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Original Article

Comparison of Essential Oils Compositions of Eryngo (*Eryngium caucasicum*) in Different Parts of Plant in Two Growth Conditions

Zohreh Abbaspour[1*], Kamkar Jaimand[2] and Shahla Mozaffari[3]

[1]*Department of chemistry, Payame Noor University, P.O. Box 19395-3697, Tehran, Iran*
[2]*Phytochemistry Group, Department of Medicinal plants & By-products, Research Institute of Forests and Rangelands, Tehran, Iran*
[3]*Department of chemistry, Payame Noor University, P.O. Box 19395-3697, Tehran, Iran*

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Abstract

Eryngium caucasicum Trautv. (Apiaceae) is a perennial herbaceous plant with about one meter height, an endemic species that has been distributed in the northern parts of Iran. The plant leaves are normally used in medicine and food industries in Iran. The plant has several medicinal properties including enforcing generative power, diuretic, lenitive and appetizer. In this research differents parts of plants (flower, leaves, stem and roots) from two locations littoral and unlittoral early reproductive phase are collected. The essential oils obtained by three methods of distillation (water distillation, steam distillation and hydro-steam distillation), the composition of essential oils was analyzed by gas chromatography (GC) and gas chromatography, coupled to mass spectrometry (GC-MS). Essential oils content in flower of plants from littoral and unlittoral locations in hydrodistallation method with mean of 0.32% and 0.38% and water and steam distillation with 0.176% and 0.21% in hydro-steam distillation with 0.06% and 0.09%, respectively. Essential oils content in fresh leaf also were with hydrod-istallation method with mean of 0.13% and 0.19% and steam distillation with 0.1% and 0.14%, hydro-steam distillation 0.1% and 0.16%, respectively. Essential oils content in dry leaf of plants with hydro-distallation method with mean of 0.17% and 0.32% and steam distillation 0.053% and 0.087%, in hydro-steam distillation with mean of 0.1% and 0.16%, respectively. Main components in flower were allo-aromadendrene (48.7 up to 71.6%), trans-calamenene (11 up to 18.2%), and dehydro abietal (1.2 up to 10.9%), respectively. Main components on fresh and dry leaf from littoral location were allo-aromadendrene (1.5 up to 30.6%), dihydro tagetone (2.9 up to 19.8%), (E,E)-farnesol (0.5 up to 28.3%), respectively. Main components on fresh and dry leaf from unlittoral location were allo-aromadenderene (13 up to 33.2%), dihydro tagetone (1.8 up to 17.9%), α-calacorene (7.7 up to 23.1%), (E,E)-farnesol (12.1 up to 17.5%), respectively. Main components on stem from both location were dihydro tagetone (1.6 up to 9.4%), allo-aromadendrene (36.0 up to 67.4%), trans-calamenene (8.3 up to 16.2%), dehydro abietal (6.3 up to 19.5%), respectively. Main components on root from both location were n-octadecanol (43.5 up to 91%), dihydro tagetone (1 up to 4.9%), γ- cadinene (0.5 up to 1.4%), respectively.

Key words: *Eryngium caucasicum* Trautv, Essential oil, distillation, Differents parts of plants (flower, leaves, stem and roots)

Introduction

There is a growing trend of consumer preference for the use of natural food preservatives either to

*Corresponding author: Phytochemistry Group, Department of Medicinal plants & By-products, Research Institute of Forests and Rangelands, Tehran, Iran
E-mail Address: Jaimand@rifr-ac.ir

prevent the growth of foodborne pathogens, or to delay the onset of food spoilage [1]. *Eryngium* L. consists of approximately 250 species in Eurasia, north Africa, north and south America, and Australia [2,3]. It is the largest and arguably the most taxonomically complex genus of the family Apiaceae [4]. *Eryngium caucasicum* Trautv. (Apiaceae) is a perennial herbaceous plant with about one meter height, an endemic species that has been distributed in the northern parts of Iran [5]. The plant leaves are normally used in medicine and food industries in Iran [6]. *E. caucasicum* has several medicinal properties including enforcing generative power, diuretic, lenitive and appetizer [7,8]. Phytochemistry of 250 species of the genus *Eryngium*, only 23 species have been more or less investigated phytochemically. To date, at least 127 compounds, primarily phenolic compounds and terpenoids have been isolated and identified from these species, including triterpenoid saponins, monoterpene, sesquiterpenes, triterpenoids, flavonoids, coumarins, steroids, acetylenes, and other classes of compounds [9]. It is well-known that essential oil components are biosynthesized in the plants as secondary metabolites; therefore their composition is highly variable and depends on several factors, such as climatic conditions, harvesting time, plant cultivar and plant chemotype [10-12]. The essential oils of plants have usually been isolated by either hydro-distillation or solvent extraction. Variations in the yield and the composition of essential oil at different vegetation phases and different climatic conditions have already been reported in some species [11]. *E. caucasicum* showed antioxidant activity [13,14]. The essential oils have already been extracted from the various parts (roots, stems, leaves and inflorescences) of *Eryngium* [15-22].

Being the largest and arguably the most taxonomically complex genus of the family Apiaceae, *Eryngium* consists of approximately 250 species in Eurasia, North Africa, North and South America, and Australia [24]. In Turkish folk medicine, various species of *Eryngium* are used for a wide range of ailments; particularly roots are used against various inflammatory disorders, edema, sinusitis, urinary infections or inflammations etc., and snake or scorpion bites or goiter, roots and leaves for infertility and herbs for wound healing as well as food preservation for fresh keeping [2]. Kupeli *et al.* [27] studied the *in vivo* antiinflammatory and antinociceptive activities of the ethanolic and aqueous extracts from either aerial parts or roots of eight *Eryngium* species growing in Turkey by *p*-benzoquinone-induced writhing test, carrageenaninduced hind paw edema test and TPA-induced ear edema test in mice. Aerial parts and roots of *Eryngium maritimum* L. and *Eryngium Kotschyi* Boiss. were found to possess most promising activities without exerting any apparent gastric damage. Therefore, in light of the previous antiinflammatory and antinociceptive activity results of the two promising *Eryngium* species grown in Turkey [28], current study was done to determine the antibacterial and antioxidant activity of the aereal and the root parts of *E. maritimum*; and the endemic *E. kotschyi*. The essential oil of *Eryngium caeruleum* M.B. (Umbelliferae) collected from the suburb of Neka, north of Iran, in July 2001, were isolated by hydro-distillation and analyzed by means of GC and GC/MS. twelve components were identified in the oils *of Eryngium caeruleum* M.Bieb.*,* The major constituents of the essential oil of the aerial parts of *E. caeruleum* were limonene (52.1%), *β*-sesquiphellandrene (8.1%), *α*-pinene (5.5%) and *δ*-2-carene (5.3%) [29].

Thus, the purpose of this study was to assess Comparison of essential oils compositions of eryngo (*E. caucasicum*) in different parts of plant in two growth conditions, in the northern parts of Iran.

Material and Methods

Plant Name

Eryngium caucasicum Trautv. (Apiaceae)

Source

Differents parts of plants (flower, leaves, stem and roots) from two locations littoral (around Fereidon kenar city) and unlittoral (around the babel city) in Mazanderan province in June 2014 early reproductive phase are collected. Samples were collected and identification of the plants was determined by Iranian Botanical Garden (IBG).

Plant Part

About 60 g fresh flower of *Eryngium caucasicum* Trautv. (Apiaceae) were to get essential oil with different methods of distillation**.** Essential oils content in flower of plants from littoral and unlittoral locations in hydrodistallation method with mean of 0.32% and 0.38% and water and steam distillation with mean of 0.176% in littoral

location and 0.21% in unlittoral location with steam distillation mean of 0.06% in littoral location and 0.09% in unlittoral location, respectively.

About 100 g fresh leaf of *E. caucasicum* were to get essential oil with different methods of distillation**.**Essential oils content in fresh leaf of plants from littoral and unlittoral locations in hydrodistallation method with mean of 0.13% and 0.19% and water and steam distillation with mean of 0.1% in littoral location and 0.16% in unlittoral location with steam distillation mean of 0.1% in littoral location and 0.14% in unlittoral location, respectively.

Essential oils content in dry leaf of plants from littoral and unlittoral locations in hydrodistallation method with mean of 0.17% and 0.32% and water and steam distillation with mean of 0.1% in littoral location and 0.16% in unlittoral location with steam distillation mean of 0.053% in littoral location and 0.087% in unlittoral location, respectively.

About 200 g roots of *E. caucasicum* were to get more essential oil we have split the roots has more surface contact with water and subjected to the essential oils obtained by three methods of distillation (Hydro-distillation, steam distillation and hydro-steam distillation), each for 4 hours and was repeated three times. Samples from littoral location (around Fereidon kenar city), oil yield for hydro-distillation method with mean of 0.50%, steam distillation 0.16% , and hydro-steam distillation 0.33%, and samples from and unlittoral (around the babel city), oil yield for hydro-distillation method with mean of 0.44%, steam distillation 0.15% , and hydro-steam distillation 0.28%, respectively. The oils were separated from the water by decantation and were dried by filtration over anhydrous sodium sulfate and stored in sealed vials at 2°C before analysis. The composition of essential oils was analyzed by gas chromatography (GC) and gas chromatography, coupled to mass spectrometry (GC-MS).

Gas Chromatography

GC analyses were performed using a gas chromatography, Ultera Fast Module –GC,– made in Italia. Profile column machine brand Ph-5 capillary column, manufactured by Shimadzu with Length of 30 mm and an inner diameter of 1/0 mm thick 25/0 mm, The inner surface of the stationary phase material is covered Phenyl Dimethyl Siloxane 5%. Column temperature program: initial temperature 60 °C to start the final temperature of 210 °C. The initial 3 °C per minute to be added and then injected into the chamber to a temperature of 280 °C. The carrier gas inlet pressure to the column: helium with a purity of 99/99% of the inlet pressure to the column equal to 5/1 kilogram per square centimeter is set.

Gas Chromatography - Mass Spectrometry

The GC/MS unit consisted of a Varian Model 3400 gas chromatograph coupled to a Saturn II ion trap detector was used . The column was same as GC, and the GC conditions were as above. Mass spectrometer conditions were: ionization potential 70 eV; electron multiplier energy 2000 V.

The identity of the oil components was established from their GC retention indices, relative to C7- C25 n-alkanes, by comparison of their MS spectra with those reported in the literature [23,24], and by computer matching with the Wiley 5 mass spectra library, whenever possible, by co-injection with standards available in the laboratories.

Results

Main components in flower which can observed in table –6, from littoral location with hydro-distillation were allo-aromadendrene (66.3%), trans-calamenene (11%), α-calacorene (6.1%), dehydro abietal (6.7%), and in unlittoral location with hydro-distillation were allo-aromadendrene (61.2%), trans-calamenene (13.4%), dehydro abietal (10.9%), respectively. Main components by hydro-steam distillation were allo-aromadendrene (71.6%), trans-calamenene (12.8%), α-calacorene (4.5%), and in unlittoral location with hydro-steam distillation were allo-aromadendrene (69.1%), trans-calamenene (15.9%), dehydro abietal (4.5%), respectively. Main components by steam distillation were allo-aromadendrene (48.7%), trans-calamenene (11.1%), α-calacorene (4.4%), and in unlittoral location with hydro-steam distillation were allo-aromadendrene (56.7%), trans-calamenene (18.2%), dehydro abietal (8.5%), respectively.

Main components on fresh leaf which can observed in table –7, from littoral location with hydro-distillation were (E, E)-farnesol (24.3%), n-nonanyl acetate (9.1%), butyl acetate (6.4%), elemicin (12.2%), and on dry leaf on were allo-aromadendrene (24%), dihydro tagetone (19.8%), (E,E)-farnesol (13.8%), elemicin (12.3%), respectively. Main components on fresh leaf by hydro-steam distillation were dihydro tagetone (12%), allo-aromadenderene (30.6%), (E,E)-

farnesol (28.3%), and on dry leaf were allo-aromadendrene (22.6%), dihydro tagetone (12.5%), (E,E)-farnesol (16.0%), elemicin (14.1%), methyl octadecanoate (10.9%), respectively. Main components on fresh leaf by steam distillation were 1-phenyl pentan-3-one (23.8%), trans-chrysanthenyl acetate (11.3%), dihydro tagetone (8.7%), α-ylangene (8.5%), and on unlittoral location were allo-aromadenderene (26.4%), (E,E)-farnesol (18%), elemicin (10.5%), methyl octadecanoate (8.3%), respectively.

Main components on fresh leaf which can observed in table –8, from unlittoral location with hydro-distillation were allo-aromadenderene(25.2%), α-calacorene (23.1%), (E,E)-farnesol (17.5%), and on dry leaf were allo-aromadenderene (33.2%), α-calacorene (14.4%), (E,E)-farnesol (16.7%), dihydro tagetone (8.3%), respectively.

Main components on fresh leaf by hydro-steam distillation were allo-aromadenderene (30.3%), α-calacorene (11.5%), (E,E)-farnesol (29.1%), and on dry leaf were allo-aromadenderene (30.8%), dihydro tagetone (17.9%), α-calacorene (11.6%), (E,E)-farnesol (13.5%), respectively.Main components on fresh leaf by steam distillation were allo-aromadenderene (13%), n-dodecanol (9%), α-calacorene (7.7%), (E,E)-farnesol (12.1%), methyl octadecanoate (7%), and on dry leaf were allo-aromadenderene (32.3%), α-calacorene (15.5%), (E,E)-farnesol (11.2%), respectively.

Main components on stem which can observed in table –9, from littoral location with hydro-distillation were allo-aromadenderene (56.4%), trans-calamenene (12%), dihydro tagetone(9.4%), dehydro abietal (9.6%), and on unlittoral location were allo-aromadenderene (36%), trans-calamenene (12.6%), dihydro tagetone(6.4%), dehydro abietal (31.5%), respectively. Main components by hydro-steam distillation from littoral location were allo-aromadenderene (55.5%), trans-calamenene (18.3%), dihydro tagetone (2.7%), and on unlittoral location were allo-aromadenderene (47.4%), trans-calamenene (14.7%), dihydro tagetone(6.9%), dehydro abietal (19.5%), respectively. Main components by steam distillation from littoral location were allo-aromadenderene (67.4%), trans-calamenene (11%), dihydro tagetone(1.6%), dehydro abietal (6.3%), and on unlittoral location were allo-aromadenderene (54.9%), trans-calamenene (16.2%), dihydro tagetone(1.9%), dehydro abietal (11.7%), respectively.

Main components in root which can observed in table – 10 , from littoral location with hydro-distillation were n-octadecanol (91%), 1-butyl acetate (1.2%), and with hydro-steam distillation were n-octadecanol (73.8%), 1-butyl acetate (4%) and trans-chrysanthenyl acetate (3.6%), and in steam distillation method were n-octadecanol (74.6%), dihydro tagetone (4.9%). Main components in root from unlittoral location with hydrodistallation were n-octadecanol (95.6%), abietatriene (1.7%), and with hydro-steam distillation were n-octadecanol (69.1%), α-terpinene (6.9%) and (E,E)-farnesol (5.2%), and in steam distillation method were n-octadecanol (43.5%), α –eudesmol (18.4%) and methyl octadecanoate (4.8%).

Table 1 Essential oil yield in flower

stage	littoral location			unlittoral location		
	Hydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
First	0.32	0.175	0.06	0.4	0.21	0.088
Second	0.32	0.175	0.06	0.37	0.21	0.088
thierd	0.32	0.18	0.05	0.37	0.21	0.1
Mean	0.32	0.176	0.06	0.38	0.21	0.09

Table 2 Essential oil yield in fresh leaf

stage	littoral location			unlittoral location		
	Hydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
First	0.14	0.11	0.09	0.2	0.14	0.14
Second	0.14	0.09	0.11	0.2	0.17	0.14
third	0.11	0.09	0.09	0.17	0.17	0.14
Mean	0.13	0.1	0.1	0.19	0.16	0.14

Table 3 Essential oil yield in dry leaf

stage	littoral location			unlittoral location		
	Hydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
First	0.18	0.09	0.06	0.31	0.16	0.1
Second	0.15	0.09	0.04	0.31	0.16	0.08
third	0.18	0.11	0.06	0.34	0.15	0.08
Mean	0.17	0.1	0.053	0.32	0.16	0.087

Table 4 Essential oil yield in stem

stage	littoral location			unlittoral location		
	Hydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
First	0.19	0.11	0.0906	0.19	0.15	0.09
Second	0.18	0.11	0.0906	0.19	0.13	0.09
third	0.17	0.11	0.0906	0.22	0.14	0.11
Mean	0.18	0.11	0.09	0.2	0.14	0.1

Table 5 Essential oil yield in Root

stage	littoral location			unlittoral location		
	Hydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
First	0.54	0.34	0.15	0.46	0.27	0.16
Second	0.48	0.35	0.16	0.46	0.28	0.16
third	0.49	0.30	0.17	0.40	0.28	0.14
Mean	0.50	0.33	0.16	0.44	0.28	0.15

Table 6 Chemical composition essential oil from Flower in *Eryngium caucasicum* Trautv

Compounds name	R.I.	littoral location			unlittoral location		
		Hydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
Butyl acetate	812	-	0.8	2.3	-	-	-
Verbenene	964	-	-	-	-	0.1	0.6
Sabinene	977	0.3	0.3	-	0.1	0.1	-
α- terpinene	1017	0.2	0.3	0.7	0.1	0.1	-
1,8- cineole	1032	0.3	0.3		0.3	0.3	-
Dihydro tagetone	1053	1.5	2.0	1.0	1.5	1.6	1.5
6-camphenol	1108	-	-	0.8	-	-	-
Terpin-4-ol	1175	-	-	1.7	-	-	-
trans-chrysanthenyl Acetate	1244	-	-	0.6	-	-	-
Bornyl acetate	1287	-	-	1.6	-	-	-
n-nonanyl acetate	1315	0.2	-	1.6	-	-	-
iso-dihydro carveol acetate	1325	0.6	-	1.5	-	-	-
α- ylangene	1377	-	-	0.5	-	-	-
β- ylangene	1426	-	-	1.1	-	-	-
Allo-aromadendrene	1463	66.3	71.6	48.7	61.2	69.1	56.7
n-dodecanol	1472	-		0.6	-		-
trans – calamenene	1531	11.0	12.8	11.1	13.4	15.9	18.2
α- cadinene	1539	-	0.3	0.5	1.7	1.5	0.5
α- calacorene	1548	6.1	4.5	2.5	-		-
Elemicin	1553	-	-	0.4	-		1.3
E- nerolidol	1563	0.6	0.5	0.6	1.6	1.1	3.5
n-tridecanol	1569	0.6	0.8	1.2	-		-
Caryophyllene alcohol	1575	0.2	0.3	0.8	-		-
spathulenol	1580	0.2	0.4	0.5	0.6	0.5	2.3
α –acorenol	1634	0.2	-	0.5	-	-	-
α –eudesmol	1652	04	0.2	4.4	-	-	-
α –cadinol	1657	1.1	0.3	-	0.5	0.7	1.2
n-heptadecane	1700	-	-	0.4	-	-	-
(E, E)-farnesol	1724	1.0	0.9	2.7	1.6	1.5	2.7
Cplppanone	1738	0.2	0.6	1.1	-	-	-
Isopropyl Tetradecanoate	1832	0.3	0.1	-	0.4	0.4	0.6
Acetate eudesm-7(11)-en-4-ol	1841	0.4	0.5	-	0.4	0.5	-
Methyl hexadecanoate	1932	-	-	-	0.3	-	-
Occidol acetate	1970	-	-	-	0.4	-	-
Iso-bergaptene	2027	-	-	-	0.1	-	-
n-octadecanol	2081	1.5	-	3.3	1.5	-	0.9
Methyl octadecanoate	2128	0.4	-	0.7	0.5	0.5	0.9
7-α- hydroxyl- manool	2245	-	-	-	1.1	-	-
Dehydro abietal	2269	6.7	1.2	4.0	10.9	4.5	8.5

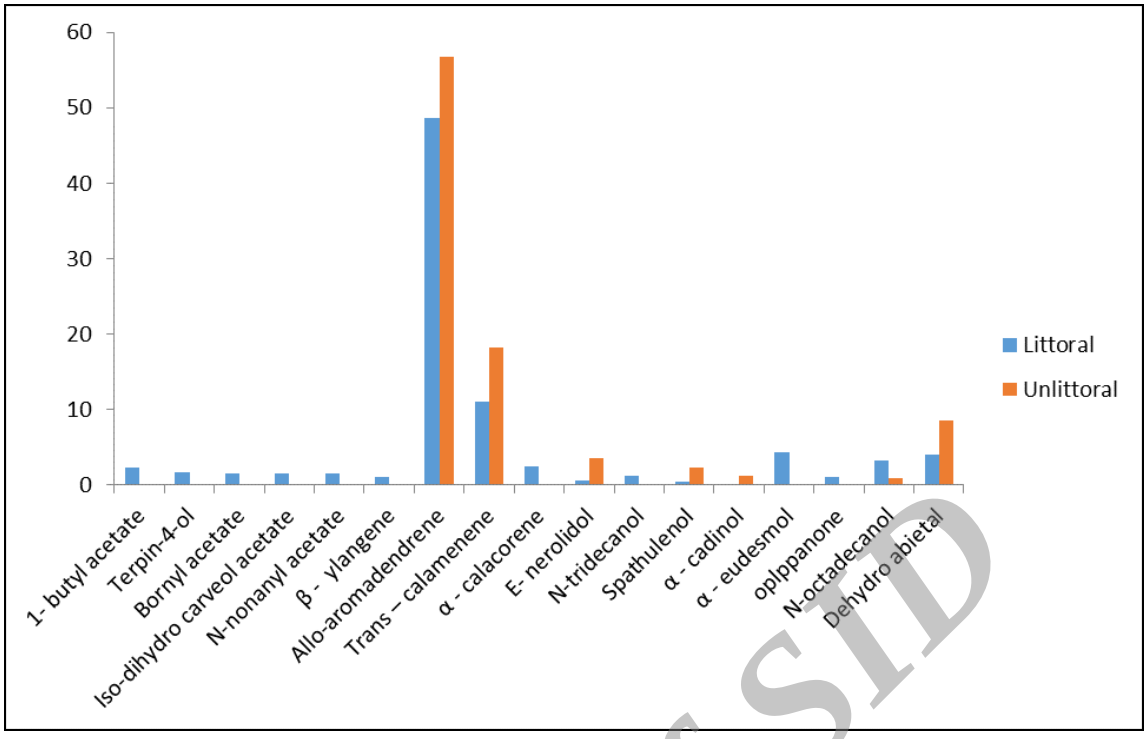

Fig. 1 Comparison of chemical composition essential oils of *Eryngium caucasicum* Trautv from flower between two littoral and un littoral location by steam distillation

Table 7 Chemical composition essential oil from Leaf in *Eryngium caucasicum* Trautv

Compounds name	R.I.	littoral location					
		Fresh leaf			Dry leaf		
		Hydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
Butyl acetate	812	6.4	-	-	-	-	-
Sabinene	977	-	0.6	-	0.5	0.3	0.4
α- terpinene	1017	0.4	-	0.5	0.2	0.2	-
1,8-cineole	1035	-	-	-	0.2	0.1	-
(E)- β – ocimene	1047	-	0.8	0.8	-	-	-
Dihydro tagetone	1053	4.4	12.0	8.7	19.8	12.5	2.9
Allyl hexanoate	1080	-	0.5	-	-	-	-
n-nonanal	1106	-	-	1.9	-	-	-
6-camphenol	1115	-	-	0.8	-	-	-
Cumin aldehyde	1239	-	-	2.4	-	-	-
trans-chrysanthenyl Acetate	1244	0.6	-	11.3	-	-	-
Carvenone	1250	-	-	2.0	-	-	-
n-nonanyl acetate	1315	9.1	-	0.6	-	-	-
Iso-dihydro carveol Acetate	1327		0.5	2.2	-	-	-
1-Phenyl pentan-3-one	1339		-	23.8	-	-	-

α- ylangene	1370		-	8.5	-	-	-
β- cedrene	1418		-		-	0.5	-
β-ylangene	1428	5.0	0.7	0.7	1.4	3.7	3.3
β –gurjunene	1431	-	-	2.7	-	-	-
Allo-aromadendrene	1464	6.0	30.6	1.5	24.0	22.6	26.4
n- dodecanol	1473	1.1	-	7.3	-	-	1.2
Allyl decanoate	1479	-	0.3	0.4	-	-	-
1,11- oxido calamenene	1488	-	0.5	-	-	-	-
Bicyclogermacrene	1494	-	0.3	-	-	-	-
n-pentadecane	1508	-	0.5	0.9	-	0.9	0.6
δ - cadinene	1523	-	0.5	0.3	1.0	0.3	0.7
trans – calamenene	1531	2.8	4.3	2.7	4.0	4.3	3.0
α- cadinene	1539	-	0.8	-	2.7	-	1.3
Elemicin	1551	12.2	2.3	0.7	12.3	14.1	10.5
Germacrene B	1555	-	0.4	0.4	-	0.1	0.4
E-nerolidol	1562	1.2	-	-	-	-	-
Viridiflorol	1585	-	0.3	-	-	0.3	0.3
α – eudesmol	1644	-	-	1.4	-	-	-
α- cadinol	1657	-	-	2.6	-	0.2	0.9
Bulnesol	1667	-	-	3.6	-	-	-
n- tetradecanol	1677	-	-	0.4	-	-	-
Germacrone	1696	-	0.3	0.5	-	-	-
n-heptadecane	1700	0.8	-	0.5	-	-	-
(Z,Z)- farnesol	1716		0.3	0.4	-	-	-
(E, E)-farnesol	1722	24.3	28.3	0.5	13.8	16.0	18.0
oplppanone	1738	0.8	0.4	-	0.7	0.7	1.2
(E, Z)-farnesol	1747	0.4	-	-	-	-	-
Cedryl actate	1766	0.8	-	-	-	0.3	0.5
Iso- acorone	1807	1.4	-	-	0.5	0.5	0.9
Isopropyl tetradecanoate	1830		-	0.3	-	-	-
Acetate eudesm-7(11)-En-4-ol	1841	2.2	1.1	-	2.5	7.2	6.8
α – chenopodiol	1856	0.4	0.5	1.0	0.4	0.5	0.8
Hexadecanol	1881	0.7	-	-	-	-	-
n-nonadecane	1900	1.6	-	1.5	-	-	0.8
Methyl hexadecanoate	1932	1.0	1.0	-	0.6	0.6	0.5
Nootkatin	1956	-	0.5	-	-	-	0.7
Occidol acetate	1974	0.3	0.4	0.9	0.4	0.3	1.5
n-eicosane	2000	0.4	0.4	-	-	-	1.2

Iso-bergaptene	2027	-	-	-	-	-	0.7
N-octadecanol	2081	5.2	1.6	-	1.8	1.2	1.0
n-henicosane	2100	0.6	-	1.0	-	-	-
Methyl octadecanoate	2132	6.8	5.6	2.2	9.8	10.9	8.3
Incensole acetate	2180	-	0.4	-	-	-	0.7
Ethyl octadecanoate	2196	-	0.3	-	1.0	-	2.3
7-α- hydroxyl- manool	2245	0.7	-	-	1.2	0.3	0.8
n-tricosane	2300	-	0.8	0.4	-	-	-

Table 8 Chemical composition essential oil from Leaf in *Eryngium caucasicum* Trautv-.

Compounds name	R.I.	unlittoral location					
		Fresh leaf			Dry leaf		
		Hydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
Sabinene	977	0.3	-	-	0.5	1.1	-
α- terpinene	1017	0.3	0.3	-	-	-	-
1,8-cineole	1035	0.1	-	-	0.4	0.9	-
Dihydro tagetone	1053	11.0	1.8	3.2	8.3	17.9	1.7
6-camphenol	1115	0.2	-	-	-	-	-
Isoborneol	1154	0.1	-	-	-	-	-
trans-chrysanthenyl acetate	1244	0.7	0.9	-	0.4	-	-
Bornyl acetate	1279	-	-	0.6	-	-	-
Iso-dihydro carveol acetate	1327	-	0.7	0.7	-	-	-
1-Phenyl pentan-3-one	1339	-	-	1.0	-	-	-
α- longipinene	1351	-	-	0.4	-	-	-
β- cedrene	1418	4.5	0.3	0.9	0.4	0.5	2.4
β-ylangene	1428	-	-	1.0	5.5	5.4	0.4
Allo-aromadendrene	1464	25.2	30.3	13.0	33.2	30.8	32.3
n- dodecanol	1473	-	-	9.0	-	-	6.6
n-pentadecane	1508	-	-	0.5	-	-	0.4
γ- cadinene	1514	0.2	1.4	2.0	0.6	0.6	1.0
δ - cadinene	1523	-	-	-		-	-
trans – calamenene	1531	0.5	0.8	1.6	0.9	0.5	0.9
α- cadinene	1539	2.4	1.8	0.9	2.4	2.9	5.1
α- calacorene	1548	23.1	11.5	7.7	14.4	11.6	15.5
E-nerolidol	1562	0.9	-	5.6	0.2	0.2	0.3
n-tridecanol	1569	-	0.4	-	-	-	-
Caryophyllene alcohol	1575	-	1.0	-	0.4	0.4	0.3
Viridiflorol	1585	-	1.2	-	-	-	-
Cubenol	1640	-	-	2.3	-	-	1.0

α – eudesmol	1644	-	0.8	4.3	-	-	1.5
Acorenone	1683	0.2	-	0.8	-	-	0.5
n-heptadecane	1700	-	-	1.3	-	-	0.3
(Z,Z)- farnesol	1716	1.5	2.2	1.4	1.7	0.8	0.7
(E, E)-farnesol	1722	17.5	29.1	12.1	16.7	13.5	11.2
oplppanone	1738	0.6	0.8	2.0	-	0.3	0.3
(E, Z)-farnesol	1747	-	-	-	-	-	-
β – acoradienol	1756	0.5	1.2	1.9	0.7	0.3	0.6
Cedryl actate	1766	-	0.6	-	-		0.7
Iso- acorone	1807	0.9	0.9	1.0	1.0	0.5	1.1
Acetate eudesm-7(11)-en-4-ol	1841	-	1.5	2.3	2.0	6.8	5.7
α – chenopodiol	1856	1.3	0.6	1.5	-	-	0.3
n-nonadecane	1900	1.0	2.0	2.0	0.2	-	0.6
Methyl hexadecanoate	1932	0.6	0.2	-	0.5	0.2	0.3
Sclarene	1967	-	0.6	4.3	-	0.3	0.7
Isokaurene	1988	-	0.7	0.7	-	-	0.4
n-eicosane	2000	-	-	0.5	-	-	-
4-hydroxy – stilbene	2042	-	0.4	-	-	-	-
N-octadecanol	2081	2.3	0.7	0.8	2.9	0.6	0.9
n-henicosane	2100	0.7	0.3	1.3	-		0.3
Methyl octadecanoate	2132	2.1	1.5	7.0	5.2	2.8	4.5
Incensole acetate	2180	-	-	0.7	-	-	-
n-docosane	2200	-	-	1.0	-	-	-
7-α- hydroxyl- manool	2245	-	-	-	0.9	-	0.3
n-tricosane	2300	-	-	0.8	-	-	-

Table 9 Chemical composition essential oil from Stem in *Eryngium caucasicum* Trautv

Compounds name	R.I.	littoral location			unlittoral location		
		Hydro distillation	Water and steam	Steam distillation	Hydro distillation	Water and steam	Steam distillation
1-butyl acetate	812	0.4	-	0.4	-	-	-
Verbenene	964	-	-	-	0.1	-	0.2
Sabinene	977	0.4	0.2	-	0.2	0.3	-
α- terpinene	1017	0.6	0.1	-	0.3	0.1	-
Dihydro tagetone	1053	9.4	2.7	1.6	6.4	6.9	1.9
Bornyl acetate	1287	0.4	-	-	-	-	-
β- cedrene	1418	-	-	-	-	0.1	-
β- ylangene	1424	-	-	0.2	-	-	-

α- himachalene	1449	-	-	-	-	0.1	-
Allo-aromadendrene	1463	56.4	55.5	67.4	36.0	47.4	54.9
n-dodecanol	1472	-	-	0.4	-	-	0.2
Trans – calamenene	1531	12.0	8.3	11.0	12.6	14.7	16.2
α- cadinene	1539	-	-	0.2	0.3	0.3	0.3
α- calacorene	1548	4.5	5.8	6.0	-	1.0	-
Elemicin	1551	-	-	-	0.5	-	3.9
E- nerolidol	1563	1.2	1.2	0.7	1.4	1.1	1.0
n-tridecanol	1569	1.2	1.0	0.9	-	-	-
Caryophyllene alcohol	1575	0.5	0.3	0.5	-	1.1	-
Spathulenol	1580	0.2	0.2	0.3	1.7	0.4	1.7
Viridiflorol	1585	-	-	-	-	0.2	-
α -acorenol	1634	0.3	0.5	0.2	-	0.6	-
Cubenol	1640	-	-	-	-	0.3	-
α-eudesmol	1652	0.6	0.6	0.5	0.4	0.8	0.3
α -cadinol	1657	-	-	0.7	1.4	0.4	1.4
(E, E)-farnesol	1724	1.0	1.0	1.3	2.9	2.2	2.3
Oplppanone	1738	0.5	0.6	-	-	0.2	0.7
Isopropyl tetradecanoate	1832	-	0.4	0.3	0.2	-	0.8
Acetate eudesm-7(11)-en-4-ol	1841	-	-	-	-	-	0.3
n-nonadecane	1900	-	0.2	-	-	-	-
Methyl hexadecanoate	1932	-	-	-	0.3	0.2	-
Nootkatin	1956	-	-	-	0.1	-	-
Sclarene	1967	-	-	-	-	0.3	-
Occidol acetate	1970	-	-	-	0.2	-	0.1
4-hydroxy – stilbene	2042	-	-	-	-	0.1	-
n-octadecanol	2081	-	0.4	-	0.5	0.1	0.2
Methyl octadecanoate	2128	-	20.2	-	0.1	0.2	0.2
7-α- hydroxyl-manool	2245	-	-	-	0.9	-	0.2
Dehydro abietal	2269	9.6	-	6.3	31.5	19.5	11.7

Table 10 Chemical composition essential oil from Roots in *Eryngium caucasicum* Trautv

Compounds name	R.I.	littoral location			unlittoral location		
		H ydro distillation	Water and steam distillation	Steam distillation	Hydro distillation	Water and steam distillation	Steam distillation
1-butyl acetate	812	1.2	4.0	-	-	-	-
α- terpinene	1017	0.5	1.5	1.1	0.5	6.9	1.8
(E)- β – ocimene	1049	-	-	-	-	-	0.3
Dihydro tagetone	1053	1.0	1.5	4.9	0.2	1.0	1.5
γ – terpinene	1061	--	0.6	-	-	-	-
n-nonanal	1102	-	-	2.4	-	-	-
6-camphenol	1108	-	-	0.5	-	-	0.3
Cis-verbenol	1133	-	-	1.0	-	-	-
Isoborneol	1154	-	-	-	-	0.4	-
trans- β – terpineol	1163	-	-	-	-	0.7	0.4
Terpin-4-ol	1175	-	-	0.3	-	-	-
octanol acetate	1217	-	0.7	0.4	-	-	-
Neo-iso-dihydro carveol	1225	-	-	-	-	1.0	-
Trans -chrysanthenyl acetate	1245	-	3.6	-	-	-	0.3
n-nonanyl acetate	1315	-	2.4	-	-	-	-
Iso-dihydro carveol acetate	1325	-	-	0.7	-	-	0.6
α- copaene	1382	-	-	0.8	-	0.7	-
β- cedrene	1418	-	-	-	-	-	0.4
β-ylangene	1428	-	-	-	-	-	2.2
Allo-aromadendrene-	1464	-	-	-	-	-	0.4
n-dodecanol	1472	-	-	2.7	-	3.8	0.6
γ- cadinene	1514	0.8	1.4	1.0	0.5	1.3	1.0
trans – calamenene	1531	-	-	0.3	-	-	-
Caryophyllene alcohol	1573	-	-	-	-	0.3	-
Viridiflorol	1586	-	-	-	-	0.5	0.7
n-hexadecane	1603	-	-	-	0.3	1.6	0.8
Tetradecanal	1617	-	-	-	-	-	0.5
Cubenol	1640	-	-	-	-	-	2.6
α –eudesmol	1652	-	-	0.9	-	-	18.4
Dihydro eudesmol	1657	-	-	-	-	-	0.7
Acorenone	1683	-	-	-	-	-	1.0
n-heptadecane	1700	0.7	1.4	-	-	-	-
(Z,Z)- farnesol	1716	-	-	-	-	-	0.6
(E, E)-farnesol	1724	-	0.9	1.1	-	5.2	1.3

oplppanone	1738	-	-	-	-	-	3.3
β – acoradienol	1756	-	-	-	-	-	0.8
Iso- longifolol acetate	1807	-	-	-	-	-	0.7
α –chenopodiol	1856	-	-	0.6	-	-	1.5
n-nonadecane	1900	1.2	1.5	0.5	-	-	0.7
Methyl hexadecanoate	1930	-	0.8	0.7	0.4	1.1	0.7
Sclarene	1967	-	-	-	-	-	1.9
n-eicosane	2000	-	-	-	0.5	-	-
Phyllocladene	2016	0.6	0.6	0.5	-	-	-
4-hydroxy – stilbene	2042	-	-	-	1.7	2.6	1.3
Abietatriene	2052	1.0	1.3	2.0	-	-	-
n-octadecanol	2081	91.0	73.8	74.6	95.6	69.1	43.5
n-henicosane	2100	0.8	1.0	-	-	-	1.0
Methyl octadecanoate	2128	-	-	0.8	-	-	4.8
n-tricosane	2300	-	2.6	0.9	-	-	-
4-epi-abietol	2340	-	-	-	-	2.2	0.7

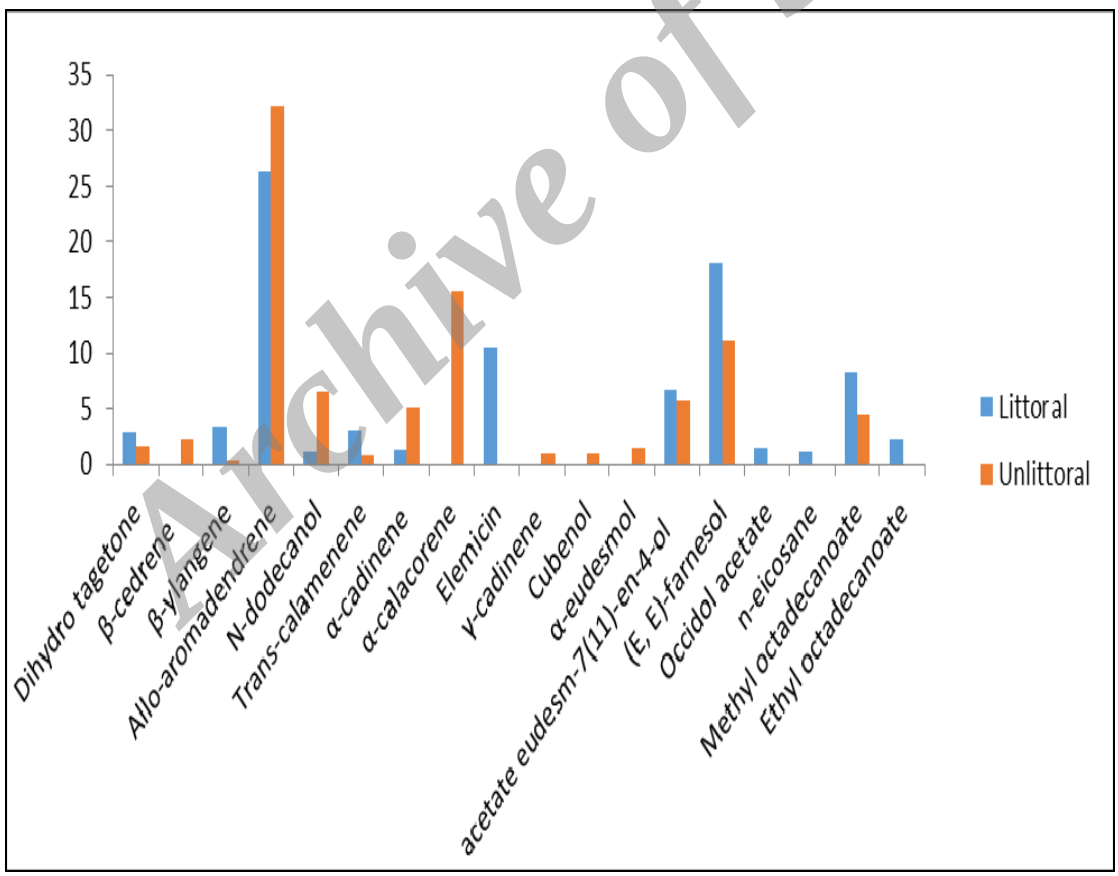

Fig. 2 Comparison of chemical composition essential oils of *Eryngium caucasicum* Trautv from leaf between two littoral and un littoral location by steam distillation

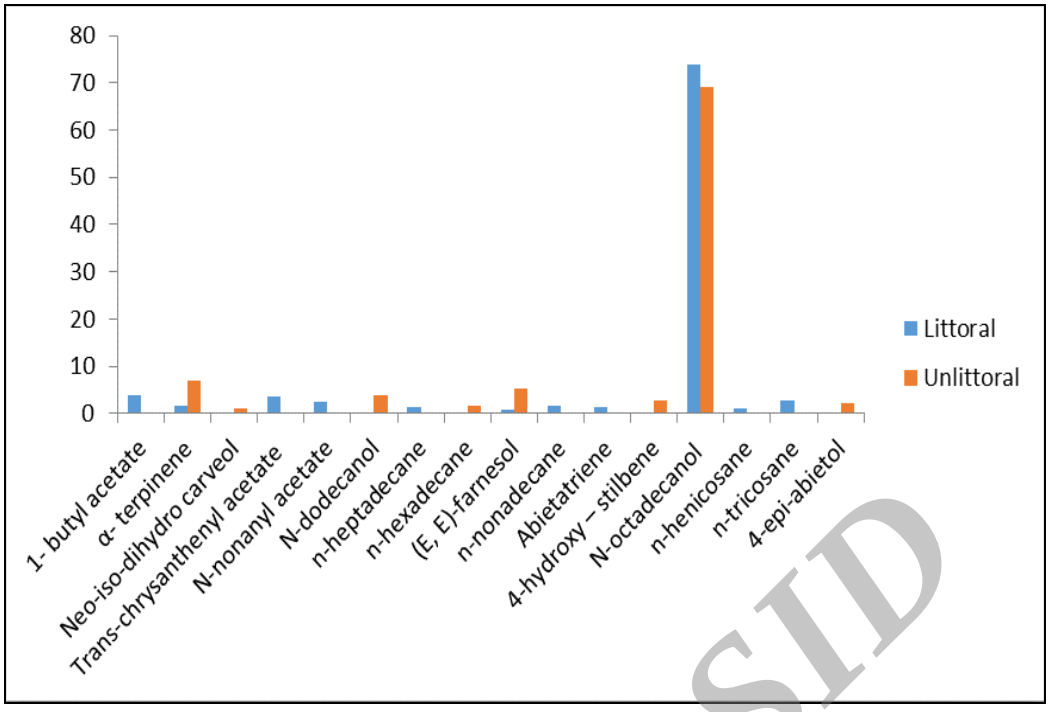

Fig. 3 Comparison of chemical composition essential oils of *Eryngium caucasicum* Trautv. from root between two littoral and un littoral location by Water and steam distillation

Discussion

The results show that the compounds of essential oil is very environmental-dependent which means a variety of plants obtained from different regions have different compounds. In our study, highly significant qualitative and quantitative differences and similarities were observed among the samples obtained from two locations littoral (around Fereidon kenar city) and unlittoral (around the babel city) in Mazanderan province in June 2014 early reproductive phase. On the contrary with our study,the contribution of the main compounds in root which can observed in table 10, from littoral location with hydro-distillation were n-octadecanol (91%), 1-butyl acetate (1.2%), and with hydro-steam distillation were n-octadecanol (73.8%), 1-butyl acetate (4%) and trans-chrysanthenyl acetate (3.6%), and in steam distillation method were n-octadecanol (74.6%), dihydro tagetone (4.9%). Main components in root from unlittoral location with hydrodistallation were n-octadecanol (95.6%), abietatriene (1.7%), and with hydro-steam distillation were n-octadecanol (69.1%), α-terpinene (6.9%) and (E,E)-farnesol (5.2%), and in steam distillation method were n-octadecanol (43.5%), α-eudesmol (18.4%) and methyl octadecanoate (4.8%).The essential oils of *E. caucasicum* have shown different compositions in previous studies. Capetanos *et al*. [16] showed that the essential oils were complex mixture of fifty eight different compounds in each investigated case on two *Eryngium* species (*E. palmatum* Pančić & Vis. and *E. serbicum* Pančić). Among fifty eight different compounds obtained by these researchers, sesquiterpenes were the main constituents in both studied species which are different –with our data. The main constituents of the investigated *Eryngium* essential oils, reported by Capetanos *et al*. [16], were germacrene D (19.7%), β-elemene (10.0%) and spathulenol (6.9%) in *E. serbicum*, and sesquicineole (21.3%), caryophyllene oxide (16.0%), spathulenol (6.6%) and sabinene (4.4%) in *E. palmatum*. Also, Brophy *et al*. [22] revealed that the major compounds of the essential oils were bornyl acetate (20.8%), selinene (13.8%), α-selinene (11.3%) and α-muurolene (8%) in *Eryngium pandanifolium* Cham. & Schltdl., and spathulenol (20%) and β-bisabolol (8.6%) in *Eryngium rostratum* Cav. In the essential oils of *Eryngium paniculatum* Cav. & Dombey ex F.Delaroche, (E)-anethole (52.6%) was found as major component [17] (Cobos *et al*., 2002), while in *Eryngium billardieri* Delile**,** α-muurolene was dominant (Sefidkon *et al*.) [26]. According to the Capetanos *et al*. [17] results, the essential oils of *E. palmatum and E. serbicum* have several differences, as their main components differ

significantly. Martins *et al*. [19] extracted the essential oils of two samples of *Eryngium foetidum* L. from different regions and observed that 2,3,6-trimethyl benzaldehyde (5.5 to 23.7%), (E)-2-dodecenal (15.9 to 37.5%) and (E)-2-tetracenal (18.7 to 25.3%) were the most important components. In this study, 24 compounds were identified with significant similarities in quality but there were some quantitative differences. For example, 2,3,6-trimethylbenzaldhyde (23.7%) was the most important in first sample, while in second sample, (E)-2-dodecenal (37.5%) was significant compound. Current study confirmed that the three important factors effective on quantitative and qualitative characters of the essential oils are highly associated with geographical position, extraction time and plant species. In this study, comparison of the essential oils obtained from *E. caucasicum* has shown in differents parts of plants (flower, leaves, stem and roots) which on this species are for first time variations in essential oils strongly depend on the genetic peculiarities, different geographical places and harvesting season.

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