Vol. 16(2), pp. 79-90, February 2022
DOI: 10.5897/AJEST2021.3083
Article Number: 4AEC3CC68700
ISSN: 1996-0786

http://www.academicjournals.org/AJEST

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African Journal of Environmental Science and Technology

Full Length Research Paper

Chemical characterization of Kenyan *Cupressus lusitanica* Mill., *Ocimum americanum* L. and *Lippia Javanica* (Burm.f.) Spreng essential oils

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Received 9 December, 2021; Accepted 24 January, 2022

The study was designed to chemically characterize essential oils from Kenyan *Cupressus lusitanica*, *Ocimum americanum* and *Lippia javanica* and bio-prospect for new compounds as possible biocontrol agents of insect pests. Leaf essential oils of the three test plants were obtained by hydro-distillation. GC-MS analysis of leaf oils revealed that monoterpenes were the major group of chemical constituents in all plants. In *C. lusitanica* oil, 91 compounds were identified with α-pinene (13.8%), umbellulone (12.66%), δ- cadinene (7.47) and Limonene (6.64%) being major compounds. The *O. americanum* oil had 72 compounds with geraniol (18.72%), 1, 8- cineole (17.48%), elemicin (8.20%) and camphor (7.55%) being main chemical constituents. Results also in *L. javanica* oil, the 47 compounds identified were dominated by ipsdienone (26.07 %), ocimenone (14.32%), bicyclo [3.1.1] hept-3-en-2-one, 4,6,6-trimethyl-, (1S)-(10.91%) and myrcene (7.04%). The chemotypes of essential oils from the tested plants may be considered as α-pinene-umbellulone, geranial-1, 8-cineole and ipsdienone-ocimenone for *C. lusitanica, O. americanicum* and *L. javanica* respectively. The chemical constituents such as α-pinene, umbellulone, geraniol, 1, 8-cineole and myrcene are known to have insecticidal properties. Therefore, the essential oils have possible uses in production of natural pesticides of plant origin for sustainable management of insect pest.

Key words: Essential oil, *Cupressus lusitanica*, *Ocimum americanum*, *Lippia javanica*, botanical pesticide.

INTRODUCTION

Essential oils are secondary plant metabolites that defend plants directly or indirectly against microorganisms and herbivores (Isman et al., 2011; Regnault-Roger et al., 2012; Isman, 2020). Many researchers have reported that essential oils mainly consist of monoterpenes, sesquiterpenes, phenylpropanoids, alcohols, esters, aldehydes, ketones, among others (Castillo et al., 2009; Bett et al., 2016). Furthermore, plants belonging to the families of Annonaceae, Asteraceae, Apiaceae, Chenopodiaceae, Cupressaceae, Lauraceae, Lamiaceae,

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Meliaceae, Myrtaceae, Poaceae, Piperaceae, Rutaceae, Verbenaceae and Zingiberaceae were reported as promising sources of botanical insecticides (Souza et al., 2008; Castillo et al., 2009; Ogendo et al., 2012; Bett et al., 2016; Kiplagat et al., 2020). However, many important compounds have been identified from plants but many remain to be identified and tested for their activity against many organisms. This huge pool of natural chemicals is largely underutilized for development of pesticides. Different authors have reported the medicinal value of *C. lusitanica*, *O. americanicum* and *L. javanica* but there been few reports of the pesticidal properties of leaf essential oils from the plants (Viljoen et al., 2005; Mujovo et al., 2008; Chikukura et al., 2011; Teke et al., 2013; Kipkore et al., 2014).

Cupressus lusitanica has been reported to have phytochemical, ethno-botanical, agricultural, ornamental and industrial importance (Kamatenesi-Mugisha et al., 2013; Teke et al., 2013). In other research reports, the essential oil *C. listanica* has been shown to have antibacterial and antifungal activities against *Bacillus cereus* and *Aspergillus niger,* respectively (Hassanzadeh et al., 2010). On the other hand *O. americanum* is useful in medical practice in treatment of dysentery, leprosy, pruritus, parasitic infections helminthiasis, anorexia, dyspepsia, flatulence, vomiting, poisonous affections, fever among others (Yamada et al., 2013). The screening of *L. javanica* for pharmacological activity has indicated that its activities include antimalarial, antimicrobial, antioxidant, antiplasmodial, anticancer, antiamoebic, antidiabetic, and pesticidal properties (Viljoen et al., 2005; Van Wyk, 2011; Mujovo et al., 2008).

It is also a known fact that plants with medicinal properties are likely to have reproductive inhibition antifeedant, toxic, repellent properties against field and stored product insect pests (Pandey et al., 2017). Furthermore, reports on the qualitative and quantitative variations of chemical constituents among plants from same species and growing in different parts of the world may be associated to environmental conditions and genetic differences. Variations in analytical methods can also be responsible. Therefore, it is scientifically stimulating to screen essential oils from different plant species to determine whether they possess pesticidal properties. In addition, few research efforts have directed towards determining chemical constituents of aromatic plants of medicinal and pesticidal importance in the Eastern African region. Therefore, the main focus of the current study was to determine chemical constituents of essential oils of *C. lusitnica*, *O. americanum* and *L. iavanica* growing in Kenya.

MATERIALS AND METHODS

Plant materials collection and essential oil extraction

The fresh plant leaves were collected from different geographic regions in Kenya: *C. lusitanica* from Busia (0º25'20.02"N, 35º7'45.00"E, 1215 MASL), *O. americanum* from Homa Bay (0º22'03''S, 35º16'59''E, 2002 MASL) and *L. javanica* from Nakuru (0º20'23.52''S, 35º56'34.67'', 2250 MASL), Kenya in December, 2019. The fresh plant leaves were separately packed in paper bags and transported to the laboratory for essential oil extraction. The identification of plant species was carried out on sight based on professional expertise, literature materials and pictorial aids (Bett et al., 2016). The preserved samples of each plant species were presented to Plant Taxonomist, from Department of Biological Sciences, Egerton University for confirmation of identity. The preserved voucher samples of plant materials were then deposited at the herbarium of Egerton University. The fresh leaves of *C. lusitanica, O. americanum* and *L. javanica* weighing 500g were water extracted using a modified Clevenger-type apparatus. After 4 (h) of hydro-distillation the floating oil on top of the water was collected. The remaining water in the oil removed over anhydrous sodium sulphate (Na2SO4) and dried oil stored in the refrigerator at below 4 ºC until use (Bett et al., 2016).

GC-MS analysis and determination of essential oil constituents

The chemical constituents of essential oils from plant leaves were analysed using an HP-7890A Gas Chromatograph (GC) connected to an HP 5975 C Mass Spectrometer (MS) (Agilent, Wilmington, USA) at the International Centre of Insect Ecology and Physiology (ICIPE), Nairobi. From each sample 1mg was separately weighed and dissolved in 1 mL dichloromethane, dried using anhydrous sodium sulphate (Na2SO4) to make a stock solution (1 mg/mL). The experimental sample was obtained whose final concentration was 100 ng/µL. The samples were analyzed on an GC-MS in in full scan mode and a HP-5 MS low bleed capillary column (30 m × 0.25 mm i.d., 0.25 µm) (J and W, Folsom, CA, USA). The carrier gas was Helium (1.25 ml/min, constant flow mode) and the injection mode was split mode. The oven temperature was programmed at 35 ºC (for 5 min) to 280 ºC at 10 ºC/ min(5.5min) and then at 285ºC @50ºC/min (14.9 min) and the total run time was 50 min. The electron ionization mass spectra were acquired at 70 eV within a mass range of 38–550 Daltons (Da) during a scan time of 0.73 scans s-1 whereas the ion source was maintained at a temperature of 230 ºC. The essential oil constituents were identified by comparing mass spectra with library data (NIST05a and Adams MS HP, USA) and by comparison of the retention times with mass spectra (Adams et al., 1997).

RESULTS

The percentage yields (w/w) of essential oil extraction indicate that *C. lusitanica* leaves were richer (0.35 ± 0.2%) in essential oils as compared to *O. americanum* (0.27 ± 0.06%) and *L. javanica* (0.15 ± 0.09%). Tables 1 to 3 shows the retention time (min) identified chemical constituents and percentage concentration of oils obtained from *C. lusitanica, O. americanum* and *L. javanica.* The results of *C. lusitanica*, *O. americanum* and *L. javanica* essential oil extraction and GC-MS analysis showed that the oils were dominated by monoterpenes. However, each of the essential oils had different major chemical constituents. In *C. lusitanica* oil, 91 compounds were identified, corresponding to 99.8% of the total essential oil composition. The monoterpene hydrocarbons were 38.63%- dominated by α-pinene (13.8%), limonene

Table 1. Retention time (min), Retention Index (RI) identified chemical constituents and percentage concentration of oils obtained from *C. lusitanica* leaves.

PK No.	Retention time	Retention index	Compound name	Mean % concentration (n=3)
1	7.38	823	(E)-3-Methylpenta-1,3-diene-5-ol	0.01
2	8.56	869	2-Heptanol	0.06
3	8.90	882	Tricyclene	0.07
4	9.31	898	α-Pinene	13.80
5	9.52	908	Camphene	0.28
6	9.66	914	2-methyl-5-(1-methylethyl)-, (1.α.,2.α.,5.α.)-Bicyclo[3.1.0]hex-3-en-2-ol,	0.04
7	10.11	934	Sabinene	3.41
8	10.29	942	1-Octen-3-ol	0.05
9	10.50	952	Myrcene	2.32
10	10.72	962	α-Phellandrene	0.85
11	10.82	966	δ-3-Carene	0.56
12	10.97	973	δ-2-Carene	1.70
13	11.18	982	ortho-Cymene	4.07
14	11.27	986	Limonene	6.64
15	11.58	1000	(E)-β-Ocimene	0.11
16	11.77	1012	γ-Terpinene	1.72
17	11.91	1021	cis-Sabinene hydrate(IPP vs OH)	0.07
18	12.29	1043	Terpinolene	2.05
19	12.34	1046	2-Nonanone	0.21
20	12.68	1067	1,3,8-para-Menthatriene	0.06
21	12.84	1077	cis-para-Menth-2-en-1-ol	0.13
22	13.07	1091	bis(1-methylethylidene)-Cyclobutene	0.06
23	13.14	1095	E,E-2,6-Dimethyl-1,3,5,7-octatetraene	0.30
24	13.30	1104	Camphene hydrate	0.22
25	13.49	1116	2,6,6-trimethyl-, (1.α,2β.,5.α.)-Bicyclo[3.1.1]heptan-3-one	0.02
26	13.83	1136	Umbellulone	12.66
27	13.87	1138	Terpinen-4-ol	1.37
28	13.90	1098	α,α,4-trimethyl-Benzenemethanol,	0.18
29	13.96	1143	Cryptone	0.19
30	14.00	1145	α-Terpineol	0.42
31	14.33	1165	1-(2-furanyl)-Ethanone	0.03
32	14.43	1171	Propanoic acid, 2-octyl ester, (R or S)	0.34
33	14.50	1175	3,7-dimethyl-2-Octen-1-ol	0.09
34	14.74	1189	Carvacrol methyl ether	0.33
35	14.93	1200	3-methyl-6-(1-methylethyl)-2-Cyclohexen-1-one	0.09
36	15.24	1220	4-(1-methylethyl)-1-Cyclohexene-1-carboxaldehyde	0.10
37	15.37	1229	Bornyl acetate	0.28
38	15.44	1234	Thymol	0.31
39	15.56	1242	3,7,7-trimethyl-Bicyclo[4.1.0]hept-2-ene	0.25
40	15.73	1254	2E,4E-Decadienol	0.15
41	15.92	1266	Myrtenyl acetate	0.10
42	16.09	1277	(1R)-2,2-dimethyl-3-methylene-Bicyclo[2.2.1]heptane	0.08
43	16.64	1315	*α*-Copaene	0.48
44	16.89	1333	cis-Muurola-3,5-diene	0.15
45	16.93	1336	1-methyloctyl ester-Butanoic acid	0.09
46	17.00	1341	α-Funebrene	0.18
47	17.10	1348	Acora-3,7(14)-diene	0.08
48	17.16	1352	α-Cedrene	0.34
49	17.24	1359	E-Caryophyllene	1.33

Table 1. Contd.

50	17.63	1386	Dauca-5,8-diene	0.81
51	17.68	1390	α-Humulene	0.46
52	17.75	1395	δ-Cadinene	0.31
53	17.81	1399	*β*-Cubebene	1.62
54	17.91	1407	trans-Cadina-1(6),4-diene	0.46
55	18.00	1414	27.96 Curcumene<ar->	2.10
56	18.17	1427	cis- Muurola-3,5-diene	1.69
57	18.26	1434	Amorpha-4,7(11)-diene	2.99
58	18.38	1443	β-Curcumene	2.71
59	18.46	1449	γ-Cadinene	3.13
60	18.58	1458	δ- Cadinene	7.47
61	18.67	1465	trans-Cadina-1,4-diene	0.52
62	18.72	1469	α-Cadinene	1.09
63	18.95	1487	trans-Dauca-4(11),7-diene	0.29
64	19.02	1492	α-Calacorene	0.13
65	19.18	1505	1,6-dien-5-ol-Germacra	0.59
66	19.26	1512	Germacrene B	0.21
67	19.53	1534	Cedrol	0.54
68	19.64	1543	1,10-di-epi-Cubenol	0.48
69	19.79	1556	1-epi-Cubenol	0.78
70	19.84	1560	Italicene	1.44
71	19.97	1570	γ-Cadinene	4.79
72	20.13	1584	α-Cadinol	3.99
73	20.39	1606	α-Bisabolol	0.57
74	20.81	1642	6-Isopropenyl-4,8a-dimethyl- 1,2,3,5,6,7,8,8a-octahydro-naphthalen-2-ol	0.10
75	20.94	1653	Cyclopentadecanolide	0.09
76	22.02	1766	6,10,14-trimethyl-2-Pentadecanone	0.03
77	22.58	1826	Cis-A/B-Sclareoloxide	0.02
78	22.75	1842	Isopimara-9(11),15-diene	0.02
79	23.43	1906	Isophyllocladene	0.61
80	23.66	1931	13-epi-Manool oxide	0.27
81	23.81	1947	4-methylene-2,8,8-trimethyl-2-vinyl-Bicyclo[5.2.0]nonane	0.02
82	23.92	1960	Phyllocladene	0.07
83	24.09	1978	7-butyl-1-hexyl-Naphthalene	0.02
84	24.23	1994	(4aS-trans)1,2,3,4,4a,9,10,10a-octahydro-1,1,4a-trimethyl-7-(1-methylethyl)Phenanthrene	0.20
85	24.40	2012	5-α-Androst-16-en-3-one	0.04
86	24.50	2022	Abietadiene	0.13
87	24.93	2068	Nezukol	0.21
88	25.46	2124	Sandaracopimarinal	0.05
89	26.25	2212	Sempervirol	0.08
90	26.48	2238	trans-Totarol	0.29
91	26.62	2255	cis- Ferruginol	0.17
			Total identified (%)	99.8
			Monoterpene hydrocarbons	38.63
			Oxygenated monoterpenes	15.77
			Sesquiterpene hydrocarbons	35.37
			Oxygenated sesquiterpenes	6.56
			Diterpenes	2.14
			Others	1.53

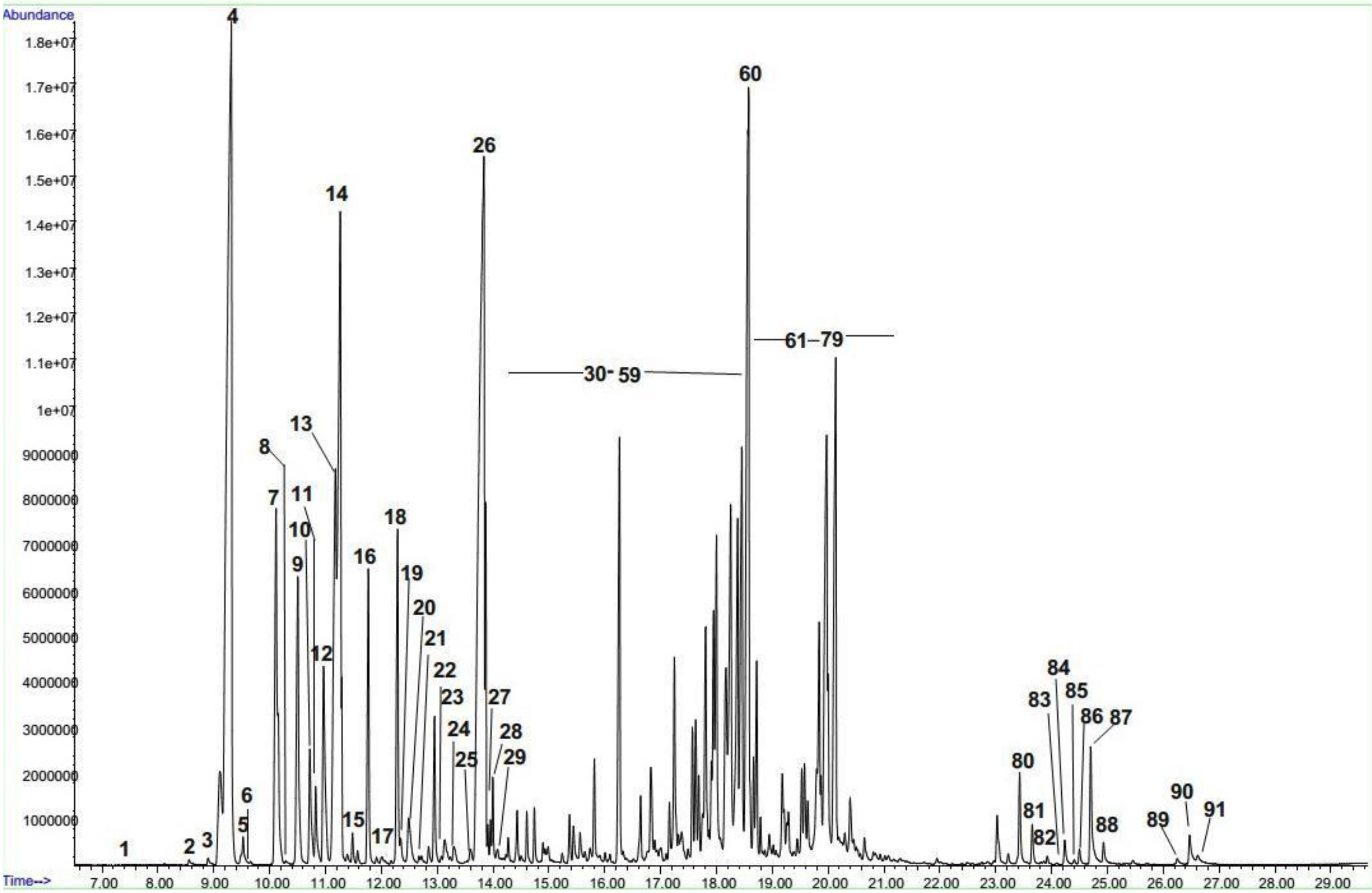

Figure 1. Representative of total ion chromatogram of the leaf essential oil of *C. lusitanica*, Peaks 1 to 91 indicate the essential oil components identified in Table 1.

(6.64%) and ortho-cymene (4.07%). On the other hand oxygenated monoterpenes were 15.77% with umbellulone (12.66%) and Terpinen-4-ol (1.37%) as major compounds. The sesquiterpene hydrocarbons and oxygenated sesquiterpenes were 35.37 % and 6.56% respectively. The major sesquiterpene hydrocarbons and oxygenated sesquiterpenes were cadinene (7.47%) and α-cadinol (3.99%), respectively (Table 1 and Figure 1).

Table 2 and Figure 2 shows the retention time (min) identified chemical constituents and percentage concentration of oils obtained from *O. americanum.* In total, 72 compounds were identified, corresponding to 99.5 % of the total essential oil composition. The leaf essential oil contained 36.32, 36.19, 24.4 and 1.85% monoterpenes hydrocarbons, oxygenated monoterpenes, sesquiterpene hydrocarbons, and oxygenated sesquiterpenes, respectively.

The major monoterpenes hydrocarbons were1, 8-cineole (17.48%), camphor (7.55%) and myrecene (2.75%) whereas oxygenated monoterpenes were geraniol (18.72%), Eugenol (6.40%), and geranyl propanoate (3.91%). On the other hand, sesquiterpenes hydrocarbons were represented by elemicin (8.20%), β-bisabolene (3.78%) and caryophyllene (E) (2.22%) whereas oxygenated sesquiterpenes were in trace amounts. The composition of the essential oil of *L. javanica* is listed in Table 3 and the peaks depicted in Figure 3. As shown, a total of forty-seven (47) compounds were identified, consisting of mainly of oxygenated monoterpenes (67.82%) followed by sesquiterpene hydrocarbons (19.35%), monoterpene hydrocarbons (10.95%) and oxygenated sesquiterpenes (1.34%). It's noted that the major monoterpene hydrocarbon was myrcene(7.04%) whereas oxygenated monotwerpenes were mainly ipsdienone (26.07%), ocimenone (14.32%), and bicyclo [3.1.1]hept-3-en-2-one, 4,6,6-trimethyl-, (1S)-(10.91%), On the other hand sesquiterpene hydrocarbons were dominated by caryophyllene(E) (5.11%) and germacrene D (4.78%). When the chemical constituents of the three essential oils were compared, the highest amounts of monoterpenes were found in *L. javanica* (87.77%), followed by *O. americanum (*72.51%) and *C. lusitanica* (54.40%) in decreasing amounts, respectively. The converse was the

Table 2. Retention time (min), Retention Index (RI) identified chemical constituents and percentage concentration of oils obtained from *O. americanum* leaves.

PK No.	Retention time	Retention index	Compound name	Mean % concentration (n=3)
1	9.07	889	α-Thujene	0.04
2	9.19	894	α-Pinene	0.59
3	9.51	907	Camphene	0.48
4	10.12	935	β-Pinene	1.81
5	10.29	942	1-Octen-3-ol	0.15
6	10.43	949	6-methyl-5-Hepten-2-one	0.45
7	10.49	951	Myrcene	2.75
8	10.61	957	3-Octanol	0.17
9	10.71	961	α-Phellandrene	0.33
10	10.95	972	δ-2- Carene	0.33
11	11.11	979	para-Cymene	0.15
12	11.18	982	D-Limonene	0.88
13	11.31	988	1,8-Cineole	17.48
14	11.38	991	(Z)-β-Ocimene	1.16
15	11.52	997	Phenylacetaldehyde	0.05
16	11.57	1000	(E)-β-Ocimene	1.09
17	11.75	1011	γ-Terpinene	0.46
18	11.91	1020	trans-Sabinene hydrate(IPP vs OH)	0.30
19	12.17	1036	trans-(-)5-methyl-3-(1-methylethenyl)-Cyclohexene	0.04
20	12.43	1051	1-(6,6-dimethylbicyclo[3.1.0]hex-2-en-2-yl)-Ethanone	0.07
21	12.49	1055	Linalool	2.34
22	12.63	1064	Ketone, isopropylidenecyclopropyl methyl	0.11
23	12.75	1011	2-methyl-6-methylene-1,7-Octadien-3-one	0.08
24	12.97	1084	allo-Ocimene	0.93
25	13.18	1097	neo-allo-Ocimene	0.15
26	13.27	1103	Camphor	7.55
27	13.52	1117	Pinocarvone	0.09
28	13.70	1128	4-methyl-Phenol	0.06
29	13.75	1131	Terpinen-4-ol	0.66
30	13.97	1143	α- Terpineol	1.31
31	14.05	1149	(-)-Myrtenol	0.52
32	14.52	1176	Nerol	0.46
33	14.71	1187	Neral	0.16
34	15.02	1206	Geraniol	18.72
35	15.16	1215	Geranial	0.47
36	15.57	1243	Geranyl formate	0.13
37	15.72	1253	(Z)-7-methyl-,2-Decene	0.05
38	16.26	1289	α-Cubebene	0.17
39	16.39	1297	Eugenol	6.40
40	16.54	1308	E-Isoeugenol	0.45
41	16.67	1317	Geranyl propanoate	3.91
42	16.78	1325	β-Bourbonene	1.00
43	16.82	1328	Germacrene D	0.53
44	17.04	1344	8,9-dehydro-Cycloisolongifolene,	0.13
45	17.10	1348	α-Gurjunene	0.07
46	17.24	1359	E-Caryophyllene	2.22
47	17.35	1366	β-Copaene	0.32
48	17.39	1369	α-cis-Bergamotene	0.56
49	17.48	1375	Sesquisabinene	0.08

Table 2. Contd.

50	17.55	1380	Germacrene B	0.14
51	17.61	1385	(E)-beta-Farnesene	1.11
52	17.67	1389	α-Humulene	0.41
53	17.79	1398	trans-5-diene-Muurola-4(14),	0.22
54	17.93	1409	γ-Amorphene	0.15
55	18.02	1415	Germacrene A	0.76
56	18.08	1420	α-trans-Bergamotene	0.38
57	18.16	1426	Z-Methyl isoeugenol	0.41
58	18.21	1430	α- Muurolene	0.26
59	18.31	1438	β-Bisabolene	3.78
60	18.41	1446	trans-Muurola-4(14),5-diene	0.29
61	18.50	1453	δ-Amorphene	0.51
62	18.63	1462	cis-Cadina-1,4-diene	0.09
63	18.70	1468	(Z)-α-Bisabolene	1.79
64	18.76	1473	α-(eller b-) Calacorene	0.13
65	18.86	1480	Elemicin	8.20
66	19.16	1503	2,7-dimethyl-5-(1-methylethenyl)-1,8-Nonadiene	0.19
67	19.25	1511	1,Z-5,E-7-Dodecatriene	0.40
68	19.29	1514	Caryophyllene oxide	1.14
69	19.89	1564	4,4-dimethyl-Tetracyclo[6.3.2.0(2,5).0(1,8)]tridecan-9ol	0.34
70	19.97	1570	Elemicin	0.20
71	20.08	1579	α-Cadinol	0.14
72	25.12	2088	Octadecanoic acid	0.02
			Total identified (%)	99.5
			Monoterpene hydrocarbons	36.32
			Oxygenated monoterpenes	36.19
			Sesquiterpene hydrocarbons	24.4
			Oxygenated sesquiterpenes	1.85
			Diterpenes	-
			Others	1.24

situation with sesquiterpenes, with the highest percentage detected in *C. lusitanica* (41.93 %) followed by *O. americanum* (26.25%) and *L. javanica* (20.69 %), respectively. Diterpenes were found in trace amounts (2.14%) in *C. lusitanica* leaf essential oils.

DISCUSSION

The chemical constituents of *C. lusitanica*, *O. americanum* and *L. javanica* essential oils revealed in the present study indicate a variation in yield, number and concentration of chemical constituents. However, the main chemical constituents in oils of the three plant species were dominated by monoterpene hydrocarbons. It is noted that in *C. lusitanica* oil, the major compounds were; α–pinene, umbellulone and Limonene. The finding of the current study are also comparable to previous researches which have shown chemical composition of *C. lusitanica*, *O. americanum* and *L. javanica* varied with countries and region. For instance Teke et al. (2013) found *C. lusitanica* to contain mainly germacrene D (18.5%), epi-zonarene (8.2%), cis-calamenene (8.2%), terpinen-4-ol (6.3%), linalool (6.0%) and umbellulone (6.0%). Similarly, the main components *C. lusitanica* oils has been found also to contain α-pinene (70.1%), δ-3-carene (45.4%), umbellulone (15.2%), β-phellandrene (10.8%) terpinen-4-ol (9.7%) and myrcene (5.8%) (Bett et al., 2016). On the other hand, the main chemical constituents in *O. americanum* essential oil were Geraniol, 1, 8-cineole, elemicin and Camphor. In other studies, the main chemical constituents in *O. americanum* oil have been reported to include citral, linalool, geraniol, citronellol and 1, 8-cineole (Ilboudo et al., 2010; Yamada et al., 2013). In the same way, *L. javanica* oil was dominated by ipsdienone, ocimenone, and bicyclo [3.1.1] hept-3-en-2-one, 4, 6, 6-trimethyl-, (1S)-, myrcene, caryophyllene (E) and germacrene D.

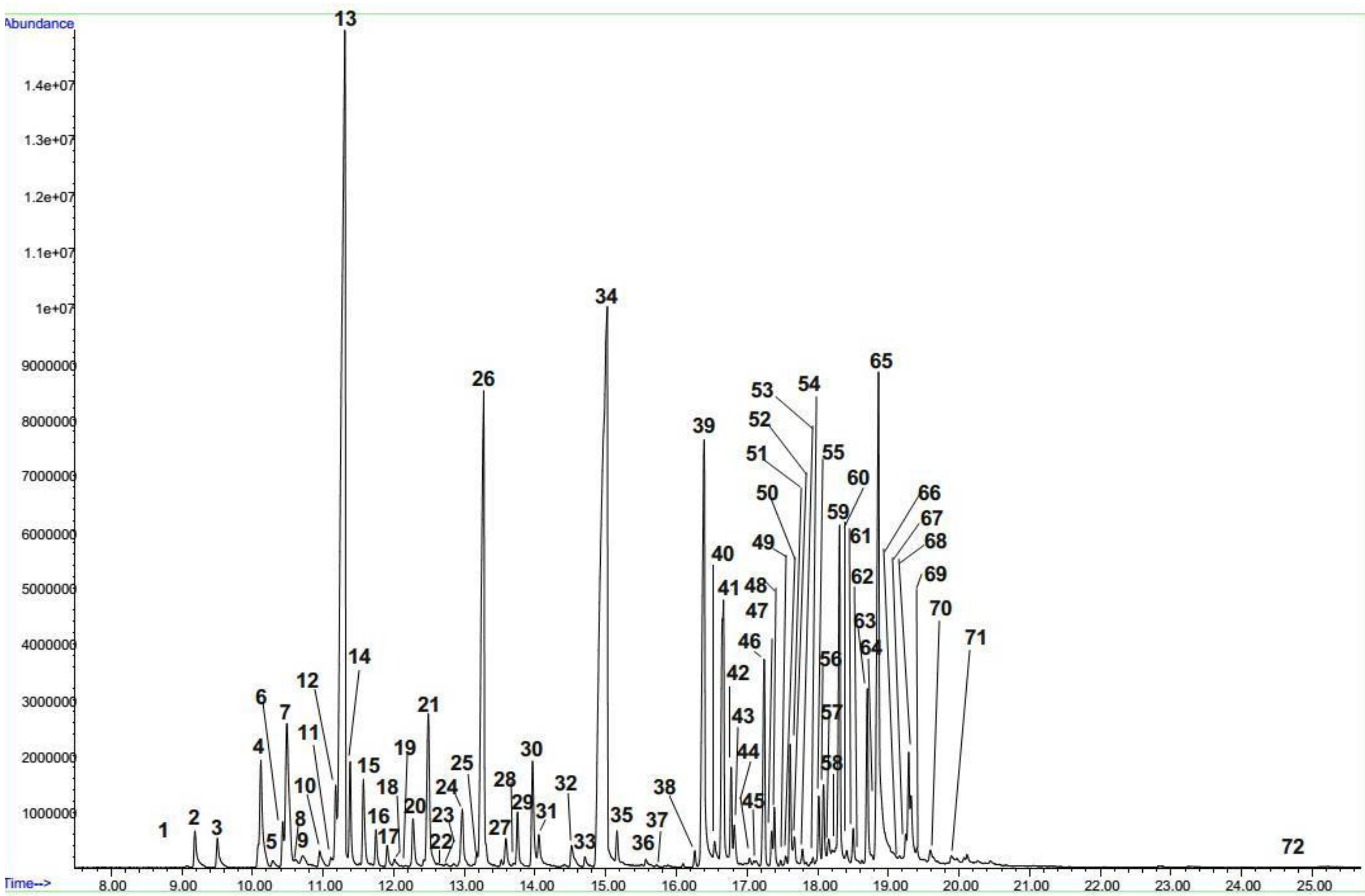

Figure 2. Representative of total ion chromatogram of the leaf essential oil of *O. americanum*, Peaks 1 to 72 indicate the essential oil components identified in Table 2.

Several other authors have indicated that *Lippia javanica* oil is rich in caryophyllene, carvone, ipsenone, ipsdienone, limonene, linalool, myrcene, myrcenone, ocimenone, *p*-cymene, piperitenone, sabinene, and tagetenone (Viljoen et al., 2005; Lukwa et al., 2009; Chagonda and Chelchat, 2015; Maroyi, 2017).

However, Viljoen et al. (2005) using cluster analysis, found that *L. javanica* chemotypes growing in South Africa and Swaziland, were rich in myrcenone (36 to 62%), carvone- (61 to 73%), piperitenone- (32 to 48%), ipsdienonerich (42 to 61%), and linalool (>65%). The variations observed in chemical constituents and concentrations may be influenced by climatic and soil conditions in different the regions, which directly affect the metabolic processes of the plant (Chéraif et al., 2007), but also may arise from interaction of different biotic components. In addition, it has also been found that chemical constituents of essential oils could differ with species of plant, season, geographic region, and age of the plant, and the method used to extract essential oil extraction (Brooker and Kleinig, 2006, Bernard et al., 2020; Baccaria et al., 2020).

The chemical constituents found in oils in current study have been found in previous studies to have insecticidal properties against insect pests (Lee et al., 2003; Rosman et al., 2007 and Nivea et al., 2013). This supports the findings of Ilboudo et al. (2010); Olivero-Verbel et al. (2013) who reported that 1, 8-cineole, limonene and α-pinene were associated with contact toxicity of essential oils against insect pests. Similarly, Rozman et al. (2007) reported essential oils constituents containing, eugenol, 1,8-cineole, camphor and linalool to cause mortality of 85-100, 80-100 and 0-13% mortality of adult *Sitophilus oryzae*, *Rhizopherta dominica* and *Tribolium castaneum,* respectively.

The repellent properties of the major chemical constituents of essential oils of plant leaves for instance 1, 8-cineole, terpineol and α-pinene have also been reported in different researches (Tapondjou et al., 2005; Toloza et al., 2006; Bett et al., 2016). Furthermore, constituents of essential oils such as 1, 8-cineole, *p*-cymene, and γ-terpinene and α-pinene have earlier been reported to possess reproductive inhibition properties against insect pests (Sedaghat et al., 2011; Alzogaray et

Table 3. Retention time (min), Retention Index (RI) identified chemical constituents and percentage concentration of oils obtained from *L. javanica* leaves.

Peak No.	Retention Time	Retention Index	Compound name	Mean% concentration (n=3)
1	9.28	897	Camphene	0.18
2	9.86	923	Sabinene	0.15
3	10.07	932	1-Octen-3-ol	0.41
4	10.28	942	Myrcene	7.04
5	10.81	966	Menthatriene<1,3,8-para->	1.50
6	10.97	973	Limonene	0.32
7	11.01	975	Eucalyptol	0.14
8	11.17	982	Ocimene<(Z)-beta->	0.40
9	11.36	990	Ocimene<(E)-beta->	0.85
10	11.45	995	Tagetone<dihydro->	2.40
11	11.64	1004	2-Methyl-6-propylphenol	0.25
12	11.76	1011	2,4,6-Octatriene, 2,6-dimethyl-, (E,Z)-	0.05
13	12.16	1035	Epoxymyrcene<6,7->	0.34
14	12.28	1043	1,6-Octadien-3-ol, 3,7-dimethyl-	3.78
15	12.70	1068	Chrysanthenone	0.40
16	12.76	1072	Ocimene<allo->	0.43
17	13.01	1087	Camphor	0.60
18	13.18	1097	Ipsdienone	26.07
19	13.34	1106	Sorbic acid vinyl ester	1.35
20	13.61	1122	Anethole<E->	0.42
21	13.77	1132	a- Terpineol	2.05
22	14.06	1149	Verbenone	0.86
23	14.44	1171	Ocimenone<E->	14.32
24	14.55	1177	Bicyclo[3.1.1]hept-3-en-2-one,4,6,6-trimethyl-, (1S)-	10.91
25	14.99	1200	2-Cyclohexen-1-one, 6-(1-hydroxy-1-methylethyl)-3-methyl-	2.62
26	15.28	1200	1,3-Cyclohexadiene-1-carboxaldehyde, 2,6,6-trimethyl-	0.66
27	15.88	1263	Germacrene B	0.23
28	15.95	1268	Piperitenone	0.51
29	16.04	1274	Muurola-3,5-diene<cis->	0.25
30	16.16	1282	Eugenol	0.44
31	16.42	1299	Copaene<alpha->	0.32
32	16.55	1308	Bourbonene<beta->	0.39
33	16.62	1313	Elemene<beta->	0.60
34	17.02	1343	Caryophyllene(E-)	5.11
35	17.13	1351	Copaene<beta->	1.56
36	17.33	1364	Cadinene<gamma->	0.58
37	17.45	1373	Humulene<alpha->	1.36
38	17.55	1380	Aromadendrene<allo->	0.55
39	17.72	1393	Cadinene<gamma->	0.31
40	17.80	1399	Germacrene D	4.78
41	17.94	1409	Cadinene<gamma->	0.31
42	18.01	1415	Muurolene<gamma->	1.35
43	18.19	1428	Muurola-4(14),5-diene<trans->	0.29
44	18.28	1435	Cadinene<delta->	0.65
45	19.05	1495	Caryophyllene oxide	0.33
46	20.25	1593	Germacra-4(15),5,10(14)-trien-1-alpha-ol	0.22
47	24.78	2052	3-Methylbut-2-enoic acid, 4-nitrophenyl ester	0.47
			Total identified (%)	99.7

Table 3. Contd.

Monoterpene hydrocarbons	10.95
Oxygenated monoterpenes	67.82
Sesquiterpene hydrocarbons	19.35
Oxygenated sesquiterpenes	0.54
Diterpenes	-
Others	1.34

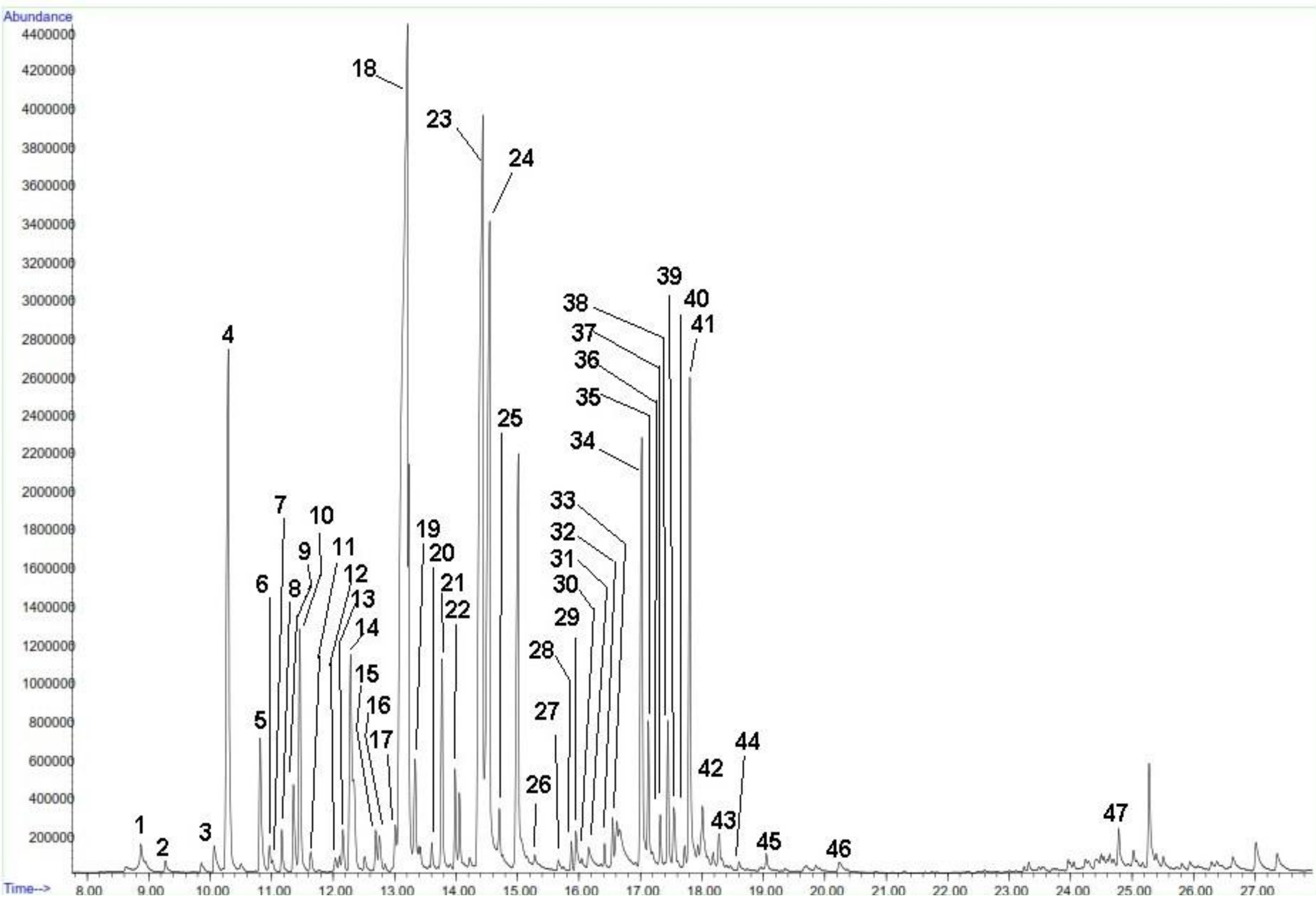

Figure 3. Representative of total ion chromatogram of the leaf essential oil of *L. javanica*, Peaks 1 to 47 indicate the essential oil components identified in Table 3.

al., 2011 and Gomah et al., 2015). For instance essential oils of *Cupressus arizonica* been found to have larvicidal activity against larvae of *Anophhleles stephensi*. The main essential oils constituents in the oil *C. arizonica* include limonene (14.44%), umbellulone (13.25%) and α-pinene (11%) (Sedaghat et al., 2011). Hence, the findings of this study is a proof that *C. lusitanica*, *O. americanum* and *L. javanica* and others possess pesticidal properties that may be exploited sustainably and cheaply for use in agriculture and related applications.

Conclusion

From the results of this study, it may be concluded that essential composition of *C. lusitanica*, *O. americanum* and *L. javanica* composition and classification were into various chemotypes varied with plant species. The essential oil constituents consisted mainly of monoterpenes that are known to have antifeedant, repellent, reproductive inhibition and insecticidal properties against insect pests of field and stored products insect pests. The presence of potentially insecticidal bioactive compounds in *C. lusitanica*, *O. amicanum* and *L. javanica* provides scientifically stimulating since natural insecticides are ecologically and environmentally friendly for the management of insect pests.

RECOMMENDATIONS

The authors recommended more studies to be carried out on the bioactivity of the essential oils against various field and stored insect pests' product. Therefore, the results of present study may lead to the formulation of new natural insecticides for management of insect pests.

ACKNOWLEDGEMENTS

The authors wish to appreciate Egerton University, through the Division of Research and Extension, for their financial and technical support towards this study. They wish also to thank the International Centre of Insect Physiology and Ecology (ICIPE) for assisting with GC-MS analysis apparatus and Mr Xavier Cheseto for providing technical support during GC-MS analysis process of essential oils.

CONFLICT OF INTERESTS

The authors have not declared any conflicts of interests.

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