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Constituents of *Cajanus cajan* (L.) Millsp., *Moringa oleifera* Lam., *Heliotropium indicum* L. and *Bidens pilosa* L. from Nigeria

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The essential oils of four plant species from Nigeria have been extracted by hydrodistillation and analyzed by GC and GC-MS. The oils of *Cajanus cajan* were comprised of sesquiterpenes (92.5%, 81.2% and 94.3% respectively in the leaves, stem and seeds). The major compounds identified were α-himachalene (9.0-11.5%), β-himachalene (8.0-11.0%), γ-himachalene (6.9-8.1%), α-humulene (7.1-8.7%) and α-copaene (4.5-5.6%). However, monoterpenoid compounds (81.8%) dominated the oil of *Moringa oleifera* with an abundance of α-phellandrene (25.2%) and *p*-cymene (24.9%). On the other hand, aldehydes (52.8%) occurred in the highest amount in *Heliotropium indicum,* represented by phenylacetaldehyde (22.2%), (*E*)-2-nonenal (8.3%) and (*E*, *Z*)-2-nonadienal (6.1%), with a significant quantity of hexahydrofarnesylacetone (8.4%). The leaf and stem oils of *Bidens pilosa* were dominated by sesquiterpenes (82.3% and 59.3%, respectively). The main compounds in the leaf oil were caryophyllene oxide (37.0%), β-caryophyllene (10.5%) and humulene oxide (6.0%), while the stem oils had an abundance of hexahydrofarnesyl acetone (13.4%), δ-cadinene (12.0%) and caryophyllene oxide (11.0%). The observed chemical patterns differ considerably from previous investigations.

Keywords: *Cajanus cajan*, *Moringa oleifera*, *Heliotropium indicum*, *Bidens pilosa*, himachalene, α-phellandrene, *ρ*-cymene, phenyacetaldehyde, caryophyllene oxide, β-caryophyllene, hexahydrofarnesyl acetone, δ-cadinene.

We have embarked on the systematic characterization of the constituents of Nigerian medicinal plants and herbs as they are made available. In this paper we report on the constituents identified from the essential oils of *Cajanus cajan*, *Moringa oleifera, Heliotropium indicum*, and *Bidens pilosa*, which is part of our extensive research program aimed at the identification of constituents of Nigerian medicinal plants and herbs [1]. Literature information is scanty on the oil compositions of these studied plants.

Pigeon pea, *C. cajan* is one of the most important tropical legumes in the world. Extracts and compounds of the plant have shown potential as hypocholesterolemic [2a] and cytoprotective [2b,2c] agents. The plant is a good source of sterols [3a], stilbenes [3b] and flavonoids [3c-3e]. *M. oleifera*, a native of the sub-Himalayan regions of north west India, is a tree, which is now cultivated in many countries of Africa, Arabia, South East Asia, the Pacific and Caribbean Islands, and South America where it is being used as a traditional food plant. The plant is also used as a water purifier [4a] and as a feed supplements for livestock [4b]. There are reports of *M. oleifera* possessing hepatoprotective [4c], antioxidant [4d], anti-inflammatory [4e], antiulcer [4f], anti-tumor [4g], and hypotensive activities [4h]. The plant is a source of a hetero-polysaccharide [4i].

H. indicum is widespread in tropical areas of the world. It is commonly referred to as Ogbe Akuko (Hens head) in Nigeria and has been useful

Table 1: Percentages of constituents of *Cajanus cajan* essential oil.

Constituents	Leaves	Stem	Seeds	LRI
(*E*)-2-Hexenal	0.2	-	tr	854
Heptanal	tr	tr	tr	901
α-Pinene	tr	tr	tr	941
Benzaldehyde	0.2	tr	0.1	963
6-Methyl-5-hepten –2-one	tr	-	tr	985
3-Octanone	tr	-	tr	988
2-Pentyl furan	tr	-	tr	993
3-Octanol	tr	tr	tr	996
n-Decane	-	0.1	-	1000
Octanal	tr	tr	tr	1003
Limonene	tr	2.8	tr	1033
Linalool	tr	tr	tr	1099
n-Undecane	tr	tr	tr	1100
Nonanal	0.3	0.2	0.2	1104
Isophorone	tr	-	tr	1120
Citronellal	-	0.4	-	1155
Benzyl acetate	-	tr	-	1165
1-Nonanol	-	0.4	-	1173
Menthol	-	4.1	-	1175
Terpinen-4-ol	-	-	tr	1179
Methyl salicylate	-	0.2	tr	1192
Dodecane	tr	-	tr	1200
Safranal	tr	-	tr	1201
Decanal	0.1	0.2	tr	1206
2-Undecanone	tr	-	tr	1291
n-Tridecane	-	-	tr	1300
Undecanal	tr	tr	tr	1308
α-Longipinene	0.6	0.4	0.7	1351
Cyclosativene	0.7	0.6	0.8	1370
α-Copaene	4.6	4.5	5.6	1376
(E)-β-Damascenone	tr	-	tr	1380
β-Maaliene	tr	tr	-	1381
Geranyl acetate	-	tr	-	1383
β-Longipinene	0.1	-	-	1398
n-Tetradecane	-	0.2	-	1400
(Z)-Caryophyllene	0.1	-	0.2	1404
Longifolene	1.5	1.0	1.6	1406
α-Gurjunene	0.1	-	0.2	1409
Dodecanal	-	0.3	tr	1410
β-Caryophyllene	3.3	2.9	3.5	1419
β-Cedrene	0.6	tr	0.9	1420
β-Duprezianene	0.2	-	0.2	1423
β-Gurjunene	0.1	-	0.2	1432
trans–α-Bergamotene	1.0	0.9	1.2	1437
α-Guaiene	0.5	0.4	0.6	1439
Aromadendrene	tr	tr	tr	1440
α-Himachalene	10.9	9.0	11.5	1451
Khusimene [#]	0.1	-	-	1455
α-Humulene	8.6	7.1	8.7	1456
allo-Aromadendrene	0.6	0.6	0.6	1461
γ-Muurolene	1.6	1.7	1.7	1477
γ-Himachalene	7.6	6.9	8.1	1483
β-Selinene	3.5	3.6	3.7	1487
Bicyclosesquiphellandrene (= *trans*-muurola-4(14),5 diene	tr	0.1	tr	1493
α-Selinene	3.9	4.4	4.5	1495
β-Himachalene	9.6	8.0	11.0	1505
β-Bisabolene	0.1	0.2	0.1	1509
trans-γ-Cadinene	0.7	0.9	tr	1513
α-Dehydro-*ar*-himachalene	0.4	0.4	tr	1517
δ-Cadinene	3.2	3.5	3.4	1524
trans-Calamenene	1.1	1.1	-	1529
γ-Dehydro-*ar*-himachalene	1.2	1.2	1.1	1530
trans-Cadina-1(2),4-diene	0.3	TR	0.4	1532
10-*epi*-Cubebol	-	-	1.1	1533
α-Cadinene	tr	0.2	0.6	1538
α-Calacorene	0.6	0.7	0.6	1542
Germacrene B	-	0.1	tr	1558
trans-Nerolidol	3.5	2.1	3.2	1564
Ledol	0.1	tr	tr	1567
Caryophyllenyl alcohol	1.7	1.1	1.4	1567
Himachalene epoxide	0.2	0.1	0.1	1580
Caryophyllene oxide	0.2	0.4	0.2	1583
Globulol	0.6	-	0.5	1585
Viridiflorol	-	-	0.2	1590
Longiborneol (= juniperol)	4.4	3.4	3.6	1592
Humulene oxide II	0.7	0.8	0.5	1608
β-Himachalene oxide	0.9	1.0	0.7	1616
Bisabolol-11-ol	0.8	tr	0.7	1619
epi-10-γ-Eudesmol	-	-	0.2	1622
1-*epi*-Cubenol	1.3	1.7	1.1	1629
α-Acorenol	2.6	0.2	tr	1633
cis-Cadina-4-en-7-ol	-	1.7	2.1	1637
τ-Cadinol	0.7	0.5	0.6	1642
Cubenol	tr	0.7	tr	1643
τ-Muurolol	1.1	-	0.9	1644
α-Muurolol	0.8	0.7	0.7	1647
Himachalol	3.2	2.9	2.6	1654
α-Cadinol	tr	1.1	-	1656
Selin-11-en-4α-ol	1.2	tr	0.9	1658
Bulnesol	-	-	1.1	1667
β-Bisabolol	0.3	-	0.2	1672
Cadalene	0.3	tr	0.3	1677
α-Bisabolol	0.2	-	0.1	1685
epi-α-Bisabolol	0.2	tr	0.2	1688
Germacrone [#]	-	2.4	-	1694
Pentadecanal	-	tr	tr	1717
n-Octadecane	-	0.3	tr	1800
Hexahydrofarnesyl acetone	0.5	1.6	0.4	1843
ar-Himachalene-2-ol	0.1	tr	tr	1848
n-Docosane	0.2	0.2	tr	2200
Total	**94.0**	**92.2**	**95.5**	

LRI –Linear retention indices on HP-5 capillary column; tr traces <0.1%; [#] tentative assignment; - not detected

traditionally in the treatment of cough, asthma, wounds and as a diuretic [5a]. The plant is a source of alkaloids [5b-5d]. *B. pilosa*, a pantropical plant growing to about 30-100 cm high, is used in folk medicine for its anti-inflammatory, liver-protective and hypoglycemic properties [6a]. Phenylpropanoid glucosides, polyacetylenes, diterpenes and flavonoids that are of biological importance have been identified from this species [6b].

A total of 100 compounds were identified from the studied oils of *C. cajan,* 59 of which are common to all of them. These compounds represent 94.0%, 92.2% and 95.5% of the oils from the leaves, stem bark and seeds, respectively. The oils were obtained in yields of 0.1% v/w on a dry weight basis. Table 1 gives the percentage of each constituent, while Table 2 represents the classes of compounds making up the oils. Apart from the ubiquitous terpenoids, aldehydes, ketones, alcohols and esters were also present. The sesquiterpene hydrocarbons were dominant in all the oil samples. The major compounds in this class were α-himachalene (9.0-11.5%), β-himachalene (8.0-11.0%), γ-himachalene (6.9-8.1%), α-humulene (7.1-8.7%) and α-copaene (4.5-5.6%). The oxygenated counterpart had *trans*-nerolidol (2.1-3.5%), longiborneol (3.4-4.4%) and himachalol (2.6-3.2%) in significant amounts. In addition, some compounds, such as himachalene oxide, ar-himachalene-2-ol, β-and himachalene oxide, that are biosynthetically

Table 2: Classes of compounds in *Cajanus cajan* essential oil.

Chemical classes	Leaves		Stem		Seeds	
	n	%	n	%	n	%
Monoterpene hydrocarbons	2	tr	2	2.8	2	tr
Oxygenated monoterpenes	3	tr	5	4.7	6	tr
Total monoterpenes	5	-	7	7.5	8	-
Sesquiterpene hydrocarbons	36	67.7	30	60.4	33	71.4
Oxygenated sesquiterpenes	23	24.8	21	20.8	26	22.9
Total sesquiterpenes	59	92.5	51	81.2	59	94.3
Aliphatic aldehydes	6	0.6	7	0.7	8	0.2
Aromatic aldehydes	2	0.2	1	tr	2	0.1
Aliphatic ketones	4	0.5	1	1.6	4	0.4
Aliphatic alcohols	1	tr	1	0.4	1	tr
Non-terpene hydrocarbons	3	0.2	2	0.8	5	0.5
Aromatic esters	-	-	1	tr	-	-
Total		**94.0**		**92.2**		**95.5**

Not identified; tr traces < 0.1%; n number present

related to himachalene could also be observed. It is worthy of mention that these three himachalene derivatives have also been identified as dominant constituents of *Cedrus atlantica* oil [7a]. Himachalene and its derivatives have shown antimicrobial [7b], insecticidal [7c] and pheromone properties [7d]. There is scanty report in the literature on the composition of the oils of *C. cajan*. Zhiging *et al*. [8a] reported the abundance of sesquiterpene hydrocarbons, such as acoradiene, β-selinene, β-guaiene, α-guaiene, α-himachalene, eremophilene and the aromatic ester benzyl benzoate in the sample earlier analyzed from China. In another study of an Indian sample, the sesquiterpenes α-, β- and γ-selinene and α-copaene occurred in high percentages, along with a mixture of eudesmols [8b]. Comparing the present study with previous ones, acoradiene and eremophilene, described earlier, are conspicuously absent in our oil sample and the content of selinenes is not significant.

Sixty-three constituents, representing 92.1% of the total, were identified in *M. oleifera* oil (Table 3). The oil (yield 0.3%,v/w, based on dry weight) was highly dominated by monoterpenoid compounds (81.8%; 72.4% of hydrocarbons and 9.4% of oxygenated derivatives), while the sesquiterpenoid counterparts were less common (10.3%). The major constituents were α-phellandrene (25.2%) and *p*-cymene (24.9%). There were significant quantities of α-pinene (6.7%), myrcene (4.8%), limonene (4.1%) and linalool (3.7%), while δ-cadinene (3.6%) and *trans*-γ-cadinene (1.5%) were the only sesquiterpenes observed above 1% of the total. A previous report [9] on the seed oil of *M. oleifera* led to the characterization of a number of sterols such as

Table 3: Percentages of constituents of *Moringa oleifera* essential oil.

Constituents	%	LRI
α-Thujene	2.2	932
α-Pinene	6.7	941
Camphene	tr	955
Sabinene	0.1	978
β-Pinene	0.5	982
6-Methyl-5-hepten-2-one	tr	987
Myrcene	4.8	991
2,3-Dehydro-1,8-cineole	tr	993
δ-2-Carene	1.3	1001
α-Phellandrene	25.2	1007
α-Terpinene	0.3	1020
p-Cymene	24.9	1028
Limonene	4.1	1033
β-Phellandrene	1.1	1035
(*Z*)-Ocimene	0.5	1040
(*E*)-Ocimene	0.2	1950
γ-Terpinene	0.3	1063
Terpinolene	0.2	1088
Linalool	3.7	1100
β-Thujone	tr	1116
cis-*p*-Menth-2-en-1-ol	0.4	1123
Borneol	0.4	1167
Terpinen-4-ol	0.2	1179
p-Cymen-8-ol	0.3	1185
α-Terpineol	1.0	1191
trans-Piperitol	0.3	1207
Methyl carvacrol	tr	1244
Carvotanacetone	0.8	1247
Piperitone	0.1	1254
Thymol	0.1	1291
Carvacrol	1.9	1299
cis-2,3-Pinanediol	0.2	1320
α-Cubebene	0.6	1351
Eugenol	tr	1356
cis-Carvyl acetate	tr	1362
α-Copaene	0.5	1376
β-Cubebene	0.1	1390
β-Elemene	0.2	1391
β-Caryophyllene	0.4	1419
trans-α-Bergamotene	tr	1439
cis-Muurola-3,5-diene	0.1	1446
α-Humulene	0.3	1456
(*E*)-β-Farnesene	0.1	1458
cis-Muurola-4(14),5-diene	0.2	1462
γ-Muurolene	0.4	1477
Germacrene D	tr	1481
β-Selinene	tr	1487
Valencene	0.1	1492
trans-Muurola-4(14),5-diene	0.2	1493
Viridiflorene	0.7	1495
trans-γ-Cadinene	1.8	1513
δ-Cadinene	3.6	1524
Cadina-1,4-diene	0.1	1533
α-Cadinene	0.2	1538
α-Calacorene	tr	1542
Spathulenol	0.1	1577
Caryophyllene oxide	tr	1583
Humulene epoxide II	tr	1608
1,10-Di-*epi*-cubenol	tr	1616
1-*epi*-Cubenol	tr	1629
τ-Cadinol	0.3	1642
α-Muurolol	0.1	1647
α-Cadinol	0.2	1655
Total	**92.1**	

LRI –Linear retention indices on HP-5 capillary column; tr traces <0.1%

β-sitosterol, stigmasterol and campesterol, in addition to α-, γ- and δ-tocopherols. The only report on the essential oil constituents recorded the hydrocarbons pentacosane (17.4%) and hexacosane (11.2%) [10].

Table 4: Percentage of compounds identified from *Heliotropium indicum*.

Constituents	%	LRI
(E)-2-Hexenal	3.4	854
Heptanal	3.8	901
Benzaldehyde	2.8	963
6-Methyl-5-hepten-2-one	1.0	987
Mesitylene	2.3	996
Pseudocumene	0.6	1027
Phenylacetaldehyde	22.2	1045
cis-Linalool oxide (furanoid)	0.9	1075
Linalool	1.6	1100
Nonanal	2.2	1104
Isophorone	0.5	1120
(E,Z)-2,6-Nonadienal	6.1	1158
(E)-2-Nonenal	8.3	1165
Borneol	0.7	1167
Naphthalene	0.4	1192
Methyl salicylate	1.2	1192
Safranal	0.4	1201
Decanal	0.9	1206
γ-Terpinen-7-al	0.8	1291
Eugenol	2.4	1356
(E)-β-Damascenone	0.7	1380
Tetradecane	tr	1399
Dodecanal	0.6	1409
(E)-Geranyl acetone	1.4	1453
cis-Muurola-4(14),5-diene	tr	1462
(E)-β-Ionone	1.9	1485
Bicyclogermacrene	tr	1495
Pentadecane	tr	1500
trans-Cadina 1(2),4-diene	tr	1535
Hexadecane	tr	1600
Apiole	0.8	1680
Heptadecane	0.4	1700
Pentadecanal	2.5	1717
Octadecane	0.9	1800
Hexahydrofarnesylacetone	8.4	1843
Nonadecane	tr	1900
Eicosane	0.9	2000
Docosane	0.8	2200
Tricosane	0.7	2300
Pentacosane	1.3	2500
Total	**83.8%**	

LRI –Linear retention indices on HP-5 capillary column; tr traces <0.1%.

In this report, terpenoid compounds were less common while the aromatic compounds were more pronounced in quantity. Neither pentacosane nor hexacosane could be detected in our oil sample. In addition, ours lacked both the aromatic and hydrocarbon compounds, but consisted exclusively of terpenoid compounds, in contrast with the previous study. There seems to be no correlation between any of the constituents in this study and the previous ones.

Table 4 reports 40 constituents of *H. indicum* oil, which represent 83.8% of the total. The yield was 0.5%, v/w, on a dry weight basis. The oil had an abundance of aldehyde compounds (52.8%), while the terpenoids formed 21.5%. The main constituents were phenylacetaldehyde (22.2%), (*E*)-2-nonenal (8.3%), hexahydrofarnesylacetone (8.4%) and (*E*, *Z*)-2-nonadienal (6.1%). Except for the presence of linalool, borneol and tricosane, the present oil sample differed greatly from the literature report [11]. Phytol and 1-dodecanol, which constituted the bulk of the

Table 5: Percentages of constituents of *Bidens pilosa* essential oils.

Constituents	Leaves	Stem	LRI
6-Methyl-5-hepten-2-one	tr	0.3	987
Mesitylene	0.8	-	996
n-Decane	tr	-	1000
Pseudocumene	-	0.9	1027
Phenyl acetaldehyde	-	0.6	1045
Linalool	tr	0.8	1100
Nonanal	0.8	-	1104
Isophorone	0.3	1.8	1120
trans-Pinocarveol	-	0.3	1141
cis-Verbenol	-	1.0	1199
n-Dodecane	tr	2.1	1200
Decanal	-	0.3	1206
Tridecane	tr	0.7	1300
Cyclosativene	tr	0.3	1370
α-Copaene	tr	1.7	1376
Daucene	tr	-	1380
β-Cubebene	-	0.2	1390
β-Elemene	1.2	0.6	1391
n-Tetradecane	-	0.5	1400
α-Gurjunene	0.6	-	1409
β-Caryophyllene	10.5	3.0	1419
β-Cedrene	-	0.3	1421
trans-α-Bergamotene	0.3	-	1439
(E)-Geranyl acetone	tr	-	1453
α-Humulene	3.2	0.8	1456
(E)−β-Farnesene	tr	-	1458
allo-Aromadendrene	-	0.8	1461
γ-Muurolene	-	0.9	1477
Germacrene D	5.5	1.8	1481
β-Selinene	tr	-	1487
Valencene	-	0.3	1492
Bicyclogermacrene	0.3	-	1495
n-Pentadecane	-	1.6	1500
Germacrene A	2.0	0.5	1505
δ-Cadinene	tr	12.0	1524
α-Calacorene	tr	-	1542
epi-Longipinanol	2.3	-	1561
trans-Nerolidol	0.8	0.5	1564
Spathulenol	1.4	1.2	1577
Caryophyllene oxide	37.0	11.0	1583
n-Hexadecane	-	0.4	1600
β-Atlantol	2.6	-	1608
Humulene oxide II	6.0	1.6	1610
epi-10-γ-Eudesmol	-	0.7	1621
1-*epi*-Cubenol	0.4	-	1629
Epoxyalloaromadendrene	-	0.5	1636
Caryophylla-4(14),8(15)-dien-5-ol	0.5	-	1640
τ-Cadinol	0.5	-	1642
Cedr-8(15)-en-9α-ol	0.2	-	1644
Selina-3,11-dien-6α-ol	1.7	-	1652
α-Cadinol	1.2	-	1655
cis-Calamenen-10-ol	-	2.9	1661
Intermedeol <neo>	-	0.4	1667
trans-Calamenen-10-ol	0.6	1.6	1669
β-Bisabolol	-	1..3	1672
Acorenone B	0.4	-	1685
Muurol-5-en-4-one < cis-14-nor >	1.4	0.7	1689
1-Heptadecene	-	0.3	1692
n-Heptadecane	-	2.5	1700
Pentadecanal	2.9	1.1	1717
14-Oxy-α-muurolene	0.3	-	1764
1-Octadecene	-	0.2	1792
n-Octadecane	tr	-	1800
14-Hydroxy-δ–cadinene	tr	-	1804
Hexadecanal	tr	0.3	1819
Hexahydrofarnesylacetone	1.4	13.4	1843
Methyl hexadecanoate	0.2	-	1927
Phytol	tr	1.3	1943
Sandaracopimara-8(14),15- diene	-	0.3	1969
1-Eicosene	tr	0.3	1988
Methyl linoleate	tr	-	2096
n-Heneicosane	-	0.3	2100
n-Docosane	-	0.1	2200
n-Tricosane	-	0.1	2300
Total	**87.3**	**77.1**	

LRI –Linear retention indices on HP-5 capillary column; tr traces <0.1%; - not detected

Table 6: Classes of compounds identified in the oils of *Moringa oleifera*, *Heeliotropium indicum* and *Bidens pilosa*.

Chemical classes	*M. oleifera*	*H. indicum*	*B. pilosa* Leaves	Stem
Monoterpene hydrocarbons	72.5	0.6	0.3	2.7
Oxygenated monoterpenes	9.3	12.5	tr	1.3
Total monoterpenes	81.8	13.1	0.3	4.0
Sesquiterpene hydrocarbons	9.6	8.4	23.6	23.5
oxygenated sesquiterpenes	0.7	-	58.7	35.8
Total sesquiterpenes	10.3	8.4	82.3	59.3
Aldehydes	-	52.8	3.7	2.3
Aromatic	-	2.7	0.8	-
Ketones	tr	1.0	tr	-
Non-terpene hydrocarbons	-	5.0	0.2	9.5
Others		0.8		1.3

tr traces <0.1%; - not detected

sample previously recorded, were conspicuously absent in our oil sample. The oil sample displayed considerable antituberculosis activity.

The chemical profile of each of the 49 constituents of the leaf and stem oils of *B. pilosa* revealed the abundance of sesquiterpene compounds (Table 5). The oils were obtained in yields of 0.2 and 0.1% v/w, respectively. The quantitatively significant constituents of the leaf oil were caryophyllene oxide (37.0%), β-caryophyllene (10.5%), humulene oxide (6.0%) and germacrene D (5.5%). Hexahydrofarnesyl acetone (13.4%), δ-cadinene (12.0%) and caryophyllene oxide (11.0%) were the main compounds in the stem oil. The authors have encountered only three literature reports on the oil constituents of this plant. The leaf and flower oils of Japanese origin [12] consisted mainly of β-caryophyllene (5.1-10.5%) and τ-cadinene (6.13-7.8%). Five sesquiterpenes namely *E*-caryophyllene, germacrene D, α-humulene, bicyclogermacrene and α-muurolene were present in high amounts in the sample, as well as in those of Brazilian *B. subalternans* and *B. alba* [13]. The polyacetylene phenylhepta-1,3,5-triyne dominated the oil of *B. alba* from Brazil [13], as well as the studied species from Cameroon [14]. Phenylhepta-1, 3,5-triyne, α-muurolene and τ-cadinene were not identified in the present oil.

Experimental

Plant materials: The whole plant of *Cajanus cajan* (L.) Millsp., was collected at a location within Ibadan Metropolis, Nigeria between February and April, 2007. The sample was separated into leaves, stems, and seeds by hand. The mature leaves of *Moringa oleifera* Lam., were harvested in May 2007 from the Campus of the University of Ibadan, Nigeria. In addition, the leaves of *Heliotropium indicum* Linn. and the aerial parts of *Bidens pilosa* Linn. were collected from individual mature plants growing at Iwo, 50 km east of Ibadan, Nigeria, in June 2007. The plants were authenticated by the Curators at the Herbarium Headquarters, FRIN, Ibadan, where voucher specimens were deposited for future reference.

Extraction of oils: Volatile oils were obtained from about 250-300 g aliquots of the air-dried and pulverized plant samples by hydrodistillation in an all glass Clevenger-type apparatus. The oils collected over water were dried over anhydrous sodium sulfate and preserved under refrigeration until analysis.

Chemical analysis: The experimental conditions and instruments used for GC and GC-EIMS analysis were reported in our earlier publication [1].

Compound identification: Identification of the constituents was based on comparison of the retention times with those of authentic samples, and by comparison of their linear indices with a series of *n*-alkanes. Further identification was made possible by use of a mass spectral homemade library built up from pure substances and components of known oils, and from MS literature data [15a-15c]. The comparative analysis of the classes of compounds identified from the oil samples are given in Tables 1-6. The molecular weights of all the identified substances were confirmed by GC-CIMS using MeOH as CI ionizing gas.

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