A CONTRIBUTION TO THE ARTEMISIA SIEBERI (ASTERACEAE) BASED ON PHYTOCHEMICAL STUDIES IN IRAN

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Rabie, M., Jalili, A., Azarnivand, H., Jamzad, Z. & Arzani, H. 2006 12 31: A contribution to the *Artemisia sieberi* (*Asteraceae*) based on phytochemical studies in Iran. *–Iran. J. Bot. 13 (2): 120-127.* Tehran.

Artemisia sieberi Besser is distributed in vast steppes of Iran. There are different opinions about the correct name of Iranian steppic *Artemisia*. Some authors believe that the Iranian specimens are *A. sieberi* and the others *A. herba-alba*. Phytochemical studies of 34 populations of the species in Iran, *A. herba-alba* specimens of Spain and *A. sieberi* specimen of Palestine confirmed that the name of *A. sieberi* is correct.

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Submitted: 2007. 06.03 Accepted for publication on: 2007. 11. 15

Key words. Artemisia sieberi, *Artemisia herba-alba*, Flora Iranica, Phytochemistry, Iran.

نگرشی بر *Artemisia sieberi* Besser بر پایه مطالعات فیتوشیمی در ایران

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گونه *Artemisia sieberi* Besser در مناطق وسیعی از استپهای ایران گسترش دارد. تاکنون نظریات مختلفی در مورد نام *Artemisia* استپهای ایران بیان شده است. برخی از محققین عقیده دارند که نمونه‌های موجود در ایران *A. sieberi* می‌باشند و برخی نیز بر این باورند که این نمونه‌ها *A. herba-alba* هستند. مطالعات فیتوشیمیایی 34 جمعیت این گونه از ایران و نمونه‌های *Artemisia herba-alba* از اسپانیا و *A. sieberi* از فلسطین تایید نمود که نام *A. sieberi* صحیح می باشد.

Introduction

Artemisia L. (*Asteraceae*), as broadly conceived by Linnaeus, is the largest genus in tribe *Anthemideae* (Heywood & Humphries 1977, Bremer & Humphries 1993, Oberpreiler & al. 2003) and one of the largest in the family (Bremer 1994). It is widespread in mid to high latitudes, and shrubby species dominate most cold and many warm deserts in the Northern Hemisphere (Watson & al. 2002).

There are 64 species of *Artemisia* in Flora Iranica area, of these 31 species are in Iran (Podlech 1986). *Artemisia sieberi* is one of the most distributed species in Iran. There are different opinions about the correct name of Iranian steppic *Artemisia*. Boissier (1875) introduced *Artemisia herba-alba* Asso in Flora Orientalis for the Irano-Turanian region steppes of Iran. He mentioned that it's distributed in Egypt, Turkey, Palestine, Syria, Qanary Islands, North of Africa, Afghanistan and Iran. Also, He believed that it has 3 varieties in Iran: *A. herba-alba* Asso var. *densiflora* Boiss., *A. herba-alba* Asso var. *laxiflora* Boiss. and *A. herba-alba* Asso var. *tenuiflora* Boiss.

Parsa (1943) in Flore de l'Iran confirmed Boissier's opinion about *A. herba-alba* and its three varieties. Poljakov (1961) in Flora of the USSR introduced *Artemisia sieberi* Besser for Irano-Turanian steppes of Russia. He synonymized *A. herba-alba* Asso var. *laxiflora* Boiss. and *A. herba-alba* Asso subsp. *saxicola* Krasch. with it.

Cullen (1975) in Flora of Turkey named *Artemisia* species in Irano-Turanian steppes of Turkey, *A. herba-alba* Asso. Its distribution was Spain, South of France, North of Africa, Egypt, Arabia, Syria, West and Central Iran. Podlech (1986) in Flora Iranica changed the name of *Artemisia herba-alba* Asso that introduced by Boissier for Irano-Turanian steppes of Iran. He named it, *A. sieberi* Besser. Although, species synonymized with *A. sieberi* by Podlech was *A. herba-alba* non Asso. He introduced two subspecies for *A. sieberi*. *A. sieberi* Besser subsp. *sieberi* and *A. sieberi* Besser subsp. *deserticola* Podl. Podlech believed that *A. sieberi* Besser subsp. *deserticola* is endemic of Afghanistan, but *A. sieberi* Besser subsp. *sieberi* has vast distribution in Palestine, Syria, Iraq, Afghanistan, Pakistan, Central Asia and Iran. He synonymized *A. herba-alba* Asso var. *laxiflora* Boiss. with *A. sieberi* subsp. *sieberi* and *A. herba-alba* Asso var. *densiflora* Boiss. with *A. olivierana* J. Gay ex DC. But, it did not determined situation of *A. herba-alba* Asso var. *tenuiflora* Boiss.

A lot of volatile molecules exist in essential oils and cause pleasant perfume in plants. Vast presence of monoterpenes and sesquiterpenes in *Asteraceae* are used as taxonomic markers for this family and especially *Artemisia* genus. Kelsey and Shafizadeh (1979) classified some *Artemisia* species by sesquiterpene lactones. They tried to solve or minimize taxonomic problems of *Artemisia* genus. Marco & al. (1993) reported main components of essential oils of *Artemisia sieberi* from Kouhdashte area in Tehran province, included: Camphor (44%), 1, 8-Cineole (19%), Camphene (5%) Terpinene-4-ol (2.5%) and Dehydro-1, 8-sesquicieole (1.5%). Weyerstahl & al. (1993) introduced four main chemical components of *A. sieberi* in Iran: Camphor, 1, 8-Cineole, Camphene, Terpinene-4-ol and α-Terpineole. Also, Azarnivand (2003) studied chemical components of *A. sieberi* in Tehran, Garmsar and Semnan. He reported Camphor, 1, 8-Cineole, Camphene and α-pinene as the main components.

In this research, we compare *Artemisia sieberi* of 34 localities in Iran with *A. herba-alba* of Spain and *A. sieberi* of Palestine from chemical viewpoint, in order to confirm correct opinion about *Artemisia* in Iranian steppes.

Material and Methods

We studied the essential oils of *Artemisia sieberi* Besser from 34 localities (populations) in Iran (table 1). At first, localities of *A. sieberi* in Iran were determined according to Flora Iranica (Podlech 1986). Then by using climatical map that prepared by Khalili & al. (1964-1984) based on corrected De Martonne method, we selected at least 3 localities in per climate condition. Also, we received specimens of *Artemisia herba-alba* from Spain and *Artemisia sieberi* from Palestine. They were analyzed by extraction and determination of essential oils, too.

The essential oils of all plant specimens were isolated by hydro-distillation in Clevenger-type apparatus for 3.5 hours. The oils were dried over anhydrous calcium chloride and stored in sealed vials at low temperature before analysis. Chemical composition of the essential oils were determined by GC and GC/MS. GC analyses were performed using a shimadzu GC-9A gas chromatograph equipped with a DB-1 fused silica column (60 m × 0.25 mm i.d., film thickness o.25 µm). Oven temperature was held at 40˚C for 5 min and then programmed to 280˚C at a rate of 4˚ C / min; for all of oils. Injector and detector (FID) temperature were 290˚ C; carrier gas, helium with a linear velocity of 32 cm/s. GC-MS analyses were carried out on a Varian 3400 GC-MS system equipped with a DB-1 fused silica column (60 m × 0.25 mm i.d.); Oven temperature was at 40˚C to 250˚C at a rate of 4˚C, transfer line temperature 260˚C, carrier gas helium with a linear velocity of 31.5 cm/s, split ratio 1/60, Ionization energy 70 e V; scan time 1 s; mass range 40-300 amu.

The components of oils were identified by comparison of their mass spectra with those of a computer library or with authentic compounds and confirmed by comparison of their retention indices either with those of authentic compounds or with data published in the literature (Shibamoto 1987, Davies 1990).

We analyzed the chemical components of essential oils by Minitab software, PCA (Principle Component Analysis) and Cluster Analysis (Ward Method).

Results and Discussion

Amounts of chemical components in studied plant specimens included *A. sieberi* of Iran and Palestine and *A. herba-alba* of Spain are shown in table 2. In PCA method, the first principal component accounts for the largest percent of the total data variation. The second principal component accounts the second largest percent of the total data variation and so on. The goal of principal components is to explain the maximum amount of variance with the fewest number of components. In this PCA analysis, first and second components account 24% and 12% of the total data variation. Also, cumulative proportion of variance explained by the first and second principal components is equal to 36%. In cluster method, Ward linkage and Euclidean Distance are used. Results of PCA and Cluster shown that Iranian *A. sieberi* (nos. 1-34) are gathered near each other (Figs. 1 and 2). They are similar to *A. sieberi* of Palestine (no. 38). They are

Table 1. Habitat characteristics of *Artemisia sieberi* populations in Iran, Spain and Palestine.

Code	Locality	Altitude (m)	Latitude and Longitude	Average of rainfall (mm)	Annual average of temperature (°C)	Absolute minimum temperature (°C)	Absolute maximum temperature (°C)	Herb. No. (TARI)
1	Esfahan, Kashan, Selkhak	1600	34 16 55 N 51 04 31 E	198.48	16.56	-14	39.6	85834
2	Esfahan, Kashan, Keh village	2010	34 07 48 N 51 04 53 E	237.16	12.55	-16.5	35	85825
3	Esfahan, 65 km Kashan to Ardestan	1700	33 42 24 N 51 53 31 E	198.48	16.56	-14	39.6	85822
4	Esfahan, 5 km Agha-Ali Abbas to Siah Kuh	1020	33 44 50 N 52 06 12 E	110.97	19.45	-16	46.5	85833
5	Esfahan, 5 km Ardestan to Zafarghand	1350	33 19 21 N 52 22 31 E	115.06	19.95	-10.6	44.4	85832
6	Esfahan, 4 km Zafarghand to Naeen	1900	33 09 47 N 52 30 49 E	115.06	19.95	-10.6	44.4	84446
7	Esfahan, Kashan, Maranjab	830	34 17 01 N 51 43 04 E	133.55	19.38	-12.5	46	84445
8	Qom, around of Qom lake	870	35 02 21 N 50 51 56 E	144.04	18.06	-12.6	46	85823
9	Qom, 60 km Qom to Tehran	1300	35 10 43 N 50 59 24 E	223.61	19.42	-11	43.6	84434
10	Khorasan, 10 km Fariman to Torbat-e Jam	1390	35 38 59 N 59 56 16 E	212.14	12.78	-21.5	38.5	85836
11	Khorasan, 130 km Torbat-e Heydarieh to Bejestan	1160	34 34 16 N 58 12 25 E	159.16	17.97	-14	43.3	85835
12	Yazd, 40 km Aliabad to Marvast	1900	30 57 29 N 54 13 03 E	88.82	18.3	-10.3	42	85827
13	Yazd, 60 km Taft to Nadushan	2350	31 52 55 N 53 39 04 E	176.66	14.34	-14	37	85826
14	Yazd, 42 km Yazd to Bafgh	1370	31 44 51 N 54 43 48 E	59.55	19.5	-12	45.4	85830
15	Yazd, 10 km Bahabad to Bafgh	1610	31 53 20 N 55 54 56 E	79	19.64	-17	45	85829
16	Yazd, 5 km Robat-e Posht-e Badam to Yazd	1340	32 59 14 N 55 32 34 E	107.47	20.79	-12.5	44.6	85828

Code	Locality	Altitude (m)	Latitude and Longitude	Average of rainfall (mm)	Annual average of temperature (°C)	Absolute minimum temperature (°C)	Absolute maximum temperature (°C)	Herb. No. (TARI)
17	Yazd, 13 km Ardakan to Naeen	1120	32 21 37 N 53 52 27 E	63.76	20.21	-14	46	85831
18	Yazd, 90 km Ardakan to Naeen	1390	32 43 18 N 53 16 29 E	101.91	13.65	-19.2	415	84447
19	Kerman, 85 km Jiroft to Kerman	1570	29 16 27 N 57 58 20 E	141.1	16.55	-17.2	42	84448
20	Kerman, 45 km Kerman to Jiroft	2240	29 56 52 N 57 23 51 E	141.1	16.55	-17.2	42	84449
21	Kerman, 15 km Kerman to Zarand	1835	30 26 49 N 57 00 31 E	141.1	16.55	-17.2	42	84450
22	Fars, 25 km Abadeh Tashk to Arsanjan	1680	29 47 14 N 53 32 52 E	350.12	18.53	-13.6	43.8	84433
23	Fars, 100 km Sirjan to Neyriz	1660	29 10 39 N 54 50 59 E	185.43	18.84	-7	42.5	84432
24	Fars, 6 km Harabarjan to Tutak	1650	30 19 23 N 54 08 46 E	162.7	16.29	-17.8	40.4	84435
25	Markazi, Anjilavand Saveh	1000	34 59 08 N 50 35 11 E	223.61	19.42	-11	43.6	84436
26	Markazi, Gheshlagh-e Nemati, Ghate 4 Zarand Saveh	1390	35 27 33 N 50 39 58 E	223.61	19.42	-11	43.6	84437
27	Tehran, Kavir National Park	1050	34 45 55 N 52 10 32 E	126.39	18.61	-11	47	84444
28	Semnan, 55 km Semnan to Damghan	1550	35 51 06 N 53 54 06 E	138.38	18	-9.8	43.6	84439
29	Semnan, 53 km Jaddeh Nezami Semnan to Anjilo	1400	35 26 12 N 53 52 49 E	138.38	18	-9.8	43.6	84440
30	Semnan,Turan Biosphere Reserve, 4 km Delbar to Ahmadabad	1050	35 58 30 N 56 02 25 E	126.69	16.47	-15.6	42.2	84441
31	Semnan, 33 km Shahroud to Sabzevar	1400	36 26 30 N 55 17 07 E	160.55	14.56	-10.8	40.8	85824
32	Semnan, 8 km Semnan to Sorkheh	1200	35 29 32 N 53 15 30 E	138.38	18	-9.8	43.6	84442

Code	Locality	Altitude (m)	Latitude and Longitude	Average of rainfall (mm)	Annual average of temperature (°C)	Absolute minimum temperature (°C)	Absolute maximum temperature (°C)	Herb. No. (TARI)
33	Semnan, 5 km Eivanekei to Garmsar	1050	35 19 11 N 52 07 09 E	126.39	18.61	-11	47	84443
34	Hormozgan, 25 km Hajiabad to Sirjan	1388	28 30 09 N 55 47 53 E	140.63	17.66	-14	42	84438
35	Spain, NW San Pedro, Castelflorite (Huesca), abandoned fields	350						
36	Spain, NW San Pedro, Castelflorite (Huesca), roadside near de village	280						
37	Spain, Peaflor (Zaragoza), roadside near de village	235						
38	Palestine, Negev desert, Be´erotayim			90				

clearly different from *A. herba-alba* of Spain (nos. 35, 36 and 37). In the obtained dendrogram (Fig 2.), *A. sieberi* of Palestine (no. 38) placed completely within the populations of Iranian *Artemisia* species (nos. 1-34).

This research confirmed the Podlech opinion about replacement of *A. sieberi* with *A. herba-alba* in Iran steppes.

Acknowledgment

The authors appreciate authorities of the Research Institute of Forests and Rangelands for financial support. We thanks Dr. Mozaffarian, Dr. Asri and Msr. Hamzehee for confirmation of identified *Artemisia* species and Dr. Sefidkon for determination of chemical components.

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Table 2. Chemical components of *Artemisia sieberi* from Iran and Palestine populations and *A. herba-alba* from Spain populations.

	α - Thujene	**α - Pinene**	**Camphene**	**Sabinene**	**β - Pinene**	**3 - Octanol**	**Myrcene**	**α - Terpinene**	**P - Cymene**	**1, 8 - Cineole**
1	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	7.39	5.30
2	0.00	0.00	6.73	0.00	0.00	0.00	0.00	0.00	4.68	5.04
3	0.00	0.00	6.37	0.00	0.00	0.00	0.00	0.00	0.79	5.25
4	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.51	1.24
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.52	7.04
6	0.00	0.00	5.03	0.00	0.00	0.00	0.00	0.00	17.20	17.82
7	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	2.36	1.62
8	0.00	0.00	10.65	0.00	0.00	0.00	0.00	0.00	1.10	9.50
9	0.00	0.00	9.64	0.00	0.00	0.00	0.00	0.00	1.19	14.32
10	0.00	0.00	3.29	0.00	0.00	0.00	0.00	0.00	3.71	6.09
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.38	4.05
12	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.86	4.46
13	0.00	0.00	1.89	0.00	0.00	0.00	0.00	0.00	3.66	8.19
14	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	2.51	1.99
15	0.00	0.00	6.89	0.00	0.00	0.00	0.00	0.00	0.88	8.55
16	0.00	0.00	5.90	0.00	0.00	0.00	0.00	0.00	1.87	23.61
17	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	7.27	12.30
18	0.00	0.00	2.55	0.00	0.00	0.00	0.00	0.00	4.58	10.24
19	0.00	0.00	4.43	0.00	0.00	0.00	0.00	0.00	1.61	4.30
20	0.00	0.00	2.53	0.00	0.00	0.00	0.00	0.00	1.19	7.04
21	0.00	0.00	7.96	0.00	0.00	0.00	0.00	0.00	1.09	24.69
22	0.00	0.00	2.61	0.00	0.00	0.00	0.00	0.00	14.28	18.85
23	0.00	0.00	5.93	0.00	0.00	0.00	0.00	0.00	1.08	13.09
24	0.00	0.00	4.19	0.00	0.00	0.00	0.00	0.00	1.99	18.29
25	0.00	0.00	11.24	0.00	0.00	0.00	0.00	0.00	0.89	10.74
26	0.00	0.00	7.61	0.00	0.00	0.00	0.00	0.00	1.77	10.22
27	0.00	0.00	8.44	0.00	0.00	0.00	0.00	0.00	3.18	7.31
28	0.00	0.00	6.58	0.00	0.00	0.00	0.00	0.00	7.15	7.95
29	0.00	0.00	9.39	0.00	0.00	0.00	0.00	0.00	0.63	6.73
30	0.00	0.00	7.31	0.00	0.00	0.00	0.00	0.00	0.96	14.93
31	0.00	0.00	9.26	0.00	0.00	0.00	0.00	0.00	2.19	26.20
32	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	2.27	32.24
33	0.00	0.00	5.84	0.00	0.00	0.00	0.00	0.00	0.74	2.41
34	0.00	0.00	6.49	0.00	0.00	0.00	0.00	0.00	1.42	25.17
35	0.00	0.00	0.00	0.00	0.00	0.00	1.41	0.30	0.90	16.62
36	0.00	0.41	2.09	0.95	0.36	0.16	0.54	0.59	5.12	1.13
37	0.10	0.30	0.08	0.05	0.12	0.00	1.00	0.00	0.06	0.41
38	0.00	0.00	0.35	0.00	0.17	0.00	0.00	0.09	1.96	33.15

Table 2 (cont.)

	(Z) - β-Ocimene	**(E) - β-Ocimene**	**γ-Terpinene**	**Artemisia ketone**	**Artemisia alcohol**	**α-Thujone**	**β-hujone**	**pinocarveol**	**Trans pinocarveol**	**Caryophyllene oxide**
1	0.00	0.00	0.00	0.00	0.00	0.72	2.65	0.00	4.74	0.00
2	0.00	0.00	0.00	0.00	0.00	14.27	9.95	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	21.95	16.91	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	66.93	14.62	0.00	0.00	0.00
5	6.90	0.00	0.00	0.00	0.00	2.63	2.46	0.00	0.00	0.00
6	0.00	0.00	3.82	0.00	0.00	1.28	0.00	0.00	0.00	0.00
7	0.00	0.00	2.41	0.00	0.00	27.67	7.08	0.00	10.63	0.00
8	0.00	0.00	0.00	0.00	0.00	0.89	1.66	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.66	1.33	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.70	0.37	38.19	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	18.77	13.13	35.21	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	41.58	15.41	0.00	8.62	0.00
13	0.00	0.00	0.00	0.00	0.00	8.06	0.00	0.00	13.93	0.00
14	0.00	0.00	0.00	0.00	0.00	17.87	5.21	0.00	2.92	0.00
15	0.00	0.00	0.00	0.00	0.00	17.76	7.49	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.74	5.47	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	32.97	0.00	0.00	5.21	0.00
18	4.65	3.17	0.00	0.00	0.00	4.57	26.00	0.00	0.00	0.00
19	1.43	0.66	0.00	0.00	0.00	7.96	1.49	0.00	17.31	0.00
20	17.94	0.87	1.50	0.00	0.00	1.06	2.98	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.38	2.10	0.00	0.00	0.00
22	0.00	0.65	0.00	0.00	0.00	2.79	22.13	0.00	1.05	0.00
23	0.00	0.00	0.00	0.00	0.00	7.33	7.98	0.00	0.00	0.00
24	0.00	0.00	0.00	0.00	0.00	1.21	3.56	0.00	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	3.48	5.25	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	2.63	2.29	0.00	0.00	0.00
27	0.00	0.00	0.00	0.00	0.00	0.67	4.51	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	1.13	0.49	0.00	38.92	0.00
29	0.00	0.00	0.00	0.00	0.00	0.43	1.05	0.00	0.00	0.00
30	0.00	0.45	0.00	0.00	0.00	0.75	1.59	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00	0.00	6.31	6.17	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.51	0.86	33.36	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	13.46	12.39	40.32	0.00	0.00
34	0.00	0.00	1.81	0.00	0.00	0.00	4.31	44.00	0.00	0.00
35	0.12	0.18	0.80	0.00	0.51	0.07	0.71	0.00	0.00	16.79
36	0.00	0.00	0.61	1.05	0.00	43.90	12.23	0.00	0.00	0.35
37	0.00	1.39	1.88	1.04	12.04	0.64	5.68	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	11.68	42.17	0.00	0.00	0.12

Table 2 (cont.)

	Camphor	**Pinocarvone**	**Borneol**	**Terpinen - 4 - ol**	**Myrtenol**	**Cuminyl aldehyde**	**Piperitone**	**Chrysanthemyl acetate**	**Bornyl acetate**	**β - Caryophyllene**	**Spathulenol**
1	0.00	0.00	44.84	0.00	0.00	0.00	0.00	0.00	2.06	0.00	0.00
2	45.44	1.15	0.36	0.00	0.59	0.00	0.00	1.94	0.00	0.00	0.00
3	36.68	1.27	0.00	0.00	0.90	0.00	0.00	1.44	0.00	0.00	0.00
4	5.81	2.16	0.00	0.00	0.00	0.00	0.00	1.09	1.53	0.00	0.00
5	6.93	4.00	0.00	29.72	0.00	0.00	0.00	2.30	0.61	0.00	0.00
6	27.79	0.00	1.97	5.18	3.30	0.00	0.00	0.61	0.00	0.00	0.00
7	1.19	2.20	16.38	0.00	0.00	0.00	0.00	1.39	1.90	0.00	0.00
8	58.97	4.03	0.56	0.55	1.47	0.00	0.00	0.32	0.00	0.00	0.00
9	60.60	0.48	0.72	0.64	1.58	0.00	0.00	0.00	0.00	0.00	0.00
10	17.34	4.28	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	5.34	2.10	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	1.52	1.03	0.00	7.96	0.00	0.00	0.00	2.29	1.51	0.00	0.00
13	0.00	13.24	0.00	0.00	0.00	0.00	0.00	2.87	1.07	0.00	0.00
14	2.53	2.37	0.00	29.57	0.00	0.00	0.00	4.43	5.30	0.00	0.00
15	41.23	4.47	0.00	4.29	0.93	0.00	0.00	1.02	1.44	0.00	0.00
16	38.57	4.31	1.58	2.36	0.56	0.00	0.00	0.54	0.46	0.00	0.00

	Camphor	Pinocarvone	Borneol	Terpinen - 4 - ol	Myrtenol	Cuminyl aldehyde	Piperitone	Chrysanthemyl acetate	Bornyl acetate	β - Caryophyllene	Spathulenol
17	6.32	12.33	0.00	4.23	0.00	0.00	0.00	2.58	0.00	0.00	0.00
18	21.32	7.53	0.00	2.85	0.00	0.00	0.00	2.04	0.00	0.00	0.00
19	0.00	1.90	0.00	14.49	1.60	0.00	0.00	7.11	2.75	0.00	0.00
20	21.56	6.56	0.00	8.06	0.00	0.00	0.00	0.68	1.69	0.00	0.00
21	52.59	1.74	0.00	0.76	1.16	0.00	0.00	0.70	0.44	0.00	0.00
22	8.78	1.26	0.00	1.91	1.28	0.00	0.00	0.00	0.61	0.00	0.00
23	53.29	0.98	0.00	0.00	1.92	0.00	0.00	0.00	0.00	0.00	0.00
24	25.46	0.00	0.00	24.90	0.00	0.00	0.00	5.92	1.44	0.00	0.00
25	57.22	3.05	0.00	0.66	1.32	0.00	0.00	0.00	0.00	0.00	0.00
26	42.69	3.05	0.00	1.58	1.57	0.00	0.00	6.59	0.00	0.00	0.00
27	51.30	2.55	0.00	0.95	0.00	0.00	0.00	0.66	0.00	0.00	0.00
28	3.62	3.00	0.00	1.20	0.00	0.00	0.00	0.55	0.00	0.00	0.00
29	59.72	2.36	0.00	0.95	0.00	0.00	0.00	0.41	0.00	0.00	0.00
30	53.92	2.63	1.81	1.13	1.06	0.00	0.00	0.50	0.00	0.00	0.00
31	42.75	1.85	0.00	0.48	0.50	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	3.67	0.00	1.96	0.00	0.00	0.00	0.46	0.00	0.00	0.00
33	0.00	3.00	0.00	1.98	0.00	0.00	0.00	1.22	0.00	0.00	0.00
34	0.00	3.14	0.00	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	1.45	1.82	31.27	0.21	0.11	2.79	0.17	0.36	0.00	0.00	6.86
36	16.94	0.29	4.93	0.15	0.62	1.05	0.31	0.44	0.00	0.00	0.18
37	0.00	0.72	0.27	7.82	0.00	0.19	0.06	0.20	0.13	0.00	0.00
38	1.14	0.24	0.68	0.37	0.51	0.06	0.00	0.00	0.11	0.40	0.00

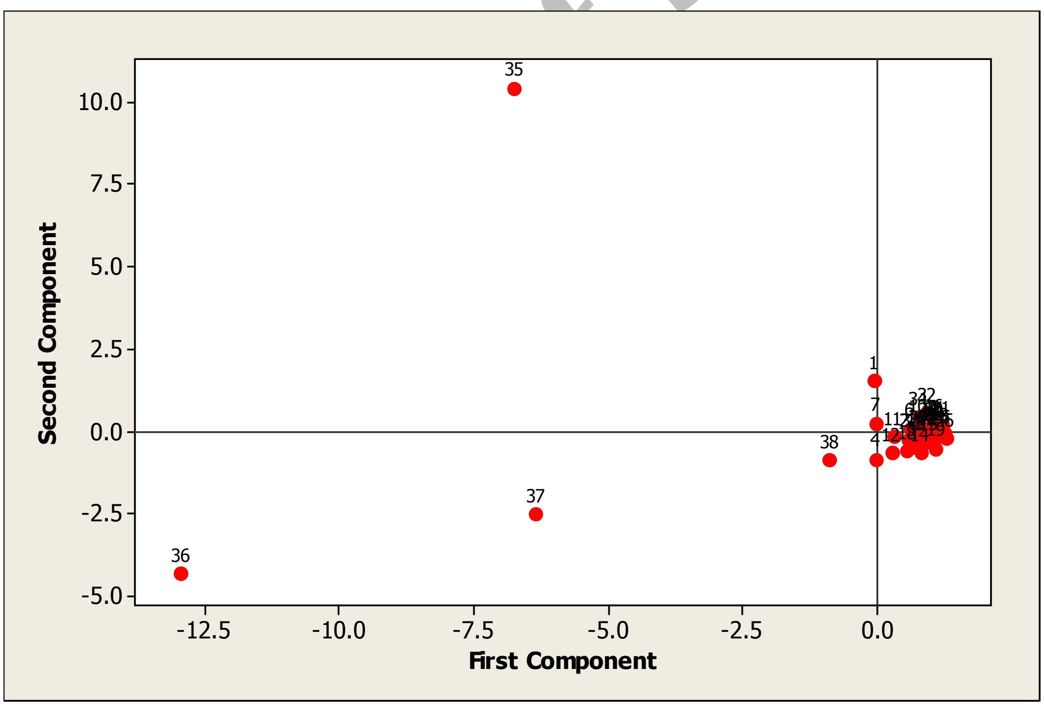

Fig. 1. Comparison between *Artemisia sieberi* of Iran and Palestine, and *A. herba-alba* of Spain with PCA method.

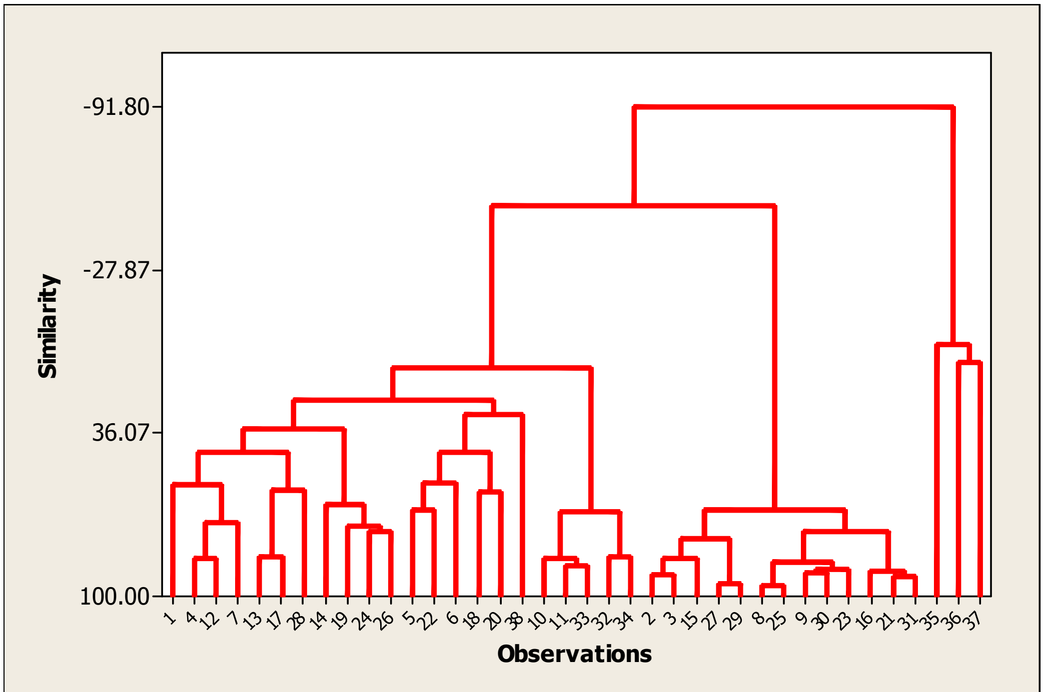

Fig. 2. Comparison between *Artemisia sieberi* of Iran and Palestine, and *A. herba-alba* of Spain with Cluster method.