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IDENTIFICATION, CHARACTERIZATION AND QUANTIFICATION OF CHEMICAL COMPOUNDS IN SELECTED EDIBLE WILD LEAFY VEGETABLES

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ABSTRACT

This study identified, characterized and quantified the constituents of *Basella alba* Linn. var. alba, *Crassocephalum crepidioides* (Benth.) S. Moore, *Launaea taraxacifolia* Amin Ex. C. Jeffrey (Wild lettuce), *Senecio biafrae* Oliv. & Hiern. and *Solanum nigrum* L. *var. virginicum* (Black nightshade) leaves. Pulverised dried leaves (10 g each) of the vegetables were separately Soxhlet-extracted with 60 ml of n-hexane (99%). Aliquots (2 µl) of each concentrated plant extract were analysed using gas chromatography - mass spectrometry (GC-MS) technique. Forty-four (44) volatile compounds were identified from the analyses. Some of them are known antioxidants that are beneficial to health. Linoleic and palmitic acids were identified in leaves of *B. alba* (6.85% and 5.47%), *C. crepidioides* (14.88% and 27.22%) and *L. taraxacifolia* (20.78% and 42.35%) respectively. However, linoleic acid was absent in *S. nigrum* but linolenic acid (47.47%) was present as the major fatty acid. Oleic acid was identified respectively in leaves of *B. alba* (2.37%), *C. crepidioides* (6.86%) and *L. taraxacifolia* (7.14%). The information obtained from the GC-MS analysis of these wild underutilized vegetables can be used to develop novel drugs or food supplements.

Keywords: Underutilized Vegetables, GC-MS Analysis, Antioxidants

INTRODUCTION

Vegetables are abundant in nature, possessing promising nutritive and therapeutic values that can nourish the ever-increasing human population (Janick, 2011; Amujoyegbe *et al*., 2015). Despite their abundance, nutritional roles in diet and possible significance in the modulation of certain diseases such as heart disease, wild leafy vegetables are usually under exploited for research and food (Amujoyegbe *et al*., 2015). There are several varieties of these vegetables in the rural areas ranging from the wild to under cultivated or underutilized. Migration to urban centres has a great impact on the choice of vegetables used as food because underutilized vegetables are not readily available in our urban markets (Odukoya *et al*., 2007). These vegetables are often considered underutilized in terms of the scanty research attention with limited scientific information on them, their underexploited economic potential and lack of technologies for improved farming practices (Osewa *et al*., 2013).

Underutilized indigenous vegetables are naturally growing wild plant species, rarely cultivated and gradually becoming endangered vegetables in the natural ecosystem (Stamp *et al*., 2012). These vegetables are usually collected from fallows, watercourses, field margins, disturbed fields, protected home gardens, refuse hills and generally in abandoned areas. Most of these wild indigenous vegetables are edible, underexploited and have served as basis of nutritional livelihood and medicinal plants in the rural areas for several years. These neglected native plant species are still harvested from wild, uncultivated and less included in scientific research (Adebooye and Ajayi, 2008). They remain less utilized resulting in low production, processing, distribution, marketing, consumption and research input which are critical for proper integration into WHO's global initiative for fruit and vegetable consumption promotion (Smith and Eyzaguirre, 2007).

Increase in human activities is equally disturbing the existence, stability and natural regeneration of these vegetables (Shabu and Uchi, 2013). Consequently, these result in gradual loss of genetic diversity of the vegetables (Nnamani *et al*., 2010). The importance of wild leafy vegetables in

folklore medicine cannot be undervalued due to their cost effectiveness, easy digestibility and efficacy.

Basella alba, a succulent green vegetable, commonly known as Ceylon spinach is a cool season plant which belongs to the family Basellaceae. It is locally called "Amunututu" (Yoruba) in southwestern Nigeria. The leaves are used traditionally as anti-hypertensive (Olowokudejo *et al*., 2008), anti-inflammatory (Kumar *et al*., 2011), antimicrobial, antioxidant (Suguna *et al*., 2015), anti-anaemic and for hepatoprotection (Bamidele *et al*., 2010), indicating the importance in ethnomedicine. *Crassocephalum crepidioides* (Asteraceae) also called "Ẹ fọ Ebòlò," (Yoruba), Babohoh (Hausa), Ṇtị-Ènē (Antelope's Ear) (Igbo), Red flower rag leaf or Fireweed (English), has been in use among folks in treating acute hepatitis and fever (Tomoyuki *et al*., 2005). Its antioxidant and hepatoprotective activities have also been reported in literature (Tomoyuki *et al*., 2005; Ng *et al*., 2012). Antioxidant and anticancer properties of *Solanum nigrum* (Solanaceae) leaves have also been well documented (Aboul-Enein *et al*., 2014). The plant has been used extensively in traditional medicine to treat various ailments such as pain, inflammation and fever.

Senecio biafrae (Compositae) is known for its therapeutic virtues, notably in Nigeria where it is used in the treatment of diabetes mellitus (Adebayo, 2009). *Senecio biafrae* leaves, "Worowo" (Yoruba), are used by traditional practitioners to treat infertility in women (Lienou *et al*., 2010), heart problems (Ayodele, 2005), as well as serve as antihypertensive (Olowokudejo *et al*., 2008). Hypolipidaemic, hypoglycemic and antioxidants properties of *Launaea taraxacifolia* (Asteraceae) plant, Ẹ̀ fọ yánrin (Yoruba), have also been reported (Dansi *et al*., 2008; Obi, 2011; Arawande *et al*., 2013).

However, standardization of the plant preparation, identification and characterization of the specific chemical components in the plant are required for optimum nutritional and therapeutic potentials. Furthermore, these wild leafy vegetables could promote socio-economic empowerment of communities where they are found and industrially exploited (Ogunwusi and Ibrahim, 2016). Considering this view, the present study was aimed to identify, characterize and quantify the chemical constituents of these wild selected leafy vegetables using gas chromatography mass spectrometry (GC-MS) technique.

MATERIALS AND METHODS

Plant Materials : The leaves' extracts of the following plants were studied

a. *Basella alba* Linn. var. alba
b. *Crassocephalum crepidioides* (Benth.) S. Moore
c. *Launaea taraxacifolia* . Amin Ex. C. Jeffrey
d. *Senecio biafrae* Oliv. & Hiern.
e. *Solanum nigrum* L. var. *virginicum*

Collection of Plant Materials

Fresh tender leaves of *B. alba* (LUH5807A), *C. crepidioides* (LUH1229A), *L. taraxacifolia* (LUH5806A), *S. biafrae* (LUH1227A) and *S. nigrum* (LUH1228A) were collected from Titi's home garden, Ota, Ogun state (Latitude 6.7°N and longitude 3.2°E), Ikoro market, Ikoro, Ekiti (Latitude 7.8°N and Longitude 5.0°E), and Kajola, Ibadan, Oyo state (Latitude 7.5°N and Longitude 3.9°E) south-western Nigeria, during the rainy season (June – August, 2014). The samples were authenticated by a taxonomist in the Botanical Herbarium, Dr. A. B. Kadiri of the Department of Botany, Faculty of Science, University of Lagos, Lagos, Nigeria. A voucher specimen for each plant was deposited in the Botanical Herbarium of the Department of Botany, Faculty of Science, University of Lagos, Nigeria where voucher numbers indicated in the brackets were obtained.

Preparation of Plant Samples

Fresh *B. alba*, *C. crepidioides*, *L. taraxacifolia*, *S. biafrae* and *S. nigrum* leaves were separately washed thoroughly with clean water and air-dried for a week under the shade at room temperature. Then the dried leaves of each of the samples were coarsely pulverized using electric blender and kept

in air tight bottle before extraction for GC-MS analysis.

Soxhlet Extraction of Vegetables for GC-MS Analysis

The Soxhlet extraction process was carried out using 60 ml of n-hexane (99%) as an extractant. Solvent was poured into the round bottomed extraction flask (capacity 100 ml), weighed and placed on the heating mantle. After this, the thimble containing the dried ground plant sample (10 g) was placed into the extraction chamber of the Soxhlet extractor. Lastly, the condenser was placed on top of the extractor and all the parts were fixed vertically. The extraction was carried out for three intervals of time, which are 3 hours, 6 hours and 9 hours (Ahmad et al., 2009). The extracts were concentrated to ~2 ml using nitrogen concentrator. Aliquot (2 µl) of each n-hexane-concentrated crude plant extract was injected into the split-less GC-MS system for analysis.

Gas Chromatography-Mass Spectrometry (GC-MS) Analysis of Bioactive Components of Vegetables Extracts

Gas Chromatography-Mass Spectrometry (GC-MS) analyses were carried out using 7890A Gas chromatography system coupled to VL/MSD 5975C mass spectrometer (GC-MS Agilent Technologies, Santa Clara, USA) instrument employing the following conditions: Column HP5MS fused silica capillary column [30 m (length) x 0.32 mm (diameter) x 0.25 µm (film thickness)] composed of 100% dimethyl polysiloxane. Helium gas (99.99%) was used as the carrier gas at constant flow rate of 1 ml/min and an injection volume of 1 µl was employed with injector temperature at 250 °C and pressure at 8.802 psi. The oven temperature was programmed initially from 80 °C (held for 2 minutes) with an increase of 5 °C/min. to 120 °C/min, then 10 °C/min to 240 °C/min, to hold for 6 min. The total GC running time for each sample was 30 min. The area under a peak accurately represents the quantity of the component present in each plant sample. Software adopted to handle mass spectra and chromatogram was a ChemStation. The interpretation of mass spectrum of GC-MS was done using the database of National Institute of Standard and Technology (NIST) version 2 year 2011 library. The mass spectrum of each of the unknown components was compared with the spectrum of the known components stored in the NIST library to ascertain the name, molecular weight and structure of the components of each of the vegetables' extracts.

RESULTS

GC-MS Analysis of Components of Vegetables Extracts

The compounds present in n-hexane extracts of *B. alba*, *C. crepidioides*, *L. taraxacifolia*, *S. biafrae* and *S. nigrum* leaves were identified by GC-MS method. The chromatograms of vegetable extracts analysed are presented in figures 1 to 5. Each peak represents a compound with different quantification and quality based on percentage by ChemStation's calibration mode (Software). Some peaks depict the same compound with different retention time and thus their area percentage compositions are additive. The GC-MS analysis of these vegetables extracts resulted in identification and quantification of 44 compounds. The identified compounds with their molecular formula, molecular weight (MW), retention time (RT), area percentage composition (quantity) and quality (matching factor) of each vegetable extract are presented in tables 1 to 5 respectively.

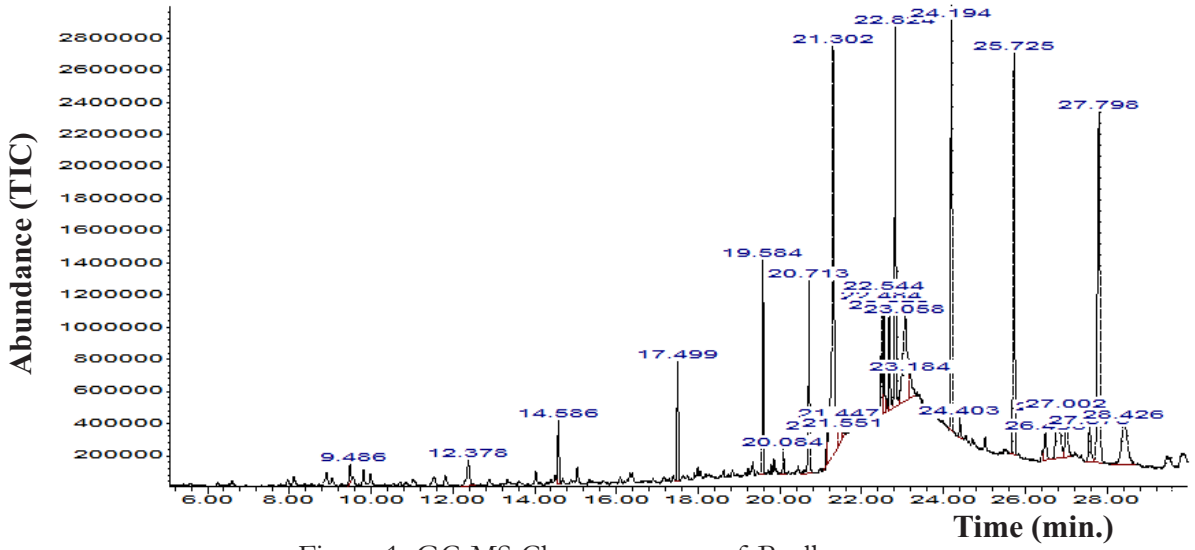

Figure 1: GC-MS Chromatogram of B. alba

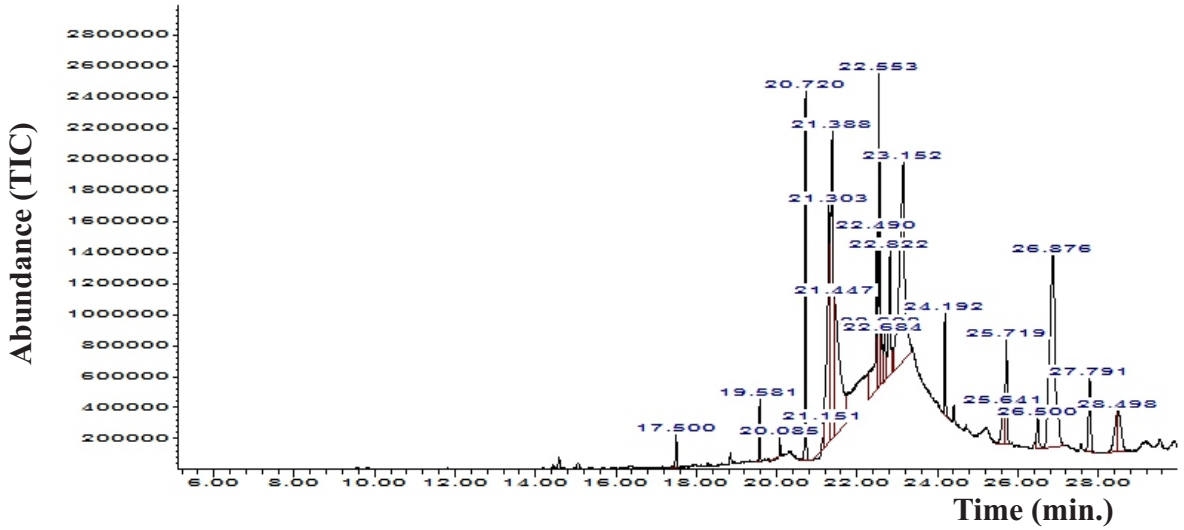

Figure 2: GC-MS Chromatogram of C. crepidioides

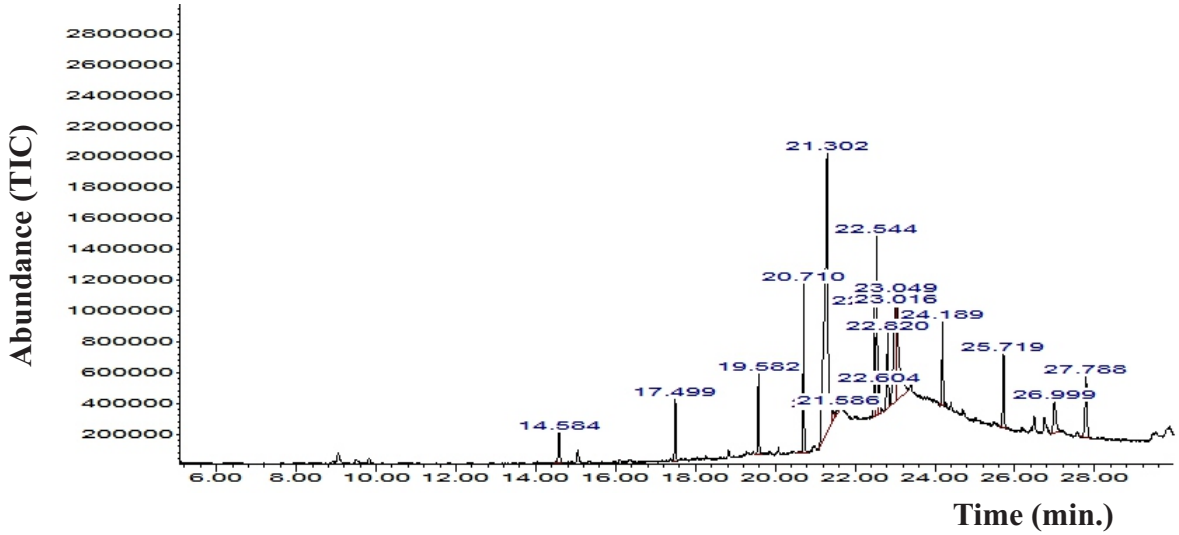

Figure 3: GC-MS Chromatogram of L. taraxacifolia

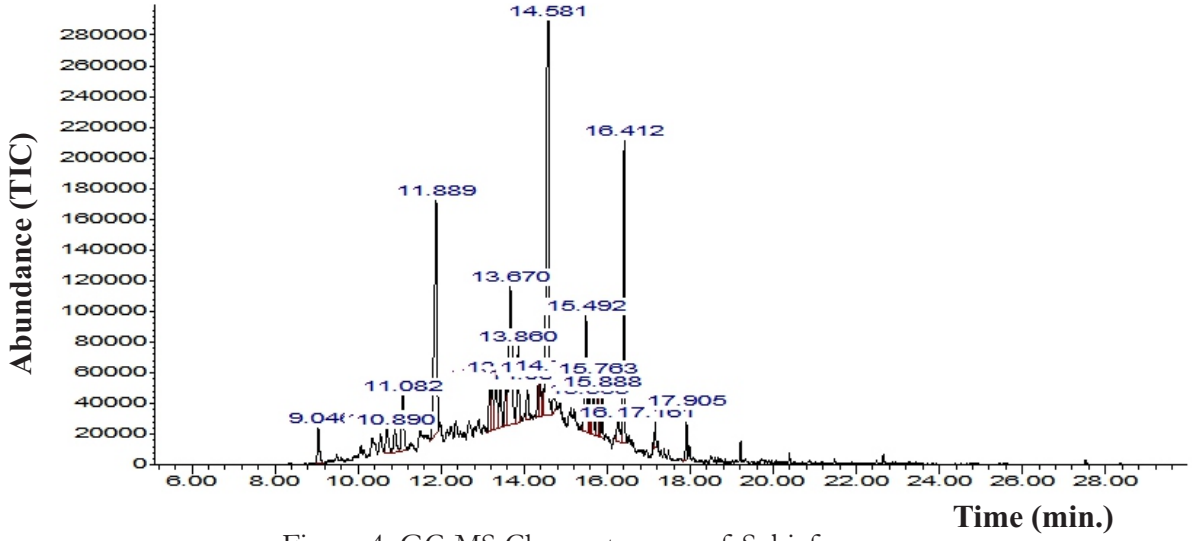

Figure 4: GC-MS Chromatogram of S. biafrae

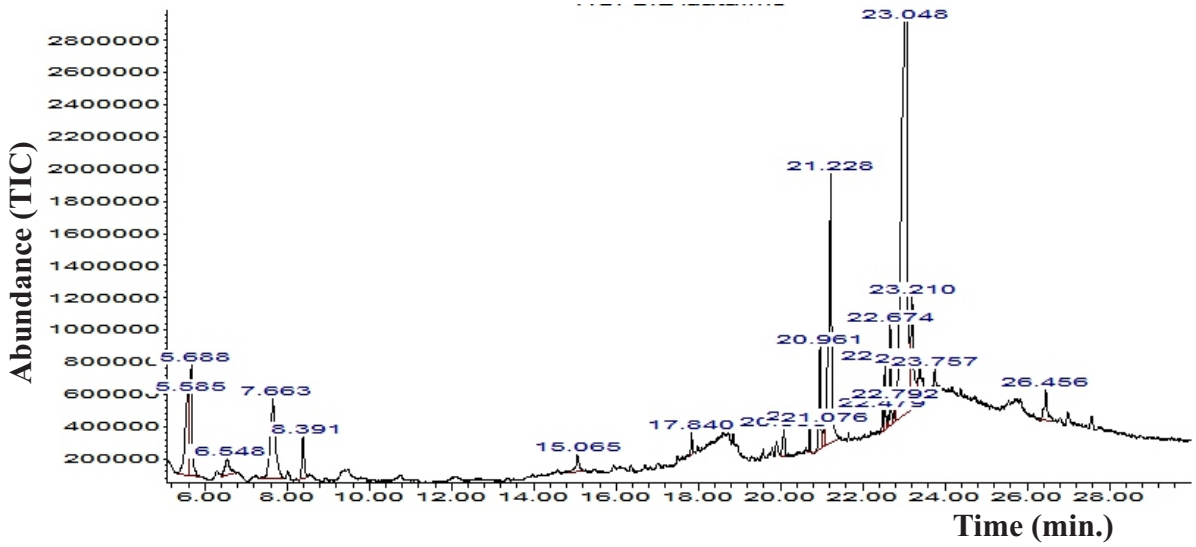

Figure 5: GC-MS Chromatogram of S. nigrum

B. albaEleven phyto-components were identified from *B. alba* leaves. High quality match linoleic (97%) and palmitic acids (98%) were identified in *B. alba* composition (6.85% and 5.47%) (Table 1). Although, 2.37% of oleic acid, 2% of phytol and 2.5% of phthalic acid were identified in *B. alba* but also with high quality match mass spectrum of 99%, 98% and 90% respectively. Small quantity of carophyllene (1.26%) and 2, 4-decadienal (trans, trans) (0.49%) were also identified in *B. alba* with 99% and 87% quality match respectively. Other noticeable compounds found in *B. alba* leaves are 8, 11-octadecadienoic acid, methyl ester (2.07%), 11,13-dimethyl-12- tetradecen-1-ol acetate (1.04%), 2,3-dihydroxypropyl elaidate (Monoelaidin) (0.48%) and cyclotetracosane (4.23%) (Table 1).

Table 1: Phyto-components of the Leaves of *B. alba*

S/N	Name of Compound	Molecular formular	Molecular weights (g·mol−1)	Retention time (RT)	Composition (%)	Quality (%)
1	2,4-Decadienal (trans,trans)	$C_{10}H_{16}O$	152.23	9.49	0.49	87
2	Caryophyllene	$C_{15}H_{24}$	204.36	12.38	1.26	99
3	Hexadecanoic acid, methyl ester (palmitic acid)	$C_{17}H_{34}O_2$	270.45	20.71	5.47	98
4	Dibutyl phthalate (phthalic acid)	$C_{16}H_{22}O_4$	278.34	21.14	2.5	90
5	8,11-Octadecadienoic acid, methyl ester	$C_{19}H_{34}O_2$	294.47	22.48	2.07	99
6	11-Octadecenoic acid, methyl ester (oleic acid)	$C_{19}H_{36}O_2$	296.49	22.55	2.37	99
7	Phytol	$C_{20}H_{40}O$	296.53	22.68	2	98
8	9,12-Octadecadienoic acid (Z,Z)- (linoleic acid)	$C_{18}H_{32}O_2$	280.45	23.06	6.85	97
9	11,13-Dimethyl-12-tetradecen-1-ol acetate	$C_{18}H_{34}O_2$	282.46	23.19	1.04	91
10	2,3-Dihydroxypropyl elaidate (monoelaidin)	$C_{12}H_{40}O_4$	356.54	24.40	0.48	81
11	Cyclotetracosane	$C_{24}H_{48}$	336.64	28.43	4.23	98

C. crepidioides

Eight compounds were identified in *C. crepidioides* leaves. High quality match (99%) linoleic acid, palmitic acid and oleic acid were the major constituents identified in *C. crepidioides* leaves in varying composition (14.88%, 27.22%, and 6.86%) respectively. However, out of the eight identified compounds, Phthalic acid (0.2%) was the least compound identified. The remaining four compounds identified include rumenic acid (5.16%), squalene (1.43%), 3-eicosene (1.81%) and hexadecane (1.93%) (Table 2).

Table 2: Phyto-components of the Leaves of *C.crepidioides*

S/N	Name of Compound	Molecular formular	Molecular weights (g·mol−1)	Retention time (RT)	Composition (%)	Quality (%)
1	1,2-Benzenedicarboxylic acid, bis 2-methylpropyl) ester (Phthalic acid)	$C_{16}H_{22}O_4$	278.34	20.08	0.2	87
2	Hexadecanoic acid, methyl ester (Palmitic acid)	$C_{17}H_{34}O_2$	270.45	20.72	27.22	99
3	Methyl 9-cis,11-trans-octadecadienoate (Rumenic acid)	$C_{18}H_{32}O_2$	280.45	22.49	5.16	99
4	11-Octadecenoic acid, methyl ester (Oleic acid)	$C_{19}H_{36}O_2$	296.49	22.55	6.86	99
5	9,12-Octadecadienoic acid (Z,Z)-(Linoleic acid)	$C_{18}H_{32}O_2$	280.45	23.15	14.88	99
6	2,6,10,14,18,22-Tetracosahexaene (squalene)	$C_{30}H_{50}$	410.72	25.64	1.43	99
7	3-Eicosene, (E)-	$C_{20}H_{40}$	280.53	28.48	1.81	94
8	Hexadecane, 1-iodo-	$C_{16}H_{33}I$	352.34	28.50	1.93	96

L. taraxacifolia

L. taraxacifolia revealed the least (4) number of compounds out of the five vegetables analysed by GC-MS (Table 3). These compounds are palmitic acid (42.35%), linoleic acid (20.78%), oleic acid (7.14%) and rumenic acid (4.06%) with 98%, 99%, 99% and 99% quality match respectively (Table 3).

Table 3: Phyto-components of the Leaves of *L.taraxacifolia*

S/N	Name of Compound	Molecular formular	Molecular weights (**g·mol−1**)	Retention time (R T)	Composition (%)	Quality (%)
1	Hexadecanoic acid, methyl ester (Palmitic acid)	$C_{17}H_{34}O_2$	270.45	20.71	42.35	98
2	Methyl 9-cis,11-trans-octadecadienoate (Rumenic acid)	$C_{18}H_{32}O_2$	280.45	22.48	4.06	99
3	11-Octadecenoic acid, methyl ester (Oleic acid)	$C_{19}H_{36}O_2$	296.49	22.54	7.14	99
4	9,17-Octadecadienal, (Z)-	$C_{18}H_{32}O$	264.45	22.60	1.37	95
5	9,12-Octadecadienoic acid (Z,Z)- (Linoleic acid)	$C_{18}H_{32}O_2$	280.45	23.01	19.41	99

S. biafrae

A total of 9 phyto-components (72% to 92% quality match) were identified from *S. biafrae* leaves (Table 4). 1-undecene (25.9%) was recorded as the most abundant compound while 1-octanol, 2-butyl-oxalic acid (1.24%) was the least compound identified (Table 4). Other compounds identified in *S. biafrae* leaves include oxalic acid (11.04%), dodecane, 2, 6, 10-trimethyl-heptadecane (2.77%), hexacosane (13.84%), tetradecane (11.57%), 1-iodo-2-methylundecane (1.75%), pentadecane (9.08%) and tetracosane (5.15%).

Table 4: Phyto-components of the Leaves of *S.biafrae*

S/N	Name of Compound	Molecular formular	Molecular weights (**g·mol−1**)	Retention time (R T)	Composition (%)	Quality (%)
1	Oxalic acid	$C_2H_2O_4$	90.04	10.70	11.04	72
2	1-Octanol, 2-butyl-oxalic acid	$C_8H_{18}O$	130.23	10.89	1.24	78
3	Dodecane, 2,6,10-trimethyl-Heptadecane	$C_{15}H_{32}$	212.42	11.08	2.77	78
4	Hexacosane	$C_{26}H_{54}$	366.71	11.89	13.84	78
5	Tetradecane	$C_{40}H_{82}$	563.08	13.67	11.57	78
6	1-Undecene	$C_{11}H_{22}$	154.29	14.58	25.90	72
7	1-Iodo-2-methylundecane	$C_{12}H_{25}I$	296.23	15.76	1.75	72
8	Pentadecane, 2-methyl-	$C_{16}H_{34}$	226.44	16.41	9.08	91
9	Tetracosane	$C_{24}H_{50}$	338.65	17.90	5.15	78

S. nigrum

S. nigrum presents the only and highest composition of linolenic acid (47.47%) with 98% quality match out of 12 compounds identified (Table 5). However, linoleic acid was absent while other compounds identified include pure phytol (2.23%), palmitic acid (14.22%), stearic acid (5.93%), 4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl (10.65%), 2,6-octadienal, 3,7-dimethyl-, (E) (1.7%), benzoic acid, 4-ethoxy-, ethyl ester (1.01%); cyclododecane (0.43%), 13-tetradece-11-yn-1-ol (0.4%), cis-13-octadecenoic acid, methyl ester (1.39%), E,E,Z-1,3,12-nonadecatriene-5,14-diol (2.91%) and 1H-1,2,3-triazolo[4,5-c]quinoline-1-hexanoic acid (1.62%) (Table 5).

Table 5: Phyto-components of the leaves of *S.nigrum*

S/N	Name of Compound	Molecular formular	Molecular weights (g·mol−1)	Retention time (R T)	Composition (%)	Quality (%)
1	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	144.13	5.69	10.65	86
2	2,6-Octadienal, 3,7-dimethyl-, (E)	$C_{10}H_{16}O$	152.23	8.39	1.70	96
3	Benzoic acid, 4-ethoxy-, ethyl ester	$C_{11}H_{14}O_3$	194.23	15.07	1.01	95
4	Cyclododecane	$C_{12}H_{24}$	168.32	17.84	0.43	89
5	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	270.45	20.71	0.57	96
6	n-Hexadecanoic acid (Palmitic acid)	$C_{16}H_{32}O_2$	256.42	21.23	13.65	99
7	13-Tetradece-11-yn-1-ol	$C_{14}H_{24}O$	208.34	22.48	0.40	96
8	cis-13-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296.49	22.54	1.39	97
9	Phytol	$C_{20}H_{40}O$	296.53	22.68	2.23	99
10	9,12,15-Octadecatrienoic acid, (ZZ,Z)-(Linolenic acid)	$C_{19}H_{32}O_2$	292.46	23.05	47.47	98
11	Octadecanoic acid	$C_{18}H_{36}O_2$	284.48	23.208	5.93	94
12	E,E,Z-1,3,12-Nonadecatriene-5,14-diol	$C_{19}H_{34}O_2$	294.47	23.386	2.91	91
13	1H-1,2,3-Triazolo[4,5-c]quinoline-1-hexanoic acid	$C_{15}H_{16}N_4O_2$	28/4.32	26.458	1.62	95

Table 6: Some Important Bioactive Components Identified in the Five Selected Vegetables Extracts by GC-MS and their Biological Activities

S/N	Name of Compound	BA	CC	LT	SB	SN	Nature of compounds/ **Biological Activities
1	Linoleic Acid	+	+	+	-	+	Polyunsaturated omega-6 fatty acid. /anti-inflammatory and antioxidant
2	Palmitic acid	+	+	+	-	+	Saturated fatty acids /Antioxidant, anti-atherosclerotic and hypocholesterolemic
3	Rumenic acid	-	+	+	-	-	Conjugated linoleic acids / Antioxidant
4	Oleic acid	+	+	+	-	-	Fatty acid / Anti-inflammatory and hypocholesterolemic
5	Phthalic acid	+	+	-	-	-	Aromatic dicarboxylic acid/Antioxidant
6	Phytol	+	-	-	-	+	Acyclic diterpene alcohol /Anti-inflammatory
8	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl	-	-	-	-	+	Flavonoid fraction /Anti-inflammatory
9	Oxalic acid	-	-	-	+	-	Organic dicarboxylic acid / Antioxidant

BA= *Basella alba*, CC= *Crassocephalum crepidioides*, LT= *Launaea taraxacifolia*, SB= *Senecio biafrae*, SN= *Solanum nigrum*,

\+ present, - absent

**Source: Dr. Duke's phytochemical and ethnobotanical database (Duke, 2014)

Important Antioxidant Compounds and their Biological Activities in the Vegetables

Some important antioxidant compounds such as phytol, linolenic, linoleic, palmitic, oleic, stearic, oxalic and phthalic acids were identified in the leaves of all plants with a substantial percentage abundance (quantity) and quality match ranging from 72% to 99%. Summary of important identified compounds with their biological activities in each vegetable extract are presented in table 6.

DISCUSSION

Analysis of Bioactive Components of Vegetables' Extracts by GC-MS

GC-MS analysis separates all the volatile components in the wild vegetable samples and presents a characteristic spectral output. A total of 44 compounds were subsequently identified in this study. Some major important fatty acids (linolenic acid, linoleic acid, palmitic acid, rumenic acid, stearic acid, oleic acid, phytol and oxalic acid) that were identified in the plants are beneficial to heart health (Okpuzor and Salisu, 2015; Bourourou *et al*., 2016).Most of these phyto-constituents have been reported to display remarkable biological activity against certain diseases, prevention of many diseases and health promoting properties (Olowokudejo *et al*., 2008; Aboul-Enein *et al*., 2014). These essential fatty acids cannot be synthesized in the body unlike most fats, but can be found in many vegetables with abundance in wild plants (Bhardwaj *et al*., 2016). The presence of linoleic and linolenic acids in 4 out of the 5 selected wild edible vegetables in this study support earlier reports of Melariri *et al*., (2012) and Bhardwaj *et al*., (2016).

However, percentage composition of linolenic acid in *S. nigrum* leaves is 47.1%. This area percentage is higher than that reported by Padmashree *et al*., (2014) in India, where the area percentage of linolenic acid in *S. nigrum* leaves was 0.41%. Also, our result revealed absence of linoleic acid (0%) in contrast to 59.1% of linoleic acid obtained by Padmashree *et al*., (2014) in *S. nigrum* leaves. This may be attributed to disparity in composition of the soil, temperature, water content and other environmental factors that may affect the bioavailability of different compounds in the leaves. Although 13.9% palmitic acid and 3.6% stearic acid from the same leaves (*S. nigrum* leaves) obtained in this study were almost consistent with 14.22% palmitic acid and 5.93% stearic acid reported by Padmashree *et al*., (2014).

Linoleic acid belongs to omega 6-fatty acids used in the biosynthesis of arachidonic acid and thus some prostaglandins, thromboxane and leukotrienes collectively known as eicosanoids. Linoleic acid (octadecadienoic acids) is a polyunsaturated fatty acid that plays a key role in support of heart vitality by lowering LDL cholesterol and reduces risk of developing heart disease (Farvid *et al*., 2014). Linolenic acid (octadecatrienoic acid) is an essential fatty acid convertible *in-vivo* to omega-3 fatty acids (Seeley *et al*., 2011). These two different essential fatty acids (linoleic and linolenic acids) are not produced in humans but usually found in plants (Melariri *et al*., 2012). Due to the health benefits associated with them, they are marketed as health supplements (Gaullier *et al*., 2005). They have been reported to be beneficial in the prevention and management of coronary heart disease and other chronic diseases (Bourourou *et al*., 2016).

It has been suggested that a combination of palmitic and linoleic acids displays antioxidant properties and can help prevent atherosclerosis (underlying pathogenesis of myocardial infarction) in rats (Cho *et al*., 2010). A combination of palmitic and linoleic acids was identified in 3 out of the 5 selected vegetables except in *S. biafrae* and *S. nigrum* leaves (Table 6). Increased antioxidant activities in myocardial infarction- induced experimental rats pretreated with these wild vegetables further confirm their antioxidant properties (Okpuzor and Salisu, 2015). Conjugated form of linoleic acid known as rumenic acid is majorly found in meat and dairy products (Gnadig *et al*., 2003). This fatty acid (rumenic acid) was also found in *L. taraxacifolia* and *C. crepidiodes* leaves. This is in agreement with the earlier study of Aberoumand (2009) which showed that conjugated linoleic acids are available in edible wild plants. Rumenic acid has been documented as antioxidative (Flintoff-Dye and Omaye, 2005), anticarcinogenic (Agnieszka *et al*., 2010), antiatherogenic (Valeille *et al*., 2005) and immune response modulators (Eder *et al*., 2005).

A saturated fatty acid (SFA), stearic acid, was present only in *S. nigrum*. Its hypocholesterolemic properties had been associated with low density lipoprotein (LDL) cholesterol levels (Mensink, 2005). Baskaran *et al*., (2015) reported oleic acid (omega-9) as anti-inflammatory compound and high quality oleic

acid (99% quality match) was identified in *B. alba*, *C. crepiodiodes* and *L. taraxacifolia*. This is in agreement with Kazadi *et al.* (2014) who pointed that wild plants are potential new sources of oleic acids.

Although, oxalates was reported as antinutrient in vegetables (Citation *et al*., 2013)., as natural antioxidant identified in only *S. biafrae* in this study, has been reported to suppress lipid peroxidation (Kayashima and Katayama, 2002). Phytol is another valuable compound documented in ethnobotanical database as natural antioxidant. This compound was present in *B. alba* (2%) and *S. nigrum* (2.3%) but absent in other vegetables. This result was not in agreement with 6.3% of phytol reported by Owokotomo *et al*. (2012) in *C. crepidioides* leaves. This disparity may be attributed to different geographical and climatic conditions associated with varying composition in the leaves. All these identified natural compounds possess antioxidant, atherosclerotic, anti-inflammatory and hypocholesterolemic properties that support previous studies and thus could serve as potent compounds for mitigation of myocardial infarction and can also found uses in drug development (Sheela and Uthayakumari *et al*., 2013; Salisu *et al*., 2014).

In conclusion, these indigenous vegetables with high antioxidants can be incorporated into our daily diet as functional foods for nutritional improvement and most importantly to prevent diseases. Furthermore, the conservation /preservation of the biodiversity of underutilized indigenous vegetables should be undertaken. Isolation of the specific active compound present in the plant extract is required for further medicinal research at the molecular level.

CONFLICT OF INTEREST

The authors have not declared any conflict of interest

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