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Physiochemical Properties of *Gundelia tournefortii* L. Seed Oil

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ABSTRACT

***Gundelia tournefortii* L. is a well known plant in mountains of Iran and is found all over the country. It traditionally has some medicinal applications. In this research, *Gundelia tournefortii* L. seed was studied as a source of edible oil. Oil was extracted with immersion method using diethyl ether as a solvent. Acidity, saponification, ester, iodine, peroxide and refractive indices, average molecular weight of fatty acids, unsaponifiable matter, viscosity, color and density of extracted oil were evaluated. In addition, fatty acid composition of oil was determined using gas chromatography analysis. The results showed that seed oil content and saponification value of its oil were 22.8% and 166.05, respectively. Oleic and linoleic acid contents of oil were 27.99% and 54.59%, respectively. It was indicated that the extracted oil is an unsaturated oil and melts at ambient temperature. Beta-sitosterol and stigmasterol were the main unsaponifiable matters of the oil. Color analysis revealed that the predominant color was yellow (0.8 red, 14 yellow). The results indicated that *Gundelia tournefortii* L. seed can be potentially applied as an excellent oil for human consumption.**

Keywords: Edible oil, Fatty acid composition, *Gundelia tournefortii* L., Physiochemical properties.

INTRODUCTION

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 [22]. Oilseeds are the most important products which contain vegetable oil and have a special role in agriculture. These high cost products are cultivated all over the world. Their importance is either due to oil contents and nutritive protein materials which are consumed as animal and human foods after oil extraction. The oil seeds are important products for global trading and they are the third most important agricultural products after meat and cereal. Development of oil technology in the world has had significant effects on the oil consumption. The oil consumption has been increased steadily from 2 kg $year^{-1}$ in 1963 to 14.5 kg $year^{-1}$ in 2000 [20]. Increasing oilseed fields area and cultivation of new oilseeds are two main strategies to maintain the supply of edible oil [21]. Gundelia (Kangar in Farsi), *Gundelia tournefortii* L., is a thistle-like, stout, perennial herb with milky latex that reaches a height of 20-100 cm [13]. It is a member of Asteraceae (compositae) family [8]. This plant is one of the most abundant plants in mountainous and steep lands of Iran. It is found in almost all mountains throughout the country, such as Hamadan, Kermanshah, Azerbaijan, Bakhtiari, Lorestan, Fars, Kurdistan and Khorasan Provinces as well as south of Alborz [16]. *Gundelia tournefortii* L. Stem, which is a rich source

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of minerals and vitamins C, B and A, is edible and has therapeutic uses in traditional medicine [8, 16]. It is claimed that this plant may act as a liver protector and a blood purifier as well. It was reported that *Gundelia tournefortii* L. has similar properties to *Cynara scolymus* L. and may reduce fat and specially cholesterol content of the blood [8]. Dry seed of *Gundelia tournefortii* L. has an effective influence for the treatment of Vitiligo [9].

Sabz Alian *et al.* (2004) studied *Cynara cardunculus* L. seed oil and determined refractive index, iodine value, acid value, saponification value and yield of oil extraction of this seed [21]. Miceli and Leo (2006) extracted seed oil of *Cynara scolymus* L. by diethyl ether as the solvent and determined its physicochemical properties [19].

MATTHÄUS and ÖZCAN (2011] studied the chemical composition and mineral contents of flower bud of wild tumbleweed (*Gundelia tourneforti* L.) growing in Turkey. The oil of flower buds were rich in linoleic acid (57.8%), followed by oleic acid (28.5%) and palmitic acid (8.1%). Stearic acid, vaccenic acid and arachidic acid were also found.

The total content of sterol of the oil was established as 3,766.60 mg kg^{-1}, with b-sitosterol as the predominant sterol that accounted for more than 51.76% of the total amount of sterols. Other sterols were established as 18.52% stigmasterol, 9.82% 5-avenasterol, 6.02% campesterol, 3.68% 7-stigmastenol and 2.63% 7-avenasterol [20].

Erclyes *et al.* (1989) studied seed oil of four plant species of Turkish origin. The results indicated that reflective index, viscosity, saponification value, acid value, unsaponifiable matter and iodine value of Gundelia seed oil were 1.4673 at 25°C, 17 cP, 58, 193.7, 1.26% and 6.7, respectively. The fatty acid composition of the oil included palmitic acid (12.08 wt%), stearic acid (2.45 wt%), oleic acid (23.43 wt%) and linoleic acid (62.04 wt%) [13].

In this research we studied physiochemical properties of *Gundelia tournefortii* L. seed oil as a potential source of edible oil.

MATERIALS AND METHODS

Materials

Seeds of *Gundelia tournefortii* L. were collected at the final stage of their maturity (July, 2009) from Golmakan town, 40 kilometers west of Mashhad, Khorasan Razavi Province, Iran. Development of light brown color is a sign of maturity of seeds. This corresponded to the dry stage of Gundelia's buds followed by loosening of seeds. The Gundelia's buds containing matured seeds were randomly harvested from a 400 m^2 area. Moisture of seeds' crust was removed by keeping them in shadow for 48 hours in a thin layer. All chemicals were analytical grade and purchased from Merck (Germany).

Preparation of Gundelia Seed Oil

The crusts of seeds were removed by hand and the kernels were milled using a grinder. The grounded kernels were immediately immersed in diethyl ether (1:10 ratio w/v) and mixed for 12 hours in darkness. The resulted miscella was separated from cake using Buchner funnel and filter paper (Whatman No.41). The solvent was evaporated by a rotary vacuum evaporator at 30ºC. The oil extraction was repeated three times and reported as the mean±SD.

Physiochemical Analysis

Percentages of kernel and crust, moisture content (vacuum oven) [1], specific gravity [2], color (lovibond and AOCS criteria) [3], free fatty acid [4], saponification value [5], refractive index [6] and acid value [7] of *Gundelia tournefortii* L. seed oil were determined according to standard methods.

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Mean molecular weight of fatty acids was calculated through saponification value [15]. Oil viscosity was evaluated by Ostwald Method at 25ºC [15]. Peroxide value [11], iodine value [10], Ester index and unsaponifiable compound were evaluated according to national standard methods of Iran. Fatty acid composition was determined by methylation of FFAs and Gas chromatography analysis. Each analysis was repeated three times and reported as mean ±SD.

Determination of Fatty Acid Composition

Analytical gas chromatography was carried out using a Termoquest 2000 GC with capillary column BPX-70 (120 m , 0.25 mm id, 0.25 µm film thickness), carrier gas Helium, split ratio 1:100, Helium flow rate 0.7 ml min^{-1} and a flame ionization detector at 280°C. The injector temperature was 250°C and the column temperature was set constant at 198°C for 100 minutes. For analysis, FFAs were first methylated by adding 7 ml of hexane and 2 ml of 2M MeOH/KOH to 15 drops of sample, mixing for 30 seconds and heating in water bath (50-55°C), while shaking the tube 2-3 times for 15 minutes and then centrifuged at 3000g for 5 minutes. The supernatant was collected and after dehydration by anhydrous Na_2SO4, 0.6 µL of the sample was injected to the GC apparatus [23]. For the determination of FFAs, the retention time of each sample was compared with standard methyl esters.

Analysis of Unsaponifiable Matters

1 ml of internal standard (alpha-cholestane, 1 mg ml^{-1}, acetone solution) was added to 250 mg sample. 5 ml KOH solution (0.5M) was added and boiled in a reflux condenser for 15 minutes. Afterwards, while the mixture was warm, 5 ml ethanol was added and mixed thoroughly. 5 ml of the resulted mixture was transferred into an aluminum oxide column. Unsaponifiable matters were washed with 5 ml ethanol. Then 30 ml diethyl ether was added (2 ml min^{-1}) and the solvent was removed using a rotary evaporator [12]. Unsaponifiable matter was dissolved in diethyl ether and 5µl of the sample was analyzed by TLC (stationary phase: silica gel, 20 cm×20 cm, 0.25 cm thickness; mobile phase: Hexane/Diethyl ether, 1:1). Standards (cholestane 1 mg ml^{-1} in acetone, Betulin 5 mg ml^{-1} in acetone) were tested as well. The plate was sprayed with methanol after developing the system and the sterols were demonstrated as white zones on a darker background. The zones were scraped and washed with ethanol and diethyl ether. Samples were concentrated in a rotary evaporator and the solvent was completely removed using a nitrogen flow [12]. 100 µL of silyl reagent (50 µL 1-Methylimidazole plus 1 ml N-methyl-N-(trimethylsilyl)-hepta-fluorobutyramide) was added to extracted sterols and kept at 105ºC for 15 minutes. After cooling, samples (1 µL) were injected to the GC apparatus. The GC analysis was carried out using a Termoquest 2000 GC equipped with SE-54 column (50m, 0.25mm ID, 250µm film thickness). Nitrogen (36 cm s^{-1}) was used as a carrier gas. The column temperature was programmed between 240 and 255ºC with a ramp rate of 4 ºC min^{-1}. Results were reported as the percent and calculated as the ratio of peak area of each sterol to whole area of peaks [12].

RESULTS AND DISCUSSION

Physicochemical Properties of Gundelia Seed Oil

Physiochemical characteristics of *Gundelia tournefortii* L. seed oil are shown in Table 1. The percentages of crust and kernel of seeds were 70.42 and 29.4%, respectively indicating more crust and less kernel percent compared to those of cottonseed (32% crust and 55% kernel) and

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Table 1. Physicochemical properties of Gundelia seed and Gundelia seed oil.

Properties	Value [a]
Oil content (%)	22.8±1.9
Acidity (%)	1.097±0.0056
Acid value (mg g^{-1})	2.199±0.012
Saponification value (mg g^{-1})	166.05±0.427
Ester value (mg g^{-1})	163.85±0.61
Iodine value (g 100 g^{-1})	132.81±0.303
Peroxide value (meq O_2 Kg^{-1})	0.896±0.002
Average molecular weight of fatty acids	377.91±0.87
Unsaponifiable matters (%)	1.68
Refractive index (25ºC)	1.4715
Refractive index (40ºC)	1.4675
Viscosity (Pa s)	0.03186±0.00008
Water (%)	0.23±0.098
Specific gravity (g cm^{-3})	0.9174±0.0007
Crust of seed (%)	70.42±0.64
Kernel of seed (%)	29.4±0.69
Color (lovibond)	Red 0.8, Yellow 14
Color (AOCS)	Red 0.5, Yellow 12

[a] Means of 3 replications±Standard deviation.

sesame seed (17% crust) [17]. Moisture and volatile content of Gundelia seed oil was 0.23%. The color results are shown using two criteria; lovibond and AOCS; and these were red 0.8, yellow 14 and red 0.5 and yellow 12, respectively. In AOCS criteria, the intensity of red color of Gundelia seed oil was lower than cottonseed, (2-2.5) [17] and soybean oil, (11.1), comparatively [14]. The Specific gravity of Gundelia seed oil was 0.9174 g cm^{-3} which is similar to vegetable oils. For example, specific gravity of cottonseed, soybean, corn, sunflower, sesame and safflower oils were reported to be 0.917, 0.9175, 0.918, 0.920, 0.918-0.921 [17] and 0.919-0.924 [14] at 25ºC, respectively. The viscosity of Gundelia seed oil was 0.03186 Pa s. This value for soybean, corn and safflower oil at 25ºC was reported to be 0.0509, 0.0565 and 0.0522 Pa s [17], respectively. Refractive indexes of Gundelia seed oil at 25º and 40ºC were 1.4715 and 1.4675, respectively while this parameter for cottonseed, safflower and soybean oils at 25ºC was 1.468-1.472, 1.473-1.476 [14] and 1.4728 [17], respectively. Specific gravities of these oils at 40ºC were 1.4648, 1.467-1.470 and 1.466-1.470 [17] respectively. Therefore, the values obtained in this study are comparable to those of other edible oils.

Acidity of Gundelia seed oil based on linoleic acid was 1.097%. This value was similar to Canola (1%) and sesame oils (1-3%) but was lower than safflower, sunflower and corn oils (maximum 2%). Reported acidity of soybean oil (0.3-0.7%) was lower than Gundelia seed oil [17, 14]. Acid value of Gundelia seed oil was 2.1987 mg g^{-1} which was higher than soybean oil (0.6) and lower than corn and sesame oils (maximum 4) [17]. Saponification value of Gundelia seed oil was calculated to be 166.05 mg g^{-1}. Almost all edible oils have saponification values ranging from 182 to 198 mg g^{-1}.

The ester index and iodine values of Gundelia seed oil were 163.85 mg $g^{-1}$and 132.81 g 100 g^{-1}, respectively. Vegetable oils are classified as drying, semi-drying and non-drying regarding to their iodine values [15]. The iodine value of Gundelia seed oil was similar to that of soybean oil (120-143 g 100 g^{-1}), corn oil (103-128 g 100 g^{-1}) and sunflower oil (125-136 g 100 g^{-1}) [15, 17]. Therefore the Gundelia seed oil can be regarded as semi-drying oil.

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Peroxide value of Gundelia seed oil was 0.89 meq O_2 Kg^{-1}. Average molecular weight of Gundelia seed oil was calculated as 377.91 while this value for cottonseed, safflower, sunflower and soybean oils was 282, 295, 283 and 291, respectively. The oil content of Gundelia seed was 22.8% which was comparable to artichoke (20.5%) [19], soybean (18-20%) and cotton seed oils (18-20%) [17].

Fatty Acid Composition

The chromatogram of fatty acids of Gundelia seed oil is presented in Figure 1. This oil has high levels of unsaturated fatty acids. The oleic acid and linoleic acid contents of Gundelia seed oil were 27.99% and 54.59%, respectively (Table 2). The total content of unsaturated fatty acids was 82.58%. These values are similar to soybean and sunflower oils. The contents of oleic acid and linoleic acid in soybean oil are 26.4 and 50.8% and sunflower oil contains 30.2 and 55.4% oleic acid and linoleic acid, respectively [23].

Sterols of Gundelia Seed Oil

Sterols are the main compounds of unsaponifiable matters of the oils. Because these compounds are relatively neutral and

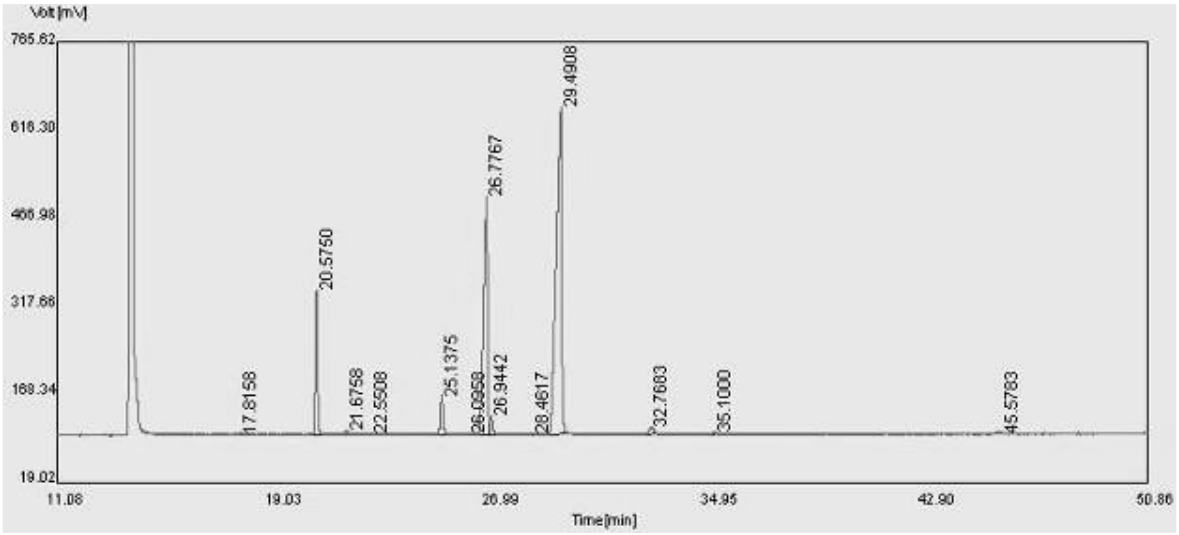

Figure 1. Chromatogram of fatty acids of Gundelia seed oil.

Table 2. Fatty acids composition of Gundelia seed oil.

Fatty acid	Formula	Retention time (Min)	Content (%)
Myristic acid	C14:0	17.82	0.1645
Palmitic acid	C16:0	20.57	9.8881
Palmitoleic acid	C16:1	21.67	0.3426
Margaric acid	C17:0	22.57	0.1618
Stearic acid	C18:0	25.14	3.3501
Elaidic acid	C18:1 t	26.09	0.1513
Oleic acid	C18:1 n-9	26.78	27.9908
Vaccenic acid	C18:1 n-7	26.94	1.6011
Rumenic acid	C18:2 t	28.46	0.1727
Linoleic acid	C18:2	29.49	54.5915
Linolenic acid	C18:3	32.77	1.0271
Gadoleic acid	C20:1	35.1	0.2653
Behenic acid	C22:0	45.76	0.2931

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do not participate in the sensory properties of the oil, food technologists are less interested in them. Vegetable oils contain 0.15-0.9% sterols (called phytosterols). Campesterol, stigmasterol and sitosterol are the main constituents of phytosterols. The main phytosterol in plants is sitosterol (24α-ethylcholesterol). Among other phytosterols, occurring in lesser contents in vegetable oils are Δ5 and Δ7-avenasterol, Δ7- stigmasterol and fucosterol [15]. Total unsaponifiable matter of Gundelia seed oil was 1.6821% which was more than cottonseed (0.5-0.7% or <1.5%), soybean (1.6%, <1.5% or 1.3-1.6%), palm seed (0.4% or <1%), safflower (0.6%, 0.3-0.6% or <1.5%) and sunflower (0.7% or up to 1.5%) [9, 15, 17], but less than maize (2%) and canola (up to 2%) [17]. The Main phytosterols in Gundelia seed oil were β-sitosterol (35.25%) and stigmasterol (11.69%). Miceli and Leo (1996) reported β-sitosterol (45.6%) and Δ7-stigmasterol (18.4%) were the main sterols of artichoke seed oil. β-sitosterol in sunflower oil (56.2-65%) was higher than Gundelia seed oil while its stigmasterol (7-11.5%) was in the same range [19]. Figure 2 shows the chromatogram of Gundelia seed oil sterols

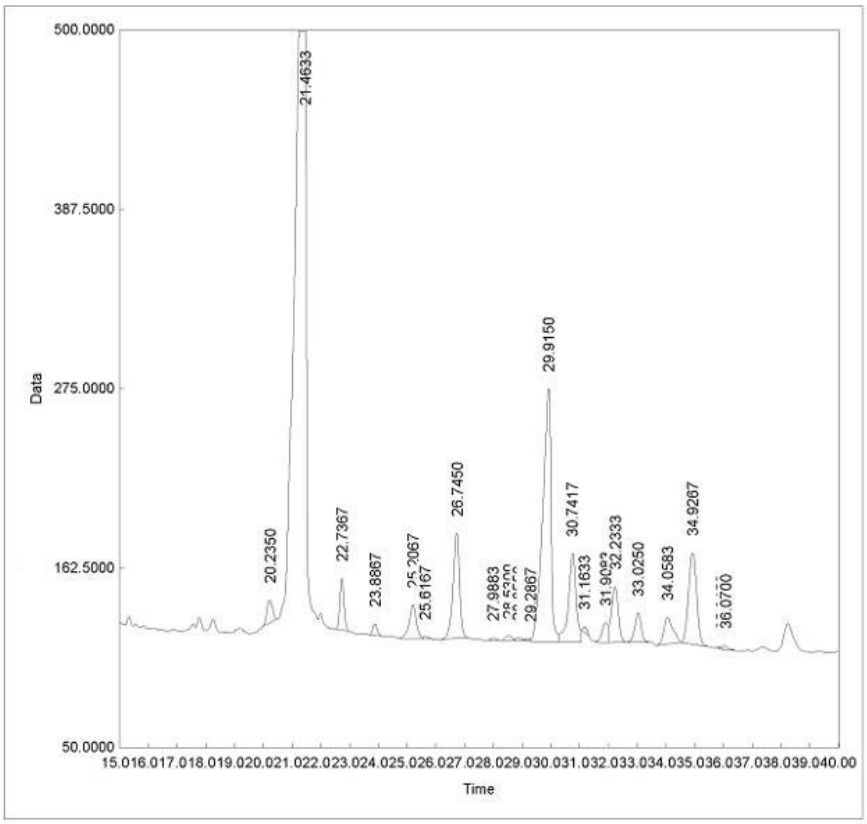

Figure 2. Chromatogram of Gundelia seed oil sterols.

Table 3. Sterol contents of Gundelia seed oil.

No.	Compound	Content (%)	Retention time (Min)
1	Brassicasterol	3.7	22.74
2	Campesterol	4.04	25.21
3	Stigmasterol	11.7	26.745
4	Δ7-Campestrol	0.22	27.99
5	β- sitosterol	35.25	29.91
6	Δ5-avenasterol	11.59	30.74

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and different sterols found in Gundelia seed oil are depicted in Table 3.

CONCLUSIONS

Because the oil content of Gundelia seed is 22.8%, it would be a potent source for extraction of edible oil. The physicochemical properties of Gundelia seed oil indicated that this oil has high edibility quality. The fatty acid composition of this oil was similar to soybean and sunflower oils. The Main phytosterols in Gundelia seed oil were β-sitosterol and stigmasterol.

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خصوصیات فیزیکوشیمیایی روغن بذر کنگر (*Gundelia tournefortii* L.)

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چکیده

گیاه گاندلیا تورنه فورتی گیاهی شناخته شده در مناطق کوهستانی ایران است که در سرتاسر ایران به وفور پیدا شده و دارای کاربردهایی در طب سنتی است. در این پژوهش، بذر گیاه گاندلیا تورنه فورتی به عنوان یکی از منابع روغن‌های خوراکی مورد مطالعه قرار گرفت. روغن بذر کنگر (*Gundelia tournefortii* L.) به روش غرقابی و با حلال دی اتیل اتر(۱:۱۰ $\frac{w}{v}$) استخراج و خصوصیات فیزیکوشیمیایی آن شامل مقدار روغن، اسیدیته آزاد، اندیس اسیدی، صابونی، استر، یدی، پراکسید، میانگین وزن مولکولی اسیدهای چرب، مواد غیر صابونی شونده، ضریب شکست، ویسکوزیته، وزن مخصوص، رطوبت، مقدار پوسته و مغز بذر ، رنگ و نمایه اسیدهای چرب به روش کروماتوگرافی گازی تعیین شدند. نتایج نشان دادند که محتوی روغن، ۱/۹±۲۲/۸ درصد و اندیس صابونی ۰/۴۲۷±۱۶۶/۰۵ میلی گرم در هر گرم روغن است. روغن بذر کنگر با داشتن به‌ترتیب ۲۷/۹۹٪ و ۵۴/۵۹٪ اولئیک اسید و لینولئیک اسید، بسیار غیراشباع بوده و در دمای اتاق مایع است. عمده‌ترین ترکیبات غیر صابونی شونده روغن بذر کنگر، عبارتند از β-سیتوسترول (۳۵/۲۵۰۶٪) و پس از آن استیگماسترول (۱۱/۶۹۴۵٪) که مجموعا ۱/۶۸۲۱٪ می‌باشند. نتایج نشان می‌دهند که رنگ آن زرد (۰/۸ قرمز، ۱۴ زرد) است. بذر گیاه گاندلیا تورنه فورتی دارای پتانسیل استفاده به عنوان منبع مناسب روغن, برای مصارف انسانی است.

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