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Comparative Study on the Nutrient Composition and *in-Vitro* Antioxidant Properties of Leaves and Stems of *Ipomoea Involucrata*

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Abstract – **The research investigated the nutritional and *in-vitro* antioxidant properties of *Ipomoea involucrata* leaves and stems grown in Southern Nigeria using standard analytical methods. The results of the proximate composition revealed that both leaves (53.10%) and stems (63.33%) had high contents of carbohydrates, followed by high contents of crude fiber of 13.00% and 31.30% for leaves and stems respectively. Vitamin and Mineral analysis showed high values of vitamin A (55.14mg/100g) and calcium (412.7mg/100g) for leaves and vitamin C (80.44mg/100g) and magnesium (202.36mg/100g) for stems. The amino acid analysis revealed high contents of leucine (9.05g/100g) for the leaves and arginine (6.01g/100g) for the stems. Results of the physiochemical parameters showed that the stem oil exhibited significant ($p<0.05$) higher saponification value than the leaf oil. However, the essential fatty acid; linoleic acid was higher in leaves (11.4%) when compared with the stem (1.49%). The *in vitro* antioxidant properties of the leaves and stems demonstrated high anti-radical activity at 40µg/ml against DPPH, Hydrogen peroxide, Nitric oxide, and FRAP. The study has shown that the leaves and stems of *Ipomoea involucrate* contained appreciable amount of nutrients and potent antioxidant properties.**

Keywords – **Ipomoea Involucrata, Nutrient Composition, in Vitro Antioxidant Properties and Leaves.**

I. Introduction

The World Health Organization (WHO) estimates that about 80% of the world populations in developing countries continue to use medicinal plant and plant products in handling primary healthcare problems due to their accessibility, availability and affordability. Plants have been used in traditional medicine and have great importance due to their nutritive value and continue to be a major source for medicine as they have been found throughout human history (Essiet and Obioboho, 2014). All human beings require number of complex organic compounds as added caloric requirements to meet the need for their muscular activities e.g. carbohydrates, fats and proteins, while minerals and vitamins form comparatively a smaller part. Plant materials form major protein of the diet; their nutritive value is important (Williams, 1972; Indrayan *et al.*, 2000). Antioxidants and reactive oxygen species (ROS) molecules are very important in maintaining the fragile balance, for instance, in humans; disturbing this balance can cause severe health challenges like cancer, cardiovascular and neurodegenerative diseases (Valko *et al*., 2007). However, antioxidant vitamins (A, C and E) which makeup the bioactive compounds in plant play a vital role in reducing oxidative stress as is known to its medicinal properties (Guo *et al.,* 2003). *Ipomoea involucrata* belongs to the Convolvulaceae family. It is a herbaceous plant used in the prevention of fever and in Sierra Leone a decoction of the fresh sap is taken as a remedy for gonorrhea while in Nigeria the leaves are used in the treatment of asthma (Essiet and Obioboho, 2014). It is estimated that over 60 species of green leafy vegetables are used as food. Apart from the well-known and easily cultivated green leafy vegetables serving as sources of micronutrients; several wild and ornamental plants are traditionally important supplements sources of food nutrients (Essiet and Obioboho, 2014). Considering the nutrient and medicinal importance of plants, this study is therefore designed to explore the nutrient and antioxidant properties of the underutilized leaves and stems of *Ipomoea involucrata*.

II. Materials and Methods

A. *Sample Collection*

The leaves and stems of Ipomoea involucrata used in this study were harvested at Rukpokwu Town in Obio-Akpor Local Government Area of Rivers State, Nigeria. The samples were identified and authenticated by Dr. Adeyemi Akinbinusu of the Department of Botany, University of Benin, Edo State, Nigeria. The samples were deposited at the Herbarium unit of same University with voucher number UBH1336.

B. *Preparation of Leaves and Stems Extract*

The leaves and stem were sorted, cleaned and air dried under a shade for 7 days. After air drying the dried leaves and stem of *Ipomoea involucrata* were separated and pulverized using electric grinder until the desired particle size were obtained and packaged for analysis.

C. *Proximate Analysis*

The standard methods of Association of Official Analytical Chemist (AOAC, 1984) were used to determine the ash, moisture, crude protein, crude lipid and crude fiber contents of the fresh leaves and stems of *Ipomoea involucrata.* Carbohydrate content was calculated by difference.

D. *Vitamin Analysis*

Determination of Vitamins A (calorimetric), C (titrimetric) and E (futter-mayer colometric) was by the methods of Kirk and Sawyer, (1991). Vitamins D and K were estimated by the method described by Yueh-Ying et al., 2013). Determination of B_1(thiamine), B_{2s}(riboflavin), B_3(niacin) and B_{12} (cyanocobalamine) was by spectropho--tometer while B_6 (pyridoxine) was by titrimetric method.

E. *Mineral Analysis*

The mineral analysis was conducted using Varian AA240 Atomic Absorption Spectrophotometer according to the method of APHA 1995 (American Public Health Association). Sample weight of 2g each of the samples was collected, placed in crucible and was heated in a furnace for 2hrs at 550^0C, the dry ash was diluted in 20ml of 20% H_2SO_4, and was filtered with filter paper.

F. *Amino Acid Analysis*

The Amino Acid profile in the samples was determined using methods described by Benitez (1989). The samples were dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

G. Physicochemical and Fatty Acid Determination

Physicochemical properties such as melting point, moisture content, saponification value, peroxide value and iodine value were determined using the AOAC method (2006). The pH was determined using pH meter, while refractive index was analyzed at 30°C following the method of Hoffman, (1986) by using the Brix refractometer. Determination of thiobarbituric acid value was estimated by the method of Menoyo *et al*., (2000). The fatty acid composition was determined according to the methods of AOAC, (1984). The fatty acids methyl esters obtained were separated using Gas Chromatography HP (Hewlett Packard 6890 GC) and the following observation was made were; Column, Hp-5 (5% diphenyl, 95% dimethyl polysiloxane), 30m, 0.32mm ID, 0.25µm film thickness, Detector, flame ionization detector, initial temp, 150˚C for 2min. Injector temp.220˚C, injection volume 2µl, splitless mode, Detector temperature 250˚C. Nitrogen was used as the carrier gas with a flow rate of one milliliter per minute.

H. *Antioxidant Assay*

Hundred grams of the dried plant powder was soaked in 400ml of de-ionized water with interrnitent shaking. At the end of extraction it was passed through a Whatman filter paper No 1. This aqueous filtrate was concentrated under reduced pressure using a rotary evaporator at 40^0C and stored at 4^0C for further use. The filtrate was reconstituted in known amount of de-ionized water to obtain aqueous extract of known concentration.

Assay of 1, 1-Diphenyl- 2- picryl hydrazyl (DPPH) was determined by the method of Gymafi *et al*., (2000), the hydrogen peroxide scavenging assay was carried out following the procedure of Ruch *et al.,* (1989). Nitric oxide scavenging activity competes with oxygen, leading to reduced production of NO and a pink coloured chromophore is formed according to the method reported by Nishaa *et al*., (2012). Determination of ferric reducing antioxidant power assay (frap) was measured using the method described by Benzie and Strain, (1996) while, ABTS scavenging radical activity of the extract was determined according to Re *et al*., (1999).

I. *Statistical Analysis*

All values were reported as mean ± standard deviations. The values of the various parameters were compared statistically by Paired-Samples T- test and analysis of variance (ANOVA). Statistical analysis was carried out u-sing SPSS16.0 version (2007) software.

III. RESULTS

The results of the proximate analysis of the stems and leaves of *Ipomoea involucrata* are shown in Table1. Ash, Moisture, Carbohydrate and Crude lipid contents were higher in stems (5.32%, 6.00%, 63.33% and 7.17%, respectively) than the leaves (1.40%, 2.07%, 53.10% and 5.10% respectively). The Crude Protein and Crude Fiber were higher in leaves (7.03% and 31.30%) than the stems (5.18% and 13.00%) respectively.

Table 1: Proximate composition of the stems and leaves of *Ipomoea involucrata.*

Parameters	Composition (%)	
	Stems	Leaves
Ash	5.32 ± 0.28^a	1.40 ± 0.30^b
Moisture content	6.00 ± 0.10^a	2.07 ± 0.33^b
Carbohydrate	63.33 ± 2.08^a	53.10 ± 0.72^b
Crude Protein	5.18 ± 0.17^a	7.03 ± 0.20^b
Lipid	7.17 ± 0.20^a	5.10 ± 0.01^b
Crude Fibre	13.00 ± 0.12^a	31.30 ± 0.30^b

The results are expressed as mean ± standard deviation of triplicate determinations. Values across a row with different superscripts letters are significant ($p<0.05$).

The results of the Vitamin composition of the stems and leaves of *Ipomoea involucrata* revealed some amounts of fat and water soluble vitamins as shown in Table 2. Vitamins A, D and B_{12} contents were significantly ($p<0.05$) higher in leaves (55.14mg/100g, 16.01mg/100g and 8.77mg/100g) than the stems (25.15mg/100g, 12.21mg/100g and 0.78mg/100g) respectively. However, Vitamins C, K and B_6 contents were significantly ($p<0.05$) higher in stems (80.44mg/100g, 22.75mg/100g and 8.87 mg/100g) than the leaves (30.45mg/100g, 12.71mg/100g and 8.87mg/100g) respectively.

The results of the mineral analysis of the stems and leaves of *Ipomoea involucrata* as shown in Table 3. Calcium, magnesium, sodium and iron contents were significantly ($p<0.05$) higher in leaves (4.12mg/100g, 255.53mg/100g, 36.80mg/100g and 21.31mg/ 100g) than the stems (160.58mg/100g, 202.36mg/100g, 7.66mg/100g and 9.31mg/100g) respectively. The potassium and zinc contents were higher in stem (122.77mg/100g and 9.44mg/100g) than the leaves (65.10mg/100g and 2.44mg/ 100g) respectively. Also there were trace amounts of heavy metals lead, cadmium and cobalt contents with more amounts in stems (0.83mg/100g. 0.73mg/100g and 0.03/mg/100g) than the leaves (0.61mg/100g, 0.40mg/ 100g and 0.01mg 100g) respectively.

Table 2. Vitamin Analysis of the stems and leaves of *Ipomoea involucrate.*

Parameters	Composition (mg/100g)	
	Stems	Leaves
Vitamin A	25.15 ± 0.40^a	55.14 ± 0.07^b
Vitamin B_1	6.56 ± 1.32^a	6.56 ± 0.06^a
Vitamin B_2	13.12 ± 1.11	ND
Vitamin B_3	ND	13.06 ± 0.0

Parameters	Composition (mg/100g)	
	Stems	Leaves
Vitamin B_6	8.87 ± 0.05^a	0.26 ± 0.08^b
Vitamin B_{12}	0.78 ± 0.04^a	8.77 ± 0.04^b
Vitamin C	80.44 ± 0.06^a	30.45 ± 0.08^b
Vitamin D	12.43 ± 0.43^a	16.01 ± 0.43^b
Vitamin E	0.06 ± 0.05^a	4.46 ± 0.70^a
Vitamin K	22.75 ± 0.06^a	12.71 ± 0.04^b

The results are expressed as mean ± standard deviation of triplicate determinations. Values across a row with different superscripts letters are significant ($p<0.05$). ND→ not detected.

Table 3. Mineral Analysis of the stems and leaves of *Ipomoea involucrate.*

Parameters	Composition (mg/100g)	
	Stems	Leaves
Calcium	160.58 ± 0.07^a	412.57 ± 0.04^b
Potassium	122.77 ± 0.04^a	65.10 ± 47.87^a
Sodium	7.66 ± 0.07^a	36.80 ± 0.04^b
Magnesium	202.36 ± 0.36^a	255.53 ± 0.07^b
Zinc	9.44 ± 0.67^a	2.44 ± 0.06^b
Iron	9.31 ± 0.06^a	21.31 ± 0.05^b
Copper	0.16 ± 0.06^b	0.16 ± 0.01^b
Lead	0.83 ± 0.05^a	0.61 ± 0.05^b
Cadmium	0.73 ± 0.10^a	0.40 ± 0.01^b
Cobalt	0.03 ± 0.02^a	ND
Selenium	ND	1.02 ± 0.00^b

The results are expressed as mean ± standard deviation of triplicate determinations. Values across a row with different superscripts letters are significant ($p<0.05$). ND→ not detected

The results of the amino acid profile of the stems and leaves of *Ipomoea involucrata* are reported in Table 4. The leaves showed high concentrations of essential amino acids in leucine, isoleucine, valine and phenylalanine (9.05, 6.03, 6.90 and 5.60g/100g) than the stems (5.60, 3.60, 4.22 and 4.98g/100g) respectively; while lysine and arginine contents were higher in stems (5.13g/100g and 6.01g/100g) than the leaves (4.42g/100g and 5.01) respectively; Glutamic acid, aspartic acid and proline contents of the non-essential amino acids were higher in stems (11.28g/100g, 8.99g/100g and 4.05g/100g) than the leaves (10.75g/100g, 8.67g/100g and 3.86g/100g) respectively, while glycine and alanine contents showed high concentrations in leaves (8.61g/100g and 5.01g/100g) than the stems (3.43g/100g and 4.02g/100g).

Table 4: Amino acid profile of the stems and leaves of *Ipomoea involucrata.*

Parameters	Composition (g/100g)	
	Stems	Leaves
Glycine	3.43	8.61
Alanine	4.02	5.01
Serine	3.10	3.94
Proline	4.05	3.86
Valine	4.22	6.90
Threonine	3.49	4.05
Isoleucine	3.60	6.03
Leucine	5.60	9.05
Aspartic acid	8.99	8.67
Glutamic acid	11.28	10.75
Lysine	5.13	4.42
Methionine	1.58	2.14
Phenylalanine	4.98	5.60
Histidine	0.22	1.95
Arginine	6.01	5.01
Tyrosine	3.27	4.12
Tryptophan	0.10	1.19
Cysteine	1.15	1.04

The results of the physiochemical properties of the stem oil and leaf oil of *Ipomoea involucrata* are shown below in Table 5. The Iodine value, peroxide value, acid value, refractive index and moisture concentrations were significantly ($p<0.05$) higher in leaf oil (76.08gI_2/100g, 24.33Meq/KOH/kg, 34.14mg/KOH/g, 1.43 and 6.24%) than the stem oil (48.65gI_2/100g, 14.21Meq/KOH/kg, 20.02mg/KOH/g 0.91and 2.51%) respectively. However, saponification value, melting point, pH, and specific gravity concentrations were significantly ($p<0.05$) higher in stem oil (196.50mg/KOH/g, 13.63^{0}C, 6.16 and 1.67) when compared to the leaf oil (173.48mg/KOH/g, 8.11^{0}C, 5.43 and1.01).

The results of the fatty acid profile of the stems and leaves of *Ipomoea involucrata* showed varying amounts of saturated and unsaturated fatty acids as shown in Table 6. Linoleic acid and Hexadecadienoic acid contents were higher in leaves (11.14% and 19.57%) than the stems (1.49% and 0.37%) respectively, while oleic acid was higher in stems (30.68%) than the leaves (20.07%). Palmitic and Heptadecnoic acid contents were higher in stems (20.81% and 25.96%) than the leaves (7.42% and ND) respectively; Whereas, lauric and myristic acids contents were higher in leaves (18.50% and 9.76%) than the stem (4.47% and 0.91%) respectively.

Table 5. Physiochemical properties of stem oil and leaf oil of *Ipomoea involucrate.*

Parameters	Stem oil	Leaf oil
Peroxide Value (Meq/KOH/kg)	14.21 ± 0.04^a	24.33 ± 4.04^a
Iodine Value (gI_2/100g)	48.65 ± 0.04^a	76.08 ± 3.72^b
Saponification Value(mgKOH/g)	196.50 ± 0.04^a	173.48 ± 2.92^b
Specific Gravity	1.67 ± 0.03^a	1.01 ± 0.04^b
Melting Point(^{0}C)	13.63 ± 0.03^a	8.11 ± 0.63^b
pH	6.16 ± 0.04^a	5.43 ± 0.04^b
Acid Value (mgKOH/g)	20.02 ± 0.01^a	34.14 ± 2.94^b
Refractive Index	0.91 ± 0.04^a	1.43 ± 0.07^b
Moisture (%)	2.51 ± 0.30^a	6.24 ± 0.67^b
Thiobarbituric Acid (µg/kg)	0.10 ± 0.04^a	0.17 ± 0.04^b

The results are expressed as mean ± standard deviation of triplicate determinations. Values across a row with different superscript letters are significant ($p<0.05$).

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Table 6. Fatty acid profile of the stems and leaves of *Ipomoea involucrate.*

Parameters	Composition (%)	
	Stems	Leaves
C_{12}= Lauric	4.47	18.50
$C_{14:0}$= Myristic	0.91	9.76
$C_{16:0}$= Palmitic	20.81	7.42
C_{17}= Heptadecanoic	25.96	ND
C_{18}=Stearic	ND	13.53
$C_{20:0}$=Arachidic	10.31	ND
$C_{16:2}$= Hexadecadienoic	0.37	19.57
$C_{18:1}$=Oleic	36.68	20.07
$C_{18:2}$= Linoleic	1.49	11.14

The results of the *in-vitro* antioxidant potentials and free radical scavenging activities of aqueous extract of stems and leaves of *Ipomoea involucrata* are shown in Table 7. The studied plant demonstrated scavenging activity against DPPH radical, Hydrogen peroxide and Nitric oxide radical at 40µg/ml concentration for the stems (67.83%, 62.86% and 68.74%) respectively and at 40µg/ml for the leaves (67.83%, 58.26% and 66.51%) respectively. However, the studied plant did not demonstrate scavenging activity against ABTS but showed effective radical scavenging activity against Ferric Reducing Antioxidant Power (FRAP) as shown in Table 7b below.

The results of the IC_{50} of the *in-vitro* antioxidants study of stems and leaves of *Ipomoea involucrata* are shown in Table 8 below. The values of the IC_{50} for DPPH and NO were significantly ($p<0.05$) lower in stems and leaves when compared to Ascorbic acid. However, the IC_{50} values were lower in the stems when compared to the leaves. ABTS IC_{50} values were significantly ($p<0.05$) higher in stems and leaves when compared to Ascorbic acid. Peroxide (H_2O_2) values were significantly ($p<0.05$) lower in leaves when compared to the stems. However the stems and leaves values were significantly ($p<0.05$) lower when compared to Ascorbic acid.

Table 7a. *In-vitro* Antioxidant Activity of aqueous extract of Stems and Leaves of *Ipomoea involucrata* against DPPH, H_2O_2 and Nitric oxide.

Concentration (µg/ml)	% Inhibition					
	DPPH		H_2O_2		Nitric oxide	
	Stems	Leaves	Stems	Leaves	Stems	Leaves
10	20.70± 0.03[a]	18.40± 0.03[a]	27.34± 0.04[a]	18.04± 0.03[a]	31.65± 0.80[a]	30.28± 0.04[a]
20	40.22± 0.03[b]	35.64± 0.04[b]	44.58± 0.03[b]	32.76± 0.03[b]	40.82± 0.04[b]	44.03± 0.05[b]
30	57.48± 0.03[c]	52.58± 0.04[c]	55.77± 0.04[c]	31.90± 0.04[c]	51.49± 0.16[c]	49.21± 0.58[c]
40	67.83± 0.04[d]	67.83± 0.04[d]	62.86± 0.03[d]	58.26± 0.04[d]	68.74± 0.10[d]	66.51± 0.04[d]

The results are expressed as mean ± standard deviation of triplicate determination. Values not sharing common superscript on the same column differ significantly at p< 0.05 levels.

Table 7b. *In-vitro* Antioxidant Activity of aqueous extract of Stems and Leaves of *Ipomoea involucrata* against ABTS and FRAP.

Concentration (µg/ml)	% Inhibition ABTS		Absorbance (593nm) FRAP	
	Stems	Leaves	Stems	Leaves
10	2.27 ±0.04[a]	12.92 ±0.04[a]	0.03 ±0.00[a]	0.04 ±0.00[a]
20	13.08 ±0.05[b]	17.05 ±0.03[b]	0.07 ±0.01[b]	0.10 ±0.00[b]
30	22.31 ±0.04[c]	30.27 ±0.04[c]	0.10 ±0.00[c]	0.19 ±0.00[c]
40	38.63 ±0.04[d]	44.85 ±0.04[d]	0.12 ±0.00[d]	0.20 ±0.00[d]

The results are expressed as mean ± standard deviation of triplicate determination. Values not sharing common superscript on the same column differ significantly at p< 0.05 levels.

Table 8. IC_{50} values of stems and leaves of *Ipomoea involucrata* and Reference compound.

Activity	Stems	Leaves	Reference	IC_{50}
DPPH	27.2 ± 1.60[a]	31.6 ± 0.90[a]	Ascorbic acid	51.5 ± 1.25[b]
NO	26.5 ± 1.45[a]	27.1 ± 0.91[a]	Ascorbic acid	91.6 ± 0.91[b]
ABTS	55.5 ± 1.34[a]	46.7 ± 1.10[b]	Ascorbic acid	29.6 ± 1.00[c]
H_2O_2	27.4 ± 1.15[a]	37.3 ± 0.97[b]	Ascorbic acid	216.4 ± 1.55[c]

The results are expressed as mean ± standard deviation of triplicate determination. Values not sharing common superscript on the same column differ significantly at p< 0.05 levels.

IV. Discussion

In this study the result of the proximate composition of the leaves and stems of *Ipomoea involucrata* were similar to those reported by Essiett and Ukpong, (2014) and Essiett and Obioboho, (2014) with crude lipid values of 8% for stems and 5% for leaves, ash content values 7.7% for stems and 1.9% for leaves and moisture content values 8% for stems and 3.11% for leaves. However, carbohydrate contents and crude protein in the present study were lower when compared to values obtained in earlier report (Essiett and Ukpong, 2014). These variations in values recorded could be as a result of soil composition. High moisture content in vegetables makes them vulnerable to microbial attack hence spoilage (Nwofia, *et al.,* 2012). The moisture content of any food is an index of its water activity and it is used as a measure for stability and susceptibility to microbial contamination (Uyoh *et al.*, 2013). Thus the leaves have a longer shelf-life than the stems. Both stem and leaves were high in carbohydrate contents. Carbohydrates are essential for cellular activities in both plants and animals and also provide raw materials for many industries (Ebun-Oluwa and Alade, 2007). Fiber cleanses the digestive tract by removing potential carcinogens from the body and prevents the absorption of excess cholesterol. Fibre also adds bulk to the diet and

prevents the intake of excess starchy food (Mensah *et al.*, 2008) and may therefore guard against metabolic conditions such as hypercholesterolemia and diabetes mellitus (Henry, 2004). The substantial amount of fiber in *Ipomoea involucrata* leaves shows that they can help in keeping the digestive system healthy and functioning properly.

The results of the vitamin composition of stems and leaves of *Ipomoea involucrata* in Table 2 show that they contain varying amounts of fat and water soluble vitamins. Vitamins A and D were most concentrated in the leaves than stems. Vitamin A is essential for vision as the precursor for the visual pupil rhodopsin and immune responses whereas, vitamin D is a nutrient that is key for metabolism of calcium and phosphorus, which is primarily acquired from sun exposure with diet (Yueh-Ying *et al.,* 2013). Vitamin C and K contents were higher in stems compared to the leaves. Vitamin C is a potent antioxidant and has been associated with lower risks of cardiovascular disease, stroke, cancer (Padayatty *et al.,* 2003), and facilitates wound healing, production of collagen, formation of red blood cells and boost immune system (Monsen, 2000). The present findings suggests that the stems and leaves of *Ipomoea involucrata* are rich in antioxidant Vitamins A and C which indicate good potential against free radicals and could have ameliorative effects if supplemented with other antioxidant plants on diseases associated with oxidative stress.

The results of the mineral composition of the stems and leaves of *Ipomoea involucrata* in Table 3 showed some amounts of macro and micro mineral elements with calcium, magnesium and sodium having higher concentrations in leaves when compared to the stems. These value compare favorably to calcium value (416.70mg/100g) of *Ipomoea aquatica* leaves reported by Umar *et al.,* (2007) and higher than that of *Ipomoea aquatica* leaves (101mg/100g) reported by Ogle *et al.*, (2001). However, magnesium content was lower than the values of *I.aquatica* leaves (301.64mg/100g) reported by Umar *et al*., (2007) and higher than the magnesium content of *I.batatas* leaves (79.10mg/100g) reported by Ishida *et al.,* (2000). The iron content was extremely low when compared to values (210.30mg/100g) reported from *Ipomoea aquatica* leaves grown in other geographical location (Ogle *et al.,* 2001). Calcium is a very important mineral for development and proper functioning of bones, teeth and muscles (Turan *et al.,* 2003) while magnesium is a component of chlorophyll and its important content in connection with Ischemic heart disease and calcium metabolism in bones (Elegbede, 1998). Iron is an essential trace element for haemoglobin formation, normal functioning of central nervous system and in oxidation of carbohydrate, protein and fats (Asaolu *et al.,* 1997). Furthermore, potassium content (122.77mg/100g) showed a higher concentration in stems than the leaves, with values lower to *Ipomoea batatas* (750mg/100g) reported by Taiye and Asibey-Berko, (2001). This difference can be attributed to soil composition and growing conditions. Potassium is the principal cation in intracellular fluids and acid-base balance as well as regulation of osmotic pressure (Soetan *et al.,* 2009). This findings revealed that *Ipomoea involucrata* leaves and stems are rich sources of essential mineral elements, which can be supplemented for other known vegetables and adequate consumption of this plant may help in preventing adverse effects of dietary deficiency (Umar *et al.*, 2007).

The Amino acids profile of the stems and leaves of *Ipomoea invloucrata* showed various amounts of essential and non-essential amino acids in Table 4. The essential amino acids leucine, valine, phenylalanine and isoleucine contents of the leaves were higher when compared to the stems. Leucine plays a role in reduction of muscle protein breakdown (Duru *et al.*, 2012) and its supplementation was found to increase fat loss and enhance muscle protein synthesis (Crozier *et al.*, 2005). Phenylalanine is the precursor of some hormones and the pigment melanin in hair, eyes and tanned skin (Ajayi *et al.,* 2014). Valine helps to stimulate the central nervous system and is needed for proper mental functioning. It prevents the breakdown of muscles by supplying muscles with extra glucose for energy production during physical activity. Isoleucine plays a major role in enhancing glucose consumption and utilization by up-regulating intestinal and muscular transporter (Doi *et al.*, 2003) also, arginine and lysine contents were the most concentrated in stem than the leaves, Arginine is an indispensable amino acid for children as a result of its role in growth and development (Feugang *et al.,* 2006). The result of the present study on amino acid profile shows that the leaves of *Ipomoea involucrata* could complement to other vegetables and dairy products added to daily diet as a result of their essential amino acid properties.

The results of the Physiochemical properties of the stem oil and leaf oil of *Ipomoea involucrata* in the current study in Table 5 revealed the leaf oil had the highest concentrations of Iodine value, Acid value, Peroxide value, moisture and refractive index when compared to the stem oil. Iodine value of oil is a measure of its unsaturation and is a useful criterion for purity and identification. In this study, the leaf and stem oil indicates that the oil is non-drying (fat) with iodine value lower than $100I_2$/100g. However, the leaf oil revealed a more preferred industrial relevance when considering the reports of Aremu *et al.,* (2015). The stem oil revealed high concentration of saponification value, melting point and pH than the leaf oil. The present study revealed that the stem and leaf oil had high saponification value which indicates low molecular weight component with enhanced oil quality and that the fatty acids in the oil were most predominantly short chains that favors stability. The results further show that the stem and leaf oil can be used in production of liquid soap, shampoos and lather shaving creams (Fahindanesh and Bahrami, 2013). The high melting point in stem oil, implies that the stem oil of *Ipomoea involucrata* is more suitable for deep frying.

The results of the fatty acids profile of the stems and leaves of *Ipomoea involucrata* (Table 6) revealed higher concentrations of lauric, Hexadecadienoic, Mystric and Linoleic acid in the leaves compared to the stems. Lauric acid is effective in preventing tooth decay and plaque

buildup (Schuster *et al.*, 1980). However, according to Mensink, (2003) and Lawrence, (2013), the ratio of total cholesterol to HDL cholesterol is a more specific marker of coronary artery diseases than the value of LDL cholesterol the linoleic acid value in this study was similar to *Ipomoea aquatica* leaves reported by Doka *et al.,* (2014). Linoleic acid, the predominant omega-6 fatty acid in vegetable oils is not a risk factor for breast, and prostate cancers in humans (Zock and Katan, 1998). The oleic fatty acid concentration in the stems of *Ipomoea involucrata* was higher than the values (22.37%) reported by Doka *et a*l., (2014) for *Ipomoea aquatic* stems. Oleic acid is a monounsaturated fatty acid and does not raise serum cholesterol concentrations. Several studies have reported the deleterious effects of small chain fatty acids on the human system mainly by lowering high density lipoprotein cholesterol levels and elevating low density lipoproteins (Denke and Grundy, 1992; Zock *et al*., 1994).

The results of the *in-vitro* antioxidants properties of aqueous extract of stems and leaves of *Ipomoea involucrata* are shown in Table 7a & b. In this study, the DPPH radical scavenging activity showed that the *Ipomoea involucrata* aqueous extract of stems(57.48%) exerted a higher percentage inhibition than the leaves (52.58%) at 30µg/ml concentrations and the IC_{50} of the aqueous extracts was lower in stems (27.2µg/ ml) and higher in leaves (31.6µg/ml). Hydrogen peroxide is a weak oxidizing agent and can inactivate a few enzymes directly, usually by oxidation of essential thiol (-SH) groups. Hydrogen peroxide can cross cell membranes rapidly once inside the cell, H_2O_2 can possibly react with Fe^{2+} and possibly Cu^{2+} to form hydroxyl radical and this maybe the origin of many of its toxic effects (Kumaran and Karunakaran, 2007). The study revealed that *Ipomoea involucarata* aqueous stems showed a maximum activity of 62.86% inhibition when compared to the leaves extract of 58.26% inhibition at the same concentration of 40µg/ml. The IC_{50} of the aqueous stems and leaves extract was 27.4µg/ml and 37.3µg/ml respectively. Nitric oxide is a potent inhibitor of physiological processes such as smooth muscle relaxation, neuronal signaling, inhibition of platelet aggregation and regulation of cell mediated toxicity (Gopalakrishnan *et al.*, 2012). It is a diffusible free radical that plays many roles as an effector molecule in diverse physiological systems including neuronal messenger, vasolidation and antimicrobial and antitumor activities (Hagerman *et al.*, 1998). The scavenging of Nitric Oxide by the aqueous extract was increased in concentration dependent manner. There was a significant decrease in NO radical due to the scavenging ability of the aqueous extract. The aqueous extract of *Ipomoea involucrata* stems showed maximum activity of 68.74% inhibition higher than 66.51% inhibition of leaves at the same concentration of 40µg/ml. The IC_{50} values were found to be 26.5µg/ml for stems which is slightly lower when compared to 27.1µg/ml for leaves extract. FRAP assay measures the reducing potential of an antioxidant reacting with a ferric tripyridyltriazine (Fe^{2+}- TPTZ) complex and producing a colored ferrous tripyridyltriazine (Fe^{2+}- TPTZ) complex (Benzie and Strain, 1996). Generally the reducing properties are associated with the presence of compounds which exerts their action by breaking a hydrogen atom (Duh *et al.*, 1999). FRAP assay treats the antioxidant in the sample as a reductant in a redox linked colorimetric reaction (Guo *et al*., 2003). In the present study, the trend for ferric ion reducing activities of aqueous extract *Ipomoea involucrata* stems and leaves in (table 4.8), showed the absorbance to be higher in the leaves than stem which clearly increased due to the formation of Fe^{2+}-TPTZ complex with increasing concentrations. Hence they should be able to donate electrons to free radicals stable in the actual biological and food system. The aqueous extract of Ipomoea involucrata leaves and stems was found to be effective scavenger of DPPH, hydrogen peroxide and Nitric oxide but not an effective scavenger of 2, 2, azinobis-3-ethylbenzothiozoline-6-sulfonic acid (ABTS). It also possessed a good FRAP activity. However, the stem exhibited a higher antioxidant activity than the leaves.

V. Conclusion

The study revealed that the leaves and stems of *Ipomoea involucrata* contain appreciable amount of carbohydrate, fiber and fat, amino acids, vitamins, mineral elements and fatty acids. The aqueous extract of the stems and leaves exhibited maximum antioxidant activity with the stem having more effective antioxidant activity. It can, therefore, be concluded that *Ipomoea involucrata* leaves and stems can contribute significantly to the nutrient requirements of man. It also justifies their medicinal usefulness in ameliorating various disease and ailments.

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