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Chemical compositions of the essential oil of *Gundelia tournefortii* L. (Asteraceae) from Central Zagros, Iran

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ABSTRACT

Background & Aim: *Gundelia tournefortii* L. (Tumbleweed) has been identified as one of the well-known and widely distributed plants with various applications in some of Asian and North African countries. It belongs to the (Asteraceae) family and grows in the Middle East particularly in the temperate, mountainous and semi desert areas of countries such as Iran, Iraq, Turkey, Jordan, Syria, Egypt, Turkmenistan and some regions of Azerbaijan and Armenia. The aim of this study was to identify of the chemical components of *G.Tournefortii* L. in some of its habitats into Central Zagros area, Iran.

Experimental: In this regard, *G. tournefortii* L. was collected from some of its natural habitats in the mentioned area and air dried. The essential oil of the plant was isolated by hydro-distillation with a yield of 0.8 % (v/w). Also, the chemical compositions of volatile oil were analyzed using GC-MS.

Results & Discussion: The results indicated that major components were palmitic acid (12.48 %), lauric acid (10.59 %), alpha ionene (6.68 %), myristic acid (4.45 %), 1-hexadecanol, 2-methyl (3.61 %), phytol (3.6 %), and beta turmerone (3.4 %).

Industrial and practical recommendations: *Gundelia tournefortii* L. is known as a plants with many therapeutic properties especially in traditional and contemporary medicine in the world. Also, this plant has a useful nutritional solute such as potassium and calcium.

1. Introduction

Gundelia tournefortii L. is from the Asteraceae family. The Asteraceae is the greatest family of flowering plants with about 900 genera and more than 13000 species. It is one of the important remedial plants which can be easily found in some regions of Iran. This plant is typically known as tumbleweed, akoub and kanger are English, Arabic and Turkish, respectively. It is a well-known medicinal plant native to some countries of middle east with temperate, mountainous and semi desert areas, particularly Egypt, Iran, Iraq, Turkey, Syria, Jordan, Azerbaijan, Armenia and Turkmenistan (Coruh *et al.*, 2007). All parts of this plant are widely used in the mentioned countries; for example, the young and still undeveloped areal parts, especially flower buds, are sold in the local fairs; it is therefore, one of the ordered items (Lev Yadun and Abbo, 1999). The leaves and stems of this plant are

used as food ingredients in soups and salads (Ertog, 2000; Lev Yadun and Abbo, 1999). In some parts of Turkey, the fruits of *Gundelia tournefortii* L. are treated with vinegar or lemon and salt and used as a garnish (Dogan *et al.*, 2004). In folk medicine, *Gundelia tournefortii* L. has advantages as some kind of herbal medicine. These advantages incloud treatment of diseases like vitiligo, chest pain, heart stroke, diabetes, splenomegaly, chewedness, cuts, gastric pain, diarrhea, bronchitis, inflammations, kidney problems and also, especially, the use of it as effective diuretics (Sezik *et al.*, 2001; Halabi *et al.*, 2005; Jarald *et al.*, 2008; Sarper *et al.*, 2009; Matthaus and Ozkan, 2011). The Stem of *Gundelia tournefortii* L. is used in various parts of Iran as an occasional food with different usages and as a traditional therapy too. According to teachings of the Persian folk medicine, the stem of the mentioned plant, can serve as an effective therapeutic by acting as hepatoprotective and blood purifier (Jamshidzadeh *et al.*, 2005; Haghi *et al.*, 2011). It is a perennial spiny plant collected at the end of vegetative phase and also dried as some kind of winter fodder for some ruminant animals such as ram, ewe, goat and camel in the countries mentioned (Kaplan *et al.*, 1995; Kamalak *et al.*, 2005). In the flora Iranica, just *Gundelia tournefortii* L. is used (Rechinger, 1989). Several years ago in Armenia two new taxa well defined localities of *Gundelia* namely *G. aragatsi* and *G. aragatsi* ssp. have been proposed with different distribution areas, flower shapes, Inflorescence and pollinators (Vitek and Jarvis, 2007). In the contemporary medicine, especially in the current decade, some researchers have investigated the wide range of the pharmacological properties of *Gundelia tournefortii* L. According to some studies, it has various advantages along with characteristics such as antibacterial activity, inflammatory activity, antiplatelet activity, hypolipemic activity (Aburjai *et al.*, 2001; Darwish and Aburjai, 2010; Oryan *et al.*, 2011; Halabi *et al.*, 2005; Sharaf *et al.*, 2004; and Mavi *et al.*, 2011). In addition, the antioxidant activity of *Gundelia tournefortii* L. has been investigated via some researchers, demonstrating that seeds antioxidant capacity is really higher than the other parts of this plant, because its seeds contain a high amount of substances such as tocopherols, fatty acids and sterols (Coruh *et al.*, 2007; Tawaha *et al.*, 2007; Matthaus and Ozkan, 2011). There are several studies regarding the evaluation of phytochemical characteristics of *Gundelia tournefortii* L. in the mentioned countries, using various experimental techniques (Erciyes *et al.*, 1989; Halabi *et al.*, 2005; Karabulut *et al.*, 2006; Matthaus and Ozkan, 2011 and Haghi *et al.*, 2011). In all these studies miscellaneous chemical compositions were identified and the amount of the yields of essential oils was varied. The majority of the identified compounds, in terms of molecular structure, belong to specified chemical functional groups; nevertheless, as the mentioned plant is situated in various areas of the world, factors such as the presence, absence and the amount of its constituent are different. The most important identified combinations are in groups such as (terpenoieds, hydrocarbons, alcohols, acids, esters, phenols). The purpose of the current study was to identify all chemical compositions of the essential oil of *Gundelia tournefortii* L. in central Zagros area, Iran; for the first time.

2. Materials and Methods

2.1. Plant Material

Gundelia tournefortii L. (Asteraceae) is a perennial spiny native herb plant grown extensively in Iran, between the months of March and April. Samples of *G. tournefortii* Arial parts consisted of the leaves, stems and flower buds collected in March, 2014 (in one of its natural habitat in central Zagros, Iran), during the flowering period and the vegetative phase. The taxonomic identity of the plant was confirmed by comparing the collected voucher specimen with that of the known identity available in the herbarium of the Department of Natural Resources, Isfahan University of Technology, Iran **(Fig. 1).**

2.2. Plant material

The aerial parts of the plant (1000 g) were dried in a standard situation without light, infection and humidity; also, the incomplete and immature samples were separated. They were powdered using a mill (Model PX-MFC90D) with the mesh size of 1mm for the following analysis. The resultant powder had low density too. Meanwhile, the sampling area was located at an altitude of 2300 m above the sea level. The mean annual rainfall and temperature were 414 mm and 10.8 ˚C respectively.

2.3. Isolation of the essential oils

100 g of air dried aerial parts of *Gundelia tournefortii* L. was separated for hydro-distillation using a Clevenger-type apparatus (European pharmacopeia, 1998) .The distillation was done for 5 hours. The essential oil obtained was kept in a dark glass vial at 4˚ C for further examination.

Fig. 1. *Gundelia tournefortii* L. Flowering Stage.

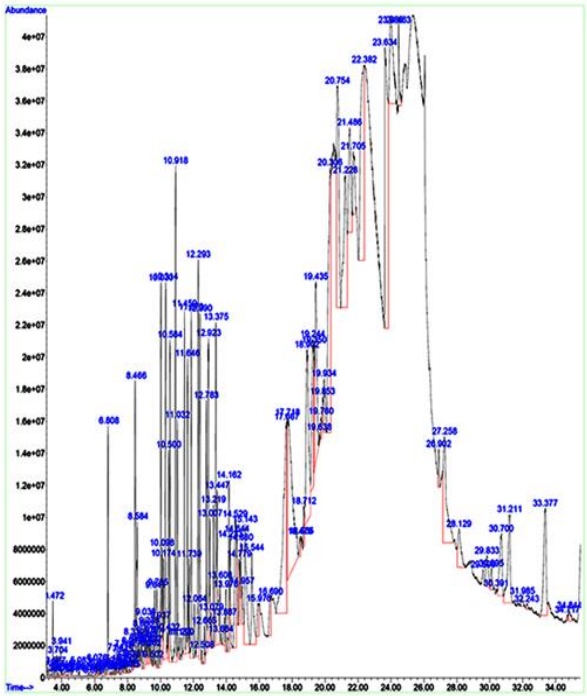

Fig. 2. GC-MS Chromatogram of the essential oil of *Gundelia tournefortii* L.

2.4. Gas chromatography/mass spectrometry (GC-MS) analysis

The oils were analyzed by GC-MS, using Agilent Technologies GC-MS 7890A (built on the industry-leading Agilent GC platform, USA) in the central laboratory of Isfahan University of Technology, Iran. The system contained a mass detector with a steady phase made of silica gel and the HP-5 MS column (30 m × 0.25 mm ID, 0.25 µm film thickness) and helium along with the purity of (% 99.999) as the carrier gas. The injector temperature was set at 220 ˚C for 5 minutes with a split ratio of 1:10. A 1 µl and a volume of 1000 ppm of the obtained oil solution in a GC grade *(n-hexane*) were injected. To separate different oil components, a linear temperature program was adapted as described here: at first, the column was kept at 50 ˚C for 2 minutes, ramped at a rate of 10 ˚C/min to 150 ˚C, and held isothermal for 5 minutes; then the ramp of 20 ˚C/min was applied up to 220 ˚C and held isothermal for 10 minutes. The mass spectrometry detector was taken at 70 eV and the mass range was 40-400 *m/z*. Component identification was done using their recorded spectra by utilizing the spectrometric electronics libraries provided by the instrument software (Wiley, 1994; Adams, 2001). Also, the identified components of the essential oil were recorded.

3. Results and discussion

The yield of the essential oil of *Gundelia tournefortii* L. was recorded to be 0.8 % (v/w). The results of analysis are presented in table 1. In this research, the 70 compounds belonged to six main chemical groups including (terpenes, hydrocarbons, alcohols, acids, esters, phenols) which were identified in *Gundelia tournefortii* L. essence. Also, the findings indicated that the major components were palmitic acid (12.48 %), lauric acid (10.59 %), alpha ionene (6.68 %), myristic acid (4.45 %), 1-hexadecanol, 2-methyl (3.61 %), phytol (3.6 %), and beta turmerone (3.4 %). All these mentioned groups were classified in minor groups such as terpenoieds (monoterpens, sesquiterpens and diterpens), hydrocarbons (aliphatic, aromatic and cyclic hydrocarbons), acid (aliphatic acid or the so-called fatty acid) and the two remaining groups were situated in miscellaneous compounds. The amount of each of the groups was as follows:

terpenoieds consists of monoterpens (20.83 %), sesquiterpens (70.83 %) and diterpens (8.33 %), aliphatic hydrocarbons (24.28 %), aromatic hydrocarbons (14.28 %), cyclic hydrocarbons (8.57 %), aliphatic acid (7.14 %) and miscellaneous coumpound (11.42 %). GC-MS chromatogram of the essential oils of *Gundelia tournefortii* L. along with its details is shown in figure 2 and table 1. **(Fig. 2** and **Table 1)**

In the present study, the major constituents were fatty acid compounds with a considerable amount. Overall, fats and oils have been one of the most important components of human food since many years ago. They release 9.2 Kcal g^{-1} and are basically derived from plant (71 %) and animal sources (Salunkhe *et al.,* 1992). Some researchers in the previous study have demonstrated the presence of this constituent in the mentioned plant. The existence of the substantial amounts of fatty acids and sterol compounds in the arial parts of *Gundelia tournefortii* L., particularly in its seeds has been confirmed in two studies in Iran and Iraq (Khanzadeh *et al.,* 2012; Dalia *et al.,* 2012). Also, naphthalene compounds and its derivatives were identified for the first time and the amount of them in this research was (9.67 %) of the total identified. Presumably, this was due to the special environmental conditions of this area in Iran. The first comprehensive study regarding the phytochemical analysis of *Gundelia tournefortii* L. was done in Jordan (Halabi *et al.,* 2005). They demonstrated that the identified major component in mentioned plant consisted of alpha terpineol acetate (36.21 %), methyl eugenol (12.57 %), eugenol (6.7 %), beta caryophyllene (5.94 %) and zingiberene (5.84 %); in the present analysis, however, the results were not similar with those of that study, showing the marked presence of a wide range of terpenoides compounds such as beta caryophyllene and other terpenoides compounds. Despite their low amount this can be considered as one of the positive points because the identified compounds in this major group enjoyed a high diversity in various sub groups. This implied that factors such as genetic patterns and environmental conditions could be very effective in the creation of diverse compounds along with a variable amount. Another study in this field investigated the essential oil of two varieties of *Gundelia tournefortii* L. from turkey (Bagci *et al.,* 2010). These two varieties were *Gundelia tournefortii* L. (var. *tournefortii* and var. *armata* Freyn and Sint). Overall, 85 compounds were identified for both of varieties. The results of this research were closer to those of the present study. In comparison with the previous research, the presence of various constituents from diverse chemical functional groups was more visible but the existing compounds in *Gundelia tournefortii* L. (var. *armata* Freyn & Sint) corresponded to the identified constituents in the present study; nevertheless, the amount of these similar constituents was completely different. In the current study, the presence of several new compounds in the essential oil of the arial parts of *Gundelia tournefortii* L. was shown for the first time. These constituents belonged to various groups identified. Some of these compounds were as follows: (alpha longipinene, alpha ionene, prehnitol, hotrienol, ar turmerone, beta turmerone) as well as some other new compounds. The molecular structure of some of the new compounds isolated from the essential oil of *Gundelia tournefortii* L. is shown in figure 3. The mentioned constituents were in some angiosperm (flowering plant) families and in families such as asteraceae, lamiaceae, malvaceae, myrtaceae, lauraceae and araceae (Pengelly, 1996). They have various usages, particulary in the field of prevention and treatment effects due to some pathogenic factors; they are also used as an ingredient in the process of manufacturing and production hygienic and cosmetic products (Hucklenbroich *et al.,* 2014; Curtis and Williams, 2001).

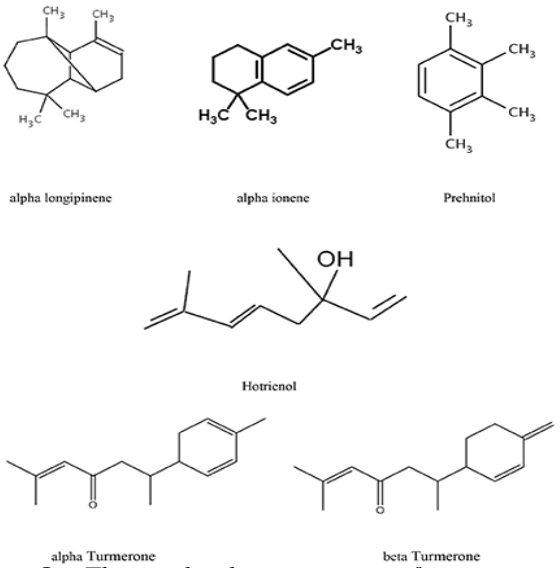

Fig. 3. The molecular structure of some new compounds isolated from the essential oil of *Gundelia tournefortii* L.

Table 1. The identified constituents of the essential oil of *Gundelia tournefortii* L.

No.	Compounds[a]	Rt[b]	%
1	Octane	3.472	0.19
2	α-Longipinene	6.076	0.11
3	Decane	6.808	0.39
4	2(5H)-Furanone, 5,5-dimethyl	5.878	0.11
5	α-Terpinolene	8.330	0.12
6	Undecane	8.466	1.01
7	2-Ethylbenzotriazole	8.584	0.7
8	*cis,cis,cis*-1-Isobutyl-2,5-dimethylcyclohexane	8.660	0.1
9	Prehnitol	8.880	0.17
10	4-Acetyl-1-methylcyclohexene	9.036	0.28
11	Cyclohexane, 1-ethyl-2-propyl	9.108	0.39
12	Cyclohexane, 3-ethyl-5-methyl-1-propyl	9.184	0.13
13	Cyclopentasiloxane, decamethyl	9.239	0.19
14	Naphthalene, decahydro-1,6-dimethyl	9.573	0.22
15	Naphthalene, decahydro-2,3-dimethyl	9.758	0.42
16	Dodecane	10.030	1.86
17	Nonadecane	10.098	0.41
18	Naphthalene, decahydro-2,6-dimethyl	10.174	0.6
19	*trans,trans*-1,8-Dimethylspiro[4.5]decane	10.500	0.7
20	Naphthalene, decahydro-1,5-dimethyl	10.584	1.75
21	α-Ionene	10.918	6.68
22	Vitispirane	11.290	0.17
23	Tridecane	11.459	2.37
24	Hexadecane	11.739	0.27
25	2-Methoxy-4-vinylphenol	11.870	1.98
26	p-Xylene	12.064	0.35
27	1H-Indene, 2,3-dihydro-1,1,4,6-tetramethyl	12.293	2.09
28	1-(2,4,6-Trimethylphenyl)buta-1,3-diene	12.390	2.3
29	α-Copaene	12.665	0.18
30	β-Damascenone	12.783	1.07
31	Dihydro aromadendrene	12.923	2.35
32	Longiborneol	13.079	0.13
33	Benzene, 4-ethyl-1,2-dimethyl	13.375	2.08
34	β-Caryophyllene	13.447	1.46
35	ar-Turmerone	13.608	0.29
36	Neryl acetone	13.887	0.21
37	Phytane	13.976	0.76
38	(3s,4as,8ar)-3,4,4a,7,8,8a-hexahydro-1,1,3,6-tetramethyl-3-vinyl-1H-2-benzopyran	14.529	2.38
39	Germacrene-D	14.644	0.59
40	Pentadecane	14.779	0.34
41	(7S,10S,5E)-2,6,10-Trimethyl-7,10-epoxy-2,5,11-dodecatriene	14.880	0.22
42	β-Bisabolene	15.143	2.02
43	β-Sesquiphellandrene	15.544	1.19
44	Hotrienol	15.976	0.65
45	α-Farnesene	16.690	0.45
46	Lauric acid	17.667	10.59
47	Aromadendrene	18.479	0.22
48	6-Aza-5,7,12,14-tetrathiapentacene	18.712	0.22
49	β-Turmerone	18.902	3.4
50	Tetradecane	19.244	1.97
51	Linalool	19.350	0.77
52	Undecane, 4-cyclohexyl	19.435	2.19
53	Oleic acid	19.760	0.16
54	Caryophyllene oxide	19.934	1.27
55	Myristic acid	20.306	4.45
56	1-Hexadecanol, 2-methyl	20.754	3.61
57	Hexahydro farnesyl acetone	21.228	1.72
58	α-Curcumene	21.705	0.7
59	Pentadecanoic acid	21.486	1.63
60	Palmitic acid	23.634	12.48
61	Phytol	23.985	3.6
62	(Z,Z)-6,9-cis-3,4-epoxy-nonadecadiene	26.902	0.24
63	Octadecane	27.258	2.62
64	Cyclododecyne	28.129	0.85
65	Eicosane	29.596	0.16
66	Phosphonic acid dioctadecyl ester	30.095	0.24
67	S-beta Aminoethylthiosulfuric acid	30.700	1.1
68	Phenol, 2,4-bis(1-phenylethyl)	31.211	1.29
69	Heneicosane	33.377	1.94
70	14-beta-H-pregna	34.844	0.14
	Total identified		99.99

[a] Compounds listed in order of elution on the DB5 column.
[b] Retention time (as min).

4. Conclusion

In the present study, existing constituents in the extract of *Gundelia tournefortii* L. were analyzed in one of the habitats in central Zagros, Iran. Some of the

identified compounds were introduced for the first time and the rest of compounds had been previously reported. Consequently, by considering the present research and previous studies, it could be stated that two important factors, namely genetic and environmental factors, have the major effect on the genesis, formation, presence and absence of available constituents in the mentioned plant. Apart from these, there are many factors that can be considered but this needs further research. Also, in Iran, traditional medicine abundance advantage of *Gundelia tournefortii* L. especially in the treatment of chronic illnesses has been confirmed. In addition, mentioned plant is used as a source of food nutrition and an additive, as well as preparation of local dishes and dietary supplements in some rural and urban areas in Iran. Finally, Iran, due to rich species storages and particular climate condition, can be regarded as a unique country in the world in terms of medicinal species productivity.

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