Nutritive Value and Heavy Metal Concentrations of Selected Wild and Domesticated Vegetables Consumed in South East, Nigeria

Prince N. Okoroh*, Eugene N. Onyeike and Bene W. Abbey
Department of Biochemistry, Nutrition and Toxicology Unit, Faculty of Chemical Science, College of Natural and Applied Sciences, University of Port Harcourt,
PMB 5323, Port Harcourt, Nigeria.
Corresponding Author. E-mail: pnokoroh@yahoo.com

Abstract
The vitamin composition, amino acid profile and heavy metal levels of *Lasianthoreafricana* (LA), *Heinsia crinata* (HC), *Vernonia amygdalina* (VA) and *Telfairiaoccidentalis* (TO) were investigated using standard methods. Niacin was highest in *Lasianthore* Africana (3.61 mg/100 g) followed by *Heinsia crinata* (3.30 mg/100 g) and lowest in *Vernonia amygdalina* (1.24 mg/100 g) and *Telfairiaoccidentalis* (1.04 mg/100 g). Vitamin C content was highest (208 mg/100 g) in *Telfairiaoccidentalis* (TO) and lowest (29.3 mg/100 g) in *Heinsia crinata* (HC). There was no significant difference ($p>0.05$) in vitamin A content of all vegetables. *Vernonia amygdalina* had the highest (2.99 mg/100 g) vitamin B_2 level while *Telfairiaoccidentalis* (TO) had the lowest value of 1.73 mg/100 g. *Telfairiaoccidentalis* had the highest value of vitamin E (42.3 mg/100 g) followed by *Vernoniaamygdalina* (32.6 mg/100 g) and lowest in *Heinsia crinata* (HC) (1.45 mg/100 g) while vitamin K was highest (2.26 mg/100 g) in *Telfairiaoccidentalis* (TO) and lowest (1.23 mg/100 g) in *Lasianthore* Africana (LA). Analysis conducted showed that the vegetables were comparatively rich in total essential amino acids. *Telfairiaoccidentalis* (TO) had the highest total amino acids (905 mg/100 g protein); *Vernoniaamygdalina* (VA) had the highest total essential amino acids (52.2 %), *Lasianthore* Africana (LA) followed with 51.4 %. *Lasianthore africana* had the highest total sulphur containing amino acids (6.3 %) while *Vernoniaamygdalina* (VA) had the highest amount of total aromatic amino acids (15.3 %). Zn, Fe and Cu were moderately in low concentrations but Cd and Pb were absent.
Keywords: Nutritive value, Heavy metal concentrations, wild and domesticated, vegetables.

Introduction

Vegetables constitute an essential part of human nutrition which serve as protective foods and are also highly beneficial for the maintenance of health and prevention of disease (Olaiya and Adebisi, 2010). In rural parts of Nigeria, they serve as sources of protein, mineral, vitamins, fiber and other phytonutrients (Mosha and Gaga, 1999). Whitney et al (2002) reported that health disorders such as appendicitis, haemorrhoids, gallstones, heart diseases, obesity and constipation can be either corrected or treated by copious consumption of vegetables. Dark green leaves provide a high amount of carotene, ascorbic acid and micro-minerals which play important roles in nutrient metabolism and slowing down of degenerative diseases (Yi-Fang et al, 2002). Anetor et al (2006) reported that the consumption of antioxidants in vegetables namely vitamins A,B,C and E, beta-carotene and selenium helps to reduce toxic effects of environmental pollutants. Heavy metals may deposit on leafy vegetables from dust, splashing water, air and soil (Donald et al, 2000). Aberoumand (2010) reported that edible wild plants are exploited as sources of food in developing nations and they provide an adequate level of nutrition to the inhabitants. According to Food and Agricultural Organization report, at least one billion people are thought to use wild foods in their diet (Burlingame, 2000). The incorporation of edible wild and semi-cultivated plant foods could be beneficial to nutritionally marginal populations, especially in developing nations where poverty and climatic changes are problems to the rural populace (Aberoumand, 2010). However, there are wild green leafy vegetables in the South East geopolitical zone of Nigeria that the rural dwellers consume as part of their diet, but they are not widely acceptable, and hence, under exploited as a result of lack of scientific evidence to justify their edibility. In this context, investigations were carried out to evaluate the vitamin composition, amino acid profile and heavy metal levels of *Lasianthore africana, Heinsia crinata, Telfairiaoccidentalis* and *Vernonia amygdalina.* The objective of this study was to determine the nutritive value and heavy metal levels of these selected wild and domesticated green leafy vegetables consumed in South East, Nigeria.

Materials and Methods

Sample: The wild vegetable samples (*Lasianthore africana* and *Heinsia crinata*) were obtained from bush marketers, while domesticated vegetable leaves (*Telfairiaoccidentalis* and *Vernonia amygdalina*) were obtained from a farm land in Isiala Ngwa, Abia State, South East of Nigeria. The plant materials were placed in a polythene bag to prevent loss of moisture of the sample during transportation to the laboratory.

Sample Processing: The stalks were removed and the leaves were washed with distilled water and dried at room temperature to remove residual moisture. They were powdered in a blender for material sample preparation for analysis.

Analysis of Sample: Vitamins A, B_2, B_3, C, E, and K were determined by high performance liquid chromatography (HPLC) with pulse flame photometric detector as described by the Association of Official Analytical Chemists (2006). Total protein content was determined according to AOAC method number 982.30 (AOAC International, 2006). The amino acid profile of the sample was determined using the method described by Speckman et al (1958). Zinc, iron, copper, lead and cadmium were determined by the use of atomic absorption spectrophotometry as reported by the Association of Official Analytical Chemists (2006).

Data Analysis: Data were analyzed by a one-way analysis of variance (ANOVA) using SPSS/PC$^+$ package. Tests of significance were carried out using Duncan's Multiple Range Tests (DMRT) on SPSS/PC$^+$ and significance was accepted at a p-value of 0.05.

Results and discussion

The concentrations of the vitamins in the vegetables determined by high performance liquid chromatography are shown in Table 1. *Lasienthore africana* had the highest (3.62 mg/100 g) level of vitamin B_3. The values for *Vernonia amygdalina* and *Telfairia occidentalis* were not significantly different (p>0.05) but significantly lower than for L. africana. The leaves had higher vitamin B_3 content than *T. triangulare*, *D. argentea*, *S. nodiflorum, B. alba, S. aethropicum, A. candatus, A. hybridus, C. pepo* and *A. spinosus* (Olaiya and Adebisi, 2010). Dietary niacin in addition to endogenous sources are necessary to provide the body with nicotinamide for normal metabolism. Niacin helps to lower levels of lipids in blood and can be used to treat dyslipidaemia. Vitamin C was found to be of highest concentration amongst the selected vitamins analyzed. All the vegetables had lower vitamin C contents than *A. hybridus, T. triangulare, T. occidentalis, P. guineese* and V. *amygdalina* (Oguntana, 1998) but higher contents than *B. alba* (Olaiya and Adebisi, 2010).

T. occidentalis had the highest vitamin C content (208 mg/100 g) while *H. crinata* had the lowest value (29.3 mg/100 g). Vitamin C acts as a hydrogen carrier and antioxidant and is also involved in the biosynthesis of collagen in biological systems. Lack of vitamin C results in a deficiency disease called scurvy with clinical manifestations such as fragility of vascular walls causing a bleeding tendency, poor wound healing, anaemia, osteoporosis due to lack of bone matrix. Intake of vitamin C from these vegetables can prevent scurvy. *H. crinata* was found to be the richest in vitamin A although the values in all the vegetables were not significantly different (p>0.05). The vitamin A content of all the vegetables were higher than the values for *T. triangulare, C. argentea, S. nodiflorum, B. alba, A. candatus, S. spinosus* as reported by Olaiye and Adebisis (2010). The consumption of these vegetables will therefore help to prevent night blindness, xerophthalmia, poor bone growth and anaemia. *V. amygdalina* had the highest (2.99 mg/100 g) riboflavin (vitamin B_2) contents and its value was not significantly different (p>0.05) from the value for *H. crinata. T. occidentalis* had the lowest vitamin B_2 content (1.73 mg/100 g). The vitamin B_2 content of the vegetables was lower than those of *A. wilkesiana* and *T. procumbens* as reported by Ikewuchi et al, (2010). Riboflavin is found in naturally occurring flavoproteins where it is incorporated as flavin mononucleotide (FMN) and flavin adeninedinucleotide (FAD). FMN and FAD are electron carriers in biological oxidation systems. The implication of consumption of these vegetables is to eliminate riboflavin deficiency (ariboflavinosis) which is characterized by rough scaly skin, angular stomatitis and swollen, tender, red tongue colour. *T. occidentalis* was the richest in vitamins E and K, *H. crinata* had the lowest value of vitamin E, *L. africana* had the lowest of vitamin K. The vitamin E contents of all the vegetables were found to be higher than the values obtained for *A. wilkensiana* and *T. procumbens* (Ikewuchi et al., 2010), Vitamin E acts as an antioxidant and its deficiency causes haemolysis while vitamin K is needed for the synthesis of prothrombin and coagulation factors VII, IX and X, while its deficiency results in a bleeding tendency with prolonged prothrombin time.

The results of amino acid composition of wild and domesticated vegetables are shown in Table 2. In all the samples investigated, glutamic acid had the highest concentration while cysteine had the lowest. Glutamate is an acidic amino acid, and it occurred in highest concentration in *Z. variegalus* (133.7 mg/ g) (Adeyeye, 2005b), in *A. archactina* (111 mg/ g) and *A. marginata* (144mg/g) (Adeyeye and Afolabi, 2004), in the oil seeds (Olaofe et al, 1994), as well as in six varieties of dehulled African yam bean (*Sphenostylis stenocarpa*) flour (Adeyeye, 1997). The total amino acid was highest in value in *T. occidentalis* (904.5mg/g, cp) and lowest (721.4mg/g cp) in *L. africana*. The value of total amino acid in *T. occidentalis* was lower (455.3mg/g) as reported by Adeyeye and Omolayo (2011) and the value was 678.1mg/g crude protein in *A. hydridus*. Total essential amino acid (TEAA) (with arginine and histidine) was highest (460.9 mg/g) in *T. occidentalis* and lowest (371.1 mg/g) in *L. africana*. The total neutral amino acid (TNAA) was lowest in *L. africana* (350.3 mg/g) followed by (356.3 mg/g) in *H. crinata* and was highest (443.6 mg/g) in *T. occidentalis*. The value was lower (264.4mg/g) in *T. occidentalis* as reported by Adeyeye and Omolayo (2011) when compared to our finding in the present study. *V. amygdalina* had the highest value of total aromatic amino acid (126.3mg/g) followed by *T. occidentalis* (109.0mg/g) and *L. africana* had the lowest (76.4mg/g) value. The total aromatic amino acid (TAAA) was 94.9mg/g cp in *T. occidentalis* and 104.4mg/g in *A. hybridus* (Adeyeye and Omolayo, 2011). Ikewuchi et al (2010) reported total aromatic amino acid in *A. wilkensiana* as 40.58mg/g and 28.98 mg/g in *T. procumbens. L. africana* had the highest (45.4 mg/g) total sulphur containing amino acids followed by *T. occidentalis* (41.5 mg/g) and lowest value was found in *V. amygdalina* (33.9 mg/g). The total essential amino acids in all the samples were comparable to that of hen's egg (50%) (FAO/WHO, 1990) as the highest value was 52.5% in *V. amygdalina* while the lowest value was 51.1% in *T. occidentalis*. In general, the highest concentration of each amino acid was found in *T. occidentalis.* The vegetables are therefore adjudged to be good sources of protein for growth and development.

The results of the heavy metal concentrations of the leaves are presented in Table 3. *T. occidentalis* had the highest value of zinc (0.07mg/100g) while *L. africana* had the lowest value of 0.03mg/100g. The zinc contents of *T. occidentalis* and *H. crinata* were not significantly different (p>0.05). They all had lower zinc content than *A. officianalis* (2.60mg/100g), A. indica (1.21mg/100g), (Aberoumand, 2010); Cashew nuts (Nandi, 1998; Nutritional Data, 2011). *T. procumbens* (1.70mg/kg), (Ikewuchi et al, 2010). *H. crinata* had the highest Fe content while *V. amygdalina* had the lowest value. The iron content of all leaves was not significantly different (p>0.05). The Fe content of *H. crinata* was close to the value for *A. caudatus* (0.60 mg/100 g) but lower than *C. pepo* (0.70 mg/100 g) and *S. aethiopicum* (0.90mg/100g) as reported by Olaiya and Adebisi (2010). Iron helps in blood haemoglobin formation. The consumption of these vegetables may help to build up the blood of patients suffering from anaemia. The value of copper was highest in *H. crinata* and lowest in *L. africana*. The copper content of *H. crinata* and *V. amygdalina* were not significantly different (p>0.05). Cadmium and lead were not detected in any of the samples. The maximum permissible limits in herbs and products are 10mg/kg and 0.3mg/kg for Pb and Cd, respectively, (WHO, 2005). This would indicate that both the wild and domesticated vegetables may be safe for consumption.

Conclusion

It can be concluded that both the wild and domesticated vegetables are good sources of nutrients such as water-soluble and fat-soluble vitamins, as well as amino acids. There were low levels of zinc, iron and copper with non-detectable levels of toxic mineral elements cadmium and lead, thus suggesting that the leaves may be safe for human consumption.

REFERENCES

Association of Official Analytical Chemists (2006) Official Methods of Analysis of the Association of Official Analytical Chemists (W. Horwitz Edition), 18th edn. Washington D.C., U.S.A.: A.O.A.C. International.

Aberoumand, A. (2010) A Comparative Study Of Composition Analysis of Plants Consumed in India and Iran. American – Eurasian J. Agric and Environ. Sci., 8(3):329-333.

Adeyeye, E.I. (1997) Amino acid composition of six varieties of dehulled African yam bean (*Sphenostylisstenocarpa*) flour, Int. J. Food Sci. Nutri., 48: 345-351.

Adeyeye, E.I. (2005b) Amino acid composition of variegated grasshopper, *zonocerus variegatus,* Trop. Sci., 45(4): 141-143.

Adeyeye, E.I. and Omolayo, F.O. (2011) Chemical composition and functional properties of leaf protein concentrates of *Amaranthus hybridus* and *Telfairia occidentalis*. J. Agr. & Bio of North America; ISSN: 2151-7517.

Adeyeye,E.I. and Afolabi, E.O. (2004) Amino acid composition of three different types of land snails consumed in Nigeria, Food Chem., 85: 535-539.

Anetor, J.I., Babalola, O.O. and Anetor, G.O. (2006) Antioxidant Micronuntrients as Intersectoral Link between Health and Agriculture. African Journal of Biomedical Research, 9: 1-10.

Burlingame, B. (2000) comparism of total lipids, fatty acids, sugars and nonvolatile organic acids in nuts from Castarea species. J. Food Composition and Analysis, 13:99-100.

Donald, R.H. and Andrew, C.C. (2000) Trace elements and urban gardens. Environmental Horticulture Programme. California, Riverside.

FAO/WHO., (1990) Protein Quality Evaluation. FAO/UN; Rome.

Fasuyi, A.O. (2006) Nutritional potential of some tropical vegetable meals. Chemical characterization and functional properties. Africa J. Biotechnol; 5: 49-53.

Ikewuchi, C.J., Ikewuchi, C.C., Onyeike, E.N. and Uwakwe, A.A. (2010) Nutritional Potential of the Leaves of *Acalypha Wilkesiana* "Godseffiana" Muell Arg. J. Appl. Sci. Environ. Manage., 14(3): 21-24.

Mosh, T.C and Gaga, H.E. (1999) Nutritive value and effect of blanching on trypsin and chymotrypsin inhibitor activities of selected leafy vegetables. Plant Foods Human Nutr., 54:271-283.

Nandi, B.K. (1998) Cashew nut nutritional aspects. In M.K. Papademe triou and E.M. Herath (Eds). Integrated Production Practices of Cashew in Asia. Food and Agriculture Organization of the United Nations Regional Office for Asia and Pacific: Bangkok, Thailand (FAO/RAP Publication 1998/12).

Nutritional Data (2011) Know what you eat: Nuts, Cashew nuts, oil roasted, without salt added. Retrieved March 18, 2011 from http://nutrition data. Self.com/facts/nut-and-seed-products/3094/2.

Oguntona, T. (1998) Green leafy vegetables. In A.U. Osagie and O.U. Eka (Eds), Nutritional Quality of Plant

Foods (pp. 120-133). Nigeria: Post Harvest Research Unit, Department of Biochemistry, University of Benin, Benin City.

Olaiya, C. and Adebisi, J. (2010) Phytoevaluation of the nutritional values of ten green leafy vegetables in South-Western Nigeria. The Internet J. Nutr. & Wellness. 9 (2)

Olaofe, O., Adeyemi, F.O. and Adediran, G.O., (1994) Amino acid and mineral compositions and functional properties of some oil seeds, J. Agric. Food Chem., 42:878-881.

Speckman, D.H., Stein, E.H. and Moore, S. (1980) Automatic recording apparatus for use in the chromatography of amino acids. Analytical Chemistry, 30 (7), 1190-1206.

Whitney, E.N., Cataldo, C.B. and Rolfes, S.R. (2002) Antioxidant nutrients and phytochemicals in disease prevention. In Understanding Normal and Clinical Nutrition (6th edn). Thompson Wadworth, Belmont. Pp. 377-385(s)

WHO Quality Control Methods for medicinal plant materials, World Health Organization, 2005.

Yi-Fang, C., Jie, S., Xian-Hong, W.U. and Rui-Hai, L. (2002) Antioxidant and antiproliferative activities of common vegetables Rev., J. Agric. Food Chem. **50**: 6910-6916. (s)

Table 1: Selected vitamin composition(mg/100g)* of wild and domesticated vegetables.

Vitamin Composition [mg/100g]*				
	Lasianthore africana	*Heinsia Crinata*	*Vernonia amygdalina*	*Telfairia occidentalis*
Constituents				
Vitamin A	9.37±0.03[a]	9.54±0.03[a]	9.35±0.16[a]	9.44±0.16[a]
Vitamin B_2 [Riboflavin]	2.50±0.01[b]	2.95±0.02[a]	2.99±0.02[a]	1.73±0.04[c]
Vitamin B_3 [Niacin]	3.62±1.01[a]	3.30±0.07[b]	1.04±0.02[c]	1.04±0.01[c]
Vitamin C [ascorbic	37.9±0.26[c]	29.3±0.32[d]	188±0.25[b]	208±0.85[a]
acid]	12.4±0.9[c]	10.7±0.04[d]	32.6±0.37[b]	42.3±0.18[a]
Vitamin E	1.23±0.14[d]	1.45±0.01[c]	2.03±0.04[b]	2.26±0.04[a]
Vitamin K				

* Values are means ± standard deviations of triplicate determinations. Values in the same row having the same superscript letters are not significantly different at the 5% level (p<0.05).

Table 2: Amino acid composition (mg/g crude protein)* of wild and domesticated vegetables.

Amino acid composition [mg/g crude protein]*				
	Lasianthore africana	*Heinsia Crinata*	*Vernonia amygdalina*	*Telfairia occidentalis*
Amino acids				
Glycine	39.3±0.53[c]	40.8±0.06[c]	46.1±0.06[b]	53.1±2.05[a]
Alanine	41.4±1.35[b]	36.2±0.80[c]	43.9±0.15[b]	59.1±5.2[a]
Serine	31.2±4.6[b]	32.4±0.25[b]	30.9±0.70[b]	40.8±1.3[a]
Proline	32.4±0.06[c]	40.4±0.10[a]	38.7±0.06[b]	39.8±1.07[a]
Valine	39.3±3.30[c]	40.9±0.01[b]	43.9±0.40[b]	66.3±1.57[a]
Threonine	43.5±0.45[a]	42.2±0.35[a]	38.7±0.30[a]	43.2±0.66[a]
Leucine	45.6±0.80[c]	53.4±0.75[b]	54.9±1.55[b]	74.5±2.05[a]
Isoleucine	62.8±0.65[c]	61.8±0.75[c]	69.2±0.35[a]	64.9±0.40[b]
Aspartate	48.6±0.75[d]	52.2±0.60[c]	72.4±1.15[a]	66.0±0.90[b]
Lysine	36.0±0.80[d]	37.8±0.76[c]	40.0±0.50[b]	47.0±0.45[a]
Glutamate	106±2.55[a]	105±0.76[a]	110±0.06[a]	113±1.5[a]
Methionine	29.9±0.60[a]	21.3±0.6[c]	21.3±0.06[c]	25.2±0.60[b]
Phenylalanine	40.9±7.56[c]	54.1±5.94[b]	86.6±1.00[a]	54.3±0.65[b]
Histidine	16.2±0.45[c]	16.7±0.76[c]	20.0±0.15[b]	24.0±0.90[a]
Arsperigine	56.9±0.45[b]	44.2±0.30[c]	56.7±2.16[b]	61.5±1.35[a]
Tyrosine	35.5±0.35[c]	36.3±0.60[c]	39.7±0.67[b]	54.7±0.55[a]
Cysteine	15.5±0.25[b]	13.6±0.10[c]	12.6±0.00[d]	16.3±0.06[a]

* Values are means ± standard deviations of triplicate determinations. Values in the same row having the same superscript letters are not significantly different at the 5% level (p<0.05).

Table 3: Heavy metal composition (mg/100g)* of wild and domesticated vegetables.

Heavy metal Composition [mg/100g of dry weight]*				
	Lasianthore africana	*Heinsia Crinata*	*Vernonia amygdalina*	*Telfairia Occidentalis*
Constituents				
Zinc [Zn]	0.03±0.00[b]	0.06±0.01[a]	0.05±0.01[b]	0.07±0.02[a]
Iron [Fe]	0.44±0.20[a]	0.50±0.05[a]	0.42±0.012[a]	0.43±0.15[a]
Copper [Cu]	0.01±0.01[b]	0.06±0.00[a]	0.05±0.01[a]	0.02±0.02[b]
Cadmium [Cd]	ND	ND	ND	ND
Lead [Pb]	ND	ND	ND	ND

ND = Not detected

* Values are means ± standard deviations of triplicate determinations. Values in the same row having the same superscript letters are not significantly different at the 5% level ($p<0.05$).