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Phytochemical and Nutritional Profile of Some Edible Plants in Nigeria

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Abstract: Edible plants from Nigeria were analyzed for phytochemicals and nutrients. These plants are *Ocimum gratissimum* (scented leaf), *Vernonia amygdalina* (bitter leaf), *Annona muricata* (soursop), *Talinum triangulare* (water leaf), *Colocasia esculenta* (cocoyam), *Solanum macrocarpon* (garden egg), *Microgreens*, *Piper guineense* (uziza), *Gangronema latifolium* (utazi) and *Telfairia occidentalis* (fluted gourd). Phytochemical and proximate composition was determined using titrimetric and spectrophotometric methods, while vitamins and minerals were determined by high-performance liquid chromatography (HPLC), emission flame photometry and atomic absorption spectrophotometry. The *C. esculenta* showed high concentrations of alkaloids and saponins, while *microgreens* and *P. guineense* recorded much tannins, flavonoids, folic acid (B_9) and iron (Fe). *S. macrocarpon* revealed high protein, niacin (B_3) and pyridoxine, while utazi is rich in fibre, vitamin E, zinc (Zn) and magnesium (Mg) with low moisture. *O. gratissimum* contained high thiamin (B_1) and riboflavin (B_2), while vitamins A and cobalamin (B_{12}) were abundant in *T. occidentalis* and *T. triangulare*. The *V. amygdalina* showed high vitamin C and calcium (Ca) levels. Highly significant variations exist among the bioactive compounds and the nutrients ($p < 0.0001$). These vegetables contained an appreciable quantity of nutrients and bioactive compounds at variable concentrations that are useful in folklore medicine and health care.

Key words: Plants · Phytochemicals · Proximate · Minerals · Vitamins

INTRODUCTION

Nutrients composition of traditionally used leafy plants species have been investigated worldwide but local species remain fundamentally underutilized [1]. Lack of sufficient information on the phytochemicals and nutrients profile of the plentiful indigenous plant species with which Nigeria is richly endowed hinders their exploitation. Most Nigerians are predominantly farmers who take advantage of the abundant and fertile soil to produce these edible plants.

Plants contain various therapeutic agents and *Talinum triangulare* (water leaf) has been involved medically in the treatment of disease such as obesity [2].

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Also, *Ocimum gratissimum* (scented leaf) has been used as a decongestant for bronchitis as well chewed to cure tooth and gum disorders [2]. Native plant species are important ingredients and cheap sources of nutrients of diet in most Nigerian homes, particularly in remote areas where they contribute significantly to their daily nutrition [3].

The pharmaceutical value of plant lies in the bioactive components which show various physiological effects on humans. Thus, phytochemical screening is useful for detecting the various important compounds applied as drugs for curing diseases [4]. Plants contain lots of nutrients and vitamins as well as secondary metabolites with high level of antioxidant activity [5]. In the area where the daily intake is primarily starchy foods, these leafy plants are the most readily available sources of important micro-nutrients like pro-vitamin A, vitamin B complex and mineral elements [6]. There are important products in the meal of poor families because they are affordable and its scarcity in food diet is the major cause of nutrients deficiency that leads to death of children within the Sub-Sahara Africa [7]. This study evaluated the nutrients and chemical compositions of ten (10) common edible plants found in Nigeria.

MATERIALS AND METHODS

Plant Materials: Ten (10) edible plants, *Ocimum gratissimum* (scent leaf), *Vernonia amygdalina* (bitter leaf), *Annona muricata* (soursop), *Talinum triangulare* (water leaf), *Colocasia esculenta* (cocoyam), *Solanum macrocarpon (*garden egg), *Microgreens*, *Piper guineense (*uziza), *Gangronema latifolium* (utazi) and *Telfairia occidentalis* were obtained from farmer in Nigeria. It was authenticated by a taxonomist in the Biology Programme, Alex Ekwueme Federal University, Ndufu-Alike Ikwo, Nigeria, sun-dried, pulverized into powder and used for the analysis.

Phytochemical Screening: Titrimetric method of Harbone [8] was used for the determination of tannins and cardiac glycosides, while the spectrophotometric method of Association of Analytical Chemists [9] and method of Odebiyi and Sofowora [10] was applied for terpenoids, alkaloids, flavonoids, phenols, saponins and phyto-sterol. Oxalate was analyzed using the method of Sanchez-Alonso and Lachica [11], while phytate was assayed by the procedure of Lucas and Markaka [12].

Proximate Analysis: The standard method of Association of Official Analytical Chemist's [13] was applied to determine the major nutrients component of the plants such as crude protein, lipids (fats), crude fibre, moisture, carbohydrate and energy.

Determination of Vitamins: Thiamin (B_1), riboflavin (B_2), niacin (B_3), pyridoxine (B_6), folic acid (B_9) and cobalamin (B_{12}) composition were analyzed using high-performance liquid chromatography (HPLC), while retinol (A), ascorbic acid (C) and tocopherol (E) were assayed using spectrophotometric method [13].

Determination of Minerals: Sodium (Na), potassium (K) and calcium (Ca) were estimated using emission flame photometry, while manganese (Mn), copper (Cu), iron (Fe), cadmium (Cd), magnesium (Mg), phosphorous (P) and zinc (Zn) were determined using atomic absorption spectrophotometry [13].

Statistical Analysis: Analyses were performed in triplicates and the data were presented as means ± MSE. One-way ANOVA or student paired t-test was accomplished using SAS software where appropriate [14]. P-values less than 0.05 were taken as statistically significant.

RESULTS AND DISCUSSION

Phytochemical analysis showed that terpenoids, tannins, alkaloids, flavonoids, oxalate, phytate, phenols, saponins, phyto-sterol and cardiac glycosides were present. The terpenoids content of the plants ranged from 17.08 ± 0.03 mg/100g in *O. gratissimum* to 64.74 ± 0.07 mg/100g in microgreens. The range of values for tannins, alkaloids, flavonoids, oxalate, phytate, phenols, saponins were 54.04 ± 1.14 mg/100g in *O. gratissimum* to 92.68 ± 0.03 mg/100g in microgreens, 28.72 ± 0.01 mg/100g in *V. amygdalina* to 120.24 ±0.05 mg/100g in *C. esculenta,* 8.31 ± 0.01 mg/100g in *T. accidentalis* to 38.11 ± 0.02 mg/100g in *P. guineense,* 21.44 ± 0.03 mg/100g in *T. triangulare* to 79.63 ± 11.55 mg/100g in *G. latifolium,* 10.86 ± 0.01mg/100g in *O. gratissimum* to 19.33 ± 0.01 mg/100g in *A. muricata,* 19.87 ± 0.06 mg/100g in *T. triangulare* to 165.25 ± 0.02 mg/100g in *C. esculenta,* 27.95 ± 0.02 mg/100g in *T. triangulare* to 125.48 ± 0.02 mg/100g in *C. esculenta*. The *G. latifolium* (78.43 ± 0.04 mg/100g) had the highest Phyto-sterol, while *C. esculenta* (22.82 ± 0.01 mg/100g) had the least. However, cardiac glycosides showed the highest concentration in *G. latifolium* (89.26 ±. 0.01 mg/100g) and least in *P. guineense* (26.34 ± 0.02 mg/100g) (Table 1).

Table 1: Phytochemical composition (mg/100g) of edible leafy vegetable in Nigeria

Edible Vegetables	Terpeniods	Tannins	Alkaloids	Flavonoids	Oxalates	Phytate	Phenol	Saponins	Phyto-sterol	Cardiac glycosides
O. gratissimum	17.08^{j}±0.03	54.0^{i}4±1.14	30.55^{h}±0.03	18.95^{d}±0.01	44.06^{d}±0.03	10.86^{i}±0.01	25.19^{g}±0.01	105.47^{b}±0.08	74.24^{b}±0.02	52.22^{e}±0.05
V. Amygdalina	31.06^{g}±0.02	57.38^{h}±0.02	28.72^{j}±0.01	22.30^{c}±0.01	68.56b±0.07	11.43^{h}±0.01	22.44^{i}±0.02	76.88^{d}±0.01	38.59^{g}±0.07	41.09^{g}±0.03
A. Muricata	47.14^{c}±0.05	73.86^{e}±0.03	50.17^{f}±0.01	17.38^{e}±0.01	73.09^{b}±0.10	19.33^{a}±0.01	32.33^{d}±0.02	45.23^{g}±0.02	54.95^{d}±0.03	33.51^{i}±0.03
T. Triangulare	23.16^{i}±0.06	62.64^{g}±0.04	42.35^{g}±0.01	11.74^{h}±0.06	21.44^{g}±0.03	17.53^{d}±0.03	19.87^{j}±0.06	27.95^{j}±0.02	68.29^{c}±0.01	35.53^{h}±0.06
C. Esculenta	53.32^{b}±0.02	69.41^{f}±0.02	120.24^{b}±0.05	9.17^{i}±0.01	35.16^{e}±0.02	17.91^{c}±0.01	165.25^{a}±0.02	125.48^{a}±0.02	22.82^{j}±0.01	72.93^{c}±0.02
S. Macrocarpon	40.22^{f}±0.02	76.23^{d}±0.01	160.56^{a}±0.04	16.46^{f}±0.026	65.37^{c}±0.02	15.22^{g}±0.01	23.59^{h}±0.03	79.72^{c}±0.02	43.33^{f}±0.02	78.54^{b}±0.02
Microgreens	64.74^{a}±0.07	92.68^{a}±0.03	58.98^{e}±0.02	32.25^{b}±0.01	42.33^{d}±0.05	17.16^{e}±0.01	38.11^{c}±0.02	68.46^{e}±0.02	29.48^{h}±0.05	49.17^{f}±0.03
P. Guineense	43.43^{e}±0.04	70.29^{f}±0.01	29.22^{i}±0.06	38.11^{a}±0.02	30.80^{e}±0.02	16.55^{f}±0.01	30.21^{f}±0.03	41.31^{h}±0.02	24.85^{i}±0.02	26.34^{j}±0.02
G. Latifolium	44.89^{d}±0.01	83.62^{c}±0.07	78.32^{c}±0.049	12.69^{g}±0.04	79.63^{a}±11.55	17.14^{e}±0.01	45.69^{b}±0.01	32.84^{i}±0.02	78.43^{a}±0.04	89.26^{a}±.0.01
T. Accidentalis	28.14^{h}±0.02	90.34^{b}±0.03	60.85d±0.01	8.31^{j}±0.01	27.54^{f}±0.03	18.65^{b}±0.01	31.36^{e}±0.04	60.86^{f}±0.05	51.28^{e}±0.02	68.81^{d}±0.06
Mean ± MSE	39.32±0.06	73.05±0.62	66.00±0.06	18.74±0.05	50.00±3.35	16.18±0.02	43.40±0.04	66.42±0.06	48.62±0.06	54.74±0.06
P-values	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
LSD	0.1035	1.072	0.0986	0.0808	5.7398	0.0285	0.0679	0.1029	0.1082	0.1021

Means with the same letter are not significantly different. Values are means ± MSE; Values followed by different letter are significantly different from each other

Table 2: Proximate composition (g/100g) of edible leafy vegetable in State Nigeria

Edible Vegetables	Protein	Fat	Fibre	Ash	Moisture	CHO	Energy (Kcal/100g)
O. gratissimum	18.34^{f}±0.04	4.85^{h}±0.01	14.29^{f}±0.02	12.65^{e}±0.03	9.47^{b}±0.04	40.41b±0.10	278.65^{f}±0.15
V. Amygdalina	27.11^{b}±0.01	8.18^{d}±0.01	13.78^{g}±0.05	11.57^{g}±0.04	8.62^{d}±0.05	30.76^{g}±0.06	305.02^{b}±0.13
A. Muricata	15.62^{h}±0.02	5.25^{g}±0.02	17.12^{c}±0.02	11.07^{h}±0.02	7.95^{g}±0.02	42.52^{a}±0.23	281.74^{e}±0.010
T. Triangulare	19.03^{e}±0.05	3.90^{i}±0.01	15.92^{d}±0.01	13.28^{d}±0.00	8.19^{f}±0.01	39.68^{c}±0.01	269.98^{i}±0.012
C. Esculenta	25.11^{d}±0.02	7.03^{e}±0.017	13.60^{h}±0.01	13.72^{b}±0.02	8.38^{e}±0.02	32.16^{f}±0.01	292.31^{c}±0.23
S. Macrocarpon	27.27^{a}±0.05	9.35^{b}±0.04	17.09^{c}±0.03	15.21^{a}±0.02	7.31^{i}±0.01	23.78^{h}±0.06	288.29^{d}±0.36
Microgreens	16.78^{g}±0.03	6.67^{f}±0.06	17.58^{b}±0.01	12.39^{f}±0.01	9.64^{a}±0.01	36.87^{d}±0.01	274.19^{h}±0.27
P. Guineense	16.83^{g}±0.03	6.66^{f}±0.04	17.61^{b}±0.02	12.40^{f}±0.03	9.66^{a}±0.01	36.85^{d}±0.03	274.66^{g}±0.36
G. Latifolium	25.78^{c}±0.05	8.93^{c}±0.01	20.19^{a}±0.02	13.59^{c}±0.03	8.79^{c}±0.01	22.72^{i}±0.01	274.33^{g}±0.03
T. Accidentalis	25.16^{d}±0.01	10.28^{a}±0.02	15.45^{e}±0.03	8.71^{i}±0.03	7.72^{h}±0.05	32.69^{e}±0.12	323.90^{a}±0.31
Mean ± MSE	21.70±0.06	7.10±0.04	16.26±0.04	12.46±0.03	8.57±0.05	33.84±0.14	286.31±0.25
P-values	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
LSD ($P \leq 0.05$)	0.1024	0.069	0.079	0.0431	0.0831	0.2465	0.4242

Means with the same letter are not significantly different. Values are means ± MSE; Values followed by different letter are significantly different from each other

The result of the proximate composition (Table 2) showed that protein value ranged from 15.62 ± 0.02 mg/100g in *A. muricata* to 27.27 ± 0.05 mg100g in *S. macrocarpon*, while *T. accidentalis* recorded the highest value of fat (10.28 ± 0.02 mg/100g) and *T. triangulare* had the lowest (3.90 ± 0.01 mg/100g). *G. latifolium* also recorded the highest fibre content (20.19 ± 0.02 mg/100g), followed by *P. guineense* (17.61 ± 0.02 mg/100g), with the *microgreens* (17.58 ± 0.01 mg/100g), *A. muricata* (17.12 ± 0.02), *S. macrocarpon* (17.09 ± 0.03 mg/100g) and *C. esculenta* (13.60 ± 0.01 mg/100g) having the least value. Ash content ranged from 8.71 ± 0.03 mg/100g in *T. accidentalis* to 15.21 ± 0.02 mg/100g in *S. macrocarpon,* while *C. esculenta* had 13.72 ± 0.02 mg/100g. The results of the moisture content showed that *P. guineense* (9.66 ± 0.01 mg/100g) had the highest value and *S. macrocarpon* (7.31 ± 0.01 mg/100g) showed the lowest. Carbohydrate composition ranged from 22.72 ± 0.01 - 42.52 ± 0.23 mg/100g in *A. muricata* and *G. latifolium*. The energy content was highest in *V. amygdalina* (323.90±0.31 Kcal/100g) and *T. triangulare* (269.98±0.012 Kcal/100g) had the lowest value (Table 2).

Vitamin composition of these plants is presented in Table 3. Six (6) water soluble vitamins: thiamin (B_1), riboflavin (B_2), niacin (B_3), pyridoxine (B_6), folic acid (B_9), cobalamin (B_{12}) and three (3) lipid soluble vitamins: retinol (A), ascorbic acid (C) and tocopherol (E) were present. Thiamin (B_1) and riboflavin (B_2) content ranged from 1.11 ± 0.02 mg/100g in *S. macrocarpon* to 1.56 ± 0.02 mg/100g in *O. gratissimum and* 1.22 ± 0.02 mg/100g in *T. triangulare* to 1.66 ± 0.01 mg/100g in O. *gratissimum,* while niacin (B_3) and pyridoxine (B_6), content were 0.33 ± 0.01 mg/100g in *T. accidentalis* to 0.95 ± 0.01 mg/100g in *S. macrocarpon /P. guineense and* 4.38 ± 0.05 mg/100g in microgreens to 9.67 ± 0.02 mg/100g in *S. macrocarpon* respectively. Similarly, folic acid (B_9) was higher in *microgreens* and *P. guineense* (4.29 ± 0.01 mg/100g) and least in *T. triangulare* (0.60 ± 0.02 mg/100g), while Cobalamin (B_{12}) showed 2.48 ± 0.02 mg/100g in *T. triangulare* to 0.79 ± 0.03 mg/100g in *P. guineense*. The concentration of the lipid soluble vitamins: retinol (A), ascorbic acid (C) and tocopherol (E) ranged from 17.86 ± 0.00 µg/g in *V. amygdalina* to 40.62 ± 0.01µg/g in *T. accidentalis,* 44.99 ± 0.08 g/100g in *O. gratissimum* to

Table 3: Vitamins composition (mg/100g) of edible leafy vegetable in State Nigeria

Edible Vegetables	Thiamin (B_1)	Riboflavin (B_2)	Niacin (B_3)	Pyridoxine (B_6)	Folic acid (B_9)	Cobalamin (B_{12})	Retinol (A) (μg/g)	Ascorbic Acid (C)	Tocopherol (E)
O. gratissimum	1.56^{a}±0.02	1.66^{a}±0.01	0.71^{d}±0.01	7.51^{c}±0.04	2.24^{d}±0.01	0.89^{e}±0.02	35.93^{b}±0.01	44.99^{i}±0.08	8.09^{g}±0.03
V. Amygdalina	1.23^{c}±0.01	1.51^{b}±0.01	0.77^{c}±0.01	8.83^{b}±0.04	0.79^{f}±0.03	1.72^{b}±0.02	17.86^{i}±0.00	112.28^{a}±0.0	13.22^{b}±0.03
A. Muricata	1.14^{e}±0.03	1.32^{d}±0.00	0.66^{e}±0.01	6.08^{g}±0.02	0.79f±0.01	0.85^{g}±0.06	33.78^{c}±0.09	94.36^{c}±0.16	10.02^{f}±0.05
T. Triangulare	1.38^{b}±0.00	1.22^{f}±0.02	0.62^{f}±0.01	4.79^{h}±0.01	0.60^{g}±0.02	2.48^{a}±0.02	18.32^{h}±0.01	66.61^{d}±0.05	5.89^{h}±0.01
C. Esculenta	1.19^{d}±0.01	1.53^{b}±0.02	0.87^{b}±0.02	6.84^{f}±0.01	3.37^{b}±0.01	1.18^{c}±0.03	32.53^{d}±0.02	50.32^{h}±0.03	10.09^{f}±0.02
S. Macrocarpon	1.11^{e}±0.02	1.42^{c}±0.00	0.95^{a}±0.01	9.67^{a}±0.02	2.86^{c}±0.03	0.78^{h}±0.01	26.38^{f}±0.02	64.89^{e}±0.03	12.71^{c}±0.04
Microgreens	1.26^{c}±0.00	1.26^{e}±0.01	0.94^{a}±0.01	4.38^{i}±0.05	4.29^{a}±0.01	0.81^{g}±0.01	22.57^{g}±0.00	106.84^{b}±0.01	11.81^{e}±0.01
P. Guineense	1.26^{c}±0.01	1.25^{e}±0.02	0.95^{a}±0.01	4.46^{i}±0.01	4.29^{a}±0.01	0.79^{h}±0.03	22.57^{g}±0.01	106.85^{b}±0.04	11.82^{e}±0.01
G. Latifolium	1.20^{d}±0.01	1.42^{c}±0.02	0.85^{b}±0.02	7.27^{d}±0.03	2.20^{d}±0.00	1.03^{d}±0.03	31.70^{e}±0.01	55.41^{g}±0.04	14.16^{a}±0.03
T. Accidentalis	1.36^{b}±0.01	1.50^{b}±0.01	0.33^{g}±0.01	7.14^{e}±0.02	0.88^{e}±0.01	0.92^{e}±0.01	40.62^{a}±0.01	59.08^{f}±0.08	12.39^{d}±0.02
Mean ± MSE	1.27±0.03	1.41±0.02	0.76±0.02	6.70±0.05	2.23±0.03	1.14±0.03	28.22±0.05	76.16±0.12	11.02±0.05
P-values	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
LSD ($P \leq 0.05$)	0.0482	0.0369	0.0355	0.0832	0.0467	0.0549	0.0883	0.2128	0.0904

Means with the same letter are not significantly different. Values are means ± MSE; Values followed by different letter are significantly different from each other

Table 4: Minerals composition (mg/100g) of edible leafy vegetable in Nigeria

Edible Vegetables	Manganese (Mn)	Copper (Cu)	Iron (Fe)	Cadmium (Cd)	Sodium (Na)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Phosphorous (P)	Zinc (Zn)
O. gratissimum	11.22^{e}±0.03	0.58^{d}±0.01	21.13^{f}±0.03	0.28^{a}±0.00	103.18^{f}±0.01	69.79^{i}±0.07	85.25^{b}±0.03	128.68^{h}±0.01	38.34^{h}±0.09	9.25^{e}±0.03
V. Amygdalina	7.43^{f}±0.01	0.43^{e}±0.01	29.38^{c}±0.03	0.24^{c}±0.00	96.74^{h}±0.00	120.11^{e}±0.11	98.54^{a}±0.62	143.90^{g}±0.00	62.16^{d}±0.02	8.47^{g}±0.04
A. Muricata	18.56^{b}±0.02	0.63^{c}±0.01	10.76^{g}±0.01	0.25^{b}±0.00	92.86^{i}±0.01	72.58^{h}±0.01	76.66^{c}±0.08	106.48i±0.06	36.15^{i}±0.05	10.44^{c}±0.04
T. Triangulare	3.74^{g}±0.02	0.67^{b}±0.01	4.50^{i}±0.00	0.17^{d}±0.00	212.84^{a}±0.01	171.66^{a}±0.04	26.05^{h}±0.09	162.79^{e}±0.02	51.93^{g}±0.03	8.70^{f}±0.09
C. Esculenta	3.77^{g}±0.05	0.31^{h}±0.01	24.56^{d}±0.03	0.07^{g}±0.00	101.92^{g}±0.01	120.61^{d}±0.01	33.71^{g}±0.05	189.57^{b}±0.04	58.30^{f}±0.03	8.46^{g}±0.08
S. Macrocarpon	14.84^{c}±0.01	0.35^{g}±0.01	34.32^{b}±0.02	0.11^{f}±0.00	144.59^{d}±0.07	129.66^{c}±0.01	46.09^{f}±0.07	172.47^{d}±0.04	92.18^{a}±0.07	10.83^{b}±0.09
Microgreens	18.54^{b}±0.00	0.39^{f}±0.00	37.64^{a}±0.01	0.14^{e}±0.00	184.53^{b}±0.00	139.18^{b}±0.00	63.32^{e}±0.01	149.18^{f}±0.01	69.66^{b}±0.05	7.47^{h}±0.01
P. Guineense	18.53^{b}±0.00	0.39^{f}±0.00	37.65^{a}±0.03	0.15^{e}±0.01	184.53^{b}±0.04	139.18^{b}±0.01	63.33^{e}±0.02	149.15^{f}±0.04	69.61^{b}±0.13	7.47^{h}±0.02
G. Latifolium	11.53^{d}±0.02	0.32^{h}±0.00	24.25^{e}±0.01	0.11^{f}±0.01	170.30^{c}±0.02	86.10^{g}±1.01	67.89^{d}±0.02	202.79^{a}±0.06	60.42^{e}±0.01	11.18^{a}±0.03
T. Accidentalis	19.03^{a}±0.06	1.07^{a}±0.01	10.19h±0.03	0.07^{g}±0.01	134.15^{e}±0.01	90.50^{f}±0.06	23.46^{i}±0.05	187.53c±0.0	65.92^{c}±0.11	10.13^{d}±0.04
Mean ± MSE	12.72±0.05	0.51±0.01	23.44±0.04	0.16±0.00	142.56±0.04	113.94±0.08	58.43±0.35	159.25±0.04	68.47±0.06	9.24±0.06
P-values	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
LSD ($P \leq 0.05$)	0.0814	0.0198	0.061	0.0072	0.0762	0.135	0.608	0.0717	0.1058	0.0977

Means with the same letter are not significantly different. Values are means ± MSE; Values followed by different letter are significantly different from each other

112.28 ± 0.05 mg/100g in *V. amygdalina* and 5.89 ± 0.01 mg/100g in *T. triangulare* to 14.16 ± 0.03 mg/100g in *G. latifolium* (Table 3). Generally, the values of B-complex vitamins were relatively low compared with lipid soluble vitamins of the vegetables.

The results of the mineral analysis (Table 4) showed that manganese (Mn) was highest in *T. accidentalis* (19.03 ± 0.06 mg/100g), while *T. triangulare* (3.74 ± 0.02 mg/100g) had the lowest value. Copper (Cu) ranged from 0.31 ± 0.01-1.07 ± 0.01 mg/100g in C. *esculenta* and *T. accidentalis*. Iron (Fe) was heaviest in *P. guineense* (37.65 ± 0.03mg/100g), microgreens (37.64 ± 0.01mg/100g) and lowest in *T. triangulare* (4.50 ± 0.00mg/100g). The *O. gratissimum* (0.28 ± 0.00) recorded the highest composition of cadmium (Cd), while *C. esculenta* and *T. accidentalis* had the lowest composition 0.07 ± 0.00 mg/100g. Sodium (Na) and potassium (K) ranged between 92.86 ± 0.01 mg/100g in *A. muricata* to 212.84 ± 0.01 mg/100g in *T. triangulare* and 69.79 ± 0.07 mg/100g in *O. gratissimum* to 171.66 ± 0.04mg/100g in *T. triangulare* respectively. The quantity of calcium (Ca) and magnesium (Mg) ranged from 23.46 ± 0.05mg/100g in *T. accidentalis* to 98.54 ± 0.62mg/100g in *V. amygdalina* and 106.48 ± 0.06 mg/100g in *A. muricata* to 202.79 ± 0.06 mg/100g in *G. latifolium,* while phosphorous (P) and zinc (Zn) concentrations were 36.15 ± 0.05mg/100g in *A. muricata* to 92.18 ± 0.07mg/100g in *S. macrocarpon* and 7.47 ± 0.01 mg/100g in Microgreens and *P. guineense* to 11.18 ± 0.03 mg/100g in *G. latifolium*.

The study revealed that these plants are abundant in phytochemicals which serves as ingredients for production of useful drugs (Table 1). The availability of tannins in these plants supports their use by herbalist for treatment of diseases. Shahidi *et al*. [15] found that tannins has remarkable effect in cancer treatments and edible plant containing tannins can be useful in treating intestinal disorders such as dysentery [16]. The alkaloid content indicates that they could be used in the management of hypertension [17], while the presence of saponins suggests that it could be useful in treating hyperglycaemia [18].

Flavonoids are free radical scavenger and its presence in human diet reduces the risk of various cancers as well as prevents oxidative cell damage [19]. *G. latifolium* with high oxalate content reduces the nutritive value of the plants [20]. However, oxalate at minute level and food processing advantageously confers antioxidant activity in both food and humans. Moreover, dietary oxalate has also been shown to bond with calcium, magnesium and iron, developing insoluble oxalate salts

Table 5: Correlation values among phytochemical components of edible leafy vegetable in Nigeria

Parameters	Terpeniod	Tannins	Alkaloid	Flavonoid	Oxalates	Phytate	Phenol	Saponins	Phyto-sterol	Cardic glycoside
Terpeniod	1.000	0.6021**	0.3520	0.3420	0.2079	0.4988**	0.4427*	0.0395	-0.5912****	0.1307*
		(0.0004)	(0.0564)	(0.0643)	(0.2702)	(0.0050)	(0.0143)	(0.8358)	(0.0006)	(0.4913)
Tannins		1.000	0.3128	0.0062	0.0708	0.6646**	0.0297	-0.2778	-0.1678	0.4078*
			(0.0924)	(0.9739)	(0.7100)	(< .0001)	(0.8762)	(0.1373)	(0.3756)	(0.0253)
Alkaloid			1.000	-0.3967***	0.2068	0.2365	0.4422*	0.3607	-0.2068	0.7246**
				(0.0300)	(0.2787)	(0.2084)	(0.0144)	(0.0502)	(0.2730)	(< .0001)
Flavonoid				1.000	-0.0740	-0.2257	-0.3221	-0.1613	-0.4723	-0.5796
					(0.6975)	(0.2305)	(0.0826)	(0.3946)	(0.0084)	(0.0008)
Oxalates					1.000	-0.1532	-0.1438	-0.1361	0.3119	0.3600
						(0.4189)	(0.4484)	(0.4735)	(0.0934)	(0.0507)
Phytate						1.000	0.2855	-0.4143	-0.1409	0.0828
							(0.1262)	***(0.0229)	(0.4578)	(0.6635)
Phenol							1.000	0.6011	-0.4251	0.3666
								**(0.0004)	***(0.0192)	*(0.0463)
Saponins								1.000	-0.3541	0.2952
									(0.0549)	(0.1133)
Phyto-sterol									1.000	0.2077
										(0.2707)
Cardic glycoside									1.000	

Note: df (n-3) for testing significance of correlations = 30; * significant positive p < 0.05; ** highly significant positive p< 0.001; *** significant negative p< 0.05; **** highly significant negatively p< 0.001.

called oxalate stone [21]. The content of oxalates in these plants is lower than the tolerable level of 250 mg/100g fresh sample which suggests its safety for human consumption [22].

Phytate is very stable and considered to be an anti-nutrient by virtue of its ability to chelate divalent metals and prevent their absorption. Its presence in plants may lead to reduced mineral absorption as a result of high density of negatively charged phosphate groups which complexes with many mineral ions, making it unavailable for intestinal absorption. However, the presence of phytate with high fibre as obtainable in these plants is good and would reduce the incidence of cardiovascular diseases [23]. Phenols which exist in the ten (10) edible plants have been testified to have potential as antioxidant due to their effective hydrogen donor ability [24], while steroid is active in regulating carbohydrate and protein metabolism and possess anti-inflammatory properties [25]. In recent time, the prevention of cancer and cardiovascular diseases has been allied with the consumption of plants rich in natural antioxidants [26]. From other current findings, *O. gratissimum* has attested to be useful for the treatment of people with HIV and AIDS [27], while *P. guineense* extract are equally a good sources of antioxidants widely used against oxidative stress. Strong positive correlations exist between the chemical compounds analyzed p < 0.001) (Table 5).

These plants are comparatively high in carbohydrate and energy, followed by protein, crude fibre and ash with low moisture and fat contents. The low moisture content is an index of stability, shelf life and quality [28], while the presence of ash is a reflection of inorganic matter in the plants (Table 2). The plants contained substantial quantity of protein meaning that it could be used for regulating body processes and restoring new body tissues. The high fibre content shows that they can assist in keeping the digestive system healthy and functional.

The low fat content in the plants could be an advantage in the diets of people aged 60 years and above. Lipids had been reported to help in the absorption of fat-soluble vitamins such as vitamins A and E [29]. This indicates that lipid content in these plants will help in the uptake of water soluble vitamins. The crude protein and carbohydrate (33.84±0.14g/100g) contents of these plants were high and agreed with the report of Isong and Essien [30], but contrary to Eleazu and Eleazu [31], who reported lower carbohydrate composition of 4.11±0.13mg/100g in *T. triangulare*. Highly significant positive and negative correlations were observed between the assayed nutrients p < 0.0001) (Table 6). Highly significant negative correlation exist between protein and moisture (r = -52%, p < 0.0034) as well as protein and carbohydrate (r = - 86%, p < 0.0001) meaning that increase in protein leads to decrease in availability of moisture and carbohydrate content respectively.

Table 6: Correlation values among proximate components of edible leafy vegetable in Ebonyi State Nigeria

Parameters	Protein	Fat	Fibre	Ash	Moisture	CHO	Energy
Protein	1.000	0.76661(< .0001)**	-0.17380(0.3583)	0.16887(0.3724)	-0.51723(0.0034)****	-0.85757(< .0001)****	0.58949 (0.0006)**
Fat		1.000	0.17538(0.3539)	-0.15577(0.4111)	-0.36712(0.0460)	-0.80896(< .0001)****	0.66480(< .0001)**
Fibre			1.000	0.20224(0.2838)	0.10452(0.5826)	-0.30700(0.0989)	-0.48756(0.0063)
Ash				1.000	0.02212(0.9076)	-0.39101***(0.0326)	-0.61567(0.0003)****
Moisture					1.000	0.32315(0.0815)	-0.48569(0.0065)****
CHO						1.000	-0.24786(0.1866)
Energy							1.000

Note: df (n-3) for testing significance of correlations = 30; * significant positive p< 0.05; ** highly significant positive p< 0.001; *** significant negative p< 0.05; **** highly significant negative p< 0.001.

Table 7: Correlation values among vitamins components of edible leafy vegetable in Ebonyi State Nigeria

Parameters	Thiamin (B_1)	Riboflavin (B_2)	Niacin (B_3)	Pyridoxine (B_6)	Folic acid (B_9)	Cobalamin (B_{12})	Retinol (A)	Ascorbic Acid (C)	Tocopherol (E)
Thiamin (B_1)	1.000	0.34683 (0.0604)	-0.43283 (0.0169)***	-0.18323 (0.3325)	-0.16404 (0.3864)	0.21219 (0.2603)	0.19867 (0.2926)	-0.35101 (0.0572)	-0.54522 (0.0018)****
Riboflavin (B_2)		1.000	-0.21843 (0.2462)	0.68845 (< .0001)**	-0.16860 (0.3731)	-0.20393 (0 .2797)	0.55963 (0.0013)**	-0.54361 (0.0019)****	0.10399 (0.5845)
Niacin (B_3)			1.000	-0.02673 (0.8885)	0.76258 (< .0001)**	-0.25138 (0.1803)	-0.48608 (0.0065)****	0.28813 (0.1226)	0.26370 (0.1591)
Pyridoxine (B_6)				1.000	-0.30209 (0.1047)	-0.11202 (0.5558)	-0.22151 (0.2394)	-0.32779 (0.0770)	-0.40058 (0.0283)***
Folic acid (B_9)					1.000	-0.54690 (0.0018)****	-0.13135 (0.4890)	0.15105 (0.4256)	0.24130 (0.1989)
Cobalamin (B_{12})						1.000	-0.54973 (0.0017)****	-0.01048 (0.9562)	-0.51565 (0.0035)****
Retinol Vit A (ug/g)							1.000	-0.62409 (0.0002)****	0.06620 (0.7282)
Ascorbic Acid (Vit. C)								1.000	0.28160 (0.1317)
Tocopherol (Vit. E)									1.000

Note: df (n-3) for testing significance of correlations = 30; * significant positive p< 0.05; ** highly significant positive p< 0.001; *** significant negative p< 0.05; **** highly significant negative p< 0.001.

Table 8: Correlation values among minerals components of edible leafy vegetable in Ebonyi State Nigeria

Parameters	Mn	Cu	Fe	Cd	Na	K	Ca	Mg	P	Zn
Mn	1.000	0.26457 (0.1577)	0.24768 (0.1870)	-0.04716 (0.0045)	0.06230 (0.7436)	-0.31325 (0.0919)	0.11745 (0.5365)	-0.27239 (0.1453)	0.20849 0.2689	0.12067 (0.5253)
Cu		1.000	-0.72716 (< .0001)****	0.01862 (0.9222)	-0.06945 (0.7154)	-0.24572 (0 .1906)	-0.37040 (0.0439)***	-0.08207 (0.6664)	-028884 (0.1216)	0.20275 (0.2826)
Fe			1.000	-0.13363 (0.4814)	0.09076 (0.6334)	0.21323 (0.2579)	0.37134 (0.0433)*	0.04206 (0.8253)	0.61535 (0.0003)**	-037517 (0.0411)
Cd				1.000	-0.35189 (0.0565)	-0.28627 (0.1251)	0.75555 (< .0001)**	-0.86555 (< .0001)****	-0.63980 (< .0001)****	-0.10974 0.5638
Na					1.000	0.68167 < .0001)**	-0.41365 (0.0231)***	0.31703 (0.0878)	0.35835 (0.0518)	-0.24653 (0.1891)
K						1.000	-0.40947 (0.0246)***	0.18771 (0.3206)	0.47916 (0.0074)**	-0.57279 (0.0009)****
Ca							1.000	-0.60177 (0.0004)****	-0.30464 (0.1017)	-0.07003 (0.7131)
Mg								1.000	0.51262 (0.0038)**	0.24640 (0.1893)
P									1.000	-0.00901 (0.9623)
Zn										1.000

Note: df (n-3) for testing significance of correlations = 30; * significant positive p< 0.05; ** highly significant positive p< 0.001; *** significant negative p< 0.05; **** highly significant negative p< 0.001.

In this study, thiamin (vit.B_1) was found higher 1.27±0.03mg/100g than the reported daily intake of 1.0-1.2 mg/day [32], while riboflavin (B_2) (1.14±0.02mg/100gm) was within the daily recommended limit of 1.1-1.3mg/day. Pyridoxine (B_6) was higher (6.70±0.05mg/100g) than the recommended daily intake of 1.2-1.3mg/day, while niacin (B_9) was maximum (0.76±0.02mg/100gm) as compared to the daily permissible range for adults up to 1000µg/day [32]. All the plants analyzed are rich in vitamins A and C meaning that their consumption is important and will help in the formation of strong bones due to high content of vitamins and proteins [33]. The range of ascorbic acid (vitamin C) obtained in this work was higher than the 1.33-48.39 mg/100g recorded by Hosam *et al*. [34].

Significant positive and negative correlations exist between the analyzed vitamins $p < 0.0001$). Highly significant positive correlation were observed between riboflavin (B_3) with pyridoxine (B_6) ($r = 69\%$, $p < 0.0001$) as well as nacin (B_3) and folic acid (B_9) ($r = 76\ \%$, $p < 0.0001$) (Table 7).

Ten (10) mineral elements were established to be present, iron, sodium, potassium, calcium, magnesium and phosphorous found in higher amount are nutritionally significant for proper body build up. Iron is essential for hemoglobin formation and normal operation of the central nervous system [35]. It is a constituent of some metalloenzymes [36], which is needed for cellular metabolism, while calcium plays a vital role in muscle contraction, bone and teeth formation [36].

Inorganic mineral elements such as potassium, calcium play important roles in the maintenance of normal glucose-tolerance and in the release of insulin from beta cells of islets of Langerhans [37]. The results of this work support the submission of Igwegbe *et al*. [38], that minerals in some leafy-vegetable are usually high (Table 4) which justifies the recommendation of fresh plants for anemic patients who require iron, zinc and magnesium supplements. Significant correlation exist between Fe and Ca ($r = 76\ \%$, $p < 0.0433$), while highly significant positive correlation were observed between Fe with P ($r = 62\%$, $p < 0.0003$ respectively (Table 8).

CONCLUSION

This study showed that these edible plants contain appreciable amount of nutrients and bioactive compounds at variable concentrations that is useful in folklore medicine and health care. They are rich in proximate and excellent dietary source of zinc, iron, magnesium, potassium and calcium that are good for human consumption and necessary for growth and development. Highly significant variation exists among the bioactive compounds and the nutrients $p < 0.0001$).

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REFERENCES

1. Kola, F., 2004. Proximate Composition of Bungu (*Ceratotheca sesamoides* endl.) leaves and seeds. Biokemistri, 16: 88-92.
2. Adewunmi, A.O. and E.A. Sofowora, 1990. Preliminary screening of some plant extracts for molluscidal activity. Planta Med., 39: 57-82.
3. Mosha, T.C. and H.E. Gaga, 1999. Nutritive value and of blanching on trypsin and chymotrypsin inhibitor activities of selected leafy vegetables. Plant Foods Human Nutri., 54: 271.
4. Sheikh, N., Y. Kumar, A.K. Misra and L. Pfoze, 2013. Phytochemical screening to validate the ethnobotanical importance of root tubers of *Dioscorea species* of Meghalaya, North East India. J. Med. Plants Studies, 1(6): 62.
5. Manjula, C.H. and K. Ammani, 2012. Phytochemical analysis and pharmacological importance of *Sophora interrupta* leaves. Int. J. Res. in Pharm. and Biomd. Sci., 3(4): 1798.
6. Martin, F.W. and L.S. Ruberte-Meitner, 1998. Edible Leaves of the Tropic: Educational concerns for Hunger organization. INC., pp: 1-14.
7. Okigbo, B.N., 1986. Broadening the food base in Africa. The potential of traditional food plants. Food Nutri., 12: 4.
8. Harbone, J.B., 1983. Phytochemical methods of determining antinutrients. J. Food Chem., 14: 10.
9. AOAC, 1989. Association of Analytical Chemist[s]. Method of determining antinutrients using spectrophotometer. Lab. Sci., 21: 8-10.
10. Odebiyi, A. and A.E. Sofowora, 2007. Phytochemical screening of Nigerian medicinal plants. Part III Iioydia, 41: 243.
11. Sanchez-Alonso, F. and M. Lachica, 1987. Seasonal trends in the elemental content of plum leaves. Commun. Soil Sci. Plant Anal., 18: 31.

12. Lucas, G.M. and P. Markaka, 1987. Phytic acid and other phosphorus compound of bean (*Phaseolus vugaris*). J. Agric. Edu. Chem., 23: 13.
13. AOAC, 2002. Official Method of Analysis 17th Edition. Association of Official Analytical. Chemists, Maryland, 1106.
14. SAS, 2008. Software Institute Inc., Release 9.0 editions, Cary, NC, USA.
15. Shahidi, F., C.M. Liyana-Pathirana and D.S. Wall, 2006. Antioxidant Activity of White and Black Sesame Seeds and their Hull Fractions. Food Chem., 99: 478.
16. Okwu, D.E. and C. Josiah, 2006. Evaluation of the chemical composition of two Nigerian medicinal plants. Afri J. Biotech., 5(4): 357.
17. Akinpelu, D.A. and T. M. Onakoya, 2006. Antimicrobial activities of medicinal plants used in folklore remedies in south-western. Afri. J. Biotech., 5: 1078.
18. Okwu, D.E., 2004. Phytochemicals and vitamin content of indigenous spices of South Eastern Nigeria. J. Sust. Agric. and the Environ., 6: 30.
19. Ross, J. and C. Kasum, 2002. Dietary Flavonoids: Bioavailability, Metabolic Effects and Safety. Ann. Review of Nutri., 22: 19.
20. Ujowundu, V.C., R. Shrivastava and R.K. Upreti, 2010. Vital infections and trace elements: A complex interaction. Current Sci., 87: 1536.
21. Oke, L.O., 1996. Chemical Composition of some Nigeria leafy vegetables. J. American Dietetic Assoc., 53: 130.
22. Oguchi, Y., W.A.P. Weerakkody, A. Tanaka, S. Nakazawa and T. Ando, 1996. Varietal differences of quality-related compounds in leaves and petioles of spinach grown at two locations. Bulletin of the Horishima Prefectural Agric. Res. Center, 64: 10-23.
23. Oboh, G., 2005. Effect of some post-harvest treatment on the nutritional properties of *Cnidoscolus acontifolus* leaf. Pakistan J. Nutri., 4(4): 226.
24. Oboh, G. and A.A. Akindahunsi, 2004. Change in the ascorbic acid, total phenol and antioxidant activity of sun-dried commonly consumed green leafy vegetables in Nigeria. Nutri. Health, 18: 29.
25. Omotayo, F.O. and T.I. Borokini, 2012. Comparative phytochemical and Ethnomedicinal survey of selected medicinal plants in Nigeria. Sci. Res. Essays, 7(9): 989.
26. Chu, Y.F., J. Sun, X. Wu and R.H. Liu, 2002. Antioxidant and ant-proliferative activities of common vegetables. J. Agric. Food Chem., 50: 6910.
27. Nwinyi, O.C., N.S. Chinedu, O.O. Ajani, C.O. Ikpo and K.O. Ogunniran, 2009. Antibacterial effects of extracts of *Ocimum gratissimum* and *Piper guineense* on *Escherichia coli* and *Staphylococcus aureus*. Afri. J. Food Sci., 3(1): 22-25.
28. Levander, O.A., 1990. Fruit and vegetable contribution to dietary mineral intake in human health and disease. Hort Sci., 25: 1486-1488.
29. Osborne, D.R. and P. Voogt, 1978. The analysis of nutrients in foods. Academic Press, NewYork, USA, pp: 49-51.
30. Isong, E.U. and I.B. Essien, 1996. Nutrition and anti-nutrient composition of tree varieties of Piper species. Plant foods Human Nutri., 49(2): 133-137.
31. Eleazu, C.O. and K.C. Eleazu, 2013. Bioactive Constituents and In-vitro Antioxidant Capacity of Water Leaf (*Talinum triangulare*) as Affected by Domestic Cooking. Euro J. Med. Plants, 3(4): 540-551.
32. Alexander, M., G. Emanuel, T. Golin, J.T. Pinto and R.S. Rivlin, 1984. Relation of riboflavin nutriture in healthy elderly to intake of calcium and vitamin supplements: Evidence against riboflavin supplementation. American J. Clin. Nutri., 39: 540 - 546.
33. Ekeanyanwu, R.C., G.I. Ogu and U.P. Nwachukwu, 2010. Biochemical characteristics of the African Nutmeg, Monodora myristica. Agric. J., 5(5): 303-308.
34. Hossam, A.S., S.A. Hussein and A.E. Ahmed, 2016. Morphological and Physiochemical Characterization of Ten Lime and Lemon Accessions and the Assessment of their Genetic Diversity Maintained at ISSR Marker. J. Hort. Sc. and Orna. Plants, 8(3): 200-211.
35. Adeyeye, E. and M.KO. Otokiti, 1999. Proximate composition and some nutritional valuable minerals of two varieties of *Capsicum annum* (bell and cherry peppers). Disc. Inn., 11: 75-81.
36. Ahmed, D. and M.A. Chaudhary, 2009. Medicinal and nutritional aspects of various trace metals determined in *Ajuga bracteosa*. J. Applied Sci. Res., 5(7): 864-869.
37. Choudhary, K.A. and N.G. Bandyopadhyay, 1999. Preliminary studies on the inorganic constituents of some indigenous hyperglycaemic herbs on oral glucose tolerance test. J. Ethnopharm., 64: 179-184.
38. Igwegbe, O., H.M. Belhaai, T.M. Hassan and A.S. Gibali, 1992. Effect of a highway's traffic on level of lead and cadmium fruits and vegetables grown along road sides. J. Food Safety, 13: 7-18.