The chemical diversity of Lantana camara : analyses of essential oil samples from Cuba, Nepal, and Yemen

The Chemical Diversity of *Lantana camara*: Analyses of Essential Oil Samples from Cuba, Nepal, and Yemen

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Abstract: The aerial parts of *Lantana camara* L. were collected from three different geographical locations: Artemisa (Cuba), Biratnagar (Nepal), and Sana'a (Yemen). The essential oils were obtained by hydrodistillation and analyzed by gas chromatography – mass spectrometry. A cluster analysis of 39 *L. camara* essential oil compositions revealed eight major chemotypes: β-caryophyllene, germacrene D, *ar*-curcumene/zingiberene, γ-curcumen-15-al/*epi*-β-bisabolol, (*E*)-nerolidol, davanone, eugenol/alloaromadendrene, and carvone. The sample from Cuba falls into the group dominated by (*E*)-nerolidol, the sample from Nepal is a davanone chemotype, and the sample from Yemen belongs to the (*E*)-caryophyllene chemotype. The chemical composition of *L. camara* oil plays a role in the biological activity; the β-caryophyllene and (*E*)-nerolidol chemotypes showed antimicrobial and cytotoxic activities.

Key-words: Essential oil composition, cluster analysis, chemotaxonomy, antimicrobial, cytotoxicity.

Introduction. – *Lantana camara* L. (Verbenaceae), is native to the Neotropics but has been introduced to tropical and subtropical locations worldwide where it has become an invasive pest [1,2]. *L. camara* has been found to be hepatotoxic to grazing animals, attributed to pentacyclic lantadene triterpenoids [3], and human poisoning has also been reported [4]. Nevertheless, *L. camara* is used as a traditional herbal medicine in many cultures. For example, in Guatemala, Mexico, and Puerto Rico, decoctions of *L. camara* are taken as a remedy for rheumatism [5]; leaves of *L. camara* are applied to swollen joints in Sri Lanka [6]; the Malayali people of Chitteri Hills, India, use *L. camara* leaf juice to treat diabetes [7]; and in Bangladesh, *L. camara* is used to treat fever and boils [8]. The phytochemistry, toxicology, and medicinal properties of *L. camara* have been extensively reviewed [9-12].

A survey of the literature indicates that there is a great deal of diversity in the composition of the essential oils of *L. camara* growing in different localities, and several chemotypes have been described, including a sabinene/cineole/β-caryophyllene chemotype from Nigeria and Iran [13-16]; β-caryophyllene/γ-muurolene/bicyclogermacrene from Costa Rica [17]; germacrene D (15.9%), β-caryophyllene (12.4%), α-humulene (9.3%) from China [18]; β-caryophyllene, (34.6%), caryophyllene oxide (10.8%) from Algeria [19]; β-caryophyllene (9.8%), 1,8-cineole (9.4%) and β-pinene (8.2%) from Egypt [20]; davanone (23.5%), β-caryophyllene (11.7%)/sabinene; or davanone (15%)/β-caryophyllene (12%) from Madagascar [21,22]; β-caryophyllene (23.3%), α-humulene (11.5%), germacrene D (10.9%) or davanone/β-caryophyllene /bicyclogermacrene from India [23,24]; (*E*)-nerolidol (43.4%), δ-cadinene (7.6%), from Cuba [25]; germacrene D (31.0%) and β-caryophyllene (14.8%) from Venezuela [26]; bicyclogermacrene (19.4%), isocaryophyllene (16.7%), valencene (12.9%) and germacrene D (12.3%) from Brazil [27]. In this report, we have analyzed the essential oil compositions of *L.*

camara collected from different geographical locations: Artemisa in Cuba, Biratnagar in Nepal, and Sana'a in Yemen. In addition, we have examined various biological activities of the oils and we have carried out a cluster analysis based on the compositions of 39 different *L. camara* essential oils.

Results and Discussion. – *Essential Oil Compositions.* The essential oils from the aerial parts of *L. camara* from three very different geographical locations, Cuba, Nepal, and Yemen were obtained by hydrodistillation and analyzed by gas chromatography – mass spectrometry (GC-MS). The essential oil compositions are summarized in Table 1.

Lantana camara *Oil from Cuba.* A total of 112 compounds were identified in the essential oil of *L. camara* from Cuba, representing 91.2% of the total oil composition. The major components of the essential oil were (*E*)-nerolidol (16.6%), (*E*)-β-farnesene (11.3%), β-caryophyllene (9.1%), germacrene D (7.3%), and 1,8-cineole (6.9%). There was also an unidentified component (RI = 1614, 7.8%). The composition of this *L. camara* sample from Cuba is qualitatively similar to a previous report of *L. camara* essential oil from Cuba [25].

Lantana camara *Oil from Nepal.* A total of 77 compounds were identified in *L. camara* oil from Nepal, 92.4% of the composition. The oil from Nepal was dominated by oxygenated sesquiterpenoids (64.0%), largely davanone (44.4%), and (*E*)-nerolidol (13.0%), with diminutive concentrations of monoterpenoids (total of 5.4%).

Lantana camara *Oil from Yemen.* Analysis of lantana oil from Sana'a, Yemen, revealed a total of 71 compounds identified (89.4% of the composition). The oil was dominated by sabinene (16.9%) and β-caryophyllene (13.8%), with lesser concentrations of 1,8-cineole (9.0%),

α-humulene (5.9%), and bicyclogermacrene (5.8%). The Yemeni lantana oil was comparable in composition to samples from Iran [16] and from Nigeria [13,14].

Hierarchical Cluster Analysis. There have been several previous investigations into the chemical diversity of *L. camara* essential oils [17,21,24,28,29], and several chemotypes have been identified (see above). This present study complements previous efforts by including three samples from different geographical locations.

We have carried out a cluster analysis of 35 published [14-18,21-23,25-44] *L. camara* essential oil compositions in addition to the three samples in this present study (see Fig. 1). The cluster analysis reveals eight different chemotypes: (**A**) a β-caryophyllene chemotype, (**B**) a germacrene D chemotype, (**C**) an *ar*-curcumene/α-zingiberene chemotype, (**D**) a γ-curcumen-15-al/epi-β-bisabolene chemotype, (**E**) an (*E*)-nerolidol chemotype, (**F**) a davanone chemotype, (**G**) a eugenol/alloaromadendrene chemotype, and (**H**) a carvone chemotype. The cluster analysis places the essential oil from Yemen in the β-caryophyllene-rich cluster, which is also the most prominent chemotype. The *L. camara* oil from Nepal represents the davanone-rich chemotype, while the sample from Cuba, along with the previous Cuban lantana oil, are in the (*E*)-nerolidol cluster. The chemical diversity displayed by *L. camara* essential oils cannot be attributed to geographical location. Thus, for example, samples from Brazil are represented in four different chemotypes and lantana oils from India are found in three chemotypes. The chemical diversity of *L. camara* may be due to the numerous different cultivars and hybrids [2,9]. The Missouri Botanical Garden currently lists 47 different varieties and subspecies of *L. camara* [45].

Bioactivity Screening. Antimicrobial assessment of essential oil from *L. camara* collected in Cuba was performed fluorimetrically after adding resazurin. The essential oil was inactive against *Escherichia coli* and *Candida albicans*, with IC_{50} values > 64 μg/mL; while an

IC_{50} of 12.13 µg/mL was obtained against *Staphylococcus aureus*. However, cytotoxicity displayed against MRC-5 cells was higher, with an IC_{50} value of 10.31 µg/mL. The *L. camara* oil from Nepal was screened for antibacterial activity against *Bacillus cereus*, *S. aureus*, *E. coli*, and *Pseudomonas aeruginosa* but was inactive (MIC > 1250 µg/mL) against all bacteria tested. The Nepalese *L. camara* oil was also inactive against *C. albicans* (MIC = 1250 µg/mL) and *Aspergillus niger* (MIC = 625 µg/mL). *L. camara* oil from Nepal was tested for brine shrimp (*Artemia salina*) lethality and nematicidal (*Caenorhabditis elegans*) activity, but was only marginally active (LC_{50} = 24.9 and 117.5 µg/mL, respectively). *In-vitro* cytotoxicity screening against MCF-7 human ductal carcinoma cells also showed marginal activity (only 24.1% kill at 100 µg/mL).

Lantana oil from Yemen was screened for antimicrobial activity using the disc diffusion assay against *S. aureus*, methicillin-resistant *S. aureus* (MRSA), *Bacillus subtilis*, *E. coli*, *P. aeruginosa*, and *C. albicans*. In this assay, *S. aureus*, *B. subtilis*, and *C. albicans* were more susceptible to the oil, with inhibition zones ranging from 26 ± 2.8 to 38 ± 3.6 mm. The essential oil of Yemeni *L. camara* showed similarities in its chemical composition with the Nigerian essential oil [13] and both oils exhibited antimicrobial activity. *L. camara* essential oils from India [38,44] also showed antimicrobial activity, and these oils also belong to the β-caryophyllene-rich chemotype. Notably, the lantana oil from Nepal (davanone chemotype) did not exhibit biological activity and the oil from Venezuela (germacrene D chemotype) [26] showed only marginal antibacterial activity. Similarly, lantana oils from Brazil (β-caryophyllene chemotype) [42] and from Cuba [(*E*)-nerolidol chemotype] showed cytotoxic activity, while the oil from Nepal was inactive. Consistent with these results, β-caryophyllene has shown both

antimicrobial [46] and cytotoxic [47-49] activities. Likewise, (*E*)-nerolidol has exhibited antibacterial [50,51] and cytotoxic [47,52] effects.

Conclusions. – *Lantana camara* essential oils show a wide diversity of chemical composition with at least eight chemotypes. The particular chemotype of *L. camara* may be important with respect to the use of this plant in herbal medicine. The β-caryophyllene and the (*E*)-nerolidol chemotypes have displayed biological activities while the davanone or the germacrene D chemotypes are less active. The chemical compositions of essential oils, particularly those with wide chemical variability such as *L. camara*, should be considered when assessing the bioactivities.

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Experimental Part

Plant Material and Essential Oils. Aerial parts of *L. camara* were collected from Artemisa in Cuba (22°49′ N, 82°45′ W, 43 m above sea level), in October 2014. The plant was identified by Eldys Bécquer Granados from the National Botanical Garden, Havana, Cuba, where a voucher specimen was deposited. The plant sample was crushed and the essential oil was obtained by hydrodistilled using a Clevenger type apparatus for 5 h to give a light-yellow-colored essential oil with a yield of 0.3%.

Aerial parts of *L. camara* were collected from city of Biratnagar (26°28′ N, 87°16′ E, and 1072 m above sea level) in Morang district in Koshi Zone in Nepal in May 2011. The plant material was identified by Tilak Gautam, and a voucher specimen has been deposited in the herbarium of the Tribhuvan University, Post-Graduate Campus, Botany Department, Biratnagar. The essential oil was extracted from fresh aerial samples (100 g) that were crushed and hydrodistilled using a Clevenger type apparatus for 4 h. The clear pale yellow essential oil (0.7 g) produced was stored at 4°C until analyzed.

The aerial parts of *L. camara* were collected in the early morning from Botanical garden, Faculty of Pharmacy, Sana'a University, Yemen, in November, 2010. The plant was identified by Hassan M. Ibrahim of the Botany Department, Faculty of Sciences, Sana'a University. A voucher specimen of the plant material (YMP-Verben.-1) has been deposited at the Pharmacognosy Department, Sana'a University, Yemen. The plant sample (100 g) was hydrodistilled using a Clevenger apparatus for 3 h to give colorless oil, 0.5% w/w yield. After separation of the obtained essential oil, it was dried over anhydrous sodium sulfate.

Gas Chromatographic – Mass Spectral Analysis. Gas chromatographic – mass spectral analyses was performed on the essential oils of *O. basilicum* using an Agilent 6890 GC with Agilent 5973 mass selective detector and a fused silica capillary column (HP 5 ms, 30 m × 0.25 mm) coated with 5% phenyl-polymethylsiloxane (0.25 μm phase thickness) as previously described [53]. Identification of the oil components was based on their Kovats retention indices determined by reference to a homologous series of *n*-alkanes, and by comparison of their mass spectral fragmentation patterns with those reported in the literature [54], and stored on the MS library [NIST database (G1036A revision D.01.00)/ChemStation data system (G1701CA,

version C.00.01.080)]. The percentages of each component are reported as raw percentages based on total ion current without standardization. The chemical compositions of the *L. camara* oils are summarized in Table 1.

Cytotoxicity Assays. Cell culture experiments were performed with MCF-7 (human mammary ductal carcinoma) using the MTT assay, as described previously [53].

Antimicrobial Assays. Antibacterial screening against *Bacillus cereus*, *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and methicillin-resistant *S. aureus* (MRSA), and antifungal screening against *Aspergillus niger* were carried out using the resazurin fluorometric assay [55], the microbroth dilution assay [56] or the disc diffusion assay [57] as previously described.

Invertebrate Toxicity Assays. Nematicidal (*Caenorhabditis elegans*) activity and brine shrimp (*Artemia salina*) lethality evaluations were carried out as previously described [58].

Hierarchical Cluster Analysis. A total of 36 *L. camara* essential oil compositions from the published literature, as well as the compositions from this study were treated as operational taxonomic units (OTUs). The percentage composition of 37 major essential oil components [β-caryophyllene, germacrene D, bicyclogermacrene, sabinene, α-humulene, davanone, 1,8-cineole, (*E*)-nerolidol, *ar*-curcumene, carvone, valencene, spathulenol, caryophyllene oxide, limonene, β-elemene, germacrene B, α-pinene, δ-3-carene, β-pinene, linalool, α-phellandrene, alloaromadendrene, β-bisabolene, α-zingiberene, δ-cadinene, α-copaene, γ-terpinene, γ-cadinene, γ-elemene, γ-curcumene, myrcene, eugenol, τ-cadinol, γ-curcumen-15-al, *epi*-β-bisabolol, α-cadinol, and cubebol] was used to determine the chemical relationship between the various *L. camara* essential oil samples by agglomerative hierarchical cluster (AHC) analysis using the XLSTAT software, version 2015.4.01. Pearson correlation was selected as a measure of

similarity, and the unweighted pair-group method with arithmetic average (UPGMA) was used for cluster definition. The resulting dendrogram is shown in Figure 1.

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Table 1. *Essential oil compositions of* Lantana camara *from Cuba, Nepal, and Yemen.*

RI[a]	Compound	% Composition		
		Cuba	Nepal	Yemen
831	Furfural	-	0.1	-
854	(2*E*)-Hexenal	-	-	tr[b]
880	Isoamyl acetate	-	-	tr
882	2-Butylfuran	tr	-	-
924	α-Thujene	0.1	-	0.4
931	α-Pinene	3.2	-	2.8
952	Camphene	1.5	-	1.0
961	Benzaldehyde	-	tr	-
973	3-methylnonane	-	0.1	-
976	Sabinene	2.0	tr	16.9
979	β-Pinene	2.5	-	1.9
981	1-Octen-3-ol	0.5	5.3	0.5
984	3-Octanone	tr	-	-
992	1-Decene	-	tr	-
992	Myrcene	0.5	-	1.2
995	3-Octanol	0.2	0.2	tr
1000	*n*-Decane	-	1.1	-
1003	α-Phellandrene	0.1	-	0.3
1008	(3*Z*)-Hexenyl acetate	-	tr	-
1010	δ-3-Carene	-	-	2.4
1016	α-Terpinene	-	-	0.1
1019	3-Methyl-1,2-cyclopentanedione	tr	-	-
1024	*p*-Cymene	1.3	-	0.4
1028	Limonene	1.3	0.1	1.0
1029	β-Phellandrene	0.3	-	-
1031	1,8-Cineole	6.9	0.3	9.0

RI[a]	Compound	% Composition		
		Cuba	Nepal	Yemen
1033	Benzyl Alcohol	-	0.4	-
1038	(*Z*)-β-Ocimene	tr	-	0.8
1049	(*E*)-β-Ocimene	0.2	-	1.1
1051	*cis*-Arbusculone	-	0.1	-
1058	γ-Terpinene	0.1	-	0.5
1064	*trans*-Arbusculone	-	tr	-
1068	*cis*-Sabinene hydrate	tr	0.2	1.2
1072	*cis*-Linalool oxide (furanoid)	-	0.1	-
1087	Terpinolene	tr	-	0.3
1097	*trans*-Sabinene hydrate	-	0.1	0.5
1099	Linalool	0.9	1.2	0.3
1103	2-Methylbutyl 2-methylbutyrate	0.1	-	0.4
1109	2-Methylbutyl isovalerate	-	-	tr
1112	*endo*-Fenchol	-	-	0.2
1113	α-Fenchocamphorone	tr	-	-
1115	*trans*-Thujone	-	-	tr
1120	*cis*-p-Menth-2-en-1-ol	tr	-	0.1
1125	α-Campholenal	-	-	tr
1139	*trans*-Sabinol	tr	-	-
1140	*cis*-Verbenol	-	tr	-
1141	*trans*-p-Menth-2-en-1-ol	tr	-	-
1144	*trans*-Verbenol	0.1	-	-
1145	Camphor	0.9	0.5	1.5
1151	Lilac aldehyde D	-	0.1	-
1153	Camphene hydrate	tr	-	-
1157	β-Pinene oxide	-	0.2	-
1162	Isoborneol	0.5	-	0.4

RI[a]	Compound	% Composition		
		Cuba	Nepal	Yemen
1165	δ-Terpineol	0.1	-	0.1
1170	Borneol	0.3	0.9	-
1171	(2*E*)-Nonenol	-	0.2	-
1174	*cis*-Pinocamphone	tr	-	-
1176	Terpinen-4-ol	0.5	0.3	0.8
1185	*p*-Cymen-8-ol	tr	-	-
1189	α-Terpineol	1.7	0.2	0.2
1192	Methyl salicylate	-	0.7	-
1200	Dodecane	-	2.3	-
1205	Verbenone	tr	0.2	-
1229	Nordavanone	-	tr	-
1230	(3*Z*)-Hexenyl 2-methylbutanoate	tr	-	-
1237	(2*Z*)-Hexenyl isovalerate	tr	-	-
1251	Piperitone	0.6	-	-
1282	Bornyl acetate	tr	-	-
1288	Davanone A	-	0.1	-
1289	Thymol	tr	-	-
1333	α-Terpinyl acetate	0.1	-	-
1337	δ-Elemene	-	-	0.1
1345	α-Cubebene	tr	-	-
1349	4′-Methoxyacetophenone	-	0.2	-
1355	Eugenol	-	1.7	-
1366	Cyclosativene	tr	-	-
1375	α-Copaene	1.5	0.5	0.6
1384	β-Bourbonene	0.3	-	0.2
1385	β-Cubebene	0.3	0.1	0.3
1392	β-Elemene	1.4	-	0.6

RI[a]	Compound	% Composition		
		Cuba	Nepal	Yemen
1400	Tetradecane + α-Funebrene	tr	-	-
1409	Davanol isomer A	-	0.1	-
1419	β-Caryophyllene	9.1	2.9	13.8
1429	β-Copaene	1.2	0.2	0.6
1431	*trans*-α-Bergamotene	tr	-	-
1432	α-Guaiene	0.2	-	-
1434	γ-Elemene	-	-	tr
1438	6,9-Guaidiene	0.1	-	-
1441	*cis*-Muurola-3,5-diene	tr	-	-
1446	(*Z*)-β-Farnesene	0.1	-	-
1455	α-Humulene	-	3.4	5.9
1457	(*E*)-β-Farnesene	11.3	tr	-
1458	Alloaromadendrene	0.6	-	0.3
1460	*cis*-Cadina-1(6),4-diene	tr	-	-
1464	9-*epi*-(*E*)-Caryophyllene	tr	-	-
1474	Dodecanol	-	0.1	-
1476	*trans*-Cadina-1(6),4-diene	0.4	0.1	-
1477	*trans*-4,10-Epoxyamorphane	tr	-	-
1477	γ-Muurolene		-	0.3
1482	Germacrene D	7.3	0.6	2.1
1485	β-Selinene	0.6	-	-
1487	(*E*)-β-Ionone	-	-	tr
1491	*trans*-Muurola-4(14),5-diene	0.1	-	tr
1492	α-Selinene	1.7	-	-
1494	*epi*-Cubebol	-	0.2	tr
1499	Bicyclogermacrene	-	0.1	5.8
1500	Pentadecane	tr	tr	-

RI[a]	Compound	% Composition		
		Cuba	Nepal	Yemen
1501	α-Muurolene	0.7	0.3	0.5
1508	α-Bulnesene	tr	-	-
1506	Isodavanone	-	tr	-
1506	Germacrene A	tr	-	0.5
1509	β-Bisabolene	0.7	0.1	-
1509	δ-Amorphene	0.1	-	-
1516	Cubebol	1.0	-	1.4
1518	*trans*-Calamenene	0.1	-	-
1521	β-Sesquiphellandrene	0.1	-	-
1523	δ-Cadinene	0.9	0.3	0.3
1533	Davana ether	-	-	0.1
1534	(*Z*)-Nerolidol	0.1	0.1	-
1538	α-Calacorene	0.1	-	-
1540	α-Copaene-11-ol	-	0.2	-
1545	Elemol	0.1	-	-
1547	(*Z*)-Caryophyllene oxide	0.2	-	-
1550	Elemol	-	0.2	-
1556	Germacrene B	0.5	0.2	0.8
1559	Davanone C	-	0.3	-
1559	Isodavanone	-	-	0.6
1560	(*E*)-Nerolidol	16.6	13.0	2.3
1562	7-Hydroxyfarnesene	0.1	-	-
1566	Palustrol	tr	-	-
1569	Longipinanol	tr	-	-
1573	Davanone B	-	0.4	0.3
1576	Germacrene D-4-ol	-	0.3	tr
1580	Spathulenol	0.7	-	2.2

RI[a]	Compound	% Composition		
		Cuba	Nepal	Yemen
1583	Caryophyllene oxide	2.3	0.7	2.2
1584	Gleenol	0.1	-	-
1588	Salvial-4(14)-en-1-one	0.1	-	-
1588	Davanone	-	44.4	0.4
1590	Viridiflorol	0.6	-	-
1595	Fokienol	0.2	-	-
1600	Ledol	0.1	-	-
1605	Humulene epoxide II	0.5	-	-
1607	1,10 di-*epi*-Cubenol	-	0.1	-
1609	Unidentified	-	-	1.4
1610	Humulene epoxide II	-	0.9	0.4
1614	Unidentified	7.8	-	-
1624	Isospathulenol	0.4	-	-
1626	Eremoligenol	-	0.1	-
1631	Unidentified	1.0	3.3	3.5
1633	Caryophylla-4(12),8(13)-dien-5α-ol	0.2	-	0.2
1636	Caryophylla-4(12),8(13)-dien-5β-ol	-	0.2	0.3
1638	α-Muurolol (= Torreyol)	0.4	-	-
1639	Unidentified	-	-	0.7
1640	τ-Cadinol	-	0.8	0.5
1641	τ-Muurolol	0.2	-	-
1643	δ-Cadinol	0.3	-	-
1647	α-Muurolol	-	-	tr
1648	15-Copaenol	-	0.3	-
1651	α-Cadinol	0.6	-	-
1652	Unidentified	-	-	1.9
1654	Selin-11-en-4α-ol	0.3	-	-

RI[a]	Compound	% Composition		
		Cuba	Nepal	Yemen
1661	*trans*-Calamenen-10-ol + β-Atlantone	tr	-	-
1670	14-Hydroxy-9-*epi*-(*E*)-caryophyllene	-	0.7	-
1677	Unidentified	-	-	2.9
1679	Khusinol	-	0.1	-
1686	Germacra-4(15),5,10(14)-trien-1α-ol	0.3	0.2	0.2
1686	α-Bisabolol	0.1	-	-
1688	Shyobunol	-	0.1	0.2
1689	Eudesma-4(15),7-dien-1β-ol	0.1	-	-
1687	Dodecyl acetate	-	0.1	-
1697	Eudesm-7(11)-en-4-ol	-	0.1	-
1714	β-Davanon-2-ol	-	0.4	-
1714	Pentadecanal	0.2	-	-
1728	Oplopanone	tr	-	-
1750	Unidentified	-	2.2	-
1919	Methyl palmitate	-	tr	-
1962	Palmitic acid	-	1.7	-
2029	(*E*,*E*)-Geranyl linalool	0.1	-	0.1
2037	(*Z*)-Falcarinol	-	tr	-
2105	(*E*)-Phytol	0.1	1.1	-
2500	Pentacosane	tr	-	-
2700	Heptacosane	tr	-	-
	Total identified	91.2	92.4	89.4
	Monoterpene hydrocarbons	13.1	0.1	30.9
	Oxygenated monoterpenoids	12.5	4.3	14.1
	Sesquiterpene hydrocarbons	39.1	8.9	32.5
	Oxygenated sesquiterpenoids	25.4	64.0	11.2
	Miscellaneous	1.1	15.0	0.8

[a] RI = “Retention Index”, determined with respect to a homologous series of *n*-alkanes on an HP-5ms column.

[b] tr = “trace” (< 0.05%).

Figure Legend

Fig. 1. *Dendrogram obtained from the agglomerative hierarchical cluster analysis of 39* Lantana camara *essential oil compositions from the literature [14-18,21-23,25-44] in addition to the compositions of the samples from Cuba, Nepal, and Yemen from this present study.*

Lantana camara Dendrogram