Studies on the Nutritional, Minerals, Mineral ratio, Anti-nutritional, Molar Ratio and Antioxidant compositions of Four Selected Leafy Wild Vegetables in Ado-Ekiti, Ekiti State, Nigeria

ABSTRACT

The study investigated the nutritional, mineral Anti-nutritional factors, molar ratios and antioxidants compositions in the leaves of four selected wild edible vegetables (*Piper guinensis, Piper umbelatum, Celosiaargentia and Jatropha tajorensis*) collected in Ado Ekiti, Ekiti State, Nigeria. The proximate, minerals and anti-nutrient compositions of the samples were determined using standard procedures. Also antioxidant activity of the samples were detected using standard assays such as 1, 1, diphenyl-2-2 picrylhydrazyl (DDPH) and Ferric Reducing Antioxidant Potential (FRAP).The mineral ratio, molar ratio and Mineral Safety Index were calculated from mineral results. The results of the proximate compositions for the four wild vegetables for moisture content, ash, crude fat, crude fiber, crude protein and carbohydrate ranged from 11.16 -12.15%, 2.76-4.03%, 4.07 -7.31%, 13.33-16.73%, 7.36 – 10.09%, and 52.09 -58.22% respectively,. The results of the mineral composition revealed high content of K, moderate content of Ca, P, and low contents of Mg, Fe, Zn,Cu and very low concentrations of Pb and Ni. Cd was absent in all the samples investigated. Zn/Cu and Fe/Cu ratios indicated low copper load. Antinutrients factors in the vegetable were low with the exception of phytate which can be reduced to non-toxic level through boiling or cooking. The calculatedmole ratio for [Phy][Zn], [Ca]/[Phy], [Phy]/[Fe] and [Ca][Phy]/[Zn] conformed with the standard values. The results of the antioxidant properties showed that the wild vegetables are good natural antioxidant sources. The assessment of the vegetables showed that they are rich sources of crude protein, crude fiber and carbohydrate with high energy calories. The mineral ratios and mineral safety index suggested that the minerals could not pose any mineral load to human body. Hence, the vegetables could be explored as supplement diet for man. The vegetables could provide the needed nutrition health benefit and also help in addressing the problem of food security in Nigeria.

Keywords: Vegetables, anti-nutrients, antioxidants, bioavailability, *Jatropha tajorensis, Piper guinensis, Piper umbelatum,* malnutrition.

1. INTRODUCTION

Low standard of living as a result of low economic status in Nigeria has led to consumption of poor and unhealthy diets. This has resulted in unbalanced nutrition with malnutrition and causes of chronic diseases such as diabetes, hypertension, cancer, obesity, respiratory disorder and other cardiovascular diseases[1]**.** The uses of vegetables for food security in the nation cannot be underestimated most especially in Nigeria and Sub- Sahara Africa where malnutrition and hunger threatens millions of people in in Sub Sahara Africa [2].

“Vegetables occupy an important place among food crops as they provide adequate amount of minerals and vitamins for humans” [3]. Nnamani *et al*. [4] reported vegetables to be important

sources of protective foods. Also, [5] and [6] reported that more than 900 millions of people are undernourished and over two billion people are afflicted by one or more micronutrients. Borokini*et al.*[7] stipulated that food plants such as leafy vegetables have played an important role in human nutrition especially in the aspect of food scarcity and micronutrient deficiencies. Lyatuu and Lebose [8] also noted that indigenous vegetables are getting more popularity than ever before due to their contributions in nutrition security to millions of people. Also, [9] in their findings emphasised that leafy vegetables contribute sustainably to protein, minerals, vitamins, fibers and other nutrients which are in short supply in people diets. Proteins in vegetables are ascertained to be superior to those in fruits but inferior to those in grains [10]. “Fats and oil obtained from vegetable had been reported to lower blood lipids thereby reducing the occurrences of diseases associated with coronary diseases” [11].
Apart from vegetables as food, it also serves as medicine to manage various ailments for their therapeutic properties. Aregheore [12] reported that anti-nutrient substances such as phytic acid, flavonoids, tannins, saponins and alkaloids are present in most vegetables. According to Jimoh and Afolayan [13], most leafy vegetables contain anti-nutrients of which most of these acts as antioxidants and are responsible for their therapeutic properties.
Consequent of the above, this research work is designed to examine the nutritional, minerals and antioxidant compositions of the leaves of four locally consumed vegetables respectively.

2. MATERIALS AND METHODS

2.1 Collection and preparation of samples

The matured leaves of indigenous vegetables of *Celosia argentea* and *Jatropha tajorensis* were obtained from Oba`s market, Ado Ekitiwhile those of *Piperguinensis, Piper umbelatum* were obtainedfromfarmlands in Ado Ekiti. The leaves were separated from the shoots, rinsed with distilled water and air dried for three weeks. The air dried leaves were pulverized into powdery form and stored separately in a covered plastic rubber at ambient temperature until it was ready for analysis at the Department of Chemical Sciences, Afe Babalola University, Ado-Ekiti, Nigeria.

2.2 Proximate Analysis

Proximate analysis of the powdered sample was carried out to determine moisture, ash, crude fiber and crude fat using standard methods of AOAC [14], protein was determined by the Kjeldahl method [15]. Carbohydrate was determined by the difference.

2.2.1 Moisture content determination

Moisture content of the powdered samples was determining using AOAC [14] method. The sample (5g) was weighed into already weighed clean dry cans. The cans with the samples were then placed in the oven at 105^0C to dry until constant weight was determined using the formula:

$$\% \text{ Moisture Content (MC)} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Where

W_1 = Weight of empty can; W_2 = Weight of can + sample before drying; W_3 = Weight of can + sample after drying.

The dry matter was used in the determination of other parameters. The protein content was determined using Micro Kjedhal method by multiplying the total organic nitrogen by 6.25 AOAC [14]. Carbohydrate content was determined by the differences obtained after subtracting the total Nitrogen protein, fat, ash, fiber from the total dry matter and expressed as percentage AOAC [14].

Available Carbohydrate = (100 - %moisture +% ash +% protein + %Fibre).

Ash continent was determined by incineration of 10.0 g sample placed in a muffle furnace maintained at 550^0C for 5h. Crude fibre was obtained by digesting 2.0g of the samples with H_2SO_4 and NaOH and incinerating the residue in a muffle furnace maintained at 550^0C for 5h.Crude fat was obtained exhaustively extracting 5.0g of the sample in Soxhlet apparatus using petroleum boiling range 40-60^0C as extract.

2.3 Determination of mineral compositions

One gram (1g) of the powdered sample was digested with 10ml of concentrated Nitric acid, 3ml of 60% Perchloric acid and 1ml of concentrated H_2SO_4. After cooling, the digest was diluted with 50ml de-ionised distil water filtered with Whatman No 42 filler paper and the filtrate was made up to 100ml in a glass volumetric flask with de-ionised distil water. Filtered solution was used to determined Zn, Fe, Mn, Cu, Pb and Cd by means of Atomic Absorption Spectrophotometer (Bulk Scientific 210 VP Spectrophotometer). The macro-elements Sodium and Potassium were analysed by Flame Photometer-Jenway (FP) 902 unit-122. Phosphorus was analysed by Jenway 6 Compressor. All chemicals used are of British Drug House (BDH, London, UK) analytical grade.

2.4 Determination of Energy

This was calculated using Atwater factor method as described by [16]. The estimated energy value in the samples in Kilocalorie (Kcal/100g) was determined by adding the multiply values for crude fat, crude protein and carbohydrate using the factor (9Kcal, 4Kcal and 4Kcal) respectively. The energy value in Kilojoule was determined by adding the multiply values for crude fat, crude protein and carbohydrate using the factor (37Kcal, 17Kcal and 17Kcal) respectively.

2.5 Determination of Anti- oxidants

DPPH Determination (1, 1-diphenyl-2-picrylhydrazyl) radical scavenging assay .The free radical scavenging ability of the sample against DPPH (1, 1-diphenyl-2-picrylhydrazyl) was determined using the method of Gyamfi *et al*. [17]. An aliquot of 1 ml of the sample was mixed with 1 ml of 0.4 mM DPPH solution and the mixture was left in the dark for 30 min before measuring the absorbance at 517 nm on JENWAY UV-visible spectrophotometer (JENWAY Inc.). The DPPH inhibition ability was calculated in percentages.

FRAP Determination (Ferric Reducing Antioxidant Power). The reducing property of the extract was determined as described by Pulido *et al.* [18]. An aliquot of 0.25 ml of the extract was mixed with 0.25 ml of 200 mM of sodium phosphate buffer pH 6.6 and 0.25 ml of 1% Potassium Ferrocyanate (KFC). The mixture was incubated at 50 ^{0}C for 20 min followed by the addition of 0.25 ml of 10% Tricarboxylic acid (TCA). The mixture was centrifuged at 2,000 rpm for 10 min and 1 ml of the supernatant was mixed with equal volume of distilled water and 0.1% of iron (III) chloride ($FeCl_3$) and the absorbance was measured at 700 nm using a JENWAY UV–visible spectrophotometer. FRAP values were obtained by comparing the absorption change in the test mixture with those obtained from increasing concentrations of $Fe^{2+,}$ and express in mg/kg.

2.6 Other Calculations

Other calculations made from the mineral elements include mineral ratios and Mineral Safety Index (MSI).

2.7 Determination of some Anti-nutrient substances

The Oxalate content was determined using High Pressure Liquid Chromatograph (HPLC)methods described by Wilson*et al*. [19] while Phytate and Cyanide were determined according to methods described by Wheeler and Ferrel [20] and AOAC [21] respectively.

2.8 Determination of molar ratio of antinutrients to minerals

The mole of phytate and minerals was determined by dividing the weight of phytate and mineral with its atomic weight (Phytate: 660g/mol.; Fe: 55.85g/mol.; Zn: 65.38g/mol.; Ca: 40.08g/mol.). The molar ratio between antinutrient and mineral was obtained using the formula described by Woldegiorgis *et al*. [22].

Molar ratio = [Moles of antinutrient] / [Moles of mineral] = [mg antinutrient/MW of antinutrient] / [mg mineral/MW of mineral]. Where MW = atomic weight.

2.9 Calculation of the mole ratio

The [phytate]:[Zn], [Ca]:[phytate], [phytate]:[Fe] and [Ca][phytate]:[Zn] mole ratios were calculated as previously described by Wyatt *et al*. [23]; IZINCG [24].

Statistical Analysis

Descriptive statistics (mean, standard deviation and coefficient of variation) [25] were determined and all data were subjected to Chi-square (X^2) test to determine significant difference among the results obtained [26].

3 RESULTS

The result of the proximate compositions as shown in the Table 1 revealed moisture values ranged from 11.16%-12.15%, ash ranged from 2.76-4.03%, crude fat (4.07-7.30 %), crude fiber (13.33-16.73%) while moderate amount of crude protein ranged from 7.36% in *J. tajorensis* to 10.90% in *P. umbelatum*. Statistical analysis at $P \leq 0.05$ revealed that there are significant differences among the selected wild vegetables investigated. The vegetables were rich in carbohydrate contents which ranged from 52.09% to 58.22%. *J. tojerensis* had the highest value 58.22% while *P. umbelatum* had the highest content (52.09%) of carbohydrate. The proportion of percentage contribution to total energy from the proximate values depicts that the total energy in KJ/100g for the four wild vegetables were very high. The results are 1265.8, 1327.5, 1302.2 and 1265.5 KJ/100g for *P. guinensis, P. umbelatum, C. argentea* and *J. tajorensis* respectively.

Carbohydrate had the highest energy percentage proportion with mean value of 935.04KJ/100g (72.22%) followed by crude fat and crude protein. The CV% of the parameters were low (Table 2).

3.1 Mineral Composition

The results of the mineral composition as presented in Table 3 revealed that all the wild vegetables have high contents of K (21.19-32.54mg/100g), moderate content of Ca, P and low contents of Mg, Fe, Zn, Cu and very low concentrations of Pb and Ni. Cd was absent in all the samples analysed (Table 3).

The calculated mineral ratios of the four vegetables (Table 4) showed that Na/K, K/Na, Ca/P, Na/Mg and Ca/K were below the critical mineral ratio level while Ca/Mg conformed to the standard values while Zn/Cu and Fe/Cu ratios indicated low copper content. The calculated [Phy]/[Zn], [Ca]/[Phy], [Phy]/[Fe] and [Ca][Phy]/[Zn] mole ratio were below the minimum good ratios. Table 5 revealed the Mineral Safety Index (MSI) values of four selected wild vegetables. The results of the calculated values were lower than the tabulated values of MSI for Na, Mg, P, Ca, Fe, Zn and Cu. All the mineral gave positive differences.

The antinutrients in the study showed low antinutrient content (Table 6) with the exception of phytate which can be reduce to non-toxic level through boiling or cooking. The antioxidant free radical scavenging activity of the four vegetables was high mostly in *P. guinensis*(Table 7). DPPH ranged in *P. guinensis*>*P umbelatum*>*C. argentea*>*J. tajorensis* respectively. Also, FRAP showed in *P. guinensis*>*T. tajorensis*>*P. umbelatum*>*C. argentea.*

Table 1: Proximate composition of Four Selected Leafy Wild Vegetables

Vegetables	Moisture content (%)	Ash (%)	Crude Fat (%)	Crude fibre (%)	Crude protein (%)	Carbohydrate (%)
Piper guinensis	11.16± 0.07d	4.03±0.01a	6.68±0.05ab	13.33± 0.05b	9.86± 0.01b	55.06± 0.01b
Piper umbelatum	11.39±0.04c	3.85±0.01b	7.31±0.00a	15.26±0.01ab	10.09± 0.04a	52.09± 0.02c
Celosia argentea	12.15±0.03a	3.18±0.01c	6.55±0.51b	14.37± 0.00b	8.76± 0.02c	54.64± 0.04b

Jatropha tajorensis	11.86±0.04b	2.76±0.12d	4.07±0.02c	16.73± 1.44a	7.36± 0.00d	58.22± 0.02a
Mean	11.64	3.46	6.15	14.92	9.02	55.00
SD	0.45	0.59	1.43	1.44	1.25	2.52
CV%	3.87	17.05	23.24	9.65	13.86	4.58

Means followed by the same letter within column are not significantly different at P≤ 0.05, SD- Standard deviation, CV%- Coefficient of variation

Table 2: Proportion of percentage contribution from fat, protein and carbohydrate to total energy

Parameter	**A**	**B**	**C**	**D**	**Mean**	**SD**	**CV%**
Total energy E in kJ/100g)	1,265.8	1,327.5	1,302.2	1,265.5	1, 294.8	33.73	2.61
(E in kcal/100g)	319.8	314.5	312.6	298.95	311.46	8.88	2.85

PEF % (E in kJ/100g)	247.16	270.47	242.35	150.59	227.64	52.82	23.20
(E in kcal/100g)	60.12	65.79	58.95	36.63	55.37	12.84	23.19
PEP % (E in kJ/100g)	82.62	171.53	35.0431	125.12	132.05	38.01	28.78
(E in kcal/100g)	39.44	40.36	35.04	29.44	36.07	4.99	13.83
PEC % (E in kJ/100g)	936.02	885.53	928.88	989.74	935.04	42.74	4.57
(E in kcal/100g)	220.24	208.36	218.56	232.88	220.01	10.06	4.57
UEDP % (E in kJ/100g)	49.57	102.92	89.35	75.07	79.23	22.81	28.79
(E in kcal/100g)	23.66	24.22	21.02	17.66	21.64	2.99	13.82

PEF = proportion of total energy due to fat; PEP = proportion of total energy due to protein; PEC = proportion of total energy due to carbohydrate; UEDP = utilization of 60% of PEP %,SD-Standard deviation, CV%- Coefficient of variation

KEY

A= *Piper guinensis*, B = *Piper umbelatum*, C= *Celosia argentea*,D= *Jatropha tajorensis*

Table 3: **Mineral composition of Four SelectedLeafy Wild Vegetables (mg/100g)**

Parameter	Sample				Mean	SD	CV%	Min (x)	Max (x)	χ^2	Remark
	A	B	C	D							
Na	11.38	12.00	8.67	10.25	10.58	1.46	13.80	8.67	12.0	0.395	NS
K	32.54	31.67	27.37	21.19	28.19	5.19	18.41	21.19	32.54	2.863	NS
P	8.02	7.51	9.21	9.57	8.58	0..97	11.31	7.51	9.57	0.331	NS
Ca	19.57	20.62	16.62	19.36	19.04	1.71	8.98	16.62	20.62	0.459	NS

Mg	2.85	3.02	2.67	2.62	2.78	0.178	6.40	2.62	3.02	0.036	NS
Mn	0.03	0.03	0.05	0.06	0.178	0.28	157.3	0.03	0.60	4.159	NS
Fe	0.20	0.19	0.05	0.06	0.125	0.081	64.80	0.05	0.2	0.140	NS
Zn	0.17	0.16	0.19	0.17	0.173	0.012	6.94	0.16	0.19	0.002	NS
Cu	0.02	0.01	0.02	0.02	0.017	0.0005	2.94	0.01	0.02	0.000	NS
Pb	0.001	0.002	0.001	0.002	0.015	0.000	3.80	0.001	0.002	0.000	NS
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	NS
Ni	0.001	0.001	0.00	0.001	0.0007	0.0005	1.42	0.00	0.001	0.000	NS

Chi-square (χ^2)at $p_{=0.05,}$ $\upsilon_{= n-1=3}$critical value = 7.81, S=results significantly different, NS=results not significantly different, SD- Standard deviation, CV%- Coefficient of variation

KEY
A= *Piper guinensis,* B = *Piper umbelatum,* C= *Celosia argentea*,D= *Jatropha tajorensis*

Table 4: Calculated mineral ratios of Four Selected Leafy Wild Vegetables

Mineral ratio	Standard	Sample				Mean	SD	CV%
		A	B	C	D			
Na/K	0.06	0.349	0.378	0.316	0.483	0.382	0.07	18.32
K/Na	5.0	2.857	2.639	3.157	2.067	2.18	1.43	65.59
Ca/P	≥0.5	2.440	2.75	1.89	2.02	2.28	0.39	17.10

Ca/Mg	6.67	6.86	6.83	6.23	7.39	6.83	0.47	6.88
Na/Mg	4.17	3.99	3.97	3.25	3.91	3.73	0.33	8.85
Ca/K	4.0	0.601	0.65	0.61	0.91	0.69	0.14	20.28
[K/(Ca+Mg)]	2.2	1.45	1.34	1.42	0.96	1.29	0.23	17.83
Zn/Cu	4.75	8.50	16.0	9.5	8.5	10.63	3.61	33.96
Fe/Cu	5.59	10.0	19.0	2.5	3.0	8.63	7.71	89.34
Ca/Pb		19,570	10,310	16,620	9,680	14,045	4835.9	34.43
Fe/Pb		200	95	50	30	86.25	85.16	98.74
Zn/Cd		0.0	0.0	0.0	0.0	-	-	-

SD- Standard deviation, CV%- Coefficient of variation

KEY
A= *Piper guinensis,* B = *Piper umbelatum,* C= *Celosia argentea*,D= *Jatropha tajorensis*

Table 5: Mineral safety index (MSI) of Na, Mg, P, Ca, Fe, Zn, Cu

Sample	Na			Mg			P			Ca			Fe			Zn			Cu		
	TV of MSI	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D	TV	CV	D
A	4.80	0.11	4.69	15.0	0.11	14.89	10.0	0.066	9.93	10.0	0.160	9.84	6.70	0.089	6.61	33.0	0.37	32.63	33.0	0.22	32.78
B	4.80	0.12	4.68	15.0	0.11	14.89	10.0	0.063	9.94	10.0	0.172	9.83	6.70	0.071	6.63	33.0	0.35	32.65	33.0	0.11	32.89
C	4.80	0.08	4.72	15.0	0.10	14.90	10.0	0.077	9.92	10.0	0.138	9.86	6.70	0.022	6.68	33.0	0.42	32.5 8	33.0	0.22	32.78
D	4.80	0.10	4.70	15.0	0.10	14.99	10.0	0.079	9.92	10.0	0.161	9.84	6.70	0.027	6.67	33.0	0.37	32.63	33.0	0.22	32.78
Mean	-	0.103	4.68	-		0.083	-	0.071	9.93	-	0.157	9.84	-	0.052	6.65	-	0.277	32..62	-	0.192	32.81
SD	-	0.017	0.17	-		0.048	-	7.93	9.57	-	0.014	0.01	-	0.033	0.033	-	0.029	0.029	-	0.055	0.055

TV = Table Value; CV = Calculate value; D = difference (TV-CV)

KEY

A= *Piper guinensis,* B = *Piper umbelatum,* C= *Celosia argentea*,D= *Jatropha tajorensis*

Table 6: Anti-nutrient composition (mg/100g), calculated [Phy]/[Zn], [Ca]/[Phy], [Phy]/[Fe] and [Ca][Phy]/[Zn] Mole ratiosof Four selected Leafy Wild Vegetables

Parameter	Ideal value	A	B	C	D	Mean	SD	CV%
Phytate	-	82.14	70.57	210.16	203.74	141.65	75.59	53.36
Oxalate	-	4.88	5.13	9.46	7.97	6.06	2.23	36.80
Cyanide	-	0.18	0.13	0.23	0.18	0.18	0.04	22.22
Saponin	-	0.42	0.36	1.31	1.20	0.82	0.50	60.97
Ca	-	19.57	20.62	16.62	19.36	19.04	1.706	8.96
Fe	-	0.20	0.19	0.05	0.06	0.125	0.081	64.80
Zn	-	0.17	0.16	0.19	0.17	0.173	0.012	6.94
[Phy]/[Zn]	>15	47.69	44.58	109.7	128.6	82.64	42.87	51.88
[Ca]/[Phy]	6<	0.25	0.208	0.767	0.638	0.466	0.278	59.65
[Ca][Phy]/[Zn]	>0.5	23.27	22.93	45.46	62.11	38.44	18.97	49.35
[Phy]/[Fe]	>1	34.44	38.21	94.52	102.86	67.51	36.19	53.36
[Oxa][Ca]	1	0.249	0.249	0.570	0.412	0.370	0.154	41.62

SD- Standard deviation, CV%- Coefficient of variation.

KEY

A= *Piper guinensis*, B = *Piper umbelatum*, C= *Celosia argentea*,D= *Jatropha tajorensis*

Table 7: Anti- oxidant composition of Four selected Leafy Wild Vegetables

Parameter	A	B	C	D	Mean	SD	CV%
DPPH (%)	83.13	80.27	74.61	70.32	77.08	5.73	7.43
FRAP (mg/kg)	92.10	90.75	88.15	91.20	90.55	1,70	1.87

SD- Standard deviation, CV%- Coefficient of variation,
KEY:
A= *Piper guinensis*, B = *Piper umbelatum*, C= *Celosia argentea*,D= *Jatropha tajorensis*
DPPH= 1, 1, diphenyl-2-2 picrylhydrazyl
FRAP= Ferric Reducing Antioxidant Potential

4. DISCUSSION

The results of the moisture content of the selected vegetables as reported in this study were in tandem with those obtained in *P. guinensis*and *O. gratisimun*[27] but were lower than the moisture content recorded in the previous work of Amata [28] for the leaf of *Myrianthusarboreous*. The values of the moisture content in this study were higher than the values reported for *T. tajorensis* [29] and *Ceratothecasesamoides*[30]. The amount of dry matter in a food is inversely related to the amount of moisture it contains. Moisture has effect on the stability and quality of food [31]. Food that has high moisture content is prone to quick deterioration from microbial attack. Low moisture content in the vegetables could be an added advantage in extending their shelf life and preventing them from spoilage for a long.

The results of the crude protein in the vegetables revealed appreciable quantities of crude protein in all the vegetables examined and were similar to the values of 8.75% and 8.77% reported for *C. argentea* and *T. tetrapleura* respectively [32]. However, they were comparably higher than the crude proteins values of 0.77% obtained for *T. tetrapleura* [33], 6.195% for *T. tajorensis* [32] and 2.24% in the leaf of *B. diffusa* [34]. Guoyao [35] reported that the dietary protein provided a significant benefit 0n bone health in humans. Whitney and Rolfes [36] noted that average crude protein would serve as enzymatic catalyst and mediate cell responses. The reasonable quantities in all the wild vegetables investigated could rank the four vegetables among the list of vegetables that could be recommended as good source of crude protein.

The results of the crude fiber in the four vegetables showed that they contained moderate amount of crude fiber. The results were in agreement with the results of Nwankwo *et al*. [27] for *T. tajorensis* (10.10%) and Ayeni *et al*. [37] in the *G. hirsutum* (8.31%). However, the results were higher when compared with the values obtained for wild vegetables such as *S. spargonopnora*(5.85%), *C. crepidiodes* (3.89%) and *S. tranganta* (6.01%) [38]. Vinuda-Martose*et al.* [39] noted that adequate intake of crude fiber can lower serum cholesterol level risk coronary diseases, hypertension, constipation, diabetes and breast cancer. Also, Egbon*et al*. [40] asserted that dietary fibre is essential as it helps to absorb water and provide roughages for the bowel. Consumption of these vegetables in this era of fast food cannot be underestimated to provide crude fibre to prevent constipation.

The results of the crude fat in these vegetables were low and were closely similar to value obtained in *C. argentea* (5.70%) at the second stage of pre flowering [41]. The values were comparatively higher that the crude fat values obtained in the roots (0.40±0.01%) and leaves (0.45±0.59%) of B. *diffusa*[34]. The low fat content in the vegetables is sheering and corroborated the assertions of some researchers that leafy vegetables are lower in lipids/fats which make it suitable to be consumed and prevent obesity [42, 43]. Singh *et al.* [44] noted that excess fat (saturated) can lead to increase in cholesterol level which is a major cardiovascular disorder.

The ash content in *P. guinensis* in this study was similar to the value 4.09% reported in the leaves of B. *diffusa* [34] and 3.14% in *P. umbelatum*[45]. However, the values in the four vegetables were lower when compared to the results obtained by Amata [28] for *Myrianthusaboreus* (16.40%) as well as 18.72% and 14.71% for *G. hirsutum* and *Momordica. charantia*respectively [37].

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High ash content would imply high mineral content and nutritious, but Uduosoro and Ekanem [42] asserted that it could be the reverse,if it contained toxic metals which also contribute to the ash percentage of leafy vegetables. Hoofman *et al.* [46] noted that ash content in any food sample depicts the quality of its elemental composition. The low ash contents in the vegetables reflect low micro and macro elements in the samples. The proximate compositions of these vegetables are rich sources of carbohydrate. The results obtained for carbohydrate in this study were similar to the values reported for *J. tajorensis*[29] but were higher than the values obtained for *Piper guinensis* and *Ocimumgratisimum* respectively [27] as well as in *L. africana* and in *P. umbelatum* as reported by Okwonu and Osuji [45]. Energy is needed in the body for metabolic activities, physiological functions, growth and synthesis of new tissues. The consumption of these vegetables could provide the body fuel and energy that is required for daily activities and exercise [42, 47].

The total calculated energy KJ/100g for the four selected vegetables showed that the vegetables could provide energy for man when consumed. The values compared favourably with the values reported for young and matured silk [48] but higher than the values reported for *Jathrophatajorensis* [40]. Carbohydrate contributed the highest proportion of energy followed by crude fat then crude protein. The best energizing foods are those that are rich in carbohydrates, protein, minerals and other health-promoting substances. Carbohydrates, crude fat and crude protein in these vegetables could provide energy in the form of calories that the body needs to work and support other metabolic activities.

Mineral Composition

The mineral compositions of the vegetables under study are rich in health promoting minerals. Potassium, Calcium, Sodium, Phosphorus and Magnesium were found in moderate quantities while the concentration of Cu, Fe, Zn and Mn werefound in lower concentration and were < 1.0mg/100g. Potassium is found naturally in many foods and has been reported to maintain the normal balance and distribution of fluids throughout the body. Alinnor and Oze [49] Akpabio and Akpakpam [50] reported potassium as electrolytes that are involved in maintaining the normal pH balance and work in conjunction with calcium and magnesium in the maintenance of normal muscle contraction and relaxation and nerves transmutation.

Calcium has been reported as a constituent of bones and teeth. Ca also helps in blood coagulation as well as activation of a large number of enzymes such as Adenine triosephosphate [51]. Also, Akubugwo*et al.* [52] noted that Ca is an important macronutrient for the growth and maintenance of teeth, bone muscle and heart functions. Calcium deficiency can have severe consequences on the body. The deficiency may leads to syndrome like rickets and calcification bones as well as osteoporosis and higher risk of fracture [53]. Calcium deficiency is a risk factor for rickets in children, osteomalacia in adults and osteoporosis in later life [54].

Phosphorus is required for bone teeth formation and its maintenance can also help in blood clothing, muscle contraction and regulation of cell permeability [55]. Moderate concentration of Potassium and Calcium in these vegetables could make them to be good sources of these essential minerals. The vegetables could be administered to people suffering from deficiency of such minerals.

Magnesium is a constituent of bone, teeth and enzyme cofactor [56, 57]. Magnesium is important in regulating inflammation [58]. Magnesium deficiency can cause low appetite, nausea and vomiting, fatigue and muscle weakness. Epstein *et al.*[59] noted that Magnesium deficiency is commonly associated with other conditions including diabetes, obesity, infection and malnutrition while some commonly used therapies such as proton pump inhibitors can also cause a significant magnesium deficiency. Also, Ismail *et al*. [60] reported that magnesium could result in abnormal energy production in cardiac myocytes.

Zinc play major role in immune functions, DNA and RNA functions. Zinc deficiency can be a serious health concern and its deficiency promotes malnutrition and may result in hypogonadism and dwarfism, dermatitis and altered reproductive performance [61]. Copper is an essential micro-nutrient necessary for hoematologic and neurologic system [62]. Murry *et al*. [56] noted that copper helps in the incorporation of iron in haemoglobin, assists in the absorption of iron from the gastrointestinal tract and in the transfer of iron from tissues to the plasma.

Very low Pb and Ni contents and absence of toxic metals Cd could allay the fear of heavy metal contamination and equally qualified the vegetables as good for human consumption

Mineral ratios are often more important in determining nutritional deficiencies and excesses than mineral levels alone, albeit both are important and should be considered together.If the synergistic relationship (or ratio) between certain minerals in the body is disturbed, the normal biological functions and metabolic activity can be adversely affected. Even at extremely low concentrations, the synergistic and/or antagonistic relationships between minerals still exist, which can indirectly affect metabolism. The calculated mineral ratios for Na/K, K/Na, Ca/P, Ca/Mg, Ca/K and K/[Ca+Mg] were below the critical mineral. Na/K ratios were higher than the standard value (0.06) and an indication that the consumption of these vegetables may allay the fear of consumers with high blood pressure and bone loss. Ca/P ratios in this study were greater than the standard value (0.5). This is in agreement with the previous reports of Adeyeye *et al*. [63] and Akinbule*et al*. [64] who reported high Ca/P ratios in their studies. When the ratio of Ca/P is high in food, it promotes calcium absorption in the intestine for bone formation and prevents metabolic disorders [65]. Calcium to Magnesium ratio shows blood sugar indicator. A high ratio indicates the propensity to improperly manage calcium and deposit it in abnormal places in the body. The Ca/Mg ratios in this study were within the standard value and this shows that there would be no hindrance of Ca absorption by Mg when the vegetables are consumed. The Fe/Cu ratios were not high. Itis of note that high Fe/Cu ratio indicates possible iron toxicity while a lower ratio indicates a possible copper toxicity.

Mineral safety index of foods is important because it measures the possibility of minerals to cause their overload in the human body [63]. Previous studies have reported that phytate to Fe molar ratio above 1 and phytate to Zn molar ratio higher than 15 have a negative effect on the bioavailability of Fe and Zn respectively [66]. The results of the calculated antinutrient-mineral molar ratios in this study had phytate to Fe and phytate to Zn were above the ideal values necessary for proper iron and zinc bioavailability. Frontela *et al*. [67] showed that when oxalate: Ca is higher than 1.0, dietary calcium availability is limited. The oxalate: Ca molar ratios of unprocessed and processed sorghum grains were below the critical level of 1.0. This implies that oxalate may not have adverse effects on bioavailability of dietary calcium in the studied samples. The results obtained in this present study revealed [Oxalate]/[Ca] ratios that ranged between0.249-0.370 were below the critical level of 1general known to impair calcium bioavailability [68]. The present of oxalate in the four vegetables may not affect the bioavailability of calcium in the vegetable samples.

The four vegetables are rich in antioxidants.This study corroborated the findings of Kris- Etherton *et al.* [69] who reported that a high intake of food rich in antioxidants had been shown to increase the antioxidant capacity of the plasma and reduce the risk of some but not all cancers, heart diseases and stroke. The consumption of these vegetables apart from its food values could also serve as medicinal purposes in combating some diseases.

The results of the Mineral Safety Index (MSI) of the four selected wild vegetables revealed that all the samples investigated have theirTable Value Index (TV) greater thanCalculated Value(CV) for Na, Mg, P, Ca, Fe, Zn and Cu. All the minerals gave positive differences with Calculated Value. The mineral safety index showed that all essential minerals were relatively low, in safe concentration and no overloading in the body if consumed.

5. CONCLUSION

The nutritional profile of the four vegetables showed that theyare rich sources of carbohydrate, protein and minerals such as calcium, potassium and phosphorus which are essential in body metabolism.Theycontainedmoderate amount of anti -nutrients except phytate which have higher concentration which can be reduced by processing such as squeezing, cooking, heating, boiling, and bleaching to leach out its concentration before consumption. The vegetableshave highantioxidantqualitieswhich could suggest their free radical scavenging activities for medicinal purposes to combat various diseases.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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