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Environmental Efficacy on *Heracleum persicum* Essential Oils

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***Abstract*—**Essential oils of *Heracleum persicum* (Apiaceae) have been widely used from many years ago, but the difference of its properties among different populations have not been identified up to now. Hydrodistilation Clevenger type was used to obtaining the fruit essential oils of four populations of *H. persicum* from different localities in Iran, then they were characterized by GC-FID and GC-MS analyses. Some ecological factors were also measured. The oils of four populations were compared to determine the similarities and differences and the relationships between these factors and ecological factors. Based on the result, 18-32 different components were identified in four populations, while the percentage of the main components was higher in population with lower number of components. According to the statistical analyses of chemical components and ecological factors, it can be concluded that some ecological factors such as altitude, less humidity, high difference between day and night temperature and salty soil would lead to lower number of components in essential oil, whereas they consist the higher percentage.

***Keywords*—**Chemotaxonomy, Persian hogweed, ecological factors, Apiaceae.

I. Introduction

ESSENTIAL oils (volatile or ethereal oils) have long been used due to their importance in medical and food industries [1]. Despite their act as attracting or repelling agents to insects and defense material against some environmental factors such as heat or cold, the role of essential oils in plants are not completely known yet [2]. Essential oils can be found in special secretory structures in 10% of the plant kingdom. Some factors such as physiological differences, environmental conditions, geographic dissimilarities, genetic factors and evolution, political/social conditions and amount of plant material/space influence chemical variability and yield for each species [3]. So similar essential oils with different chemical composition can be achieved from the same plant species that reminds us the concept of chemotypes [1]. In other words chemotaxonomy helps us in selection of commercially valuable chemotypes [4].

The genus *Heracleum* L. with more than 100 species is considered as one of the widespread members of the Apiaceae family (Umbellifera). Eight species of this genus are distributed in Iran, often growing along the riversides and humid mountain regions [5]-[7]. *Heracleum persicum* Desf. ex Fischer is a polycarpic, perennial herb with the height of 150 to 200 cm, with numerous hairy hollow stems, up to 50 mm thick and red brown at the base. The sheathing leaves are alternate and pinnate with 5-6 leaflets. There are 5 white petals, 5 minute sepals and 5 stamens in each flower. Fruits are schizocarp, broadly obovate with 9-12 mm long and clavate oil ducts [8]-[10].

The fruits of *H. persicum* are widely used as flavoring ingredient. They have also been widely used in traditional and folk medicine of Iran (carminative, antiseptic, anthelminthic, diuretic, digestive, tonic, aphrodisiac and analgesic agent) [5], [6], [11].

Heracleum species are known as aromatic and rich source of essential oils since many years ago [12]. Different reports showed that the essential oils exist in different parts of *Heracleum* species [5], [6], [11]-[20]. Different pharmacological activities such as anti-inflammatory, analgesic [21], antioxidant [14], [20], [22], anticonvulsant [23], antitumor [22], cytotoxic [7], [24], [25], immunomodulatory effects, antimicrobial and antifungal activities [6], [12], [14], [17], [26], antidermatophytic [11], contraceptive [27] and adjunctive treatment for patients with hypertriglyceridemia [28] have been reported for different species of *Heracleum*. In addition, their essential oils have showed insecticidal activity [29] and enhancing broiler performance [30]. The chemical composition of essential oils from different parts of *Heracleum* species mainly consists of monoterpenes, oxygenated monoterpens, sesqiterpenes, and aliphatic esters [5], [11], [18]. Coumarins, furanocoumarins, anthraquinones, stilbenes, furanocoumarin dimers, flavonoids and the other kinds of metabolites have been isolated and identified from different species of this genus [12].

In order to evaluate whether different conditions (environmental and edaphic factors) would change the quality and quantity of oil yield, we analyzed essential oils isolated from the ripen fruits of *Heracleum persicum* growing wild in four different parts of Iran. Beside this, some morphometrical characters of fruits and soil characteristics were analyzed in order to find any possible relationships between different factors.

II. Material and Methods

A. Essential Oils' Analyses

1. Plant Material

The fruits of four populations of *Heracleum persicum* Desf. Ex Fischer were collected from their natural habitats in different parts of Iran, during July and August of 2014. Voucher specimens have been deposited at Islamic Azad University Herbarium (IAUH), Tehran (Table I).

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TABLE I
SAMPLE NUMBER, GEOGRAPHICAL LOCATION AND VOUCHER NUMBER OF FOUR INVESTIGATED POPULATIONS OF *HERACLEUM PERSICUM*

Sample	Species	Collection Site	Province	Latitude (N)	Longitude (E)	Altitude (m.a.s.l.)	Voucher number [a]
P1	*H. persicum*	Bardsir- Lalehzar	Kerman	29º30´49.8´´	056º41´06.5´´	2879 m	IAUH-000014879
P2	*H. persicum*	Mashhad- Zoshk	Razavi Khorasan	36º19´28.3´´	059º10´59.2´´	1770 m	IAUH-000014880
P3	*H. persicum*	Hamedan- DarehMoradBeik	Hamedan	34º44´53.8´´	048º30´25.1´´	2027 m	IAUH-000014881
P4	*H. persicum*	Ramsar- JavaherDeh	Mazandaran	36º 51´ 20´´	050º 28´ 28´´	1800 m	IAUH-000014882

a. Voucher Nos. of samples deposited with Avicenna Herbarium of Islamic Azad University of Tehran (IAUH).

2. Isolation of Essential Oils

Clevenger-type apparatus was used to obtain the essential oils from the air dried fruits by hydrodistillation for 3 h. The pale yellow essential oils were mixed with hexane, dried by adding anhydrous Na_2SO_4, and then stored in sealed dark vials at 4-5ºC until GC analyzing. The percentage of essential oils yields were calculated as w/w.

3. GC Analysis

The GC analyses were carried out using a Shimadzu 15A gas chromatography with a split/splitless injector (250°C) and a flame ionization detector (250°C). The type of the column was DB-5 capillary (30 m × 0.25 mm, film thickness 0.32 μm) with N_2 (1 mL/min) as carrier gas. The oven temperature was programed at 60°C for 3 min, then rising to 250°C with a 6°C/min rate and finally held constant at 250°C for 5 min. For qualification purpose, the relative contents of the essential-oil constituents being calculated based on their peak areas in the GC-FID profiles without using of internal standards or correction factors, expressed as percentage.

4. GC/MS Analysis

The GC/MS analyses were performed using Hewlett-Packard (HP-6890/5973) GC-MS system coupled with an HP-5MS column (30 m × 0.25 mm, film thickness 0.32 μm). The column temperature was the same as described above (cf. GC analysis). Helium (1 ml/min) was used as carrier gas with 70 eV ionization energy in MS, 40-300 amu mass range and 1 s scan time. The percentage of essential oil components was calculated from GC pack areas without correction factors. The identification of the individual compounds was based on the comparison of their mass spectra, retention times and indexes with corresponding data in the literature [31] and websites [9], [32], [33]. Retention indexes were determined by retention times for n-alkanes being injected with the same chromatographic condition.

B. Soil Analysis

Soil samples were taken from the base of the plants at 20 cm depth in all localities and the samples were carried to the laboratory for more analyses. Physical analysis of the soil sample to determine the soil texture was performed by bouyoucos hydrometer method [34]. Likewise chemical analysis was carried out to determine the acidity rate (in saturation extract examined by pH meter) [35] and EC (by electrical conductivity meter) [36]. Moreover, organic carbon (OC) (modified Walkley and Black method, [37]), some cations such as Ca^{2+}, K^+ and Na^+ (Atomic absorption spectroscopy (AAS)) [36], Cl^- anion (ion chromatography) [38], $CaCO_3$ (Calcimeter Bernard method) [37], phosphor (Olsen method) [39], and available nitrogen (Kjeldahl method) [40] were analyzed.

C. Fruits' Morphological Analysis

For morphological survey, following morphological data were measured: height and basal diameter of five individuals in each population, and the length, width and weight of 10 fruits from five individuals in each population.

D. Statistical Analyses

SPSS v. 21 software (IBM Inc, Chicago, IL) was applied for statistical analysis. First of all, normality of data was analyzed by Kolmogorov–Smirnov test. In order to compare the means, ANOVA test and non-parametric Kruskal-Wallis test were performed for normal and non-normal data, respectively. Using the essential oil components as variables, the Ward method [5] with the standard Euclidean coefficient was used to do hierarchical cluster analysis (HCA). We used the same method for cluster analysis of populations using morphological. In order to find the relationship between different factors, bivariant analysis with Pearson and Spearman correlation coefficient were used.

III. RESULTS

A. Characterization of Essential Oils

Table II represented the composition, their relative percentages and oil yields of the essential oils isolated from four populations of *H. persicum*. All examined essential oils with yellow color and a strong odor, exhibited a considerable variation both in the oil yields and their contents. The oil yields showed wide-ranging from 2.24 to 6.02% being recorded for Kerman and Hamedan, respectively. While those of the oils from Mashhad (3.26%) and Ramsar populations (3.40%) showed intermediate values.

An obvious variation was found in the number and the percentage of oil composition. According to Table II, the minimum and maximum number of oil components were related to the Kerman (18) and Ramsar (32) and these numbers were 30 and 31 for Hamedan and Mashhad, respectively.

Based on our results, 47 different compounds were identified by GC/MS in different populations (Table II). The essential oils were complex mixtures of alcohol (0-0.86%), aldehyde (0-1.72%), aliphatic esters (with the highest amount of 84.29-92.64%), monoterpene hydrocarbons (0-3.19%), oxygenated monoterpenes (0-3.39%), hydrocarbon (0-0.38%) and phenylpropanoids (0-3.18%). Hexyl butyrate with contents of 16.54% (Mashhad) – 26.41% (Kerman) and octyl

acetate with 16.09% (Hamedan) – 17.71% (Mashhad) were recognized as the two main oil components with equally high amounts in different populations of *H. persicum*. Hexyl 2-methyl butyrate (3.03% in Hamedan and 9.53% in Kerman) and N-Octyl 2-methyl butyrate (4.92% in Ramsar and 9.95% in Hamedan) showed the next higher amounts.

TABLE II
ESSENTIAL-OIL COMPOSITION AND YIELDS OF THE FRUITS OF FOUR INVESTIGATED POPULATIONS OF *H. PERSICUM*

Number	Compound Name	CAS#	KI	P1	P2	P3	P4
1	Octane	111-65-9	800	-	-	0.38	-
2	Isopropyl butyrate	638-11-9	844	-	-	0.57	-
3	Hexanol	111-27-3	870	-	-	-	0.86
4	Isopropyl-2-methyl butyrate	66576-71-4	885	1.15	3.5	1.05	4.43
5	Isopropyl 3-methyl butyrate	32665-23-9	904	1.38	4.22	1.69	2.92
6	Isobutyl isobutyrate	97-85-8	911	-	0.36	0.43	0.74
7	*α*-Pinene	90-56-8	939	-	-	-	0.42
8	Butyl isobutyrate	97-87-0	955	1.07	0.61	-	2.15
9	unknown			-	1.52	0.74	1.38
10	Butyl butyrate	109-21-7	994	-	-	1.61	1.67
11	*n*-Octanal	124-13-0	998	-	0.45	1.72	0.81
12	unknown			-	0.79	-	1.23
13	Isobutyl isovalerate	589-59-3	1004	-	-	-	0.48
14	Hexyl acetate	142-92-4	1009	1.31	1.09	1.68	2.57
15	Isopentyl isobutyrate	2050-01-3	1013	-	-	-	0.31
16	*p*-Cymene	99-87-6	1026	-	1.97	-	1.61
17	unknown			1.21	-	-	-
18	Butyl isovalerate	109-19-3	1047	-	0.67	-	2.49
19	unknown			0.77	0.58	-	1.82
20	Pentyl isobutyrate	2445-72-9	1055	-	-	-	0.62
21	*γ*-Terpinene	99-85-4	1059	-	3.19	0.83	2.24
22	Linalool	78_70_6	1096	3.39	-	1.61	-
23	Hexyl propanoate	2445-76-3	1101	-	1.13	-	0.53
24	2-Methyl butyl isovalerate	2445-77-4	1104	-	-	-	0.44
25	**Hexyl isobutyrate**	2349-07-7	1151	6.29	6.06	2.16	7.12
26	**Hexyl buyrate**	2639-63-6	1192	**26.41**	**16.54**	**21.77**	**19.56**
27	**Octenol acetate**	26806-12-2	1198	7.93	2.89	4.89	2.48
28	Decanal	112-31-2	1201	-	1.09	-	-
29	***n*-Octyl acetate**	112-14-1	1211	**16.93**	**17.71**	**16.09**	**16.43**
30	unknown			-	-	0.73	-
31	**Hexyl 2-methyl butyrate**	10032-15-2	1236	**9.53**	**8.58**	**3.03**	**8.46**
32	Hexyl isovalerate	10032-13-0	1244	-	-	0.81	-
33	*E*-Anethole	4180-23-8	1284	-	1.21	-	-
34	Octyl propionate	142-60-9	1302	-	0.36	1.16	-
35	unknown			-	0.54	-	0.43
36	**Octyl isobutyrate**	109-15-9	1317	5.73	5.44	4.91	3.88
37	unknown			-	0.78	1.56	0.53
38	**Hexyl Hexanoate**	6378-65-0	1383	5.94	4.4	7.45	3.35
39	*n*-Octyl butyrate	110-39-4	1434	1.32	3.92	7.5	2.63
40	unknown			-	-	1.25	-
41	unknown			-	-	0.67	-
42	unknown			-	0.42	-	-
43	unknown			-	0.62	0.61	0.47
44	***N*-Octyl 2-methyl butyrate**	29811-50-5	1436	**7.65**	**6.81**	**9.95**	**4.92**
45	unknown			-	-	0.72	-
46	unknown			0.97	1.58	1.72	-
47	unknown			1.01	0.98	0.69	-
	Alcohol			-	-	-	0.86
	Aldehyde			-	1.54	1.72	0.81
	Aliphatic esters			92.64	84.29	86.75	88.18
	Monoterpene hydrocarbons			-	3.19	0.83	2.66
	Oxygenated monoterpenes			3.39	-	1.61	-
	Hydrocarbon			-	-	0.38	-
	Phenylpropanoids			-	3.18	-	1.61
	oil yield %			**2.24%**	**3.26%**	**6.02%**	**3.40%**
	The number of components in each population			18	31	30	32
	Total identified %			**97.25**	**92.19**	**91.31**	**94.14**
	The percentage of unknown components in each population			2.75	7.81	8.69	5.86

B. Properties of the Soil Analysis

Table III shows the results of soil analysis for four locations. Among these data EC (2.76 ms/cm in Kerman and 1.6 ms/cm in Ramsar), Na (14.7% in Kerman and 1.2% in Ramsar), Cl (18.9% in kerman and 8% in Ramsar) and $CaCO_3$ (14.6% in Kerman and 7.3% in Hamedan) showed the considerable variety.

TABLE III
SOIL ANALYSES RESULTS

Number	EC (ms/cm)	pH	Ca (meq/lit)	Na (meq/lit)	Cl (meq/lit)	CaCo3%	Sand %	Silt %	Clay %	Texture	OC %	N %	P (ppm)	K (ppm)
P1	2.76	7.77	5.1	14.7	18.9	14.6	53.2	30.1	16.7	Loam	0.13	0.019	4.51	191.7
P2	1.909	7.59	4.6	10.9	13.1	11.8	57.3	27.9	14.8	Sandy Loam	0.16	0.18	6.07	201.9
P3	1.614	7.19	2.8	7.3	12.8	7.3	45.9	32.3	21.8	Loam	0.31	0.039	8.34	231.7
P4	1.587	7.12	9.6	1.2	8	8.12	42.8	35.1	22.1	Loam	1.22	0.16	8.07	231.5

TABLE IV
THE MEAN AND STANDARD DEVIATION OF MORPHOLOGICAL DATA

Population	Height cm	Basal Diameter cm	Length mm	Width mm	Weight g
P1	183.0 ± 59.56^{b}	3.000 ± 0.96^{b}	12.2390 ± 1.13^{c}	7.2044 ± 0.68^{b}	$.027980 \pm 0.0064^{b}$
P2	204.0 ± 60.14^{c}	3.000 ± 1.11^{b}	9.3452 ± 1.2^{a}	6.7162 ± 0.75^{a}	$.020120 \pm 0.007^{a}$
P3	153.0 ± 16.16^{a}	1.740 ± 0.56^{a}	11.5280 ± 1.13^{b}	6.4970 ± 0.52^{a}	$.020800 \pm 0.0044^{a}$
P4	174.0 ± 21.29^{b}	3.400 ± 0.93^{c}	12.9722 ± 1.88^{d}	7.8248 ± 1.25^{c}	$.028920 \pm 0.012^{b}$

The descriptive statistics are presented in terms of the mean ± SD. Mean values with the same letters indicated homogeneous subsets for α=0.05 according to Duncan test

TABLE V
CORRELATION COEFFICIENT OF SOME ESSENTIAL OIL ELEMENTS WITH ECOLOGICAL FACTORS

Elements name Ecological factors	The number of components	Oil yield	Hexyl isobutyrate	Hexyl buyrate	Octenol acetate	n-Octyl acetate	Hexyl 2-methyl butyrate	Octyl isobutyrate	Hexyl hexanoate	N-Octyl 2-methyl butyrate
Altitude	-0.990**	-0.427**	0.057	0.935**	0.974**	-0.032	0.276**	0.604**	0.438**	0.293**
EC	-0.959**	-0.693**	0.318**	0.706**	0.841**	0.382**	0.569**	0.755**	0.184**	0.08
pH	-0.756**	-0.680**	0.314**	0.356**	0.617**	0.717**	0.589**	0.898**	0.096	0.074
Ca	0.217**	-0.466**	0.774**	-0.170*	-0.429**	-0.077	0.556**	-0.713**	-0.852**	-0.919**
Na	-0.765**	-0.386**	-0.041**	0.453**	0.739**	0.540**	0.266**	0.898**	0.436**	0.423**
Cl	-0.900**	-0.354**	-0.089**	0.692**	0.903**	0.303**	0.209**	0.916**	0.543**	0.479**
$CaCO_3$	-0.797**	-0.810**	0.480**	0.411**	0.615**	0.681**	0.724**	0.788**	-0.43	-0.095
OC	0.506**	0.015	0.380**	-0.257**	-0.582**	-0.451**	0.088	-0.961**	-0.629**	-0.673**
N	0.723**	-0.192**	0.516**	-0.906**	-0.898**	0.480**	0.346**	-0.427**	-0.841**	-0.723**
P	0.813**	0.787**	-0.445**	-0.434**	-0.641**	-0.664**	-0.697**	-0.808**	0.002	0.055
K	0.725**	0.743**	-0.405**	-0.306**	-0.558**	-0.761**	-0.663**	-0.854**	0.005	0.026

**Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

C. Fruits Morphometric Feature

Table IV demonstrates means and standard deviations of morphometric data. Based on Duncan test, Mashhad and Ramsar populations showed the lower and higher amounts, respectively.

D. Statistical Analyses

The dendrogram achieved from hierarchical cluster analysis (HCA) of the relative contents of the essential oils (Fig. 1) indicated that four populations of *H. persicum* were divided into two clusters; one including Kerman population and the other one divided to two clusters: Hamedan and Ramsar-Mashhad.

The dendrogram achieved from hierarchical cluster analysis (HCA) of the morphological data (Fig. 2) indicated that four populations of *H. persicum* were divided into two clusters; one including Mashhad population and the other one divided to two clusters: Hamedan and Ramsar-Kerman.

Interaction between altitude, the soil properties and the essence efficiency as correlation coefficient between them, were given in Table V. As it is observed, the number of components for essential oil in each populations were negatively correlated with altitude, EC, pH, Na, Cl and $CaCO_3$. Oil yield is negatively correlated with altitude, EC, pH, Ca, Na, Cl, $CaCO_3$ and N. The main components of the essential oil that are mentioned in Table V totally showed positive correlation with altitude, EC, pH, Na and Cl and negative correlation with Ca, P, K and N. Interaction between morphometrical data and some ecological factors are given in Table VI. Morphometrical data of the fruits showed positive correlation with altitude, Ca and OC. Table VII demonstrated the correlation coefficient of some essential oil with morphometrical elements. Oil yield showed negative correlation with width and weight of the fruits. The number of oil components showed negative correlation with length and weight of the fruits.

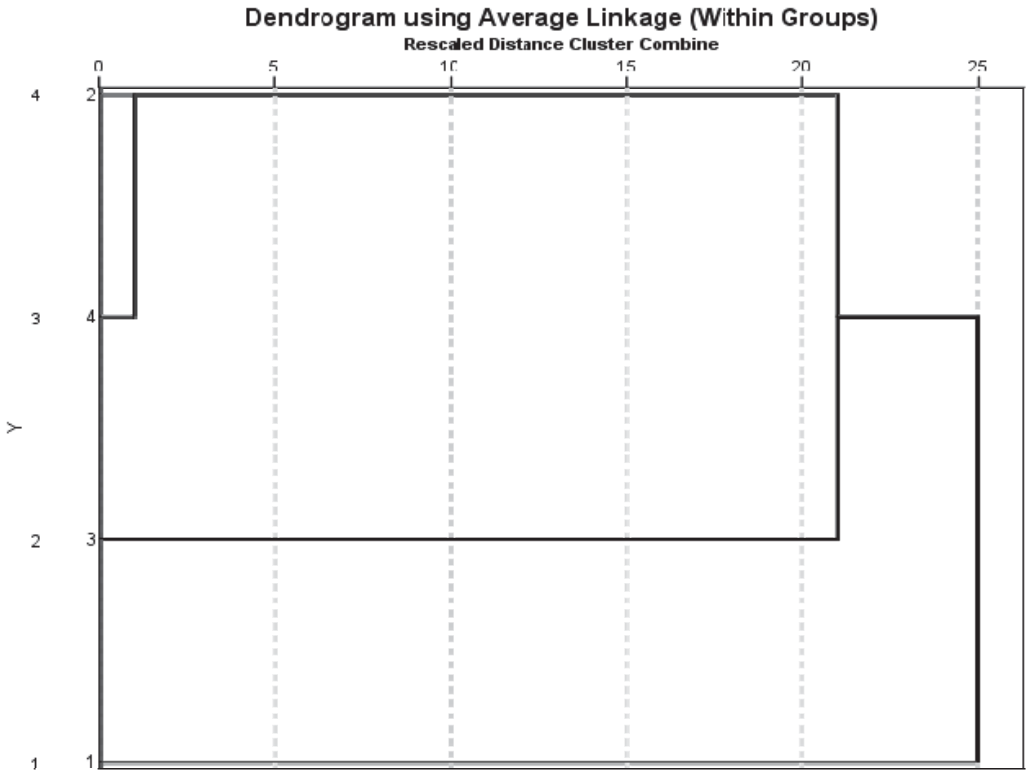

Fig. 1 Dendrogram achieved from hierarchical cluster analysis of the contents of the essential-oil components of the four populations of *H. persicum*, using average linkage between groups (rescales distance cluster combine)

TABLE VI
CORRELATION COEFFICIENT BETWEEN SOME MORPHOMETRICAL ELEMENTS AND ECOLOGICAL FACTORS

Elements name / Ecological factors	Height	Basal Diameter	Length	Width	Weight
Altitude	-0.020	-0.006	0.244**	0.021	0.192**
EC	0.142*	0.141**	0.039	0.023	0.155**
pH	0.254**	0.141**	-0.267**	-0.102	0.000
Ca	0.054	0.461**	0.396**	0.501**	0.341**
Na	0.161**	-0.064**	-0.298**	-0.248**	0.094
Cl	0.077	-0.093**	-0.109	-0.191**	-0.009
$CaCO_3$	0.258**	0.236**	-0.149*	0.011	0.094
OC	-0.103	0.249**	0.443**	0.412**	0.254**
N	0.218**	0.321**	-0.267**	0.147*	-0.055
P	-0.249**	-0.216**	0.150*	0.004	-0.087
K	-0.278**	-0.194**	0.263**	0.063	-0.020

**Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

TABLE VII
CORRELATION COEFFICIENT OF SOME ESSENTIAL OIL WITH MORPHOMETRICAL ELEMENTS

Elements / Ecological factors	Oil yield	number of components	Hexyl isobutyrate	Hexyl buyrate	Octenol acetate	Octyl acetate	Hexyl 2-methyl butyrate	Octyl isobutyrate	Hexyl hexanoate	N-Octyl methyl butyrate
Plant Height	-0.284**	-0.035	0.262**	-0.150*	-0.065	0.375**	0.301**	0.163*	-0.224**	-0.197**
Basal diameter	-0.493**	-0.046	0.568**	-0.094	-0.133	0.276**	0.529**	-0.111	-0.514**	-0.538**
Fruit Length	-0.048	-0.181*	0.114	0.417**	0.184**	-0.520**	0.024	-0.381**	-0.033	-0.153*
Fruit Width	-0.292**	-0.024	0.405**	0.055	-0.085	-0.074	0.317**	-0.309*	-0.378**	-0.437**
Fruit Weight	-0.260**	-0.185**	0.287**	0.225**	0.111	-0.116	0.251**	-0.158*	-0.186**	-0.261**

**Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

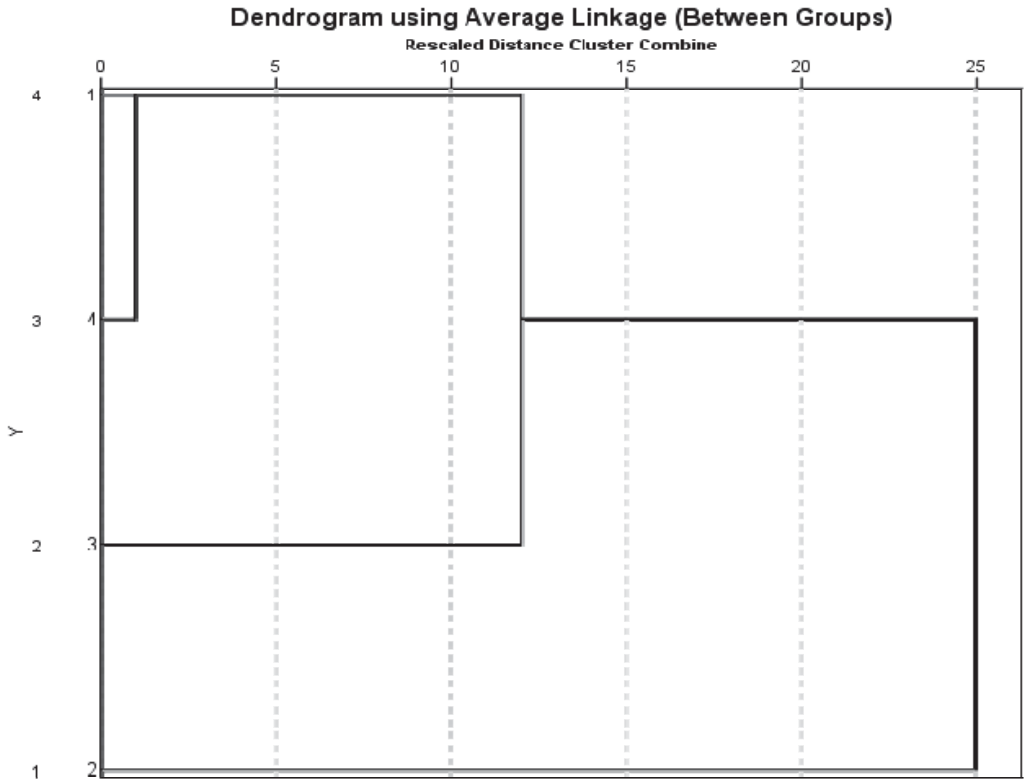

Fig. 2 Dendrogram achieved by hierarchical cluster analysis of the contents of the morphological data of the four populations of *H. persicum*, using average linkage between groups (rescales distance cluster combine)

IV. Discussion

In fact, an important part of this study is the variation of the oil yields and their contents within different populations. The range of oil yields of the fruits in this study was 2.24-6.02% that is consistent with the result of prior studies; 3.8% [5], 1.6-4.9% [18], 4 [21], 1.6 [29], 1.8 [22]. Based on Tables II, III, and V, oil yield showed higher amounts in low altitudes, with acidotic pH and low amounts of salts. Such a this result can be inferred from study of [18]; some locations such as Yazd showed low oil yield (2.2%), while Kelardasht showed the high one (3.5%) [18].

The second factor is the number of components in each population which was changed from 18 (Kerman) to 32 (Ramsar). Similar studies recorded the same results: 33 [5], 21-35 [18], 32 [7], [22], [29], 23 [21]. Based on [18], Yazd with the climate similar to Kerman in our study, showed the lowest number of components in that study (21), while Kelardasht with the climate similar to Ramsar in our study showed high number of components (32) [18].

The main part of the components are aliphatic esters; hexyl butyrate and octyl acetate are the components with the highest amounts in our study. It is proposed that co-occurrence of these two components is one character to determine *H. persicum* base on chemical composition [5], [18]. Octenol acetate, n-octyl acetate, hexyl-2-methyl butyrate, octyl isobutyrate, hexyl hexanoate and n-octyl-2-methyl butyrate showed the next high amounts. These results were in agreement with the previous reports [5], [7], [18], [21], [29].

Kerman population with the highest elevation, EC, pH and salt (Table III), having the lowest oil yield and number of components and higher amounts in main components (Table II), separated from other populations at the first based on dendrogram 1 (Fig. 1). At the second step, Hamedan population separated and Mashhad and Ramsar populations showed the most similarity in chemical composition. Kerman is located in the southern half of Iran with low precipitation, large difference in temperature in day and night and higher amount of salt in soil and is the first cluster separated from other populations; whereas three other populations are located in northern half of Iran with higher amount of precipitation, small day/night temperature difference lower amount of salt in soil and showed the high similarity in number of the components and their percentage.

Duncen test results approved the results of clustering analysis of morphometrical data; Ramsar and Mashhad populations are totally differentiated from each other. It should be mentioned that these results are not consistent with the essential oil clustering analysis. It can be concluded from Table VII that lower weight of the fruits, higher number of components and amount of oil yields.

V. Conclusion

Our findings in this study enable us to predict some essential oil properties of *Heracleum persicum* base on ecological factors. It can be inferred from above discussion that some ecological factors such as high altitude, low precipitation and salty soil would result in few components in essential oil, while the main components including the high percentage. However, more phytochemical studies with more samples and genetic investigation would help us to establish a strong relationship among these factors.

References

[1] Djilani, A. and A. Dicko, *The therapeutic benefits of essential oils*2012: INTECH Open Access Publisher.
[2] Koul, O., S. Walia, and G. Dhaliwal, *Essential oils as green pesticides: potential and constraints.* Biopesticides International, 2008. 4(1): p. 63-84.
[3] Figueiredo, A.C., et al., *Factors affecting secondary metabolite production in plants: volatile components and essential oils.* Flavour and Fragrance Journal, 2008. 23(4): p. 213-226.
[4] Sadgrove, N. and G. Jones, *A Contemporary Introduction to Essential Oils: Chemistry, Bioactivity and Prospects for Australian Agriculture.* Agriculture, 2015. 5(1): p. 48-102.
[5] Radjabian, T., A. Salimi, and N. Rahmani, *Essential-Oil Composition of the Fruits of Six Heracleum L. Species from Iran: Chemotaxonomic Significance.* Chemistry & biodiversity, 2014. 11(12): p. 1945-1953.
[6] Torbati, M., et al., *Composition and antibacterial activity of heracleum transcaucasicum and heracleum anisactis aerial parts essential oil.* Advanced pharmaceutical bulletin, 2013. 3(2): p. 415.
[7] Saeidnia, S., et al., *Cytotoxicity and chemical constituens of the volatile oil of golpar (Heracleum persicum desf. Ex Fischer).* Biosci. Res, 2005. 2: p. 107-10.
[8] Asgarpanah, J., et al., *Chemistry, pharmacology and medicinal properties of Heracleum persicum Desf. Ex Fischer: A review.* J Med Plants Res, 2012. 6: p. 1813-1820.
[9] Rechinger, K.H., *Flora Iranica, No. 162, Umbelliferae*1987, Graz, Austria.
[10] Mozaffarian, V., *Flora of Iran, No. 54, Umbelliferae*1986: Ministry of Agriculture, Islamic Republic of Iran.
[11] Sefidkon, F., M. Dabiri, and N. Mohammad, *Analysis of the Oil of Heracleum persicum L. (Seeds and Stems).* Journal of Essential Oil Research, 2004. 16(4): p. 296-298.
[12] Kuljanabhagavad, T., N. Sriubolmas, and N. Ruangrungsi, *Chemical composition and antimicrobial activity of the essential oil from Heracleum siamicum.* J Health Res, 2010. 24(2): p. 55-60.
[13] Sefidkon, F., M. Dabiri, and N. Mohammad, *Analysis of the oil of Heracleum persicum L. (leaves and flowers).* Journal of Essential Oil Research, 2002. 14(4): p. 295-297.
[14] Torbati, M., et al., *Chemical composition and in vitro antioxidant and antibacterial activity of Heracleum transcaucasicum and Heracleum anisactis roots essential oil.* BioImpacts: BI, 2014. 4(2): p. 69.
[15] Scheffer, J., et al., *Composition of Essential Oil of Heracleum persicum Fruits.* Planta medica, 1984. 50(1): p. 56-60.
[16] Mojab, F. and B. Nickavar, *Composition of the Essential Oil of the Root of Heracleum persicum from Iran.* Iranian Journal of Pharmaceutical Research, 2003: p. 245-247.
[17] Kharkwal, G., et al., *Composition and Antimicrobial Activity of the Essential Oil of Heracleum lanatum Michx. from Uttarakhand Himalaya*. 2014.
[18] Radjabian, T., et al., *Essential oil composition of some wild populations of Heracleum persicum Desf. Ex Fischer growing in Iran.* Journal of Essential Oil Bearing Plants, 2013. 16(6): p. 841-849.
[19] Mojab, F., A. Rustaiyan, and A. Jasbi, *Essential oils of Heracleum persicum Desf. ex Fischer leaves.* DARU Journal of Pharmaceutical Sciences, 2002. 10(1): p. 6-8.
[20] Masoumeh Mazandarani, et al., *Evaluation of phytochemical and antioxidant activity in different parts of Heracleum gorganicum Rech. F. in Golestan province of Iran.* Iranian Journal of Plant Physiology, 2012. 2(2): p. 381-386.
[21] Hajhashemi, V., S.E. Sajjadi, and M. Heshmati, *Anti-inflammatory and analgesic properties of Heracleum persicum essential oil and hydroalcoholic extract in animal models.* Journal of ethnopharmacology, 2009. 124(3): p. 475-480.
[22] Firuzi, O., et al., *Composition and biological activities of essential oils from four Heracleum species.* Food chemistry, 2010. 122(1): p. 117-122.
[23] Sayyah, M., S. Moaied, and M. Kamalinejad, *Anticonvulsant activity of Heracleum persicum seed.* Journal of ethnopharmacology, 2005. 98(1): p. 209-211.
[24] Sharififar, F., et al., *Bioassay screening of the essential oil and various extracts from 4 spices medicinal plants.* Pak J Pharmcol Sci, 2009. 22: p. 317-322.
[25] Moshafi, M.H., et al., *Bioassay screening of the essential oil and various extracts of fruits of Heracleum persicum desf. and rhizomes of Zingiber officinale rosc. using brine shrimp cytotoxicity assay.* Iranian Journal of Pharmaceutical Research, 2009: p. 59-63.
[26] Habibi, Z., et al., *Chemical composition and antibacterial activity of essential oil of Heracleum rechingeri Manden from Iran.* Natural product research, 2010. 24(11): p. 1013-1017.
[27] Hemati, A., et al., *Effect of the Hydroalcoholic Extract of Heracleum persicum (Golpar) on Folliculogenesis in Female Wistar Rats.* Cell Journal (Yakhteh), 2010. 14(1): p. 47.
[28] Dadjo, Y., et al., *Effects of Supplementation with Heracleum persicum Fruit Extract on Serum Lipids in Patients Undergoing Coronary Angiography: A Pilot Trial.* Phytotherapy Research, 2014. 29(1): p. 141-143.
[29] Ebadollahi, A., et al., *Chemical composition and bio-pesticidal values of essential oil isolated from the seed of Heracleum persicum Desf. ex Fischer (Apiaceae).* Spanish Journal of Agricultural Research, 2014. 12(4): p. 1166-1174.
[30] Kheiri, F., Y. Rahimian, and A. Rafiee, *Effect of Heracleum persicum extract on performance and some haematological parameters in broiler chicks.* Research Opinions in Animal and Veterinary Sciences, 2014. 4(9): p. 522-525.
[31] Adams, R.P., *Identification of essential oil components by gas chromatography/mass spectrometry*2007: Allured publishing corporation.
[32] Pence, H.E. and A. Williams. *ChemSpider: an online chemical information resource*. 2010; Available from: www.chemspider.com.
[33] Lemmon, E., et al. *NIST chemistry WebBook, Nist standard reference database number 69*. 2011; Available from: http://webbook.nist.gov/chemistry/.
[34] Gee, G. and J. Bauder, *Particle size analysis by hydrometer: a simplified method for routine textural analysis and a sensitivity test of measurement parameters.* Soil Science Society of America Journal, 1979. 43(5): p. 1004-1007.
[35] McLean, E., *Soil pH and lime requirement.* Methods of soil analysis. Part 2. Chemical and microbiological properties, 1982 (methodsofsoilan2): p. 199-224.
[36] U.S. Soil Salinity Laboratory Staff, *LA Richards (ed.) Diagnosis and improvement of saline and alkali soils*, in *US Dept. of Agriculture Handbook*1954, U.S. Govt. Print. Office: Washington, DC. p. 160.
[37] Nelson, D. and L. Sommers, *Total carbon, organic carbon and organic matter.* Methods of soil analysis. Part 2. Chemical and microbiological properties, 1982(methods of soil analysis 2): p. 539-579.
[38] Khym, J.X., *Analytical ion-exchange procedures in chemistry and biology: theory, equipment, techniques*1974: NJ, Prentice-Hall.
[39] Buurman, P., B.v. Lagen, and E. Velthorst, *Manual for soil and water analysis*1996: Backhuys Publishers.
[40] Bremner, J.M. and C. Mulvaney, *Nitrogen—total.* Methods of soil analysis. Part 2. Chemical and microbiological properties, 1982(methods of soil analysis 2): p. 595-624.