and markets should be encouraged to checkmate possible health hazard from consumptions of these vegetables.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Akinwunmi OA, Omotayo FO. Proximate analysis and nutritive values of ten common vegetables in South-West (Yoruba Land). Communications in Applied Science. 2016;4:79-91.
2. Ozel B, Cikrikci S, Aydin O, Oztop MH. Polysaccharide blended whey protein isolate-(WPI) hydrogels: A physicochemical and controlled release study. Food Hydrocoll. 2017;71:35–46.
3. Gilani SA, Fujii Y, Shinwari ZK, Adnan M, Kikuchi A, Watanabe KN. Phytotoxic studies of medicinal plant species of Pakistan. Pak. J. Bot. 2010;42:987–996.
4. Hussain J, Rehman NU, Khan AL, Hamayun M, Hussain SM, Shinwari ZK. Proximate and essential nutrients evaluation of selected vegetables species from Kohat region, Pakistan. Pak. J. Bot. 2010;42:2847–2855.
5. Szymanska-Chargot M, Zdunek A. Use of FT-IR spectra and PCA to the bulk characterization of cell wall residues of fruits and vegetables along a fraction process. Food Biophys.2013;8:29–42.
6. Williams P, Phillips G. Introduction to food hydrocolloids. In Handbook of Hydrocolloids; Elsevier: Amsterdam, The Netherlands, 2009;1–22.
7. Oguntona T. Green Leafy Vegetable in Osagie, AU. Eka, O.U. (eds): Nutritional Quality of Plant Foods. Post Harvest Research Unit, University of Benin, Benin City. 1998;120-133.
8. Schippers RRAfrican Indigenous vegetables: An overview of the cultivated species NRI/ACP-EU Technical centre for Agricultural and Rural Co-operation, Chatham UK. 2000;1-214.
9. Bett L, Gilbert O, Phanice W, Mule S. Determination of Some Heavy Metals in Soils and Vegetables Samples from Kericho West Subcounty, Kenya. Chem. Sci. Inter. J. 2019;28(2): 1–10.
10. Balkhair KS, Ashraf MA. Field accumulation risks of heavy metals in soil and vegetable crop irrigated with sewage water in western region of Saudi Arabia. Saudi Journal of Biological Sciences. 2016; 23(1):S32–S44.
11. Shaheen N, Irfan NM, Khan IN, Islam S, Islam MS, Ahmed MK. Presence of heavy metals in fruits and vegetables: Health risk implications in Bangladesh. Chemosphere. 2016;152:431–438.
12. Bi C, Zhou Y, Chen Z, Jia J, Bao X. Heavy metals and lead isotopes in soils, road dust and leafy vegetables and health risks via vegetable consumption in the industrial areas of Shanghai, China. Science of the Total Environment. 2018;619–620:1349–1357.
13. Ray S, Kanti P, Ray M. Bioremediation of Heavy Metal Toxicity-With Special Reference To Chromium. Al Ameen J Med Sci. 2009;2(9): 4–1.
14. Chemerys I, Myslyuk O, Chemerys V. Effect of vehicle emissions on the morphological and physiological changes of Taraxacum officinale web. Ukrainian Journal of Ecology,2020;10:15-27.
15. Kumar A, Kumar P, Singh H, Kumar N. Adaptation and mitigation potential of roadside trees with bio-extraction of heavy metals under vehicular emissions and their impact on physiological traits during seasonal regimes. Urban Forestry & Urban Greening. 2021;58:126-900.
16. Visez N, Ivanovsky A, Roose A, Gosselin S, Se´ne´chal H. Atmospheric particulate matter adhesion onto pollen: a review. Aerobiologia. 2020;36:49–62.
17. Banerjee S, Palit D, Banerjee A. Variation of tree biochemical and physiological characters under different air pollution stresses. Environmental Science and Pollution Research: 2021;1–21.
Available:https://doi.org/10.1007/s11356-020-11060-z
18. De Silva S, Ball AS, Indrapala DV, Reichman SM. Review of the interactions between vehicular emitted potentially toxic elements, roadside soils, and associated biota. Chemosphere: 2020;128-135.
Available://doi.org/10.1016/j.chemosphere.2020.128135
19. Azab E, Hegazy AK. Monitoring the efficiency of Rhazya stricta L. plants in phytoremediation of heavy metal-contaminated soil. Plants, 2020;9:10-57.
20. Wu Z-z, Zhang Y-x, Yang J-y, Zhou Y, Wang C-q. Effect of Vanadium on Testa, Seed Germination, and Subsequent Seedling Growth of Alfalfa (*Medicago*

sativa L.). Journal of Plant Growth Regulation. 2020;1–13.

21. Al-Jassir MS, Shaker A, Khaliq MA. Deposition of heavy metals on green leafy vegetables sold on roadsides of Riyadh city, Saudi Arabia. Bulletin of Environment Contamination and Toxicology. 2005;75: 1020–1027.
22. Sharma RK, Agrawal M, Marshall FM. Heavy metals (Cu, Cd, Zn and Pb) contamination of vegetables in Urban India: a case Study in Varanasi. Environmental Pollution. 2008a;154:254–263.
23. Sharma RK, Agrawal M, Marshall FM. Atmospheric depositions of heavy metals (Cd, Pb, Zn, and Cu) in Varanasi city, India Environmental Monitoring and Assessment. 2998b;142 (1–3):269–278.
24. WHO (World Health Organization). Cadmium. Environmental Health Criteria, Geneva. 1992;134.
25. Jarup L. Hazards of heavy metal contamination. British Medical Bulletin, 2003;68:167–182.
26. AOAC. Official methods of Analysis of Association of Analytical Chemists. AOAC International, 18th ed; Horrowitz, W.(ed) vol 1 & 2, AOAC International Maryland. USA. 2005;774-784.
27. Pearson D. Chemical analysis of food, 7th (ed.), Churchill, London. 1976;218-336.
28. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists 15thEd.Washington. DC; 1990.
29. WHO/FAO. Expert committee on food additives. Cambridge: Cambridge University Press; 2007;329–36.
30. Hodson RE, Aina EJ, Mynepalli GI, Shrihah H, Gina E. Analysis of proximate composition and mineral nutrients of three leafy vegetables commonly consumed in Lagos, Nigeria. Journal of Science and Geosciences. 2018 6(4):42-48.
31. Emmanuel UD, Uwemediomo EU, Ekemini BI. Comparative Assessment of Proximate Metal Composition in Some Selected Edible Vegetable Leaves Source from Three Major Markets in Akwa Ibom State. Australian Journal of Basic and Applied Sciences. 2013;7(8):676-682.
32. Idoko O, Emmanuel SA, Aguzue OC, Akanji FT, Thomas SA, Osouagwu I. Phytochemical Screening, Proximate Analysis and mineral composition of some leafy vegetables consumed in Nigeria. International Journal of Advanced Chemistry. 2014; 2(2): 175-177.
33. Oluwole SO, Makinde SCO, Ogun ML, Nwachukwu IR. Evaluation of Heavy Metal Concentrations and Proximate Compositions of *Amaranthus spinosus* L. and *Talinum triangulare* J. and Soils Collected from Dumpsites in Some Selected Areas in Lagos State, Nigeria. World Environment. 2020;10(1):16-26. DOI: 10.5923/j.env.20201001.03.
34. Ali A. Proximate and mineral composition of the marchubeh (*Asparagus officinalis*). World Diary and Food Science. 2009;4(2): 142-149.
35. Lehninger AL. Principles of Biochemistry, 2nd edition, Royal offset Press, Delhi, India, 1999; 249-264.
36. Rumeza H, Zafar I, Mudassar S, Masooma R. Use of Vegetables as Nutritional Food: Role in Human Health. J. Agric. Biochem. Sci. 2006;1:18-20.
37. Taiga A, Suleiman MN, Aina DO, Sule WF, Alege GO. Proximate analysis of some dry season vegetables in Ayigba, Kogi State, Nigeria. Afri. J. Biotechnol. 2008; 7(10): 1588-1590.
38. Ishida H, Suzuno H, Sugiyama N, Innami S, Todokoro T. National evaluation of chemical component of leaves stalks and stem of sweet potatoes (Ipomea batata) Food Chem. 2000;68:359-367.
39. Ifon ET. Bassir O. The Nutritive Value of some Nigerian Leafy Green Vegetables, Vitamin and Mineral contents. Food Chemistry,1979; 4(4): 263-267.
40. Lente I, Keraita B, Drechsel P, Ofosu-Anim J, Brima AK. Risk assessment of heavy metal contamination on vegetables grown in long-term wastewater irrigatedurban farming sites in Accra, Ghana. Water Qual Expo Health. 2012; 4:179–86.
41. Suruchi P, Pankaj K. Assessment of heavy metal contamination in different vegetables grown in and around urban areas. Res J Environ Toxicol. 2011;5(3):162–79.
42. Guerra F, Trevizam AR, Muraoka T, Marcante NC, Canniatti-Brazaca SC. Heavy metals in vegetables and potential risk for human health. Sci Agric. 2012; 69(1):54–60.
43. World Health Organization (WHO). Evaluation of certain food additives and Contaminants. In: Sixty-First Report of the Joint FAO/WHO Expert Committee onFood Additives. Geneva: WHO; 2004. (WHO Technical Series, 922).

44. Kohlmeier M. Nutrient metabolism. San Diego: Elsevier; 2003.
45. Maihara VA, Fávaro DIT. Toxic Elements. In: Cozzolino SMF, editor. Bioavailability of nutrients. Barueri: Manole (in Portuguese). 2006;629–660.
46. Monu A, Bala K, Shweta R, Anchal R, Barinder K, Neeraj M. Heavy metal accumulation in vegetables irrigated with water from different sources. Food Chemistry, 2008;111(14):811-815.
47. Codex Alimentarius Commission. Joint FAO/WHO Food Standards Programme Codex Committee on Contaminants in Foods Fifth Session: Working Document; 2011.
48. Singh A, Sharma RK, Agrawal M, Marshall FM. Risk assessment of heavy metal toxicity through contaminated vegetables from wastewater irrigated areas in Varanasi, India. Trop Eco Iss. 2010; 2:375–87.
49. Hambidge KM, Krebs NF. Zinc deficiency: a special challenge. J Nutr. 2007;137(4): 110-115.
50. Rahman MA, Rahman MM, Reichman SM, Lim RP, Naidu R. Heavy metals in Australian grown and imported rice and vegetables on sale in Australia: Health hazard. Ecotoxicol Environ Saf. 2014; 100:53–60.
51. Harmanescu M, Alda LM, Bordean DM, Gogoasa L, Gergen L. Heavy metals health risk assessment for population via consumption of vegetables grown in oldmining area, a case study: Banat County, Romania. Chem Cent J. 2011; 5:64–73.
52. Prasad ASZinc deficiency: has been known of for 40 years but ignored by global health organisations. Br Med J. 2003; 326(7386):409–10.

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