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Araştırma Makalesi

Essential oil composition of *Ferula orientalis* L. from different locations of Turkey and a chemotaxonomic approach

Ömer KILIÇ[a,*]

[a] *Department of Garden and Park Plants, Technical Vocational College, Bingol University, Bingol, TURKEY*
** Corresponding author's e-mail address: omerkilic77@gmail.com*

ABSTRACT

In this study, essential oil composition of *Ferula orientalis* L. from three different locations of Turkey have been studied to determine chemotaxonomy based on essential oil characters. For this purpose, aerial parts of plant samples were investigated by HS-SPME/GC-MS. As a result, 33, 29, 30 compounds were identified in *F. orientalis* from Bingol, Elazig, Malatya locations accounting from 92.2%, 96.9%, 96.3% of the whole oil, respectively. In all locations α-pinene, camphene, β-pinene, sabinene, naphthalene and β-phellandrene were detected among the main compound and in all localities α-pinene and β-phellandrene were found to be most percentage of Bingöl (28.4%-5.6%), Elazığ (35.5%-6.4%), Malatya (27.7%-7.4%) locations. α-pinene and β-phellandrene were detected the chemotypes of *F. orientalis.*

Keywords: *Ferula orientalis, Essential oil, Chemotaxonomy, Turkey*

Türkiye'nin farklı lokasyonlarından toplanan *Ferula orientalis* L. türünün uçucu yağ kompozisyonu ve kemotaksonomik bir yaklaşım

ÖZET

Bu çalışma Türkiye'nin üç farklı lokasyonundan toplanan *Ferula orientalis* L. türünün uçucu yağ kompozisyonunun kemotaksonomik özelliklerini belirlemek amacıyla yapılmıştır. Bu amaçla, bitkinin toprakϋstü kısımları HS-SPME/GC-MS tekniği ile analiz edilmiştir. Sonuçta, Bingöl, Elazığ ve Malatya lokasyonlarından sırasıyla toplam yağ miktarları olan %92.2, %96.9 ve %96.3' lük değerlerden 33, 29 ve 30 bileşen tespit edilmiştir. Tüm lokasyonlarda α-pinen, kamfen, β-pinen, sabinen, naftalen ve β-fellandren ana bileşenler olarak tespit edilmiş olup, tüm lokasyonlarda α-pinen ve β-fellandren en yüksek oranlarda [Bingöl (%28.4-%5.6), Elazığ (%35.5-%6.4), Malatya (%27.7-%7.4)] bulunmuştur. α-pinen ve β-fellandren *F. orientalis* 'in kemotipleri olarak tespit edilmiştir.

Anahtar Kelimeler: *Ferula orientalis, Uçucu yağ, Kemotaksonomi*, *Türkiye*

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I. Introduction

AROMATIC plants had been used since ancient times for their preservative and medicinal characters, and to impart aroma and flavor to food, the pharmaceutical properties of aromatic plants are partially attributed to their essential oils [1]. Essential oils are aromatic oily liquids obtained from different plant parts [2] and they have been shown to possess antibacterial [3], antifungal [4], antiviral [5], insecticidal [6] and antioxidant [7] properties. "Plant families extensively studied for essential oils were *Lamiaceae*, *Apiaceae* and *Asteraceae*" [8]; there are some researches in the literature records about chemical composition of plant samples [9-19].

The genus *Ferula* L. belongs to the *Apiaceae* family and is one of the most important genera in Turkey and represented in Turkey by 25 taxa [20-22]. *F. orientalis* is glabrous glaucescent perennial, stem terete and weakly sulcate, 100-150 cm. Leaves 5-6 pinnate, sheaths strongly inflated, inflorescence paniculate-corymbose, flowers 8-18 per-umbellule [20]. "*Ferula*s pecies are generally named Çakşır, Çakşır otu or Çaşır in Turkey. The same name is also given to *Prangos* Lindl., some *Ferulago* W.Koch and *Hippomarathrum* Link species in Central and East Anatolia. Herbal parts of çakşır plants are used as animal fodder for winter months in Eastern Turkey. Roots of çakşır are used as aphrodisiac" [23]. "Some species of *Ferula* have been used in folk medicine as sedatives and for the treatment of rheumatism, digestive disorders, headache, arthritis, toothache, diabetes" [24]. *F. communis* L. was reported to be highly toxic to animals and humans [25]. "*Ferula* taxa have also their hormonal effects especially *F. communis* has been detected as a possible source of phytoestrogens" [26].

Some factors such as collection time, plant maturity, drying conditions, mode of distillation, geographic and climatic factors play a role in the essential oil composition of plants. But generally the main compounds of essential oil of plants don't change very much according as these factors. Therefore, in this study, aerial parts of *F. orientalis* from three different localities of Turkey were analyzed by HS-SPME/GC-MS and the results were discussed in respect to chemotaxonomy and essential oil composition of studied samples.

II. Experimental

A. PLANT HARVESTING AND ANALYSIS OF GAS EXCHANGE

Collect information of plant samples; Bingöl-vicinity of Dikme village, rocky areas, 1650-1700 m., 20.VI.2013, Kilic, 4770; Elazığ-Keban, north of Pinarlar village, rocky slopes, 1400-1500 m., 25.V.2011, Kilic, 3722; Malatya-Akçadağ, south of Akçadağ teacher scholl, rocky areas, 1300-1400 m., 15.VI.2012, Kilic, 4522. Plant materials were identified with Flora of Turkey and East Aegean Islands [20].

"The extraction of dried aerial part of five grams powder of plant samples were carried out by a HS-SPME method using a DVB/CAR/PDMS fiber, with 50/30 lm film thickness; before the analysis, the fiber was preconditioned in the injection port of the GC as indicated by the manufacturer. For each sample, 5 g of plant samples, previously homogenized, were weighed into a 40 ml vial; the vial was equipped with a "minimert" valve. The vial was kept at 35 °C with continuous internal stirring and the sample was left to equilibrate for 30 min and then, the SPME fiber was exposed for 40 min to the headspace while maintaining the sample at 35 °C. After sampling the SPME fiber was introduced into the GC injector, and was left for 3 min to allow the analyzes thermal desorption. In order to optimize the technique, the effects of various parameters, such as sample volume, sample headspace volume, sample heating temperature and extraction time, were studied on the extraction efficiency as previously reported by Verzera et al. [27].

"A Varian 3.800 gas chromatograph directly interfaced with a Varian 2.000 ion trap mass spectrometer (Varian Spa, Milan, Italy) was used. Injector temperature, 260 °C, injection mode, splitless, column, 60 m, CP-Wax 52 CB 0.25 mm, i.d., 0.25 lm film thickness (Chrompack Italy s.r.l., Milan, Italy). The oven temperature was programmed as follows: 45 °C held for 5 min, then increased to 80 °C at a rate of 10 °C /min, and to 240 °C at 2 °C/min. The carrier gas was helium used at a constant pressure of 10 psi; the transfer line temperature, 250 °C, the ionization mode, electron impact (EI); acquisition range, 40-200 m/z; scan rate, 1 us^{-1}. The compounds were identified using the NIST library,mass spectral library and verified by the retention indices, which were calculated as described by Van den Dool and Kratz" [28]. The relative amounts were calculated on the basis of peak-area ratios. Cluster analysis of studied samples seen in Figure 1; essential oil composition of the studied and literature samples are reported in Table 1 and 2.

B. STATISTICAL ANALYSIS

The statistical software Cropstat (IRRI 2005) was used to perform the ANOVA and pattern analysis. Standard analyses of variance (anova) were used to analyze the data obtained.

Table 1. *Essential oil composition of F. orientalis from different localities (%).*

COMPOUNDS	**RRI***	***Bingol***	***Elazig***	***Malatya***
Hexenal	895	0.1	0.1	0.3
α-pinene	936	**28.4**	**35.5**	**27.7**
Camphene	951	1.9	**6.5**	0.8
Sabinene	972	**15.4**	**22.0**	4.6
β-pinene	977	0.3	3.3	**20.1**
Mrycene	988	2.2	0.2	3.8
n-octanal	995	0.1	0.4	0.1
β-phellandrene	999	**5.6**	**6.4**	**7.4**
δ-3-Carene	1005	0.2	-	-
α-terpinene	1015	0.5	0.6	0.3
p-cymene	1026	4.2	-	-
Limonene	1029	-	1.8	1.4
β-ocimene	1037	3.8	0.7	0.3
γ-terpinene	1058	0.4	-	-
Linalool	1095	-	2.4	-
n-undecane	1101	0.2	0.3	0.4
n-nonanal	1105	-	-	-
Camphenol	1125	-	-	0.3
Verbenol	1140	0.1	0.1	0.3
Linanyl acetate	1265	-	-	0.2
Bicycloelemene	1325	1.3	0.5	-
α-cubebene	1340	0.6	-	0.4
α-longipinene	1342	0.4	0.2	0.6
α-ylangene	1361	-	-	-
α-copaene	1365	0.2	2.3	2.7
β-cubebene	1374	0.1	0.4	0.1
β-bourbonene	1378	-	-	-

β-elemene	1380	0.2	-	-
α-cedrene	1395	0.5	0.6	0.3
β-caryophyllene	1406	3.6	3.5	2.7
α-copaene	1420	1.5	-	-
γ-elemene	1425	0.2	1.7	2.3
Aromadendrene	1430	-	-	-
α-humulene	1440	2.8	0.4	2.7
β-farnesene	1443	-	0.3	1.4
β-gurjunene	1458	0.1	-	-
γ-muurolene	1463	-	0.1	0.3
γ-curcumene	1465	0.1	0.1	0.1
α-amorphene	1472	0.6	-	-
Germacrene D	1485	-	0.5	0.3
β-bisabolene	1493	0.4	0.2	0.6
γ-cadinene	1517	-	-	-
Naphthalene	1520	**15.3**	4.3	**13.5**
Caryophyllene oxide	1561	-	-	-
α-cadinol	1615	0.2	-	-
β-eudesmol	1632	0.5	0.6	0.3
	Total	**92.2**	**96.9**	**96.3**

RRI*: Relative Retention Index

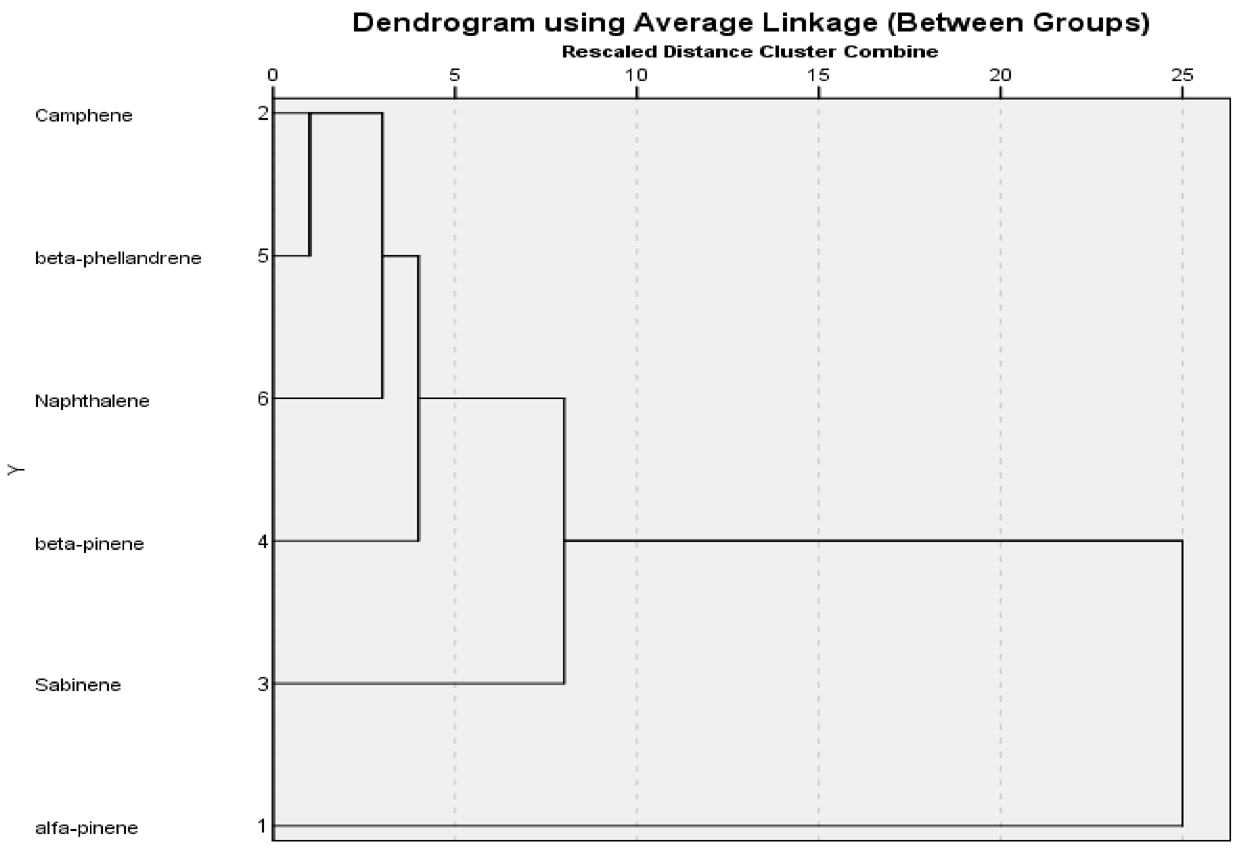

Figure 1. *Hierarchical cluster analysis essential oil of studied F. orientalis.*

Table 2. *Main constituents of Ferula taxa from literature (%).*

Main constituents	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
α-pinene	65	32	72	73	80	34	37	60	60	69	11	7	-	-	-
β-phellandrene	7	-	-	-	-	-	-	-	-	5	-		14	-	-
β-pinene	7	5	-	15	9	-	11	17	14	4	14	4	-	-	-
Naphthalene	4	-	-	-	-	5	-	4	6	-	15	28		22	10
Camphene	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-
Mryrcene	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-
Bornyl acetate	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabinene	-	-	-	-	12	-	38	-	-	-	-	4	-	-	-
Eremophilene	-	-	-	-	-	9	-	-	3	-	-	-	9	-	-
Germacrene D	-	-	-	-	-	-	-	-	-	-	5	-	-	30	25
Tricyclene	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-
β-caryophyllene	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-

1: *F. brevipedicellata,* **2:** *F. haussknechtii,* **3:** *F. hermonis,* **4:** *F. elaeochytris,* **5:** *F. mervynii,* **6:** *F. parva,* **7:** *F. coskunii,* **8:** *F. communis,* **9:** *F. rgidula,* **10:** *F. lycia,* **11:** *F. tingitana,* **12:** *F. szowitsiana,* **13:** *F. halophila,* **14:** *F. anatolica,* **15:** *F. duranii* [23].

III. Results & Discussion

The essential oil composition of dried aerial parts of *F. orientalis* from different localities of Turkey, were analyzed by HS-SPME (Headspace Solid Phase Microextraction Method) extraction technique combined with the GC-MS (gas chromatography-mass spectrometry) system. 33, 29 and 30 compounds were identified *F. orientalis* from, Bingol, Elazig and Malatya samples accounting from 92.2%, 96.9%, 96.3% of the whole oil, respectively.

α-pinene (28.4%), sabinene (15.4%), β-phellandrene (5.6%) and naphthalene (15.3%) were detected the main compounds of *F. orientalis* from Bingol location; α-pinene (35.5%), sabinene (22.0%), camphene (6.5%) and β-phellandrene (6.4%) were detected the main compounds of *F. orientalis* from Elazig location; α-pinene (27.7%), β-pinene (20.1%) and naphthalene (13.5%) were detected the main compounds of *F. orientalis* from Malatya location (Table 1). α-pinene was detected one of the major compound of *F. orientalis* from all locations (Table 1). Similarly, α-pinene (40.8%) was found to be the major compound of *F. communis* from Constantine, Algeria [29]. α-pinene was also detected main compound of *F. brevipedicellata*, *F. haussknechtii*, *F. lycia* and *F. rigidula* from Malatya samples; it is noteworthy that in the essential oil composition of *F. duranii* and *F. anatolica*, α-pinene was not among the major compounds [23]. β-pinene (19.01%) was found to be main compound of *F. lycia* from Turkey [30]; this constituent was also detected high percentage from *F. elaeochytris*, *F. parva* and *F. cuskunii* [23]; it is noteworthy that, β-pinene was detected only low amounts in the essential oil contents of *F. orientalis* from Bingol and Elazig locations (Table 1). As we can see in the Table 1, sabinene was found principal constituents of *F. orientalis* (15.4%, 22.0% and 4.6%) from Bingol, Elazig and Malatya samples, respectively; like our results, this compound also has been detected as principal constituent in *F. parva* (38.0%) and *F. mervynii* (12.0%) oils [23]. β-phellandrene was determined high percentage of *F. orientalis* from Bingol (5.6%), Elazig (6.4%) and Malatya (7.4%) samples (Table 1); it is interesting that this compound was determined very low percentages in *F. lycia* (0.08%) [30] and no percentages from *Ferula communis* L. subsp. *communis* growing spontaneously in Greece [31]. Table 1 shows the percentage composition of this characterized by the prevalence of naphthalene as the major constituent of Bingol and Malatya localities samples oil (15.3% - 13.5%)

respectively as well as the reported essential oil of the *F. tingitana* (15.0%) and *F. szowitsiana* (28.0%) [23].

Comparing the essential oil composition of *F. orientalis* (Table 1) with those of other *Ferula* species revealed some differences and similarities. The major compounds of *F. persica* were dill-apiole (57.3%) and elemicine (5.6%) [32]. Guaiol (58.76%), (E)-nerolidol (10.16%) and α-eudesmol (3.05%) were found to be the main constituents of the essential oil of *Ferula ferulaoides* from western Mongolia [33]. These components were not present in *F. orientalis* essential oil (Table 1). According to GC-MS analyzes result of the essential oil of *Ferula elaeochytris* collected from Turkey, nonane (27.1%), α-pinene (12.7%) and germacrene B (10.3%) were found as major components [34]. Research with *Ferula szowitsiana* from Iran showed that the essential oil included α-pinene (12.6%), germacrene D (12.5%) and β-pinene (10.1%) as the major compounds [35]. Nonane and germacrene B did not exist in the essential oil of *F. orientalis* (Table 1). In addition, the main constituents in the oil of *Ferula gummosa* were β-pinene (50.1%), α-pinene (18.3%) and 3-carene (6.7%) [36], α-pinene and β-pinene were also detected in our sample, but α-pinene was found more than β-pinene in all locations (Table 1). The main differences between the studied *F. orientalis* samples from three localities; high percentage of β-pinene (20.1%) in Malatya locality than Bingol (0.3%) and Elazig (3.3%) localities; also sabinene and naphthalene amounts shows significant differences (Table 1). Hierarchical cluster analysis essential of *F. orientalis* is seen in Figure 1. Results of cluster analysis based on the distribution of essential oil compounds show two main groups; α-pinene and the other compounds (camphene, β-pinene, sabinene, naphthalene,β-phellandrene) (Figure 1).

IV. CONCLUSION

In conclusion, the essential oil of *F. orientalis* collected at three different localities from eastern part of Turkey, is mainly characterized by the presence of α-pinene, camphene, β-pinene, sabinene, naphthalene and β-phellandrene. α-pinene reported as a major constituent of most studied *Ferula* taxa, could be considered as a chemotype of *Ferula* (Apiaceae) genus, but camphene, α-pinene, sabinene, naphthalene and β-phellandrene, seem to be important to the present essential oil as major components. In addition studied samples synthesized many similar compounds in their essential oils that could be justified by the similar ecological conditions of their habitat and environment. However, essential oil composition of *F. orientalis* in taxa showed differences in respect to some constituents owing to the genetic, local, climatic and seasonal factors etc., but major compounds of three locality of *F. orientalis* are generally the same in currently studied as in the literature samples.

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V. REFERENCES

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