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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 8 (2): 249-254, 2005
ISSN 1028-8880

Chemical Composition of Essential Oils from Leaves-stems, Flowers and Roots of *Inula graveolens* from Tunisia

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Abstract: This study lies within the scope of the valorisation of medicinal and aromatic plants of the Tunisian flora in the aim to find novel bioactive natural products. The essential oil constituents from the aerial part without flowers (stems and leaves), flowers and roots of *Inula graveolens* (L.) Desf., syn. *Dittrichia graveolens* (Desf.) Greuter, gathered in the area of Monastir (Tunisia) have been studied by GC-FID and GC-MS. Remarkable differences were found between the constituent percentages of the different studied organs. The most important compounds from the aerial part without flowers were τ-cadinol (9.2%), borneol (21.4%), bornyl acetate (33.4%). In the flowers oil, the main components found were Camphene (5.5%), τ-cadinol (11.3%), borneol (19.3%), bornyl acetate (39.6%). The major constituents in the oil roots were found to be carvone (5.0%), bornyl acetate (5.3%), p-mentha-1(7), 2-dien-8-ol (5.3%), β-selinene (11.5%) and a non identified compound (n°85, 22.2%). A comparison of these data with previous results reported in the literature showed surprising differences.

Key words: *Inula graveolens*, different organs, essential oil, hydrodistillation, GC-FID, GC-MS

INTRODUCTION

The genus *Inula* L. belongs to the Asteraceae family. Pottier-Alapetite[1], considered for this genus four species occurring in Tunisia: *Inula viscosa* (L.) Ait, *I. graveolens* (L.) Desf., *I. crithmoides* L. and *I. montana* L. Var. *calycina* (Presl) Batt.

Inula graveolens, syn. *Dittrichia graveolens* (Desf.) Greuter, is one of the most conspicuous plants of late summer flowering in large profusion from September to December. It grows along road sides, on waste grounds, in humid soil and near subsalt lands. It is distributed in the Eastern part of the country and some scattered places in the north east, but never can it be found in the south. *Inula graveolens* is an annual plant that grows about 80 cm high. The stems are covered with small, soft hair, the leaves are oval and pointed, the flowers are small, yellow and have the smell of camphor. The roots are fleshy. The essential oil is known as the most effective oil for loosening mucous and deep congestion. It is also useful for cute and chronic respiratory conditions such as coughs, colds, sinusitis (sinus infections) laryngitis and bronchitis. It supports lymphatic circulation as well as the immune system, it also reduces acneic skin inflammation[2]. Le Floc'h[3] and Boukef[4] have not reported about its possible use in popular medicine in Tunisia. Several *Inula* species have been used in various treatments; for calculus, for eye, as diuretic, poison and sudorific[5].

The essential oil composition of some species of this genus has been previously reported[6-8]. Previous studies on *I. graveolens* revealed that studies on the essential oil composition of the aerial parts are very scarce. Most have been carried out on dried material. There are no studies on the composition of the essential oil of the roots. Nevertheless, different aerial part extracts have been chemically investigated and several sesquiterpene lactones[9], benzoic acid derivatives and other compounds[10, 11], were reported. Only one work has been done on *I. graveolens* from Tunisia and 17 constituents were identified in the aerial part essential oil showing, in mixture, antibacterial activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*[12].

The oil of aerial parts of *I. graveolens* growing in Corsica[13], showed the occurrence of 13 main components

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from which bornyl acetate and borneol (65.8-75.6%) were always the two major compounds. Camphene, limonene, α-terpineol, 1, 5 and 1(7), 2-*p*-menthadienols were present at appreciable contents. *(E)*-caryophyllene and *(E)*-caryophyllene epoxide, caryophylladienol as well as τ-cadinol were the most important sesquiterpenes. The same authors showed that proportion of the compounds bornyl acetate, borneol and τ-cadinol changes throughout the life of the plant. Nevertheless, some differences were reported between oil compounds proportion of several plants collected in a restricted area. Marongiu *et al.*[14] reported that the hydrodistilled essential oil of *I. graveolens* aerial parts was mainly made up of selin-11-en-4-α-ol (14.1%), 1,10-di-*epi*-cubenol (10.3%), cedr-8(15)-en-9-α-ol (10.3%), caryophyllene oxide (6.2%) and nerolidol acetate (5.9%). This study reports the composition of the essential oils obtained by hydrodistillation from the whole stems and leaves, flowers and roots of *I. graveolens*. It also discusses the differences between the three compositions.

MATERIALS AND METHODS

Plant material: *Inula graveolens* was identified according to the flora of Tunisia[1]. A specimen was collected, dried and a voucher specimen was deposited at the herbarium (Asteraceae, n°23) of the Ecole Supérieure d'Horticulture et d'Elevage de Chott-Meriem, Université du Centre, Sousse, Tunisia. Plants were gathered at the flowering stage in November 2004 in the area of Monastir (latitude 35°46'0" N, longitude 10°59' 0" E, coastal region, east of Tunisia, with a sub-humid climate). The fresh plant was separated in three parts: stems and leaves (SL), flowers (F) and roots (R). Each part was divided in little peaces and weighted before extraction of essential oils.

Extraction of essential oils: Hydrodistillation of the fresh material was performed in a Clevenger-type apparatus for 4 h up to the point at which the oil contained in the matrix was exhausted. The oil obtained was collected and dried over anhydrous sodium sulphate and stored in sealed glass vials in a refrigerator at 4-5°C prior to analysis. Yield based on fresh weight of the sample was calculated.

Analyses of the essential oil

Gas Chromatograph: HP 5890-series II equipped with: Flame ionization detectors (FID), HP-5 (BP-1) (5% phenyl+95% dimethylpolysiloxane) 30 m x 0.25 mm ID, 0.25 μm film thickness fused capillary column and HP Innowax (BP-20) (polyethylenglycol) 30 m x 0.25 mm ID, 0.25 μm film thickness fused capillary column. The carrier gas was nitrogen (1.2 mL min^{-1}). The oven temperature program was 1 min isothermal at 50°C, then 50-280°C at rate of 5°C/min and held isothermal for 1 min. The injection port temperature was 250°C, detector 280°C. Volume injected: 0.1 μL of 1% solution (diluted in hexane). Percentages of the constituents were calculated by electronic integration of FID peak areas without the use of response factor correction.

GC/MS: The analyses of the volatile constituents were run on a Hewlett-Packard GC-MS system (GC: 5890 series II; MSD 5972).The fused-silica HP-5 MS capillary column (30 mx0.25 mm ID, film thickness of 0.25 μm) was directly coupled to the MS. The carrier gas was helium, with a flow rate of 1.2 mL min^{-1}. Oven temperature was programmed (50°C for 1 min, then 50-280°C at 5°C/min) and subsequently, held isothermal for 20 min. Injector port: 250°C, detector: 280°C, split ratio 1:50. Volume injected: 0.1 μL of 1% solution (diluted in hexane).

Mass spectrometer: HP5972 recording at 70 eV; scan time 1.5 sec; mass Range 40-300 amu. Software adopted to handle mass spectra and chromatograms was a ChemStation.

Identification of the compounds: The components of the oils were identified by comparison of their mass spectra with those of a computer library (Wiley 275 library). Further confirmation was done by referring to Kovαts Index data generated from a series of alkanes (C_9-C_{28})[15,16].

RESULTS AND DISCUSSION

I. graveolens do not yield the same amount of oil from the different parts. The total yield of essential oil obtained from (SL), (F) and (R) was 0.07, 0.17 and 0.06 (w/%), respectively. The three oils were light yellow, liquid at room temperature, their odours are agreeable. The composition of the volatile oils extracted by hydrodistillation from the different parts of the plant is reported in Table 1 together with the Kováts' Indices (KI) calculated for each compound, the percentage composition and the identification methods. The constituents are arranged according to their elution on the polar BP-20 capillary column. A total of 88 constituents were found from which 5 are Not Identified (NI).

Oils obtained from (SL) and (F) were characterized by the predominance of oxygenated monoterpenes in comparison with the rest of the constituents (Fig. 1). On the contrary, oil obtained from roots (R) was riche in oxygenated sesquiterpenes and sesquiterpene hydrocarbons (Fig. 1). Monoterpene hydrocarbons and

Table 1: Percentage composition of the essential oils from different parts of *I. graveolens*

N°	Compound	KI (BP-1)	KI (BP-20)	Percentage			Identification
				SL	F	R	
1	Tricyclene	926	1015	0.1	0.2	0.1	MS, KI
2	α-Thujene	931	1020	0.1	0.1	tr	MS, KI
3	α-Pinene	939	1026	tr	tr	tr	MS, KI
4	Camphene	944	1064	1.2	5.5	0.2	MS, KI
5	Cis-dihydroocimene	982	1088	-	0.1	-	MS, KI
6	β-Pinene	976	1107	0.2	1.0	0.1	MS, KI
7	δ-3-Carene	1010	1148	tr	tr	tr	MS, KI
8	Myrcene	991	1158	tr	tr	tr	MS, KI
9	α-Phellandrene	1002	1160	0.1	0.1	0.1	MS, KI
10	α-Terpinene	1015	1176	0.1	0.1	0.2	MS, KI
11	Dehydrocineole	978	1187	0.2	0.3	0.1	MS, KI
12	Limonene	1016	1196	tr	tr	tr	MS, KI
13	β-Phellandrene	1020	1206	tr	tr	0.1	MS, KI
14	γ-Terpinene	1057	1239	0.1	tr	tr	MS, KI
15	*(Z)*-β-Ocimene	1035	1244	tr	tr	tr	MS, KI
16	p-Cymene	1011	1265	0.1	tr	tr	MS, KI
17	Terpinolene	1078	1276	tr	tr	0.1	MS, KI
18	Tridecane	1300	1300	tr	0.1	0.1	MS, KI
19	Tetradecane	1400	1400	tr	tr	tr	MS, KI
20	p-Cymenene	1071	1430	0.1	0.1	0.1	MS, KI
21	α-Copaene	1378	1484	tr	tr	0.5	MS, KI
22	Artemisia alcohol	1066	1495	0.1	0.1	0.1	MS, KI
23	Clovene	1376	1496	0.1	0.1	tr	MS, KI
24	Camphor	1120	1508	0.1	0.1	0.1	MS, KI
25	β-Bourbobene	1380	1513	0.1	0.1	tr	MS, KI
26	Linalool	1081	1535	0.1	tr	0.3	MS, KI
27	β-Caryophyllene	1420	1567	0.3	0.4	2.4	MS, KI
28	Fenchol	1098	1571	0.1	0.1	0.5	MS, KI
29	Bornyl acetate	1272	1578	33.4	39.6	5.3	MS, KI
30	*(E)*-Caryophyllene	1419	1588	0.3	0.3	0.4	MS, KI
31	Terpinen-4-ol	1161	1590	1.7	0.9	1.1	MS, KI
32	Camphene hydrate	1133	1596	0.1	tr	tr	MS, KI
33	Hexadecane	1600	1600	0.2	0.2	tr	MS, KI
34	Allo-aromadendrene	1459	1633	0.5	0.4	tr	MS, KI
35	*(E)*-2-Decanal	1236	1634	0.1	tr	0.7	MS, KI
36	α-Humulene	1457	1658	0.1	0.1	0.3	MS, KI
37	γ-Muurolene	1471	1677	0.2	0.1	0.4	MS, KI
38	α-Terpineol	1171	1685	0.1	0.1	tr	MS, KI
39	Borneol	1149	1690	21.4	19.3	1.5	MS, KI
40	Heptadecane	1700	1700	0.1	0.1	0.4	MS, KI
41	Zonarene	1519	1702	0.4	0.3	0.3	MS, KI
42	p-Mentha-1,5dien-8-ol	1145	1708	0.6	0.4	2.6	MS, KI
43	α-Muurolene	1492	1712	1.4	1.2	0.6	MS, KI
44	Dihydrocarveol	1188	1713	0.1	0.1	tr	MS, KI
45	α-Bisabolene	1498	1715	0.1	0.1	0.2	MS, KI
46	β-Selinene	1483	1718	0.1	0.3	11.5	MS, KI
47	Germacrene-D	1478	1721	0.5	0.2	4.3	MS, KI
48	Carvone	1215	1727	0.3	0.1	5.0	MS, KI
49	Piperitone	1227	1732	0.8	0.5	1.2	MS, KI
50	δ-Cadinene	1514	1747	2.1	1.3	0.9	MS, KI
51	α-Amorphen	1527	1752	0.1	0.1	2.7	MS, KI
52	γ-Cadinene	1507	1758	0.1	1.5	0.2	MS, KI
53	4-Methylacetophenone	1154	1770	0.1	0.1	0.2	MS, KI
54	p-Mentha-1(7), 2-dien-8-ol	1168	1773	0.3	tr	5.3	MS, KI
55	Cadina-1,4-diene	1527	1776	0.1	0.1	tr	MS, KI
56	α-Cadinene	1530	1783	0.1	0.1	tr	MS, KI
57	Cis-Calamenene	1517	1827	0.5	0.3	0.6	MS, KI
58	Trans-Calamenene	1517	1830	0.1	0.1	1.3	MS, KI
59	Geranyl acetone	1426	1848	0.1	tr	0.2	MS, KI
60	p-Cymen-8-ol	1158	1852	0.3	0.2	0.1	MS, KI
61	Nonadecane	1900	1900	tr	tr	0.1	MS, KI
62	α-Calacorene	1539	1922	0.1	0.2	0.1	MS, KI
63	β-Ionone	1462	1933	0.3	0.4	tr	MS, KI
64	β-Calacorene	1548	1955	0.4	0.2	tr	MS, KI
65	Caryophyllene oxide	1572	1979	0.4	0.8	0.1	MS, KI

Table 1: (Continued)

66	Eicosane	2000	2000	tr	tr	tr	MS, KI
67	*(E)*-Nerolidol	1544	2032	0.2	0.2	tr	MS, KI
68	Heneicosane	2100	2100	0.1	tr	tr	MS, KI
69	6-Eudesmen-4-α-ol	1604	2167	0.1	0.1	1.1	MS, KI
70	τ-Cadinol	1628	2167	9.2	11.3	2.1	MS, KI
71	δ-Muurolol	1640	2177	0.7	0.4	0.3	MS, KI
72	Thymol	1266	2188	0.3	0.3	0.2	MS, KI
73	Docosane	2200	2200	0.3	0.2	0.1	MS, KI
74	Carvacrol	1273	2210	0.2	0.8	0.5	MS, KI
75	α-Cadinol	1640	2227	0.5	0.1	1.1	MS, KI
76	Tricosane	2300	2300	0.5	0.4	0.4	MS, KI
77	α-Cyperone	1729	2348	2.8	1.8	0.3	MS, KI
78	Tetracosane	2400	2400	1.5	0.4	0.1	MS, KI
79	NI MW 220 ($C_{15}H_{24}O$)	2215	2452	0.5	0.2	4.8	MS, KI
80	Pentacosane	2500	2500	1.1	0.9	tr	MS, KI
81	NI MW220 ($C_{15}H_{24}O$)	2248	2573	0.5	0.2	4.1	MS, KI
82	Hexacosane	2600	2600	0.8	0.3	0.4	MS, KI
83	Heptacosane	2700	2700	0.6	0.2	tr	MS, KI
84	Octacosane	2800	2800	0.4	0.1	tr	MS, KI
85	NI MW 232 ($C_{15}H_{20}O_2$)	2358	2812	3.7	0.6	22.2	MS, KI
86	NI MW 232 ($C_{15}H_{20}O_2$)	2440	2833	1.8	0.2	4.7	MS, KI
87	87NI MW 234 ($C_{15}H_{22}O_2$)	2580	2876	0.2	tr	0.1	MS, KI
88	Nonacosane	2900	2900	0.2	0.1	0.2	MS, KI
	Monoterpene hydrocarbons			2.3	7.2	1.0	
	Oxygenated monoterpenes			60.1	62.9	24.2	
	Sesquiterpene hydrocarbons			8.3	7.5	27.4	
	Oxygenated sesquiterpenes			20.6	15.9	41.8	
	Hydrocarbons			5.8	3.0	1.8	
	others			0.5	0.5	0.4	

The components and their percentages are listed in order of their elution on polar column (BP-20); tr : traces (<0.1%); (-) compound absent in the oil, SL: stems and leaves, F: Flowers; R: Roots.

Compound n° 79: EIMS *mz* (rel. intensity) 220 [M^+] (12.0); 55 (23.8); 67 (24.3); 79 (32.8); 91 (26.4); 93 (53.2); 107 (30.4); 121 (100); 122 (22.8); 149 (27.6).

Compound n° 81: EIMS *mz* (rel. intensity) 220 [M^+] (58.4); 55 (26.5); 67 (27.3); 77 (24.2); 79 (37.6); 91 (31.67); 93 (54.32); 107 (33.1); 121 (100); 122 (22.0); 149 (33.8).

Compound n° 85: EIMS *mz* (rel. intensity) 232 [M^+] (15.6); 71 (45.5); 77 (30.5); 79 (16.1); 103 (18.1); 105 (36.9); 133 (31.7); 145 (28.4); 162 (100).

Compound n° 86: EIMS *mz* (rel. intensity) 232 [M^+] (28.3); 71 (20.4); 77 (15.6); 91 (23.4); 105 (12.4); 115 (51.5); 133 (9.1); 145 (100); 146 (12.1); 162 (51.5).

Compound n° 87: EIMS *mz* (rel. intensity) 234 [M^+] (10.4). 71 (36); 77 (5.6); 91 (6.9); 105 (4.7); 115 (7); 131 (9.3); 133 (5.3); 135 (6.9); 145 (64.2);146 (100).

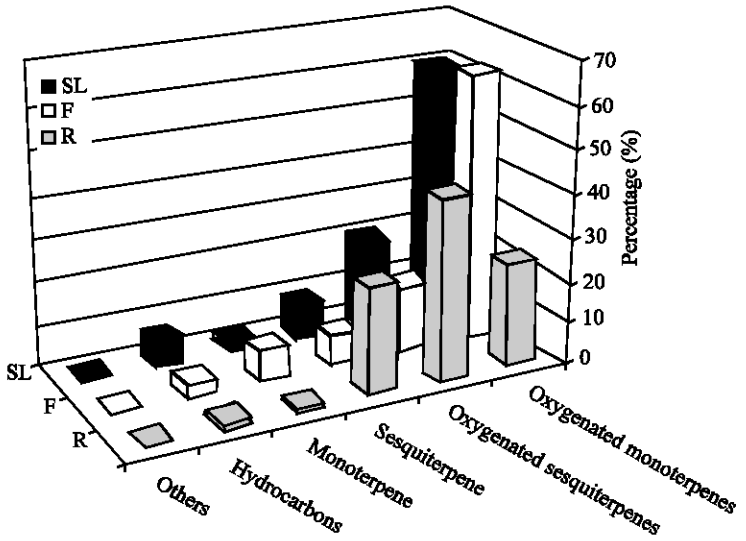

Fig. 1: Repartition of terpene compounds, hydrocarbons and others in the different organs of *Inula graveolens* (SL: Stems and leaves; F: flowers; R: roots)

hydrocarbons are not representative in all the studied organs (Fig. 1). Figure 1 also shows that the aerial parts (SL and F), are richer in oxygenated monoterpenes (60.1-62.9%), monoterpene hydrocarbons (2.3-7.2%) and hydrocarbons (5.8-3.0%) than roots. The latter contained more oxygenated sesquiterpenes (20.6-15.9%) and sesquiterpene hydrocarbons (8.3-7.5%). Oil from (SL) showed as main constituents τ-cadinol (n°70, 9.2%), borneol (n°39, 21.4%), bornyl acetate (n°29, 33.4%) (Fig. 2a). Hydrodistilled oil of flowers (F) contained mainly camphene (n°4, 5.5%), τ-cadinol (n°70, 11.3%), borneol (n°39, 19.3%), bornyl acetate (n°29, 39.6%) (Fig. 2b). The main components found in the oil obtained from roots were carvone (n°48, 5.0%), bornyl acetate (n°29, 5.3%), p-mentha-1(7), 2-dien-8-ol (n°54, 5.3%), β-selinene (n°46, 11.5%) and an unknown compound (n°85, 22.2%) (Fig. 2c).

We report differences between percentages of several constituents identified in (SL) and in (F) oils (Table 1). The latter was richer in camphene (n°4, 5.5%), bornyl acetate (n°29, 39.6%) and τ-cadinol (n°70, 11.3%) than (SL). Percentages in borneol (n°39, 21.4%), δ-cadinene (n°50, 2.1%) and compound 85 (n°85, 3.7%) were more important in the (SL) essential oil.

Roots essential oil shows great differences in the percentages of its constituents compared to those from the aerial parts without flowers (SL). It is especially richer in piperitone (n°49, 1.2%), β-caryophyllene (n°27, 2.4%), p-mentha-1, 5-dien-8-ol (n°42, 2.6%), α-amorphen (n°51, 2.7%), germacrene-D (n°47, 4.3%), carvone (n°48, 5.0%), p-mentha-1(7), 2-dien-8-ol (n°54, 5.3%), β-selinene (n°46, 11.5%) and in the unknown compounds 79, 81, 85, 86, 87, but exhibited less percentages in β-pinene (n°6, 0.1%), camphene (n°4, 0.2%), α-cyperone (n°77, 0.3%), α-muurolene (n°43, 0.6%), δ-cadinene (n°50, 0.9%), borneol (n°39, 1.5%), τ-cadinol (n°70, 2.1%) and bornyl acetate (n°29, 5.3%).

The chemical oil composition of the investigated samples exhibited significant differences with that extracted from the air-dried aerial parts of *I. graveolens* from Southern Sardinia[14]. It was mainly constituted of selin-11-en-4-α-ol (14.1%), 1,10-di-*epi*-cubenol (10.3%), cedr-8(15)-en-9-α-ol (10.3%), nerolidol acetate (5.9%) not identified in our samples and caryophyllene oxide (6.2%). Essential oil for the same species growing in Iran shows also differences in its main constituents and their percentages[17]. Those main constituents were borneol (60.7%), β-caryophyllene (8.3%), bornyl acetate (6.8%),

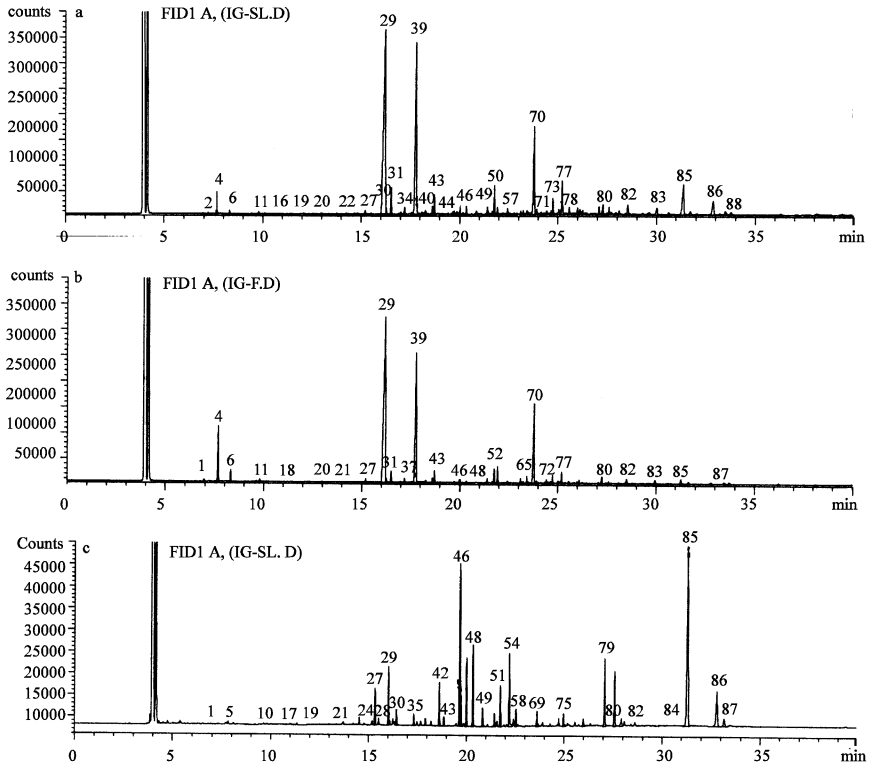

Fig. 2: Chromatograms *I. graveolens* (IG) essential oil of whole stems and leaves (SL) (a), flowers (F) (b) and roots (R) (c), run on a BP-20 capillary column

acetate (6.8%), τ-cadinol (5.2%) and caryophyllene oxide (4.3%). This comparative study shows clearly the effect of the plant origin on the composition of the corresponding essential oil. On the other hand, our results show more concordance with those given by Blanc *et al.*[13] done on the same species gathered in Corsica and permit to confirm the occurrence of the most constituents identified in *I. graveolens* commercial oil.

REFERENCES

1. Pottier-Alapetite, G., 1981. Flore de la Tunisie. Angiospermes-Dicotylédones Gamopétales. Publication Scientifiques Tunisiennes, pp : 971.
2. Oshadhi, USA., 2005. Authentic and genuine aromatherapy essential oils and products. http.//www.oshadhiusa.com/index.php.
3. Le Floc'h, E., 1983. Contribution à une étude ethnobotanique de la flore tunisienne. Programme flore et végétation tunisiennes. Publications scientifiques tunisiennes, Imprimerie Officielle de la République tunisienne, pp: 402.
4. Boukef, M.K., 1986. Les plantes dans la médecine traditionnelle tunisienne. Agence de coopération culturelle et technique, pp: 350.
5. Duke's, phytochemical and ethnobotanical databases, http://www.ars-grin.gov/cgi-bin/duke/ethanobot.pl
6. Bokadia, M.M., A.J. Macleod, S.C. Mehta, B.K. Mehta and H. Patel, 1986. The essential oil of *Inula racemosa*. Phytochemistry, 25: 2887-2888.
7. Shtacher, G. and Y. Kashman, 1971. Chemical investigation of volatile constituents of *Inula viscose*. Tetrahedron, 27: 1343-1349.
8. Pérez-Alonso, M.J., A. Velasco-Negueruela, M. Emin Duru, M. Harmandar and M.C.G. Vallejo, 1996. Composition of the volatile oil from the aerial parts of *Inula viscosa* (L.) Aiton. Flavour and Flagrance J., 11: 349-351.
9. Rustaiyan, A., J. Jakupovic, T.V. Chau-Thi, F. Bohlmann and A. Sadjadi, 1987. Further sesquiterpenes lactones from the genus *Dittrichia*. Phytochemistry, 26: 2603-2606.
10. Öksüz, S. and G. Topçu, 1992. A eudesmanolide and other constituents from *Inula graveolens*. Phyochemistry, 31: 195-197.
11. Topçu, G., S. Öksüz, H.L. Shieh, G.A. Cordell, J.M. Pezzuto and B.J. Candan, 1993. Cytotoxic and antibacterial sesquiterpenes from *Inula graveolens*. Phytochemistry, 33 : 407-410.
12. Braham, H., H. Ben Jannet, M.T. Martin and Z. Mighri, 2001. Etudes biologiques et chimique d'*Inula graveolens*, structures de sesquiterpènes, identification par CPG/SM de constituants des huiles essentielles. J. de la Société Chimique de Tunisie, 4: 1215-1222.
13. Blanc, M.C., A. Muselli, P. Bradesi and J. Casanova, 2004. Chemical composition and variability of the essential oil of *Inula graveolens* from Corsica. Flavour and Flagrance J., 19: 314-319.
14. Marongiu, B., A. Piras, F. Pani, S. Porcedda and M. Ballero, 2003. Extraction, separation and isolation of essential oils from natural matrices by supercritical CO_2. Flavour and Flagrance J., 18: 505-509.
15. Shibamoto, T., 1987. Retention indices in essential oil analysis, In: Capillary Gas Chromatography in Essential oil (Eds. P. Sandra and C. Bicchi) Dr. Alfred Heuthig, pp: 259-275.
16. Adams, R.P., 1995. Identification of Essential Oil Components by Gas Chromatography/Mass Spectrometry. Allured: Carol Stream, IL.
17. Mirza, M. and L. Ahmadi, 2000. Composition of the essential oil of *Dittrichia graveolens* (L.) Greuter. J. Essent. Oil Res., 12: 507-508.