Available online at http://www.ifgdg.org

Int. J. Biol. Chem. Sci. 10(5): 2351-2367, October 2016

ISSN 1997-342X (Online), ISSN 1991-8631 (Print)

International Journal of Biological and Chemical Sciences

Original Paper http://ajol.info/index.php/ijbcs http://indexmedicus.afro.who.int

Chemical compositions of seven essential oils from *Blighia sapida* (K. Koenig), (Sapindaceae)

Oluwafunmilola Elizabeth AKINPELU[1*], Dorcas Olufunke MORONKOLA[1], Folasegun A. DAWODU[1] and K. SICHILONGO[2]

[1]*Department of Chemistry, University of Ibadan, Ibadan, Nigeria*
[2]*Chemistry Department, University of Botswana, Gaborone, Botswana*
[*]*Corresponding author; E-mail: funmightfavour@yahoo.com; Tel: +2348132957467*

ABSTRACT

Blighia sapida essential oils were obtained in Nigeria by hydro-distillation, using all-glass apparatus (British Pharmacopeia specifications). Yields of essential oils procured were from 0.38% to 0.77%. Characterization of the chemical components was done using gas chromatography and gas chromatography-mass spectrometry to detect compounds for pharmaceutical and industrial applications in the future, this can also establish ethnomedicinal uses of *Blighia sapida*. A total of one hundred and forty-two compounds were identified in the seven essential oils of *Blighia sapida.* Percentage characterized compounds in leaf, leaf stalk, stem bark, root, fruit pulp, fruit husk and fruit seed essential oils were 78.77%, 70.98%, 32.89%, 33.08%, 45.25%, 68.88% and 87.37% respectively. The dominating identified compound are butyl cyclobutyl phthalate (9.11%), pentadecanal (5.18%), (E)-1,10-dimethyl-trans-9-decalol (6.31%), 4,8,12,15,15-pentamethyl-bicyclo[9,3,1]pentadeca-3,7-den-12-ol (7.92%), tributyl-1-propene-1,2,3-tricarboxylate (12.69%), 4,8,12,15,15-pentamethyl-bicyclo[9,3,1]pentadeca-3,7-den-12-ol (29.10%) and (Z)-vaccenic acid (14.24%) respectively. This study revealed important compounds in the leaf, leaf stalk, stem bark, root, fruit pulp, fruit husk and fruit seed essential oils of *Blighia sapida* which have not been reported earlier in literature despite the use of *Blighia sapida* traditionally to treat many ailments, these chemical constituents identified might be useful pharmaceutically and industrially. These results indicate that *Blighia sapida* essential oils were mostly dominated by terpenoids and esters.

Keywords: Hydrodistillation, gas chromatography-mass spectrophotometry, terpenoids, esters.

INTRODUCTION

Blighia sapida (ackee) is a perennial plant which belongs to sub-kingdom Tracheobionta rosidae, order saphindales and family sapindaceae (Atolani et al., 2009). It is indigenous to the forest of the Ivory Coast and Gold Coast of West Tropical Africa (Atolani et al., 2009). It is found in West African countries like Nigeria, Ghana, Togo, Guinea, Benin, Mali and Burkina Faso. It is called 'ackee' in English, 'aki' and 'arbe fricassee' in French, 'arbol de seso' and 'seso vegetal' in Spanish, 'arbor del huevo' and 'peraroja' in Mexico, 'bien me sube' or 'pan quesito' in Colombia, 'aki' in Costa Rica, 'castanna' or 'castanheiro de Africa' in Potuguese (Atolani et al., 2009).

DOI : http://dx.doi.org/10.4314/ijbcs.v10i5.32

In Nigeria: Yoruba, South –western, it is known as "isin"; Igbo, Eastern Nigeria, ''Okpu''; Hausa, Northern-western, "Gwanjakusa'' and Nupe, North central Nigeria, "*Yilanchi"*. It is propagated by seeds, cutting, grafting or shooting (Atolani et al., 2009). Fresh arils are consumed directly; they can be added to sauce or grounded into powder to release oil contents into the sauce. They can also be fried in peanut or oil palm and can be parboiled with salt and sometimes with spices (Ekué et al., 2010). Aqueous extract of the seed is used as parasites expellant in Brazil and Colombia, bark and leaves are considered stomachic; stem bark, seeds and husks are dried, ground into powder and used to poison fishes so as to catch them easily (Ekué et al., 2010). Fruit husks have the property of producing saponins that lather in water and its soap is valued mainly for its medicinal and esthetical properties (Ekué et al., 2010). Seed and ashes of the dried husk of the fruit are used for soap making because they are rich in potash (John-Dewole & Popoola, 2013). The whole immature fruits are cut in small pieces and plunged into water for washing clothes (Ekué et al., 2010). Pulp and leaves are used in the treatment of eye conjunctivitis (Oladiji et al., 2009) and diabetics (Gbolade, 2009). In Benin, 22 diseases including dental decay, fever, malaria, internal haemorrhage, dysentery, burns, eyes inflammation, yellow fever, constipation, cutaneous infections, whitlow and head lice were healed with the roots, stem bark, leaves, fruit husk and seeds of *Blighia sapida* (Ekué et al., 2010). *Blighia sapida* pod is a good adsorbent for the removal of Pb (II), Cd (II) and Co (II) ions from aqueous solution (Jimoh et al., 2012*). Ackee* seed is a moderate oil seed that could be exploited with proper refining for the production of consumable oil and other industrial products (Onuekwusi et al., 2014). Proximate nutritional composition and chemical properties of the aril has high fat and carbohydrate contents, low protein, moisture and total ash contents with low iodine, acid, peroxide and saponification values (Ouattara et al., 2010). We present our reports on the study of chemical compositions of seven essential oils from leaf, leaf stalk, stem bark, root, fruit pulp, fruit husk and fruit seed of *Blighia sapida* (K. Koenig), which have not been reported earlier in literature despite its traditional uses.

MATERIALS AND METHODS

Plant materials

Fresh samples of *Blighia sapida* were collected at Abadina Primary School, University of Ibadan, Ibadan, Oyo State, Nigeria. The plant was authenticated in the Herbarium, Department of Botany, University of Ibadan, Ibadan, Nigeria, where voucher samples were deposited with specimen voucher number UIIH - 22407. Collection of the sample was done during the day time. The plant was separated into leaf, leaf stalk, stem bark, root, fruit pulp, fruit husk and fruit seed.

Extraction of the essential oil

Each separated part of *Blighia sapida* was crushed and ground using Hammer mill crusher (15 Horse power) and hydro-distilled for 3 hours in an all glass Clevenger-type apparatus designed to British Pharmacopeia specifications and the oils refrigerated until analyses.

Gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) analyses

Essential oils of *Blighia sapida* leaves, leaves stalk, stem bark, root and fresh fruit pulp, fruit husk and seeds were analyzed using an Agilent 5975C series Gas Chromatograph-Mass Spectrometer (GC-MS) system.

Data analysis was done using Productivity Chemstation Version E.02.01.1177 in conjunction with the Automated Mass Spectral Deconvolution and Identification System (AMDIS). For the column oven program, the equilibration time was set at 0.25 min; the initial temperature was set at 70 °C, held there for 4 mins, and then ramped at 6 °C/min to 140 °C for 6 min. It was further ramped at 15 °C/min to 300 °C for 4 minutes. The total run time was 36.333 minutes. 1 µL of sample extract was injected in the splitless mode. The injector temperature was set at 280 °C and the column head pressure was 56.756 kPa yielding a total flow of 64 mL/min. The transfer line temperature was 280 °C. A HP-5MS 5% Phenyl Methyl Silox column with dimensions of 30 m x 250 µm x 0.25 µm and maximum recommended temperature (MRT) of 325 °C was used throughout. Helium was used as a carrier gas at a flow rate of 1 mL/min.

The acquisition mode was full scan with a solvent delay of 4.00 minutes. Acquisition mass range was set at m/z 50 – 600 and the electron multiplier detector voltage was auto set to 1082 V. The mass spectrometer source and quadrupole mass analyzer temperatures were set to 230 °C and 150 °C respectively. The filament emission current was auto set to 34.610 µA.

Compounds identification

Identification of the chemical components of the essential oils was performed by their retention indices which were determined with reference to a homologous series of n-alkanes and by comparison of their mass spectral fragmentation patterns with the reference compounds in the data systems of National Institute of Standards and Technology (NIST) spectra libraries matching version 8.0.

The AMDIS software version 2.71 build 134.27 was used to compare the NIST library spectra with component spectra (deconvolution). The minimum match factor was for deconvolution on AMDIS was set to 70 and all identified components had match factors between 70 and 100. Some mass spectral fragmentation patterns with characteristic retention time were compared with standard in-built data (Adams, 2007).

RESULTS

The percentage yields of essential oils procured range from 0.38 to 0.77%. All the oils were colourless but each has characteristic odour (Table 1). Leaf oil (0.77% yield) had a leafy and aromatic odour; leaf stalk (0.44%) had leafy and woody odour; stem bark (0.47%) possessed nut and slightly choking smell; root (0.61%) with faint woody odour; fruit pulp (0.71%) possessed palatable odour; fruit husk (0.64%) also had palatable odour while the fruit seed (0.38%) had a fibre-like smell. Each of the oils was subjected to GC and GC-MS analysis. Seventy-eight compounds representing 78.77% were identified in leaf; forty-one in leaf stalk (70.98%); ten in stem bark (32.89%); fourteen in root (33.08%); twelve in fruit pulp (45.25%); eleven in fruit husk (68.88%) and thirty-one in fruit seed (87.37%); all together, one hundred and forty-two compounds were identified in the seven essential oils (Table 2). The dominant identified compounds in each of *Blighia sapida* essential oils are butyl cyclobutyl phthalate (9.11%), α-Ionone (5.17%) and β-Ionone (4.14%) in leaf; pentadecanal (5.18%), cyclobutyl isobutyl phthalate (5.05%) and hexahydrofarnesyl acetone (3.82%) in leaf stalk; (E)-1,10-dimethyl-trans-9-decalol (6.31%), pentadecanal (4.83%) and farnesol (3.93%) in stem bark; 4,8,12,15,15-pentamethyl-bicyclo[9,3,1]pentadeca-3,7-den-12-ol (7.92%), 2,3,4,5,6-pentachloroanisole (6.79%) and 1,7-dimethyl-4-(1-

Table 1: Yields of essential oils procured from leaf, leaf stalk, stem bark, root, fruit pulp, fruit husk and fruit seed of *Blighia sapida* (K. Koenig).

No	Plant Part	Weight of Sample (g)	Weight of Essential Oil Procured (g)	%Yield of Essential Oil Procured	Physical Properties
1	Leaf	150	1.15	0.77	Colourless; leafy and aromatic odour
2	Leaf Stalk	200	0.88	0.44	Colourless; leafy and woody odour
3	Stem Bark	200	0.94	0.47	Colourless; nut and slightly choky odour
4	Root	150	0.91	0.61	Colourless; faint woody odour
5	Fruit Pulp	100	0.71	0.71	Colourless; palatable odour
6	Fruit Husk	200	1.28	0.64	Colourless; palatable odour
7	Fruit Seed	200	0.76	0.38	Colourless; Fibre-like odour

Table 2: Chemical compositions of the seven essential oils of *Blighia sapida*.

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
1	6.55	2-Pentyl-furan	1273	-	0.48	-	-	-	-	-
2	9.57	Nonanal	1543	-	0.57	-	-	-	-	-
3	11.31	(E)-2-Nonen-1-ol	1698	1.39	-	-	-	-	-	-
4	12.03	Methyl salicylate	1765	0.66	-	-	-	-	-	-
5	12.69	β-Cyclocitral	1826	0.83	-	-	-	-	-	-
6	12.91	(Z)-3-Hexenyl-α-methylbutyrate	1848	0.34	-	-	-	-	-	-
7	13.19	4-Methylthiazole	1875	0.22	-	-	-	-	-	-
8	13.60	β-Homocyclocitral	1915	0.49	-	-	-	-	-	-
9	13.61	(Z)-2-Decenal	1917	-	-	-	-	-	-	0.38
10	14.92	2,4-Decadienal	2053	0.26	-	-	-	-	-	0.73
11	15.10	1-Azabicyclo(3,1,0)hexane	2073	0.66	-	-	-	-	-	-
12	15.23	Hexyl cyclobutanecarboxylate	2087	0.06	-	-	-	-	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
13	15.39	Cyclohexyl propyloxalate	2105	0.12	-	-	-	-	-	-
14	15.83	1,3,5-Trimethyl-2-(1,3-butadienyl)benzene	2153	0.27	-	-	-	-	-	-
15	15.91	1,1,6-Trimethyl-1,2,3,4-tetrahydro- Naphthalene	2161	0.25	-	-	-	-	-	-
16	15.98	2-Undecenal	2169	-	-	-	-	-	-	0.38
17	15.99	1,2-DimethylAzetidine	2170	0.12	-	-	-	-	-	-
18	16.52	Hexyl hexanoate	2230	0.18	-	-	-	-	-	-
19	16.78	Germacrene	2261	-	-	-	-	-	-	0.48
20	16.86	1-Iodononane	2270	-	0.07	-	-	-	-	-
21	17.12	(E)-1,10-dimethyl-trans-9-decalol	2301	-	1.16	6.31	-	-	-	-
22	17.58	β-Caryophyllene	2355	-	-	-	-	-	-	0.67
23	17.66	4-Nitrophenyl-2-fluorobenzoate	2366	0.08	-	-	-	-	-	-
24	17.72	4(2,2,-Dimethyl-6-methylenecyclohexyl)-3-buten-2-one	2372	-	0.91	-	-	-	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)
25	17.81	α-Ionone	2383	5.17	-	-	-	-	-
26	17.98	(E)-Butyl-2-hexenoate	2403	0.32	-	-	-	-	-
27	18.43	(E)-6,10-Dimethyl-5,9-undecadien-2-one	2460	-	1.47	-	-	-	-
28	18.52	(Z)-6,10-Dimethyl-5,9-undecadien-2-one	2471	3.25	-	-	-	-	-
29	18.62	α-caryophyllene	2484	-	-	-	-	8.05	-
30	18.70	3,8-Dimethyldecane	2494	0.10	-	-	-	-	-
31	19.64	1,3-di-n-Propyladamantane	2612	-	1.07	-	-	-	-
32	19.75	β-Ionone	2626	4.14	-	-	-	-	-
33	20.48	α-Farnesene	2718	1.46	-	-	-	-	-

34	21.37	(Z)-1,8(2H,5H)-hexahydro-8a-methyl-naphthalenedione	2830	3.34	-	-	-	-	-	
35	22.67	(Z)-3,7,11-Trimethyl-1,6,10-dodecatrien-3-ol	2994	0.31	-	-	-	-	-	
36	22.90	(Z)-3-Hexen-1-ol,benzoate	3023	1.56	-	-	-	-	-	

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)
37	23.08	Hexyl benzoate	3046	1.58	-	-	-	-	-
38	23.56	4-Methyl-1-undecene	3106	-	0.48	-	-	-	-
39	23.85	Tetradecanal	3142	0.30	-	-	-	-	-
40	24.46	-Alanine,N-(4-butylbenzoyl)-,isobutyl ester	3219	0.10	-	-	-	-	-
41	24.60	1,3-Diphenylpropane	3237	0.04	-	-	-	-	-
42	24.68	(Z)- 2 (3H)- dihydro-5-(2-Octeny1)-Furanone	3247	0.11	-	-	-	-	-
43	24.69	α-cadinol	3249	-	-	-	2.01	-	-
44	24.95	5,9-Dimethyl-2-decanone	3281	0.14	-	-	-	-	-
45	24.99	1-Dodecanol	3286	0.15	-	-	-	-	-
46	25.01	8-Heptadecene	3289	-	0.24	-	-	-	-
47	25.02	Aspirin	3290	-	-	-	-	-	-
48	25.03	n-Hexyl salicylate	3292	0.30	-	-	-	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
49	25.04	Cadalene	3292	-	1.44	-	1.45	-	-	-
50	25.13	(Z)-3-Hexenyl Salicylate	3303	0.12	-	-	-	-	-	-
51	25.29	1,7-Dimethyl-4-(1-methylethyl)-spiro(4,5)dec -6-en-8-one	3324	0.14	0.78	-	4.49	-	-	-

52	25.31	5-Methyl-2-hexanone	3327	-	-	-	-	-	-	0.25
53	25.32	4,7-Dimethylundecane	3328	-	0.59	-	-	-	-	-
54	25.37	3,7,7-Trimethyl-1-penta-1,3-dienyl-2- Oxabicyclo(3,2,0)hept-3-ene	3334	0.32	-	-	-	-	-	-
55	25.51	9,9-Dimethyl-9-silafluorene	3352	-	-	2.68	-	-	0.94	-
56	25.52	2, 2^1 $5,5^1$-tetramethyl-$1,1^1$-Biphenyl	3353	0.15	2.99	-	1.77	-	-	0.63
57	25.53	Pentadecanal	3354	-	5.18	4.83	-	-	0.41	0.15
58	25.68	2,3,4,5,6-pentachloroAnisole	3373	0.39	0.83	-	6.79	-	-	-
59	25.76	Pyrethrin	3383	0.54	-	-	-	-	-	-
60	25.81	1-Butyloctylbenzene	3389	-	0.59	-	-	-	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
61	26.16	Tetradecanoic acid	3433	0.29	-	-	-	-	-	0.37
62	26.27	2-Acetyl-5-methylfuran	3447	0.12	0.19	-	0.76	-	-	-
63	26.32	Pentadecanol	3454	0.29	-	-	-	-	-	-
64	26.38	Anthracene-9,10-dihydro-diethyl-9,10-biimine-11,12-dicarboxylate	3462	-	-	-	0.60	-	-	-
65	26.40	9-Methylene-9H-fluorene	3463	0.39	0.43	-	-	-	-	-
66	26.43	1,2,3,4,5,6,7,8-Octahydro-1,4-dimethyl-7-(1-methylethenyl)-,(1s-(lα,4α,7α)]-Azulene	3467	0.10	-	-	-	-	-	-
67	26.54	2,6,10-trimethyl-1,5,9-undecatriene	3481	0.40	-	-	-	-	-	-
68	26.55	2,2,5-Trimethyl-3,4-hexanedione	3482	-	-	0.70	0.49	-	-	-
69	26.74	(Z)-2-Dodecenol	3506	-	0.49	-	-	-	-	-
70	26.99	3,7,11,15-Tetramethyl-2-hexadecen-1-ol	3538	4.03	1.74	-	-	-	-	-

71	27.06	Hexahydrofarnesyl acetone	3542	2.79	3.82	3.61	-	-	1.51	0.51
72	27.20	1-Hexadecyne	3565	-	0.78	-	-	-	-	-

Table 2 (Continued)

S/N	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
73	27.25	1-(Phenylmethylene)-1H-Indene	3571	0.11	-	-	-	-	-	-
74	27.29	Cyclobutyl isobutyl phthalate	3576	0.34	1.02	-	0.60	-	-	0.43
75	27.31	Tonalid	3578	-	-	-	-	-	-	0.51
76	27.46	(Z),(Z)-7,10-Hexadecadienal	3597	0.38	-	-	-	-	-	-
77	27.50	(Z)-7-Tetradecenal	3602	-	-	-	-	-	-	0.38
78	27.51	(Z), (Z)-6,9-Pentadecadien-1-ol	3604	0.70	-	-	-	-	-	-
79	27.56	Trimethylamine	3610	-	-	-	-	-	-	0.40
80	27.60	4-Methyl-phenanthrene	3614	-	0.45	-	-	-	-	-
81	27.65	9-Methyl-anthracene	3621	-	0.49	-	-	-	-	-
82	27.69	Butanimidamide	3627	0.28	-	-	-	-	-	-
83	27.72	2-methyl-3-(3-methyl-but-2-enyl)-2-(4-methyl-pent-3-enyl)-oxetane	3630	-	-	2.40	-	-	-	-
84	27.73	(E),(E)-6,10,14-Trimethyl-5,9,13-pentadecatrien-2-one	3631	2.55	3.02	-	-	-	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
85	27.75	2-Methyl-butanoic acid	36.34	-	1.16	-	-	-	-	-
86	27.76	Methyl palmitate	3634	0.27	-	-	-	-	1.06	1.64
87	27.84	2-Phenyl-1H-indene	3645	0.37	1.45	-	-	-	-	-
88	27.95	Isophytol	3659	0.58	1.90	-	-	-	-	-
89	27.97	1-(1,3α,4,5,6,7-Hexahydro-4-hydroxy-3,8-dimethyl-5-azulenyl)-ethanone	3661	-	1.48	-	-	-	-	-
90	28.01	3, 3-Dimethylhexane	3667	0.24	-	-	-	-	-	-
91	28.10	Cyclobutyl hexyl phthalate	3678	-	-	-	0.73	-	-	-
92	28.11	Butyl cyclobutyl phthalate	3679	9.11	5.05	-	-	-	-	-
93	28.20	1-Ethenyl-1-methyl-2,4-bis(1-methyletheny1) - (1S-(1α,2α,4α))cyclohexane	3690	-	-	-	4.40	-	-	-
94	28.21	Hexadecanoic acid	3691	0.37	-	-	-	-	-	1.22
95	28.27	2-Phenyl-naphthalene	3700	0.60	-	-	-	-	-	-
96	28.30	Methyl-6-deoxy-6-fluoro-2,3,4-tri-O-ethylàd-galactopyranoside	3703	-	-	-	0.47	-	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
97	28.34	3,3-Dimethylhexane	3708	-	1.12	-	-	-	-	-
98	28.54	3-Cyclohexene-1-methanol-α,α,4-trimethyl-acetate	3733	-	-	-	-	-	4.43	-
99	28.57	Isoterpinolene	3736	-	-	-	-	-	-	3.83
100	28.61	Farnesol	3742	-	-	3.93	-	-	-	-
101	28.63	Geranylgeraniol	3744	0.59	-	-	-	-	-	-
102	28.66	4,8,12,15,15,Pentamethyl-bicyclo[9,3,1] pentadeca-3,7- den-12-ol	3748	0.69	-	-	7.92	-	29.1	9.84
103	28.73	Cembrene	3757	-	-	-	-	4.16	-	-
104	28.97	2,4,6,8-Tetramethyl-1-undecene	3788	-	1.81	-	-	-	-	-
105	29.01	Pyrene	3792	0.41	1.95	-	-	-	-	-
106	29.02	Alloaromadendrene oxide	3793	-	-	-	-	-	4.39	-
107	29.06	4,4, 11,11-Tetramethyl-7-tetracyclo(6,2,1,0 (3.8) 0 (3.9)) undecanol	3798	0.88	-	-	-	-	-	-
108	29.06	$1,1^1$-Dimethyl-1, 1^1-bicyclopropyl	3799	-	-	-	-	1.13	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
109	29.07	2, 6,10-Trimethyldodecane	3800	0.61	-	-	-	-	-	-
110	29.10	(Z)-Methyl 9-Octadecenoate	3804	-	-	-	-	-	-	1.58
111	29.21	α-Springene	3818	-	-	-	-	-	-	1.22
112	29.44	Cis –Vaccenic acid	3841	-	-	-	-	-	-	14.24
113	29.46	Phytol	3815	2.57	1.89	-	-	-	-	-
114	29.51	Tributyl-1-propene-1,2,3-tricarboxylate	3856	0.41	1.71	2.21	-	12.69	2.73	1.95
115	29.57	p-Terphenyl	3863	0.38	-	-	-	-	-	-
116	29.69	2-ethoxy-ethanol	3878	0.15	-	-	-	-	-	3.20
117	30.15	Tributyl acetylcitrate	3935	0.71	1.20	-	-	1.36	2.35	4.92
118	30.34	Heptacosane	3960	-	1.72	-	-	-	-	-
119	30.73	Propanal(1-methylethy1)hydrazone	4010	-	1.10	-	-	-	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
120	30.83	Decyl trans-hex-3-enyl fumarate	4021	0.51	-	-	-	-	-	-
121	30.90	2,6,10-Dodecatrien-1-ol,3,7,11-trimethyl-acetate	4030	0.65	-	-	-	-	-	-
122	30.91	6-Ethyl-2-methyl-octane	4032	-	-	1.14	-	-	-	-
123	30.92	Tridecane	4032	-	2.11	-	-	-	-	-
124	31.11	2,5-Dimethyl-3-Hexanone	4057	0.22	-	-	-	-	-	-
125	31.46	2,2,3,3-Tetramethylpentane	4101	-	-	-	-	1.43	-	-
126	31.47	Heptacosane	4102	0.71	-	-	-	-	-	-
127	31.79	Bis(2-pentyl)-phthalate	4143	0.44	-	0.98	-	0.52	-	0.95
128	31.79	Mono(2-ethylhexyl)-1,2-benzenedicarboxylate	4142	-	1.36	-	-	-	-	-
129	31.79	2-Methylbutyl octyl phthalate	4142	-	-	-	0.61	-	1.12	-
130	31.82	(Z)-8-methyl-exo-tricyclo(5,2,1,0 (2.6) decane	4147	0.30	-	-	-	-	-	-
131	31.98	2-Methyl-dodecane	4167	-	-	-	-	-	-	0.87
132	31.99	2,2,5-Trimethyl-3,4-hexanedione	4267	-	-	-	-	0.52	-	-

Table 2 (Continued)

No	Rt (Mins)	Compound	R1	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)	
133	32.37	1,2-Diiodo-ethane	4215	-	-	-	-	-	-	1.08	
134	32.38	1-Docosene	4217	-	-	-	-	1.71	-	-	
135	32.48	Heneicosane	4231	-	-	-	-	7.03	-	0.72	
136	32.98	4-Bromophenyl nonyl 1,2-cyclohexanedicarboxylate	4293	-	-	-	-	-	0.66	-	
137	33.02	Decyl 2-ethylhexyl Sulfurate	4297	0.33	-	-	-	-	-	-	
138	33.13	Dinonyl 1,2-cyclohexanedicarboxylate	4312	-	-	-	-	-	-	0.39	Es
139	33.25	Squalene	4327	0.33	-	-	-	-	-	-	
140	33.48	Trifluoro-3,7-dimethyloctyl acetate	4356	-	-	-	-	1.71	-	-	
141	33.60	Butyldecylsulfurate	4371	-	-	-	-	2.39	-	-	
142	35.02	2-Ethylhexyl isohexyl sulfurate	4550	0.10	-	-	-	-	-	-	
Total number of Identified compounds				**78**	**41**	**10**	**14**	**12**	**11**	**31**	**142**
% Characterized compounds				**78.77**	**70.98**	**32.89**	**33.08**	**45.25**	**68.88**	**87.37**	

Rt: retention time (minutes); RI: retention index

Table 3: Classes of chemical compositions of essential oils of *Blighia sapida*.

No	Class of compound	Leaf (%)	Leaf stalk (%)	Stem bark (%)	Root (%)	Fruit pulp (%)	Fruit husk (%)	Fruit seed (%)
1	Me	0.40	-	-	-	-	-	3.83
2	Mo	10.63	-	-	-	-	-	-
3	Se	1.46	3.25	-	1.45	8.05	4.39	3.3
4	So	7.16	10.61	7.54	8.27	-	1.51	1.14
5	De	0.61	-	-	-	4.16	-	1.22
6	Do	9.0	5.53	-	7.92	-	29.1	9.84
7	Te	0.33	-	-	-	-	-	-
8	Aka	1.35	6.61	1.14	4.40	9.59	-	-
9	Ake	-	0.72	-	-	1.71	-	-
10	Aky	-	0.78	-	-	-	-	-
11	Es	17.21	10.34	3.19	2.54	16.28	12.35	11.86
12	Ca	0.66	1.16	-	-	-	-	15.97
13	Ht	1.44	0.67	5.08	0.76	-	0.94	-
14	Ar	6.65	5.6	-	7.26	-	-	-
15	Al	2.99	1.65	6.31	-	-	-	-
16	Ad	0.94	5.75	4.83	-	-	0.41	2.02
17	Ke	3.72	3.86	-	0.49	0.52	-	0.25
18	Ha	-	0.07	-	-	-	-	-
19	Hy	-	1.10	-	-	-	-	-
20	Am	-	-	-	-	-	-	0.40
21	Amd	0.28	-	-	-	-	-	-
22	Su	0.43	-	-	-	2.39	-	-

Me: monoterpene; Mo: monoterpenoid; Se: sesquiterpene; So: sesquiterpenoid; De: diterpene; Do: diterpenoid; Te: triterpene; Aka: alkane; Ake: alkene; Aky: alkyne; Es: ester; Ca: carboxylic acid; Ht: heterocyclic; Ar: aromatic; Al: alcohol; Ad: aldehyde; Ke: ketone; Ha: halogenated; Hy: hydrazone; Am: amine; Amd: amide; Su: sulphate.

methylethyl)-spiro (4,5)dec-6-en-8-one (4.49%) in root; tributyl-1-propene-1,2,3-tricarboxylate (12.69 %), α-caryophyllene (8.05%) and heneicosane (7.03%) in fruit pulp; 4,8,12,15,15-pentamethyl-bicyclo[9,3,1]pentadeca-3,7-den-12-ol (29.10%), 3-cyclohexene-1-methanol-α,α,4-trimethyl- acetate (4.43%) and alloaromadendrene oxide (4.39%) in fruit husk; (Z)-vaccenic acid (14.24%), 8,12,15,15-pentamethyl-bicyclo[9,3,1]pentadeca-3,7-dien-12-ol (9.84%) and tributyl acetylcitrate (4.92%) in fruit seed. The one hundred and forty-two compounds identified in all seven essential oils are classified into twenty-two organic compounds (Table 3). *Blighia sapida* leaf essential oil is dominated by ester (17.21%), monoterpenoid (10.63%) and diterpenoid (9.0%); leaf stalk by sesquiterpenoid (10.61%), ester (10.34%) and alkane (6.61%); stem bark by sesquiterpenoid (7.54%), alcohol (6.31%) and heterocyclic (5.08%); root with sesquiterpenoid (8.27%), diterpenoid (7.92%) and aromatic (7.26%); fruit pulp dominated by ester (16.28%), alkane (9.59%) and sesquiterpene (8.05%); fruit husk have diterpenoid (29.1%), ester (12.35%) and sesquiterpene (4.39%) and fruit seed with carboxylic acid (15.97%), ester (11.86%) and diterpenoid (9.84%).

DISCUSSION

Interestingly, some of these identified compounds found to be present in this plant have been scientifically proved to be responsible for important bioactivities. Examples of such are α-caryophyllene which is present in fruit pulp (8.05%) and fruit seed (1.64%), it has been reported to be present in essential oils of *Harungana madagascariensis* leaf and stem (Moronkola et al., 2015) and *Cannabis sativa* (hemp) (Gertsch et al., 2008)., it is an anti-inflammatory agent (Gertsch et al., 2008); β-caryophyllene in fruit seed (0.67%) reported present in cinnamon (*Cinnamomum* spp.) and black pepper (*Piper nigrum* L.) **(**Jayaprakasha et al., 2003; Orav et al., 2004), it is useful as food additive, cosmetics (*Sköld* et al., 2006) and anti-inflammatory agent (Jürg et al., 2008); farnesol is detected in stem bark (3.93%) and it is responsible for antibacterial activity (Derengowski et al., 2009; Jabra-Rizk et al., 2006), as well as chemopreventative and an anti-tumor agent (Joo and Jetten, 2009). α-Ionone (5.17%) and β-ionone (4.14%) are present in leaf, they have been reported in *Terminalia catappa* fruits (Moronkola and Ekundayo, 2000). Ionones are important in perfumery industries (Sell, 2007). Our study resulted in the identification of one hundred and forty-two compounds in *Blighia sapida* (K. Koenig) essential oils which have potential applications pharmaceutically and industrially. The results indicate that *Blighia sapida* essential oils are mostly dominated by terpenoids and esters. This study is the first of its kind which revealed important compounds in *Blighia sapida* (K. Koenig) leaf, leaf stalk, stems bark, root, fruit pulp, fruit husk and fruit seed essential oils which have not been reported earlier in literature. The identified volatile metabolites may be responsible for the reported vast ethno-medicinal uses and biological activities of *Blighia sapida* (K. Koenig).

Conclusion

The results of our study indicate that *Blighia sapida* (K. Koenig) essential oils possess chemical compounds which have potential applications pharmaceutically and industrially, they are mostly dominated by terpenoids and esters. This study is the first of its kind which revealed important compounds in *Blighia sapida* (K. Koenig) leaf, leaf stalk, stems bark, root, fruit pulp, fruit husk and fruit seed essential oils which have not been reported earlier in literature. The identified volatile metabolites may be responsible for the reported vast ethno-medicinal uses and biological activities of *Blighia sapida* (K. Koenig).

COMPETING INTERESTS

The authors declare that they have no competing interest.

ACKNOWLEDGEMENTS

We acknowledge the use of J-laboratory facilities, Chemistry Department, University of Ibadan, Nigeria in essential oils isolations and TWAS-UNESCO Associateship [3240278167] awarded to Dr. Dorcas O. Moronkola that facilitated the GC-MS analysis provided with research space and facilities at NABSA, Chemistry Department, University of Botswana, Botswana.

REFERENCES

Adams RP. 2007. *Identification of Essential Oil Components by Gas Chromatography/Mass Spectroscopy* (4th Edition). Allured Publishing Corporation: Carol Stream, IL. 1-804.

Atolani O, Olatunji GA, Fabiyi OA. 2009. *Blighia sapida*: The plant and its hypoglycins an overview. *Journal of Scientific Research*, **39**: 2. DOI: http://dx.doi.org/10.5138/ijpm.v8i2.1817

Derengowski LS, De-Souza-Silva C, Braz SV, Mello-De-Sousa TM, Báo SN, Kyaw CM, Silva-Pereira I. 2009. Antimicrobial effect of farnesol, a *Candida albicans* quorum sensing molecule, on *Paracoccidioides brasiliensis* growth and morphogenesis. *Annals of Clinical Microbiology and Antimicrobials*, **8**: 13. DOI: 10.1186/1476-0711-8-13

Ekué MRM, Sinsin B, Eyog-Matig O, Finkeldey R. 2010. Uses, traditional management, perception of variation and preferences in ackee (*Blighia sapida* K. Koenig) fruit traits in Benin: Implications for domestication and conservation. *Journal of Ethnobiology and Ethnomedicine*, **6**(12): 1-14. DOI: 10.1186/1746-4269-6-12

Gbolade AA. 2009. Inventory of antidiabetic plants in selected districts of Lagos State, Nigeria. *Journal of Ethnopharmacology*, **121**: 135-139. DOI: 10.1016/j.jep.2008.10.013

Gertsch J, Leonti M, Raduner S. 2008. Beta-caryophyllene is a dietary cannabinoid. *Proceedings of the National Academy of Sciences of the United States of America*. **105**(26): 9099-9104. DOI: 10.1073/pnas.0803601105

Jabra-Rizk MA, Meiller TF, James CE, Shirtliff ME, 2006. Effect of Farnesol on *Staphylococcus aureus* Biofilm Formation and Antimicrobial Susceptibility. *Antimicrobial Agents and Chemotherapy*, **50**(4): 1463–1469. DOI: 10.1128/AAC.50.4.1463-1469.2006

Jayaprakasha GK, Jagan Mohan Rao L, Sakariah KK. 2003. Volatile constituents from *Cinnamomum zeylanicum* fruit stalks and their antioxidant activities. *J Agric Food Chem.*, **51**: 4344-4348. DOI: 10.1021/jf034169i

Jimoh TO, Buoro AT, Muriana M. 2012. Utilization of *Blighia sapida* (akee apple) pod in the removal of lead, cadmium and cobalt ions from aqueous solution. *Journal of Environmental Chemistry and Ecotoxicology*, **4**(10): 178-187. DOI: 10.5897/JECE12.015

John-Dewole OO, Popoola OO. 2013. Chemical, phytochemical and antimicrobial screening of extracts of *B. sapida* for agricultural and medicinal relevances. *Nature and Science*, **11**(10): 12.

Joo JH, Jetten AM. 2010. Molecular mechanisms involved in farnesol-induced apoptosis. *Cancer Letters*, **287**(2): 123-135. DOI: 10.1016/j.canlet.2009.05.015

Jürg G, Marco L, Stefan R, Ildiko R, Jian-Zhong C, Xiang-Qun X, Karl-Heinz A, Meliha K, Andreas Z. 2008. Beta-caryophyllene is a dietary cannabinoid. *Proceedings of the National Academy of Sciences of the United States of America* **105**(26): 9099-9104. DOI: 10.1073/pnas.0803601105

Moronkola DO and Ekundayo O. 2000. Chemical constituents in the fruit essential oil of *Terminalia catappa* Linn (Almond fruits). *Journal of Tropical Forest Resources*, **16**(1): 72-79.

Moronkola DO, Yeboah SO, Majinda RRT, Sichilongo K. 2015. Compositions of Harungana madagascariensis Lam. ex Poiret leaf and stem essential oils. *Journal of Chemical and Pharmaceutical Research*, **7**(5): 959-964.

Oladiji AT, Shoremekun KL, Yakubu MT. 2009. Physicochemical properties of the oil from the fruit of *Blighia sapida* and toxicological evaluation of the oil-based diet in wistar rats. *Journal of Medicinal Food*, **12**: 5. DOI: https://dx.doi.org/10.1089/jmf.2008.0219

Onuekwusi EC, Akanya HO, Evans EC. 2014. Phytochemical constituents of seeds of ripe and unripe *Blighia Sapida* (K. Koenig) and physicochemical properties of the seed oil. *International Journal of Pharmaceutical Science Invention*, **3**(9): 31-40.

Orav A, Stulova I, Kailas T, Müürisepp M. 2004. Effect of storage on the essential oil composition of *Piper nigrum L.* fruits of different ripening states. *J Agric Food Chem.*, **52**: 2582-2586. DOI: 10.1021/jf030635s

Ouattara H, Niamké B, Dally T, Kati-Coulibaly S. 2010. Nutritional composition studies of Sun dried *Blighia sapida* (k. koenig) aril from Côte d'Ivoire. *Journal of Applied Biosciences*, **32**: 1989-1994.

Sell CS. 2007. Terpenoids in the Kirk-Othmer Encyclopedia of Chemical Technology (5th edition). New York: Wiley.

Sköld M, Karlberg AT, Matura M, Börje A. 2006. The fragrance chemical beta-caryophyllene- air oxidation and skin sensitization. *Food Chem Toxicol*, **44**: 538-545. DOI: https://dx.doi.org/10.1016/j.fct.2005.08.028