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Comparative compositions of essential oils of *Ferula*

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Abstract
The essential oil obtained by hydrodistillation of *Ferula vesceritensis* Coss. & Dur seeds (Apiaceae) was analyzed by GC and GC/MS. Fifty compounds were characterized representing 96.0% of the essential oil with the prevalence of β-pinene (24.3%), α-pinene (17.3%), limonene (10.0%), β-myrcene (6.6%) and carotol (6.1%). A comparative study on the compositions of essential oils of different *Ferula* species growing in different countries has been carried on

Keywords: Ferula vesceritensis; Apiaceae; essential oil; β-pinene ; α-pinene ; limonene; β-myrcene; carotol

1. Introduction
The genus *Ferula* (Apiaceae), "Kelkha", is represented by more than 170 species distributed in Central Asia and the Mediterranean region [1]. Antimicrobial, antioxidant and antiepileptic activities have been reported for *Ferula* essential oils [2-8]. The Algerian flora comprises 5 species of *Ferula* of which 2 are endemic [9;10]. In continuation of our works on Apiaceae [11-24], we report here, for the first time, the composition of the essential oil seeds of the endemic species *Ferula vesceritensis* Coss. & Dur, collected from Ghardaia (Septentrional Algerian Sahara). A comparative study on the compositions of essential oils of different *Ferula* species growing in different countries is also carried on

2. Experimental
Plant material
Ferula vesceritensis was collected in March 2010 from Ghardaia (Septentrional Algerian Sahara). A voucher specimen was deposited at the herbarium of the Laboratory of Therapeutic Substances, Faculty of Sciences, University of Constantine 1 (LOST ZK Fv03/10).

Extraction
The hydrodistillation of *Ferula vesceritensis* seeds (100 g) for 3 h in a Clevenger-type apparatus, yielded 1.4 % (w/w) of a yellow essential oil which was stored at +4 °C until analyzed by GC and GC-MS.

GC/MS: The essential oil was analyzed on a Shimadzu gas chromatograph Model GC2010 coupled to a Shimadzu MS model QP2010, equipped with a DB5 MS column (30m x 0.25mm; 0.25µm), programming from 50°C (5 min) to 300°C at 5°C/mn, 5 min hold. Helium was used as carrier gas (1.0 ml/min); injection in split mode (1:30); injector and detector temperature, 250 and 280°C respectively. The MS working in electron impact mode at 70 eV; electron multiplier, 2500 V; ion source temperature, 180°C; mass spectra data were acquired in the scan mode in *m/z* range 33-450.

GC/FID: The essential oil was analyzed on a Shimadzu gas chromatograph Model GC2010, equipped with a DB5 MS column (30m x 0.25mm; 0.25µm), programming from 50°C (5 min) to 300°C at 5°C/mn, 5 min hold. Hydrogen was used as carrier gas (1.0 mL/min) ; injection in split mode (1: 60) ; injector and detector temperature, 280 and 300°C respectively. The essential oil is diluted in hexane: 1/30. The compounds assayed by GC were identified by comparing their retention indices with those of reference compounds (major components) in the literature and confirmed by GC-MS by comparison of their mass spectra with those of reference substances [25;26].

3. Results and Discussion
50 compounds were determined in the reported essential oil (1.4 % yield), representing 96% of total oil content. The main constituents of the essential oil were found to be β-pinene (24.3%), α-pinene (17.3%), limonene (10.0%), β-myrcene (6.6%) and carotol (6.1%) (Table 1).

Table 1: Chemical composition of the essential oil of *Ferula vesceritensis* seeds

	Compound[a]	RI[b]	(%)
1	α-Thujene	932	1.8
2	α-Pinene	940	17.3
3	Camphene	954	1.2
4	β-Pinene	977	24.3
5	β-Myrcene	991	6.6
6	α-Phellandrene	1002	0.3
7	*p*-Cymene	1024	0.5
8	Limonene	1029	10.0
9	Δ^3-Carene	1031	0.1
10	β -*trans*-Ocimene	1037	0.3
11	β -*cis*-Ocimene	1050	0.1
12	Linalool	1096	0.1
13	6-Campheol	1114	0.1
14	*cis*-*p*-Mentha-2,8-dien-1-ol	1138	0.2
15	*trans*-Pinocarveol	1139	0.4
16	Pinocarvone	1165	0.3
17	Terpinen-4-ol	1177	0.3
18	Terpinenol	1192	0.2
19	Myrtenol	1194	0.2
20	1-Verbenone	1205	1.0
21	Exo-Fenchyl acetate	1232	0.8
22	Nopol	1280	0.3
23	Bornyl acetate	1289	0.1
24	2-Undecanone	1294	3.0
25	Carvacrol	1299	0.1
26	α-Terpinyl acetate	1349	0.1
27	α- Cubebene	1351	0.1
28	*cis*-Carvyl acetate	1368	0.2
29	Copaene	1377	0.5
30	β-Cubebene	1387	3.3
31	β-Elemene	1391	0.2
32	Cedrene	1413	0.1
33	β-Gurjenene	1433	0.8
34	α-Himachalene	1451	0.7
35	Aristolene	1444	4.3
36	Dehydro-Aromadendrene	1464	0.4
37	*cis*-Cadinen-1,4-diene	1496	0.8
38	α-Muurolene	1500	0.2
39	γ-Cadinene	1510	1.3
40	δ-Cadinene	1523	2.1
41	Di-epi-α- Cedrene epoxide	1575	0.3
42	Germacren-4-ol	1575	1.5
43	Spathulenol	1577	0.3
44	α-Copaen-11-ol	1588	1.2
45	Carotol	1594	6.1
46	Guaiol	1601	0.2
47	Alloaromadendrene oxide	1641	0.1
48	Muurolan-3,9(11)-diene-10-peroxy	1650	0.4
49	α-Cadinol	1654	0.8
50	8-Hydroxy-4-isopropylidene-7-methylbicyclo[5.3]undec-1-ene	1746	0.1
	Total (%)		**96.0**

[a] RI (retention index) measured relative to n-alkanes (C_6-$C2_4$) using a DB5 MS column
[b] Compounds listed in order of their RI

Compared with reported essential oils from North Algerian [18;24], it appears that α-pinene is mainly present in these oils but it's more abundant in the essential oil of *Ferula communis* L. (20.90%) [18] while β-myrcene was identified only in the oils of *F. vesceritensis* and *F. communis* where it's predominent in the latter. However, the essential oil of *F. vesceritensis* is exclusively characterized by the main presence of β-pinene (24.30%), limonene (10.00%) and carotol (6.10%) which has been not found in the other Algerian *Ferula* oils (table 2).

Table 2. Percentages of major components (≥5%) of essential oils of Algerian *Ferula* species

Compound *	**Percentage %**		
	F. vesceritensis	***F. communis*** L. [18]	***F. lutea*** [24]
α-Pinene	17.30	20.90	10.90
β-Pinene	24.30	-	-
β-Myrcene	6.60	52.50	-
Limonene	10.00	-	-
Carotol	6.10	-	-

*****The compounds appear according to their RI values order

From table 3, presenting the major components of essential oils of *Ferula* growing in other countries, it appears that carotol is found exclusively in the essential oil of *F. vesceritensis* seeds, reported here for the first time. α-Pinene together with β-pinene have been found as major components in essential oils of *F. badrakema* (fruits) (10.90%, 45.80 %) [*2*], *F. szovitsiana* (stem/leaves and flowers/fruits) (8.00%, 6.70%) [*4*], *F. lycia* Boiss (aerial parts) (59.89%, 19.01%) [7], *F. gummosa* Boiss. (seeds) from Kashan, Iran (5.70%, 58.80%) [27], *F. stenocarpa* Boiss. (aerial parts) (48.80%, 30.10%) [29], *F. jaesekheama* (roots) (30.00%, 16.20%) [30] and *F. assafoetida* (latex) (21.30%, 47.10%) [31]. α-Pinene (20.90, 8.20%), without the presence of β-pinene, was detected in the essential oils of *F. communis* (aerial parts) from Algeria and *F. ovina* (aerial parts), respectively [18; 27]. β-Myrcene (13.60%, 34.40%) was detected in essential oils of *F. gummosa* Boiss. (aerial parts) and F. *Oopoda* (aerial parts) [27; 28], respectively while limonene (28.80%, 10.00%) was reported from essential oils obtained from roots of *F. oopoda* [28] and the present reported essential of *F. vesceritensis* seeds.

Table 3. Percentages of major components (≥5%) of essential oils of *Ferula*

	F. badrakema [*2*]	*F. Szovistisana* [4]	*F. communis subsp. glauca* L. [6]	*F. lycia* Boiss. [7]	*F. ovina* [27]	*F. gummosa* [27]	*F. oopoda* [28]	*F. stenocarpa* [29]	*F. jaesekheama* [30]	*F. assafoetida* [31]	*F. communis* [32]
α-Pinene	10.90	8.00	24.20	59.89	8.20	5.70	-	48.80	30.00	21.30	35.20
β-Pinene	45.80	6.70	14.70	19.01	-	58.80	-	30.10	16.20	47.10	-
β-Myrcene	-	-	-	-	-	13.60	34.40	-	-	-	-
Limonene	-	-	-	-	-	-	28.80	-	-	-	-
Carotol	-	-	-	-	-	-	-	-	-	-	-

*****The compounds appear according to their RI values order

- It appears that α-pinene and β-pinene are chemotypes of *Ferula* essential oils
- Carotol is exclusive to the essential oil seeds of *F. vesceritensis*, reported here for the first time. Besides the established antioxidant activity of this component, the anticorrosive effect may be tested [33].
- Limonene is exclusive to essential oils of *F. vesceritensis* and *F. oopoda* from Pakistan
- β-Myrcene is the major component of essential oils of *F. communis* from Algeria, and *F. Oopoda*
- β-Pinene is the major component of essential oils of *F. gummosa* Boiss. essential oil.
- It's important to mention the difference in the composition of the essential oils of *F. commmunis*, collected from Italy [6], from Algeria [18] and from Greece [32] which may be due to the nature of soil, climate, altitude which change from each region to another.

Conclusion

The essential oil *Ferula vesceritensis* seeds, reported here for the first time, is mainly characterized by β-pinene, α-pinene, limonene, β-myrcene and carotol. It's the first time that carotol is found as a component of a *Ferula* oil (6.1%). In addition, it appears that α-pinene and β-pinene are chemotypes of essential oils of *Ferula*. However, α-Pinene, without the presence of β-pinene, was detected only in the essential oils of *F. communis* from Algeria and *F. ovina*, as main components. β-Myrcene was detected in essential oils of *F. gummosa* Boiss. and *F. oopoda* and in the presently reported essential oil of *F. vesceritensis* seeds, while limonene was reported only from the essential oil obtained from roots of *F. oopoda* and seeds of *F. vesceritensis* essential oils. The compositions of the essential oils of *F. commmunis*, collected from Italy, Algeria and Greece are different; that may be explained by the environmental factors which influence differently in each region.

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