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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.

| (E)-2-lexenal 0.2 - tr 853 Ochman tr tr tr tr tr 901 o-Pinene tr tr tr tr 901 6-Methyl-5-hepten -2-one tr - tr 985 3-Octanon tr - tr 993 3-Octanol tr tr tr 17 993 3-Octanol tr tr tr 1000 0 Octanal tr tr tr 1000 0 Octanal tr tr tr 1100 100 Nonanal 0.3 0.2 0.2 1104 Isophorne tr tr tr 1175 Terpinen-4-ol - tr 1175 Terpinen-4-ol - tr 1200 Safranal tr - tr 1201 Ar-Tridecane - - tr 1308 | Constituents | Leaves | Stem | Seeds | LRI |
|---|---|------------|------------|-----------|------|
| Heptanaltrtrtrtr941Benzaldehyde0.2tr0.19636-Methyl-5-hepten -2-onetr-tr9853-Octanonetr-tr9853-Octanonetr-tr9853-Octanoltrtrtrtr2-Pentyl furantr-tr996 n -Decane-0.1-1000Octanaltrtrtrtrtimonenetr2.8tr1003Linalooltrtrtrtrn-UndecanetrtrtrtrNullsophoronetr-trCitronellal-0.4-1173Menthol-4.1-1173Methyl salicylate-0.2tr1201Deceanal0.10.2tr1201Deceanal0.10.2tr1201Deceanal0.10.2tr1201Deceanal0.10.2tr1300Undecanonetr-tr1380G-Longipinene0.60.4-1381Geranyl acetate-tr1381Geranyl acetate-tr1383G-Longipinene0.1-1381Geranyl acetate-tr1383G-J-Pamascenonetr-1404Logifolene0.1-1381 <tr< td=""><td>(<i>E</i>)-2-Hexenal</td><td>0.2</td><td>-</td><td>tr</td><td>854</td></tr<> | (<i>E</i>)-2-Hexenal | 0.2 | - | tr | 854 |
| Derine u u u u v Fill Benzaldehyde 0.2 tr 0.1 963 6-Methyl-5-hepten-2-one tr - tr 983 2-Pentyl furan tr - tr 993 3-Octanol tr tr tr 17 988 2-Pentyl furan tr tr tr 1893 3-Octanol tr tr 17 993 3-Octanol tr tr tr tr 1000 0 0 1033 1103 1033 11033 11033 11033 1104 1033 11033 1104 1033 11033 1104 1103 11033 1104 1155 1105 1165 1105 1165 1105 | Heptanal | tr | tr tr | tr | 901 |
| 6.4. ethyl-3-Repten -2-one tr - tr 7 3-Octanone tr - tr 985 3-Octanol tr - tr 993 3-Octanol tr tr tr 17 993 3-Octanol tr tr tr 1000 Octanal tr tr tr 1000 Octanal tr tr tr 1009 n-Undecane tr tr tr 1009 Nonanal 0.3 0.2 102 1104 Isophorone tr tr tr 11120 Citronellal - 0.4 - 1173 Menhol - 4.1 - 1173 Menhol - 4.1 1200 Safranal tr - tr 1120 Safranal tr - tr 1308 a-Longipinene 0.6 0.4 0.7 1351 Cyclosativene 0.6 0.4 0.7 1351 Sciatiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiii | Renzaldehyde | 02 | u tr | 0.1 | 963 |
| 3-Octanone tr - tr 983 2-Pentyl furan tr - tr 993 3-Octanol tr tr tr tr 993 3-Octanol tr tr tr tr 996 n-Decane - 0.1 - 1000 Detanal tr tr tr tr 1100 Nonanal 0.3 0.2 0.2 1104 Isophorone tr - tr 1100 Nonanal 0.3 0.2 0.2 1104 Isophorone tr - tr 1173 Menthol - 0.4 - 1173 Menthol - 4.1 - 1173 Methyl salicylate - 0.2 tr 1201 Decanal 0.1 0.2 tr 1206 2-Undecanone tr - tr 1300 Undecanal tr | 6-Methyl-5-hepten –2-one | tr | - | tr | 985 |
| 2-Pentyl furan tr tr tr tr 996 n -Decane - 0.1 - 1000 Octanal tr tr tr tr 1000 Octanal tr tr tr 1000 0 Linalool tr tr tr 1000 Nonanal 0.3 0.2 0.2 1104 Isophorone tr tr tr 1100 Nonanal 0.3 0.2 0.2 1104 Isophorone tr - tr 1155 Benzyl acetate - tr - 1165 I-Nonanol - 0.4 - 1175 Methyl salicylate - 0.2 tr 1200 Safranal tr - tr 1130 Undecanae tr - tr 1300 Undecanal tr tr tr 1300 Undecanae tr tr tr 1300 Cyclosatroe 0.6 0.4 <td< td=""><td>3-Octanone</td><td>tr</td><td>-</td><td>tr</td><td>988</td></td<> | 3-Octanone | tr | - | tr | 988 |
| 3-Octanol tr tr tr tr 996 n-Decane - 0.1 - 1000 Octanal tr tr tr tr 1003 Limonone tr 2.8 tr 1033 Limonone tr 2.8 tr 1033 Decame tr tr tr tr tr 1100 Nonanal 0.3 0.2 0.2 1104 Isophorone tr - tr 1120 Citronellal - 0.4 - 1155 Denzyl acetate - tr - 1165 I-Nonanol - 0.4 - 1175 Terpinen-4-01 - tr 1179 Methyl salicylate - 0.2 tr 1192 Dodecane tr - tr 1200 Safranal tr - tr 1200 Safranal tr - tr 1200 Safranal tr - tr 1200 Undecane tr - tr 1308 α -Longipiene 0.6 0.4 0.7 1351 Cyclosativene 0.7 0.6 0.8 1370 α -Copaene tr - tr 1380 β -Maaliene tr tr - tr 1380 β -Maaliene tr tr - tr 1380 β -Maaliene 0.1 - 0.2 ta 138 Geranyl acetate - tr - 1383 β -Longipinene 0.1 - 1381 β -Maaliene tr tr - tr 1380 β -Maaliene 0.1 - 0.2 1404 Longifolene 0.1 - 0.2 1404 Longifolene 0.1 - 0.2 1404 Longifolene 0.1 - 0.2 1404 Longifolene 0.1 - 0.2 1404 β -Caryophyllene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1404 β -Caryophyllene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1404 β -Caryophyllene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1404 β -Caryophyllene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1404 β -Caryophyllene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1404 β -Caryophyllene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1404 β -Caryophyllene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1403 β -Garjunene 0.1 - 0.2 1403 β -Garjunene 0.1 - 0.2 1437 α -Guaiene 0.5 0.4 0.6 1439 A-romadendrene 1.0 0.9 1.2 1437 α -Guaiene 0.5 0.4 0.6 1439 A-romadendrene 0.6 0.6 0.6 1461 γ -Muurolene 1.6 1.7 1.7 1477 γ -Himachalene β .6 3.7 1487 β -Selinene 3.5 3.6 3.7 1487 β -Selinene 3.5 3.6 3.7 1487 β -Selinene 3.9 4.4 4.5 1495 β -Himachalene β .6 8.0 11.0 1505 β -Bistabolene 0.1 - 0.2 1432 α -Calanenene 1.1 1.1 - 1533 α -Calanenene 1.1 1.1 - 1539 α -Calanenene 1.1 1.1 - 1539 α -Calanenene 1.2 1.2 1.1 1530 α -Calanenene 1.2 1.2 1.545 α -Hunul | 2-Pentyl furan | tr | - | tr | 993 |
| n-Decane - 0.1 - 1003 Linnonene tr tr tr tr tr tr tr 1003 Linalool tr tr tr tr tr tr 1003 Nonanal 0.3 0.2 0.2 1104 Sophorone tr tr tr tr 1120 Citronellal - 0.4 - 1173 Menthol - 4.1 - 1175 Terpinen-4-ol - - tr 1120 Odecane tr - tr 1201 Decanal 0.1 0.2 tr 1300 Undecanone tr - tr 1201 Decanal 0.1 0.2 tr 1300 Undecanal tr tr tr 1301 Q-Longipinene 0.6 0.4 0.7 1351 Q-closene 4.6 4.5 5.6 1376 Q'-Caryophyllene 0.1 - 1381 <tr< td=""><td>3-Octanol</td><td>tr</td><td>tr</td><td>tr</td><td>996</td></tr<> | 3-Octanol | tr | tr | tr | 996 |
| Octainal u u u u u u u 1003 Linalool tr tr tr tr tr tr 1033 Linalool tr tr tr tr tr 1033 Nonanal 0.3 0.2 0.2 1104 Isophorone tr - tr tr 1173 Menthol - 0.4 - 1173 Menthol - 4.1 - 1173 Methyl salicylate - 0.2 tr 1192 Dodecane tr - tr 1200 Safranal tr - tr 1212 Decanal 0.1 0.2 tr 1200 Safranal tr - tr 1301 $\alpha-Copane 4.6 4.5 5.6 1376 \alpha-Copane 4.6 4.5 5.6 1376 \alpha-Copane 1.6 $ | <i>n</i> -Decane | - tr | 0.1 tr | - tr | 1000 |
| Linalool tr tr tr tr tr tr 1099 n-Undecane tr tr tr tr tr 1100 Isophorone tr - tr 1120 Citronellal - 0.4 - 1155 Benzyl acetate - tr - 1165 1-Nonanol - 0.4 - 1173 Menthol - 4.1 - 1175 Terpinen-4-0l tr 1179 Methyl salicylate - 0.2 tr 1192 Dodecane tr - tr 1200 Safranal tr - tr 1200 Safranal tr - tr 1201 Decanal 0.1 0.2 tr 1206 2-Undecane tr - tr 1300 Undecane tr - tr 1381 Geranyl acetate - 15.5.6 1376 (E)- β -Damascenone tr - tr 1381 Geranyl acetate - 12. 1400 (Z)-Caryophyllene 0.1 - 0.2 1404 Dodecanal - 0.2 - 1400 G)-Caryophyllene 0.1 - 0.2 1409 Dodecane 0.1 - 0.2 1409 Dodecane 0.1 - 0.2 1409 Dodecane 0.1 - 0.2 1409 Dodecane 0.1 - 0.2 1409 Caryophyllene 3.3 2.9 3.5 1419 β -Cadrene 0.6 tr 0.9 1420 β -Duprezianene 0.1 - 0.2 1432 drams- α -Bergamotene tr tr tr tr 4400 α -Guriunene 0.1 - 0.2 1432 β -Guruene 0.1 - 12 1432 β -Guruene 0.1 - 12 1432 β -Guruene 0.1 - 12 1432 β -Guruene 0.1 - 1455 β -Burpezianene 0.1 - 1451 Khusimen ⁶ 0.1 - 150 β -Bisabolene 0.1 - 150 β -Bisabolene 0.1 - 150 β -Bisabolene 0.1 0.2 0.1 1503 α -Calanene 0.1 0.2 0.1 1505 β -Bisabolene | Limonene | u tr | 2.8 | u tr | 1003 |
| 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 - 1173 Menthol - 0.4 - 1173 Methyl salicylate - 0.2 tr 1192 Dodecane tr - tr 1201 Decanal 0.1 0.2 tr 1201 Decanal 0.1 0.2 tr 1201 Decanal 0.1 0.2 tr 1201 Decanal 0.1 r tr 1300 Undecane tr tr 1300 Undecane tr tr 1300 or-Copaene 4.6 4.5 5.6 1376 or-Copaene 4.6 4.5 5.6 1376 Q | Linalool | tr | tr | tr | 1099 |
| Nonanal 0.3 0.2 0.2 1104 Isophorone tr - tr 1120 Citronellal - 0.4 - 1155 Benzyl acetate - tr - 1173 Menthol - 4.1 - 1173 Methyl salicylate - 0.2 tr 1192 Dodecane tr - tr 11200 Safranal tr - tr 12200 Safranal tr - tr 1200 Culdecanone tr - tr 1201 A-Longipinene 0.6 0.4 0.7 1351 Cyclosativene 0.6 0.4 5.5 5.6 1376 Cyclosativene 0.1 - | <i>n</i> -Undecane | tr | tr | tr | 1100 |
| Isophorone tr - tr - tr 1120 Citronellal - 0.4 - 1155 Benzyl acetate - tr - 1165 I-Nonanol - 0.4 - 1173 Terpinen-4-ol - tr 1179 Methyl salicylate - 0.2 tr 1120 Safranal tr - tr 1201 Decanal 0.1 0.2 tr 1201 Decanal 0.1 0.2 tr 1201 Decanal 0.1 0.2 tr 1300 Undecanal tr tr tr 1300 Undecanal tr tr tr 1300 Qclosativene 0.6 0.4 0.7 1351 Cyclosativene 0.7 0.6 0.8 1370 α-Longipinene 0.1 - tr 1380 β-Longipinene 0.1 - | Nonanal | 0.3 | 0.2 | 0.2 | 1104 |
| Chronelial - 0.4 - 1153 Benzyl acetate - tr - 1165 I-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 1300 Undecanal tr tr - tr 1300 Undecanal tr tr - tr 1300 Undecanal tr tr tr tr 1308 α -Longipinene 0.6 0.4 0.7 1351 Cyclosativene 0.7 0.6 0.8 1370 α -Copaene tr - tr 1380 β -Maaliene tr tr - tr 3880 β -Maaliene tr tr - 1388 Geranyl acetate - tr - 1388 Geranyl acetate - tr - 1388 β -Longipinene 0.1 - 1998 α -Corgophyllene 0.1 - 1998 α -Caryophyllene 0.1 - 0.2 1404 Longifolene 0.1 - 0.2 1404 Longifolene 0.1 - 0.2 1404 Longifolene 0.1 - 0.2 1404 Longifolene 0.1 - 0.2 1404 Ac-Gurjunene 0.1 - 0.2 1404 Ac-Gurjunene 0.1 - 0.2 1404 Ac-Gurjunene 0.1 - 0.2 1404 β -Caryophyllene 0.1 - 0.2 1409 Dodecanal - 0.3 tr 1410 β -Caryophyllene 0.1 - 0.2 1409 Dodecanal - 0.3 tr 1410 β -Caryophyllene 0.1 - 0.2 1403 β -Gurjunene 0.1 - 0.2 1403 β -Gurjunene 0.1 - 0.2 1403 β -Gurjunene 0.1 - 0.2 1404 β -Caryophyllene 0.1 - 10.2 1409 Dodecanal - 0.3 tr 1410 β -Caryophyllene 0.1 - 0.2 1432 β -Gurjunene 0.5 0.4 0.6 1439 Aromadendrene tr tr tr 1440 α -Himachalene 10.9 9.0 11.5 1451 Khusimene β 0.1 - 1455 α -Humulene 8.6 7.1 8.7 1456 α -Humulene 1.6 1.7 1.7 1477 γ -Himachalene 9.6 8.0 11.0 1505 β -Himachalene 9.6 | Isophorone | tr | - | tr | 1120 |
| $\begin{aligned} & Prince large lar$ | Citronellal Benzyl acetate | - | 0.4 tr | - | 1155 |
| Menthol - 4.1 - 1175 Terpinen-4-ol - 0.2 tr 1192 Dodecane tr - tr 1179 Methyl salicylate - 0.2 tr 1192 Dodecane tr - tr 1201 Decanal 0.1 0.2 tr 1206 2-Undecanone tr - tr 1206 2-Undecanone tr - 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 tr 1381 Ø-tangipinene 0.1 - 1383 β -Dapracetate - tr 1383 β -Caryophyllene 0.1 - 0.2 1404 Longifolene 1.5 1.0 1.6 1406 | 1-Nonanol | - | 0.4 | - | 1173 |
| Terpinen-4-ol - - tr 1179 Methyl salicylate - 0.2 tr 1192 Dodecane tr - tr 1201 Safranal tr - tr 1201 Decanal 0.1 0.2 tr 1206 2-Undecanone tr - tr 1206 2-Undecanal tr tr tr 1300 Undecanal tr tr tr 1308 α -Longipinene 0.6 0.4 0.7 1351 Cyclosativene 0.7 0.6 0.8 1370 Cyclosativene 0.7 0.6 0.8 1370 Geranyl acetate - tr tr 1381 Geranyl acetate - tr - 1383 β -Dagipinene 0.1 - 0.2 1404 Longipolene 0.1 - 0.2 1404 Longipolene 0.3 tr 1410 β -Caryophyllene 3.3 2.9 3.5 | Menthol | - | 4.1 | - | 1175 |
| Methyl salicylate - 0.2 tr 1192 Dodecane tr - tr 1200 Safranal tr - tr 1200 Safranal 0.1 0.2 tr 1200 2-Undecanone tr - tr 1200 n-Tridecane - - tr 1300 Quecanal tr tr tr 1300 Quecanal tr tr tr 1301 Quecanal tr tr tr 1308 Quecanal tr tr tr 1308 Quecanal tr tr tr 1308 Quecanal tr tr tr 1381 Geranyl acetate - tr - 1388 B-Longipinene 0.1 - 0.2 1400 Q'-Caryophyllene 0.3 2.9 3.5 1410 B-Caryophyllene 3.3 2.9 3.5 1410 B-Cartene 0.6 tr 0.9 1.2 < | Terpinen-4-ol | - | - | tr | 1179 |
| Dodecane tr - tr 1200 Safranal tr - tr 1201 Decanal 0.1 0.2 tr 1206 2-Undecanone tr - tr 1201 n-Tridecane - - tr 1300 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-Longipinene 0.1 - 1381 Geranyl acetate - tr - 1383 Geranyl acetate - tr - 1398 n-Tetradecane - 0.2 - 1400 Longifolene 0.1 - 0.2 1409 Dodecanal - 0.3 tr 1410 β-Carpophyllene 3.3 2.9 3.5 1419 Geranyohyllene | Methyl salicylate | - | 0.2 | tr | 1192 |
| Sartani Decanal 0.1 0.2 tr 1206 2-Undecanone tr - tr 1291 n-Tridecane - tr 1300 Undecanal tr 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 - tr 1381 Geranyl acetate - tr - 1383 β -Longipinene 0.1 - 1388 β -Longipinene 0.1 - 1388 β -Longipinene 0.1 - 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 0.1 - 0.2 1409 Dodecanal - 0.3 tr 1410 β -Caryophyllene 0.1 - 0.2 1409 Aromadendrene 0.1 - 0.2 1409 Aromadendrene 0.1 - 0.2 1423 β -Duprezianene 0.2 - 0.2 1423 β -Duprezianene 0.5 0.4 0.6 1439 Aromadendrene 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 1.5 0.1 - 1455 α -Humulene 8.6 7.1 8.7 1456 $allo-Aromadendrene 0.6 0.6 0.6 0.6 1439Aromadendrene 0.6 0.6 0.6 1439Aromadendrene 0.7 0.9 11.5 1451Khusimene# 0.1 - 1455\alpha-Humulene 8.6 7.1 8.7 1456allo-Aromadendrene 0.6 0.6 0.6 0.6 1439Aromadendrene 0.6 0.6 0.6 1439Aromadendrene 0.6 0.6 0.6 0.6 1439Aromadendrene 0.6 0.6 0.6 1439Aromadendrene 0.6 0.6 0.6 0.6 1439Aromadendrene 0.6 0.6 0.6 0.6 1439Aromadendrene 0.6 0.6 0.6 0.6 1461\gamma-Murolene 1.6 1.7 1.7 1477\gamma-Himachalene 9.6 8.0 11.0 1505\beta-Bisabolene 0.1 0.2 0.1 1509trans-\gamma-Cadinene 0.1 0.2 0.1 1509trans-\gamma-Cadinene 0.1 1.1 1.529\gamma-Dehydro-a-himachalene 1.2 1.2 1.1 1530trans-Cadinaene 1.1 1.1 - 1529\gamma-Dehydro-a-himachalene 1.2 1.2 1.1 1530trans-Cadinene 0.6 0.7 0.6 1542Germacrene B - 0.1 tr 1558trans-Nerolidol 3.5 2.1 3.2 1564Ledol 0.1 tr tr 1567Caryophyllene oxide 0.2 0.4 0.2 1583$ | Dodecane | tr | - | tr | 1200 |
| Decimal0.10.2a1201 n -Tridecanonetrt-tr1300 n -Tridecane0.60.40.71351 Q -Longipinene0.60.40.71351 Q -Copaene4.64.55.61376 (E) -B-Damascenonetrtr-tr B -Maalienetrtr-1381 β -Longipinene0.11398 n -Tetradecane-0.2-1400 (Z) -Caryophyllene0.1-0.21404Longifolene1.51.01.61406 α -Gurjunene0.1-0.21409Dodecanal-0.3tr1410 β -Caryophyllene3.32.93.51419 β -Carlene0.6tr0.91420 β -Duprezianene0.2-0.21432 β -Gurjunene0.1-0.21432 α -Guaiene0.50.40.61439Aromadendrenetrtrtrtr α -Humulene8.67.18.71456 $allo$ -Aromadendrene0.60.60.61461 γ -Murolene1.61.71.71477 γ -Himachalene3.94.44.51493 α -Esclinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1450 α -Humulene8.6 <td< td=""><td>Decanal</td><td>0 1</td><td>02</td><td>u tr</td><td>1201</td></td<> | Decanal | 0 1 | 02 | u tr | 1201 |
| n -Tridecane - tr 1300 Undecanal tr tr tr tr tr 1308 α -Longipinene 0.6 0.4 0.7 1351 α -Copaene 4.6 4.5 5.6 1370 α -Copaene 4.6 4.5 5.6 1376 (E) -B-Damascenone tr - tr 1381 β -Maaliene tr tr - 1383 β -Longipinene 0.1 - 1398 n-Tetradecane - 0.2 - 1400 (Z)-Caryophyllene 0.1 - 0.2 1404 1406 α -Gurjunene 0.1 - 0.2 1404 α -Gurjunene 0.1 - 0.2 1409 Dodecanal - 0.3 tr 1410 β -Carpophyllene 3.3 2.9 3.5 1419 β -Catrene 0.6 tr 0.9 1.2 1420 β -Duprezianene 0.2 - 0.2 1423 α -Gurjunene 0.6 1.6 1.7 1.7 | 2-Undecanone | tr | | tr | 1200 |
| Undecanal tr tr 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 -Longipinene 0.1 - 1381 Geranyl acetate - tr - 1383 β -Longipinene 0.1 - 0.2 1400 (Z)-Caryophyllene 0.1 - 0.2 1404 Longifolene 1.5 1.0 1.6 1406 α -Guripunene 0.1 - 0.2 1409 Dodecanal - 0.3 tr 1410 β -Caryophyllene 3.3 2.9 3.5 1419 β -Catryophyllene 0.3 2.9 1.5 1432 α -Stanene 0.6 tr 0.9 1.2 1433 α -Guaiene 0.5 0.4 0.6 1439 | <i>n</i> -Tridecane | - | - | tr | 1300 |
| 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 (\mathcal{E})- \mathcal{P} -Damascenone tr - tr 1380 β -Maaliene tr - tr - 1381 Geranyl acetate - tr - 1381 β -Longipinene 0.1 - - 1398 n -Tetradecane - 0.2 - 1400 (Z)-Caryophyllene 0.1 - 0.2 1404 Longifolene 1.5 1.0 1.6 1409 Dodecanal - 0.3 tr 1410 β -Caryophyllene 3.3 2.9 3.5 1419 β -Cedrene 0.6 tr 0.9 1.2 1432 β -Gurjunene 0.1 - 0.2 1432 β -Gurjunene 0.5 0.4 0.6 1439 Aromadendrene 1.0 9 1.5 1451 | Undecanal | tr | tr | tr | 1308 |
| 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 - tr 1381 Geranyl acetate - tr - 1383 β -Longipinene 0.1 - 0.2 1400 (Z) -Caryophyllene 0.1 - 0.2 1404 Longifolene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1404 Dodecanal - 0.3 tr 1410 β -Cadrene 0.6 tr 0.9 1420 β -Duprezianene 0.2 - 0.2 1423 β -Gurjunene 0.1 - 0.2 1432 α -Guaiene 0.5 0.4 0.6 1439 α -Humulene 8.6 7.1 8.7 1456 α -Humulene 8.6 7.1 8.7 1456 α -Humulene | α-Longipinene | 0.6 | 0.4 | 0.7 | 1351 |
| $C-Copaene$ 4.0 4.5 5.0 1376 (E) - β -Damascenone tr - tr 1380 β -Maaliene tr tr - tr 1381 Geranyl acetate - tr - 1383 β -Longipinene 0.1 - 0.2 1400 (Z) -Caryophyllene 0.1 - 0.2 1404 Longifolene 1.5 1.0 1.6 1406 α -Gurjunene 0.1 - 0.2 1404 Dodecanal - 0.3 tr 1410 β -Carrene 0.6 tr 0.9 1420 β -Duprezianene 0.2 - 0.2 1422 β -Gurjunene 0.1 - 0.2 1432 α -Guaiene 0.5 0.4 0.6 1439 α -Himachalene 10.9 9.0 11.5 1451 Khusimene [#] 0.1 - - 1455 α -Humulene 8.6 7.1 8.7 1456 α -Humulene | Cyclosativene | 0.7 | 0.6 | 0.8 | 1370 |
| (L) -p-Diffractioneu1u11380 β -Maalienetrtrtr-1381 β -Longipinene0.1-tr1383 β -Longipinene0.1-0.21400 (Z) -Caryophyllene0.1-0.21404Longifolene1.51.01.61406 α -Gurjuene0.1-0.21409Dodecanal-0.3tr1410 β -Caryophyllene3.32.93.51419 β -Caryophyllene0.6tr0.91420 β -Duprezianene0.2-0.21423 β -Gurjunene0.1-0.21432trans- α -Bergamotene1.00.91.21437 α -Guaiene0.50.40.61439Aromadendrenetrtrtrtr α -Himachalene10.99.011.51451Khusimene*0.11455 α -Humulene8.67.18.71456allo-Aromadendrene1.61.71.71477 γ -Himachalene7.66.98.11483 β -Selinene3.94.44.51495 β -Bisabolene0.10.20.11505 β -Bisabolene0.70.9tr1513 α -Dehydro- α -himachalene1.11.1- β -Dihydro- α -himachalene1.21.21.1 γ -Dehydro | α -Copaene | 4.6 | 4.5 | 5.0 tr | 13/0 |
| p-Matricleaaab1383β-Longipinene0.11383β-Longipinene0.1-0.21400(Z)-Caryophyllene0.1-0.21404Longifolene1.51.01.61406α-Gurjunene0.1-0.21404Dodecanal-0.3tr1410β-Caryophyllene3.32.93.51419β-Cedrene0.6tr0.91420β-Duprezianene0.2-0.21423β-Gurjunene0.1-0.21433 <i>trans-α</i> -Bergamotene1.00.91.21437α-Guaiene0.50.40.61439Aromadendrenetrtrtr1440α-Humulene8.67.18.71455α-Humulene8.67.18.71455α-Humulene1.61.71.71477γ-Himachalene7.66.98.11483β-Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493 <i>trans-</i> Q-Cadinene0.10.20.11505β-Bisabolene0.10.20.11509 <i>trans-</i> Q-Cadinene3.94.44.51493 <i>trans-</i> Calamenene1.11.1-1529γ-Dehydro- <i>ar</i> -himachalene0.3TR0.4153210- <i>epi</i> -Cubebol- | (E)-p-Damascenone | u tr | - tr | u - | 1381 |
| β-Longipinene0.11398n-Tetradecane-0.2-1400(Z)-Caryophyllene0.1-0.21404Longifolene1.51.01.61406 α -Gurjunene0.1-0.21409Dodecanal-0.3tr1410β-Caryophyllene3.32.93.51419β-Cedrene0.6tr0.91420β-Duprezianene0.2-0.21423β-Gurjunene0.1-0.21432trans-α-Bergamotene1.00.91.21437α-Guaiene0.50.40.61439Aromadendrenetrtrtr1440α-Humulene8.67.18.71456allo-Aromadendrene1.61.71.71477γ-Humulene3.53.63.71483β-Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-muurola-4(14),5 diene1513α-Dehydro-ar-himachalene9.68.011.01505β-Bisabolene0.10.20.11509trans-Calimene3.23.53.41524trans-Calimene1.11.1-1529trans-Calimene1.21.21.11530trans-Calimene0.3TR0.4153210-epi-Cubebol< | Geranyl acetate | - u | tr | _ | 1383 |
| <i>n</i> -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 -Carene 0.6 tr 0.9 1420 β -Duprezianene 0.2 - 0.2 1423 β -Gurjunene 0.1 - 0.2 1432 <i>trans</i> - α -Bergamotene 1.0 0.9 1.2 1437 α -Guaiene 0.5 0.4 0.6 1439 Aromadendrene tr tr tr tr α -Humulene 8.6 7.1 8.7 1456 <i>allo</i> -Aromadendrene 0.6 0.6 0.6 1483 β -Selinene 3.5 3.6 3.7 1487 Bicyclosesquiphellandrene (= tr 0.1 tr 1493 <i>aras</i> | β-Longipinene | 0.1 | - | - | 1398 |
| (Z)-Caryophyllene0.1-0.21404Longifolene1.51.01.61406 α -Gurjunene0.1-0.21409Dodecanal-0.3tr1410 β -Caryophyllene3.32.93.51419 β -Cdrene0.6tr0.91420 β -Duprezianene0.2-0.21432 β -Gurjunene0.1-0.91.21437 α -Guaiene0.50.40.61439Aromadendrenetrtrtr1440 α -Himachalene10.99.011.51451Khusimene*0.11455 α -Humulene8.67.18.71456 <i>allo</i> -Aromadendrene0.60.60.61461 γ -Muurolene1.61.71.71477 γ -Himachalene7.66.98.11483 β -Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493 <i>trans</i> -muurola-4(14),5 diene0.70.9tr1513 α -Dehydro- <i>ar</i> -himachalene0.10.20.11505 β -Bisabolene0.10.20.11505 β -Bisabolene0.10.20.11509 <i>trans</i> -Cadinene1.11.1-1529 γ -Dehydro- <i>ar</i> -himachalene1.21.21.11530 <i>trans</i> -Cadinene1.21.2 <t< td=""><td><i>n</i>-Tetradecane</td><td>-</td><td>0.2</td><td>-</td><td>1400</td></t<> | <i>n</i> -Tetradecane | - | 0.2 | - | 1400 |
| Longifolene1.51.01.61406 α -Gurjunene0.1-0.21409Dodecanal-0.3tr1410 β -Caryophyllene3.32.93.51419 β -Cedrene0.6tr0.91420 β -Duprezianene0.2-0.21432 β -Gurjunene0.1-0.21432trans- α -Bergamotene1.00.91.21437 α -Guaiene0.50.40.61439Aromadendrenetrtrtrtrthimachalene10.99.011.51451Khusimene #0.11455 α -Humulene8.67.18.71456 <i>allo</i> -Aromadendrene0.60.60.61461 γ -Muurolene1.61.71.71477 γ -Himachalene7.66.98.11483 β -Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493 <i>trans</i> -murola-4(14),5 diene1.509 α -Selinene3.23.53.41524 α -Dehydro- <i>ar</i> -himachalene0.10.20.11505 β -Bisabolene0.10.20.11503 <i>trans</i> -Cadimene1.11.1-1529 γ -Dehydro- <i>ar</i> -himachalene1.21.21.11533 <i>a</i> -Cadiacorene0.60.70.61538 <td>(Z)-Caryophyllene</td> <td>0.1</td> <td>-</td> <td>0.2</td> <td>1404</td> | (Z)-Caryophyllene | 0.1 | - | 0.2 | 1404 |
| 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 1432 β -Gurjunene 0.1 - 0.2 1432 α -Guaiene 0.5 0.4 0.6 1439 α -Guaiene 0.5 0.4 0.6 1439 Aromadendrene tr tr tr tr α -Himachalene 10.9 9.0 11.5 1451 Khusimene # 0.1 - - 1455 α -Humulene 8.6 7.1 8.7 1456 α -Humulene 8.6 7.1 8.7 1456 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 (= | Longifolene | 1.5 | 1.0 | 1.6 | 1406 |
| Doubceanal-0.311410β-Caryophyllene3.32.93.51419β-Cedrene0.6tr0.91420β-Duprezianene0.2-0.21423β-Gurjunene0.1-0.21432trans-α-Bergamotene1.00.91.21437α-Guaiene0.50.40.61439Aromadendrenetrtrtrtrthimachalene10.99.011.51451Khusimene #0.11455α-Humulene8.67.18.71456allo-Aromadendrene0.60.60.61461γ-Muurolene1.61.71.71477γ-Himachalene7.66.98.11483β-Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-murola-4(14),5 diene1513α-Dehydro-ar-himachalene0.10.20.11505β-Bisabolene0.10.20.11509trans-Calinene3.23.53.41524trans-Calamenene1.11.1-1529γ-Dehydro-ar-himachalene1.21.21.11533α-Calacorene0.60.70.61538α-Calacorene0.60.70.61538α-Calacorene0.60.70.61538α-Calacorene0.6 | α-Gurjunene | 0.1 | - | 0.2 | 1409 |
| $\begin{array}{cccc} 3.5 & 2.5 & 2.5 & 3.5 & 145 \\ \beta-Cedrene & 0.6 & tr & 0.9 & 1420 \\ \beta-Duprezianene & 0.2 & - & 0.2 & 1432 \\ trans-\alpha-Bergamotene & 1.0 & 0.9 & 1.2 & 1437 \\ \alpha-Guaiene & 0.5 & 0.4 & 0.6 & 1439 \\ Aromadendrene & tr & tr & tr & 1440 \\ \alpha-Himachalene & 10.9 & 9.0 & 11.5 & 1451 \\ Khusimene ^{\#} & 0.1 & - & - & 1455 \\ \alpha-Humulene & 8.6 & 7.1 & 8.7 & 1456 \\ \alpha-Humulene & 8.6 & 7.1 & 8.7 & 1456 \\ \alpha-Humulene & 1.6 & 1.7 & 1.7 & 1477 \\ \gamma-Himachalene & 0.6 & 0.6 & 0.6 & 0.6 & 1461 \\ \gamma-Muurolene & 1.6 & 1.7 & 1.7 & 1477 \\ \gamma-Himachalene & 7.6 & 6.9 & 8.1 & 1483 \\ \beta-Selinene & 3.5 & 3.6 & 3.7 & 1487 \\ Bicyclosesquiphellandrene (= tr & 0.1 & tr & 1493 \\ trans-murola-4(14),5 diene & & & & \\ \alpha-Selinene & 9.6 & 8.0 & 11.0 & 1505 \\ \beta-Bisabolene & 0.1 & 0.2 & 0.1 & 1509 \\ trans-\gamma-Cadinene & 0.7 & 0.9 & tr & 1513 \\ \alpha-Dehydro-ar-himachalene & 0.4 & 0.4 & tr & 1517 \\ \delta-Cadinene & 3.2 & 3.5 & 3.4 & 1524 \\ trans-Calamenene & 1.1 & 1.1 & - & 1529 \\ \gamma-Dehydro-ar-himachalene & 1.2 & 1.2 & 1.1 & 1530 \\ trans-Calanene & tr & 0.2 & 0.6 & 1538 \\ \alpha-Calacorene & 0.6 & 0.7 & 0.6 & 1542 \\ Germacrene B & - & 0.1 & tr & 1558 \\ trans-Nerolidol & 3.5 & 2.1 & 3.2 & 1564 \\ Ledol & 0.1 & tr & tr & 1567 \\ Caryophylleny lacohol & 1.7 & 1.1 & 1.4 & 1567 \\ Himachalene epoxide & 0.2 & 0.4 & 0.2 & 1583 \\ \end{array}$ | B-Carvophyllene | 33 | 2.9 | 35 | 1410 |
| p - Current0.211< | B-Cedrene | 0.6 | ±.) | 0.9 | 1420 |
| β-Gurjunene0.1-0.21432trans-α-Bergamotene1.00.91.21437α-Guaiene0.50.40.61439Aromadendrenetrtrtrtrα-Guaiene10.99.011.51451Khusimene #0.11455α-Humulene8.67.18.71456αllo-Aromadendrene0.60.60.61.6γ-Murolene1.61.71.71477γ-Himachalene7.66.98.11483β-Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-murola-4(14),5 diene3.94.44.51495β-Himachalene9.68.011.01505β-Bisabolene0.10.20.11513α-Dehydro-ar-himachalene0.40.4tr1517δ-Cadinene3.23.53.41524trans-Calamenene1.11.1-1529γ-Dehydro-ar-himachalene1.11.1-1529γ-Dehydro-ar-himachalene1.11.111533α-Cadinenetr0.20.61538α-Calacorene0.60.70.61542Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1tr1.11.41557 | B-Duprezianene | 0.2 | - | 0.2 | 1423 |
| trans- α -Bergamotene1.00.91.21437 α -Guaiene0.50.40.61439Aromadendrenetrtrtrtr α -Himachalene10.99.011.51451Khusimene #0.11455 α -Humulene8.67.18.71456 α -Homadendrene0.60.60.61461 γ -Muurolene1.61.71.71477 γ -Himachalene7.66.98.11483 β -Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-muurola-4(14),5 diene1505 β -Bisabolene0.10.20.11505 β -Bisabolene0.10.20.11505 β -Bisabolene0.10.20.11505 α -Dehydro-ar-himachalene0.40.4tr1517 δ -Cadinene3.23.53.41524trans-Calamenene1.11.1-1529 γ -Dehydro-ar-himachalene1.21.21.11533trans-Calanenene1.11.1-1529 γ -Dehydro-ar-himachalene1.11.11533 α -Calacorene0.60.70.61538 α -Calacorene0.60.70.61538 α -Calacorene0.60.70.61542Germacrene B-0.1tr | β-Gurjunene | 0.1 | - | 0.2 | 1432 |
| α-Guaiene0.50.40.61439Aromadendrenetrtrtrtrtr1440α-Himachalene10.99.011.51451Khusimene #0.11455α-Humulene8.67.18.71456αllo-Aromadendrene0.60.60.61461γ-Muurolene1.61.71.71477γ-Himachalene7.66.98.11483β-Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-murrola-4(14),5 diene1505β-Bisabolene0.10.20.11505β-Bisabolene0.10.20.11505β-Bisabolene0.10.20.11509trans-γ-Cadinene3.23.53.41524trans-Calamenene1.11.1-1529γ-Dehydro-ar-himachalene1.21.21.11533α-Cadinene1.11.1-1529γ-Dehydro-ar-himachalene1.11.11153210-epi-Cubebol1.11533α-Cadiacorene0.60.70.61538α-Cadiacorene0.60.70.61542Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1trtr1.567Caryoph | trans-a-Bergamotene | 1.0 | 0.9 | 1.2 | 1437 |
| Aromadendrenetrtrtrtr1440 α -Himachalene10.99.011.51451Khusimene #0.11455 α -Humulene8.67.18.71456 α -Homadendrene0.60.60.61461 γ -Muurolene1.61.71.71477 γ -Himachalene7.66.98.11483 β -Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-muurola-4(14),5 diene1505 β -Bisabolene0.10.20.11505 β -Bisabolene0.10.20.11505 β -Bisabolene0.10.20.11509trans- γ -Cadinene3.23.53.41524trans-Calamenene1.11.1-1529 γ -Dehydro-ar-himachalene1.21.21.11530trans-Calanenene1.11.1-1529 γ -Dehydro-ar-himachalene1.11.1153210-epi-Cubebol1.11533α-Cadinenetr0.20.61538α-Calacorene0.60.70.61542Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1trtr1567Caryophylleny lacohol1.71.11.41567 | α-Guaiene | 0.5 | 0.4 | 0.6 | 1439 |
| α -Himachalene 10.9 9.0 11.5 1451 Khusimene # 0.1 - - 1455 α -Humulene 8.6 7.1 8.7 1456 α -Humulene 8.6 7.1 8.7 1456 α -Muurolene 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 (= tr 0.1 tr 1493 $trans-murola-4(14),5$ diene - - 1505 β -Bisabolene 0.1 0.2 0.1 1505 β -Bisabolene 0.1 0.2 0.1 1509 $trans-\gamma$ -Cadinene 0.7 0.9 tr 1513 α -Dehydro-ar-himachalene 1.1 1.1 - 1529 γ Dehydro-ar-himachalene 1.2 1.2 1.1 1533 a -Calanenene 1.1 1.1 - 1529 | Aromadendrene | tr | tr | tr | 1440 |
| Ruisinence0.11433α-Humulene8.67.18.71456 α -Murolene0.60.60.61461γ-Muurolene1.61.71.71477γ-Himachalene7.66.98.11483β-Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-murola-4(14),5 diene1495β-Himachalene9.68.011.01505β-Bisabolene0.10.20.11509trans-γ-Cadinene0.70.9tr1513α-Dehydro-ar-himachalene0.40.4tr1517δ-Cadinene3.23.53.41524trans-Calamenene1.11.1-1529γ-Dehydro-ar-himachalene1.21.21.11530trans-Calanene1.11.1-1529γ-Dehydro-ar-himachalene1.21.21.11530trans-Calanene1.11.1-1529γ-Dehydro-ar-himachalene1.11.1153210-epi-Cubebol1.11532α-Calacorene0.60.70.61538α-Calacorene0.60.70.61542Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1trtr1580Caryophyllen | α -Himachalene | 10.9 | 9.0 | 11.5 | 1451 |
| CarabinationConstraintConstraintConstraint α -Rainable definition0.60.60.61461 γ -Muurolene1.61.71.71477 γ -Himachalene7.66.98.11483 β -Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493 $trans$ -muurola-4(14),5 diene σ -Selinene3.94.44.51495 β -Himachalene9.68.011.01505 β -Bisabolene0.10.20.11509 $trans-\gamma$ -Cadinene0.70.9tr1513 α -Dehydro-ar-himachalene0.40.4tr1517 δ -Cadinene3.23.53.41524 $trans-Calamenene$ 1.11.1-1529 γ -Dehydro-ar-himachalene1.21.21.11533 $trans-Calanenene$ 1.11.1-1523 α -Calacorene0.60.70.61538 α -Calacorene0.60.70.61538 α -Calacorene0.60.70.61542Germacrene B-0.1tr1557Caryophyllenyl alcohol1.71.11.41567Himachalene epoxide0.20.10.11580 | α-Humulene | 0.1 8.6 | 71 | 87 | 1455 |
| γ -Muurolene1.61.71.71477 γ -Himachalene7.66.98.11483 β -Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493 $trans$ -muurola-4(14),5 diene | allo-Aromadendrene | 0.6 | 0.6 | 0.6 | 1461 |
| γ-Himachalene7.66.98.11483β-Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-muurola-4(14),5 diene α -Selinene3.94.44.51495β-Himachalene9.68.011.01505β-Bisabolene0.10.20.11509trans-γ-Cadinene0.70.9tr1513 α -Dehydro-ar-himachalene0.40.4tr1517δ-Cadinene3.23.53.41524trans-Calamenene1.11.1-1529γ-Dehydro-ar-himachalene1.21.21.11530trans-Calina-1(2),4-diene0.3TR0.4153210-epi-Cubebol1.11533α-Cadiacorene0.60.70.61532Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1trtr1567Caryophyllenyl alcohol1.71.11.41567Himachalene epoxide0.20.10.11580 | γ-Muurolene | 1.6 | 1.7 | 1.7 | 1477 |
| β-Selinene3.53.63.71487Bicyclosesquiphellandrene (=tr0.1tr1493trans-muurola-4(14),5 diener0.1tr1493α-Selinene3.94.44.51495β-Himachalene9.68.011.01505β-Bisabolene0.10.20.11509trans-γ-Cadinene0.70.9tr1513α-Dehydro-ar-himachalene0.40.4tr1517δ-Cadinene3.23.53.41524trans-γ-Cadinene1.11.1-1529γ-Dehydro-ar-himachalene1.21.21.11530trans-Calamenene1.11.1-1529γ-Dehydro-ar-himachalene1.21.21.11530trans-Cadina-1(2),4-diene0.3TR0.4153210-epi-Cubebol1.11533α-Cadiacorene0.60.70.61538α-Calacorene0.60.70.61542Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1trtr1567Caryophyllenyl alcohol1.71.11.41567Himachalene epoxide0.20.10.11583 | γ-Himachalene | 7.6 | 6.9 | 8.1 | 1483 |
| Bicyclosesquiphellandrene (= tr 0.1 tr 1493 trans-muurola-4(14),5 diene 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-Calina-1(2),4-diene 0.3 TR 0.4 1532 10-epi-Cubebol - - 1.1 1533 α-Cadiacorene 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 1587 | β-Selinene | 3.5 | 3.6 | 3.7 | 1487 |
| trans-mutrola-4(14),5 diene α -Selinene3.94.44.51495 β -Himachalene9.68.011.01505 β -Bisabolene0.10.20.11509trans- γ -Cadinene0.70.9tr1513 α -Dehydro-ar-himachalene0.40.4tr1517 δ -Cadinene3.23.53.41524trans-Calamenene1.11.1-1529 γ -Dehydro-ar-himachalene1.21.21.11530trans-Calina-1(2),4-diene0.3TR0.4153210-epi-Cubebol1.11533 α -Cadiacorene0.60.70.61538 α -Calacorene0.60.70.61542Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1trtr1567Caryophyllenyl alcohol1.71.11.41567Himachalene epoxide0.20.40.21583 | Bicyclosesquiphellandrene (= | tr | 0.1 | tr | 1493 |
| 0.5 4.4 4.5 14.7 β -Himachalene 9.6 8.0 11.0 1505 β -Bisabolene 0.1 0.2 0.1 1505 β -Bisabolene 0.1 0.2 0.1 1505 μ -Dehydro-ar-himachalene 0.4 0.4 tr 1513 α -Dehydro-ar-himachalene 0.4 0.4 tr 1517 δ -Cadinene 3.2 3.5 3.4 1524 <i>trans</i> -Calamenene 1.1 1.1 $ 1529$ γ -Dehydro-ar-himachalene 1.2 1.2 1.1 1530 <i>trans</i> -Calina-1(2),4-diene 0.3 TR 0.4 4532 0 -epi-Cubebol - - 1.1 1533 α -Calacorene 0.6 0.7 0.6 1542 Germacrene B - 0.1 tr 1558 <i>trans</i> -Nerolidol 3.5 2.1 3.2 1564 Ledol 0.1 tr tr 1567 Caryophylleny lalcoh | trans-muurola-4(14),5 diene | 2.0 | 4.4 | 4.5 | 1405 |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | B-Himachalene | 96 | 4.4 8.0 | 11.0 | 1495 |
| <i>trans-γ</i> -Cadinene0.70.9tr1513 α -Dehydro-ar-himachalene0.40.4tr1517 δ -Cadinene3.23.53.41524 <i>trans-</i> Calamenene1.11.1-1529 γ -Dehydro-ar-himachalene1.21.21.11 1.1 1.1-1529 γ -Dehydro-ar-himachalene1.21.21.11 $trans-$ Cadina-1(2),4-diene0.3TR0.41532 10 -epi-Cubebol1.111533 α -Cadiacorene0.60.70.61542Germacrene B-0.1tr1558 <i>trans</i> -Nerolidol3.52.13.21564Ledol0.1trtr1567Caryophyllenyl alcohol1.71.11.41580Caryophyllene oxide0.20.40.21583 | B-Bisabolene | 0.1 | 0.2 | 0.1 | 1509 |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | trans-y-Cadinene | 0.7 | 0.9 | tr | 1513 |
| $\begin{array}{llllllllllllllllllllllllllllllllllll$ | α -Dehydro- <i>ar</i> -himachalene | 0.4 | 0.4 | tr | 1517 |
| trans-Calamenene1.11.1-1529 γ -Dehydro-ar-himachalene1.21.21.11530trans-Cadina-1(2),4-diene0.3TR0.4153210-epi-Cubebol1.11533 α -Cadinenetr0.20.61538 α -Calacorene0.60.70.61542Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1trtr1567Caryophyllenyl alcohol1.71.11.41567Himachalene epxide0.20.10.11580Caryophyllene oxide0.20.40.21583 | δ-Cadinene | 3.2 | 3.5 | 3.4 | 1524 |
| γ -Dehydro- ar -himachalene1.21.21.11530 $trans$ -Cadina-1(2),4-diene0.3TR0.4153210-epi-Cubebol1.11533 α -Cadinenetr0.20.61538 α -Calacorene0.60.70.61542Germacrene B-0.1tr1558trans-Nerolidol3.52.13.21564Ledol0.1trtr1567Caryophyllenyl alcohol1.71.11.41580Garyophyllene oxide0.20.40.21583 | trans-Calamenene | 1.1 | 1.1 | - | 1529 |
| $hrans-Cadma-1(2), 4-diene 0.3 1 R 0.4 1532 10-epi-Cubebol - - 1.1 1533 \alpha-Cadinene tr 0.2 0.6 1538 \alpha-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 Himachalene epoxide 0.2 0.1 0.1 1580 Caryophylleno oxide 0.2 0.4 0.2 1583 $ | γ-Dehydro- <i>ar</i> -himachalene | 1.2 | 1.2 TD | 1.1 | 1530 |
| α -Cadinene tr 0.2 0.6 1533 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 Caryophylleny 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 | <i>trans</i> -Cadina-1(2),4-diene | 0.3 | IK | 0.4 | 1532 |
| α -Calacorene 0.6 0.7 0.6 1542 Germacrene B - 0.1 tr 1558 <i>trans</i> -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 1580 | α-Cadinene | - tr | 02 | 0.6 | 1538 |
| 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 | α-Calacorene | 0.6 | 0.7 | 0.6 | 1542 |
| 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 | Germacrene B | - | 0.1 | tr | 1558 |
| 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 | trans-Nerolidol | 3.5 | 2.1 | 3.2 | 1564 |
| Caryophylienyl alconol 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 | Ledol | 0.1 | tr | tr | 1567 |
| Caryophyllene oxide 0.2 0.4 0.2 1583 | Caryopnyllenyl alcohol Himachalene enovide | 1.7 | 1.1 | 1.4 | 156/ |
| | Caryophyllene oxide | 0.2 | 0.4 | 0.1 | 1583 |

| | | | Table 1 | (contd.) |
|----------------------------|------|------|---------|----------|
| 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-4a-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-a-Bisabolol | 0.2 | tr | 0.2 | 1688 |
| Germacrone # | - | 2.4 | - | 1694 |
| Pentadecanal | - | tr | tr | 1717 |
| <i>n</i> -Octadecane | - | 0.3 | tr | 1800 |
| Hexahydrofarnesyl acetone | 0.5 | 1.6 | 0.4 | 1843 |
| ar-Himachalene-2-ol | 0.1 | tr | tr | 1848 |
| <i>n</i> -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 | Le | eaves | St | em | Se | eds |
|----------------------|----|-------|----|------|----|------|
| | n | % | n | % | n | % |
| Monoterpene | 2 | tr | 2 | 2.8 | 2 | tr |
| hydrocarbons | | | | | | |
| Oxygenated | 3 | tr | 5 | 4.7 | 6 | tr |
| monoterpenes | | | | | | |
| Total monoterpenes | 5 | - | 7 | 7.5 | 8 | - |
| Sesquiterpene | 36 | 67.7 | 30 | 60.4 | 33 | 71.4 |
| hydrocarbons | | | | | | |
| Oxygenated | 23 | 24.8 | 21 | 20.8 | 26 | 22.9 |
| sesquiterpenes | | | | | | |
| 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 | 3 | 0.2 | 2 | 0.8 | 5 | 0.5 |
| hydrocarbons | | | | | | |
| 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 |
| B-Pinene | 0.5 | 982 |
| 6 Mathul 5 hantan 2 one | 0.0 tr | 087 |
| Murcana | 18 | 001 |
| 2 2 Dehudro 1 8 sincele | 4.0 | 991 |
| 2,5-Deliyulo-1,8-cilleole | 12 | 1001 |
| o-2-Carene | 1.3 | 1001 |
| α-Phellandrene | 25.2 | 1007 |
| α-Terpinene | 0.3 | 1020 |
| <i>p</i> -Cymene | 24.9 | 1028 |
| Limonene | 4.1 | 1033 |
| β-Phellandrene | 1.1 | 1035 |
| (Z)-Ocimene | 0.5 | 1040 |
| (E)-Ocimene | 0.2 | 1950 |
| v-Terninene | 0.3 | 1063 |
| Terpinolene | 0.2 | 1088 |
| Linalool | 3.7 | 1100 |
| B-Thuione | tr | 1116 |
| p-mujone aig n Month 2 on 1 ol | 0.4 | 1122 |
| Domaal | 0.4 | 1125 |
| Borneon Transienan A. al | 0.4 | 110/ |
| rerpinen-4-oi | 0.2 | 11/9 |
| 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-Conaene | 0.5 | 1376 |
| B-Cubebene | 0.1 | 1390 |
| β-Elemene | 0.1 | 1201 |
| | 0.2 | 1410 |
| p-Caryophyllene | 0.4 | 1419 |
| <i>trans</i> -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 |
| B-Selinene | tr | 1487 |
| Valencene | 0.1 | 1492 |
| trans-Muurola-4(14) 5-diene | 0.2 | 1493 |
| Viridiflorene | 0.2 | 1495 |
| trans v Codinana | 1.8 | 1513 |
| rans-γ-Caumene | 1.0 | 1524 |
| o-Cadinene | 5.0 | 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 |
| a-Muurolol | 0.1 | 1647 |
| a-Cadinol | 0.1 | 1655 |
| u-Cauliful Total | 0.2 | 1000 |
| 1 (141 | 74.1 | |

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

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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 |
| Nonanai | 0.8 | - | 1104 |
| trans-Pinocarveol | 0.5 | 1.8 | 1120 |
| <i>cis</i> -Verbenol | _ | 1.0 | 1199 |
| <i>n</i> -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 |
| <i>n</i> -reliadecale | - | 0.5 | 1400 |
| B Carvonhvllene | 10.5 | 3.0 | 1409 |
| B Cedrene | 10.5 | 0.3 | 1419 |
| trans-a-Bergamotene | 03 | - | 1439 |
| (E)-Geranyl acetone | tr | - | 1453 |
| α-Humulene | 3.2 | 0.8 | 1456 |
| $(E)-\beta$ -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 | 20 | 1.6 | 1500 |
| S Cadinana | 2.0 tr | 12.0 | 1505 |
| a Calacorene | u tr | 12.0 | 1542 |
| eni-Longininanol | 23 | - | 1561 |
| trans-Nerolidol | 0.8 | 0.5 | 1564 |
| Spathulenol | 1.4 | 1.2 | 1577 |
| Caryophyllene oxide | 37.0 | 11.0 | 1583 |
| <i>n</i> -Hexadecane | - | 0.4 | 1600 |
| β-Atlantol | 2.6 | - | 1608 |
| Humulene oxide II | 6.0 | 1.6 | 1610 |
| epi-10-γ-Eudesmol | - | 0.7 | 1621 |
| I-epi-Cubenoi Epoxyalloaromadandrono | 0.4 | - | 1629 |
| Carvonhylla-4(14) 8(15)-dien-5-ol | 0.5 | 0.5 | 1640 |
| T-Cadinol | 0.5 | - | 1642 |
| Cedr-8(15)-en-9 α -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></neo> | - | 0.4 | 1667 |
| trans-Calamenen-10-ol | 0.6 | 1.6 | 1669 |
| β-Bisabolol | - | 13 | 1672 |
| Acorenone B | 0.4 | - | 1685 |
| Muurol-5-en-4-one < cis-14-nor > | 1.4 | 0.7 | 1689 |
| n Hentadecane | - | 0.3 | 1092 |
| Pentadecanal | 2.9 | 11 | 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 |
| r Hylui Sandaraconimara 8(14) 15 diana | tr | 1.5 | 1943 |
| 1-Eicosene | - tr | 0.5 | 1909 |
| Methyl linoleate | tr | - | 2096 |
| n-Heneicosane | - | 0.3 | 2100 |
| <i>n</i> -Docosane | - | 0.1 | 2200 |
| <i>n</i> -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 oil | ls of |
|---|--------|
| Moringa oleifera, Heeliotropium indicum and Bidens | pilosa |

| Chemical classes | М. | Н. | B. pilosa | |
|----------------------------|----------|---------|-----------|------|
| | oleifera | indicum | 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 δ-cadinene (12.0%)acetone (13.4%). 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-trivne 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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