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Original Article

Functional Components and Biological Activities of *Peucedanum chenur* Mozaff as a Natural Spice From the Apiaceae Family

Omid Asgari[1], Dara Dastan[1*]

[1]Department of Pharmacognosy, School of Pharmacy, Medicinal Plants and Natural Products Research Center, Hamadan University of Medical Sciences, Hamadan, Iran

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***Corresponding author:**
Dara Dastan,
Email: d.dastan@umsha.ac.ir

Abstract

Background: *Peucedanum chenur* Mozaff has been used by local people as a spice and for the treatment of urinary infections. The chemical constituent and biological activities of the essential oil (EO) and the extract of *P. chenur* Mozaff were evaluated in this study.

Methods: The EO components were qualitatively and quantitatively identified by gas chromatography/mass spectrometry (GC/MS) and gas chromatography/flame ionization detector. The phytochemical analyses, total flavonoids, and phenolic contents of the extract were determined, and then the phenolic compounds of the extract were quantified by reverse-phase high-performance liquid chromatography.

Results: Based on the results, 36 compounds were identified in the volatile oil, accounting for 94.7% of the total oil. The major components were α-pinene, limonene, γ-terpinene, β-pinene, and sabinene. The EO exhibited significant antibacterial activity on *Bacillus cereus, Escherichia coli, Staphylococcus aureus*, and *Klebsiella pneumoniae*, whereas it exerted no effect on *Pseudomonas aeruginosa*. The antioxidant activity of the volatile oil had a half maximal inhibitory concentration value of 122 ± 2.1 (μg/mL). Rutin, caffeic acid, naringenin, apigenin, and quercetin (183.6, 132.8, 38.4, 13.1, and 3.5 mg/100 g of the plant, respectively) were quantified in the methanolic extract.

Conclusion: The various bioactive compounds and the antibacterial and antioxidant activities of *P. chenur* Mozaff confirmed the potential of this plant for use in the food, pharmaceutical, and cosmetic industries.

Keywords: Antibacterial, Caffeic acid, DPPH, Essential oil, *Peucedanum chenur* Mozaff, α-Pinene

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Introduction

The genus *Peucedanum* with more than 120 species, belonging to the Apiaceae family, is widely found in various regions of Asia, Europe, Africa, and Iran (with 21 species). Previous studies have shown that plants in the genus *Peucedanum* are rich sources of different compounds such as essential oils (EOs), coumarins, flavonoids, diterpenes, phenolic acids, and glycosides. They possess different biological effects such as anticancer, antimicrobial, antioxidant, anti-obesity or bodyweight reducing, cardiopulmonary protection, antihyperlipidemic, and antityrosinase properties. Furthermore, the plants of this genus have been used in traditional medicine in many countries as diuretic, expectorant, sedative, and antimicrobial agents and for the treatment of various problems such as headache, sore throat, coughs, and respiratory, cardiovascular, and inflammatory diseases (1). In "The Canon of Medicine" by Avicenna, the *Peucedanum grande* fruit was mentioned as an effective diuretic in the prevention and treatment of kidney stones (2). Moreover, *Peucedanum pastinacifolium* is known as an antihyperlipidemic vegetable among the local people in Iran (3). Today, one of the challenges facing human beings is the resistance of pathogenic microorganisms to current antibiotics, underlining the need for new antibiotics. In this regard, the search for natural products with antibacterial effects to develop new antibiotics with different mechanisms of action and fewer side effects can be an important step to overcome this problem (4). Studies have revealed that EOs have remarkable antibacterial activity against different bacterial strains. In addition, combining EOs with antibiotics to increase the antibacterial effect and reduce the effective dose of antibiotics is a method that has recently attracted the interest of researchers to achieve a new generation of herbal medicines. The synergistic effects of the EOs obtained from some *Peucedanum* species in combination with other antibiotics have been established thus far (5,6).

EOs are volatile, nonpolar, and generally aromatic compounds, which are found in various parts of plants. Due to their various volatile compounds, EOs produce various biological effects such as antiseptic (antiparasitic, antiviral, antibacterial, and antifungal), insecticidal, antioxidant, and cytotoxic effects; demonstrating great potential uses in a variety of fields such as food, pharmaceutical, and cosmetic industries (e.g., as preservatives and flavors). The history of the application of EOs goes back to the Middle Ages (7,8).

The overactivity of free radicals in the body can lead to various injuries and diseases such as premature aging, cancer, and cardiovascular disorders. Antioxidants have been identified as important agents in the regeneration of damaged cells and the defense against oxidative stress. Functionally, there are different types of antioxidants, among which antioxidants that inhibit free radicals are considered one of the most essential antioxidants, and the study of their capacity has been the subject of much scientific research (9-11).

Peucedanum chenur Mozaff is one of the endemic plants of Iran that has not been studied so far. With regard to studies on the other species of the genus *Peucedanum* and their various pharmacological effects, in this study, the chemical composition and the antibacterial and antioxidant activities of *P. chenur* Mozaff EOs were qualitatively and quantitatively investigated for the first time. Moreover, the plant extracts were phytochemically studied for the presence of different compounds. Concerning the presence of flavonoids and phenolic compounds in the other species of the genus *Peucedanum*, the total flavonoid and phenolic contents of the *P. chenur* Mozaff extract were evaluated in this investigation. Subsequently, the phenolic compounds of the methanolic extract were quantified by the high-performance liquid chromatography-photodiode array detector (HPLC-PDA).

Materials and Methods

Plant Materials

Peucedanum chenur Mozaff was collected from the natural habitat (Kurdistan province, Iran) 35.88993°N, 46.97429°E in the flowering season. The voucher specimen (Herbarium No. 409) of the plant was deposited in the Herbarium of the School of Pharmacy, Hamadan, Iran.

Preparation of EO

The volatile oil of the aerial parts of *P. chenur* Mozaff was obtained by the hydrodistillation technique for 4 hours. A sample (110 g) of the plant was ground and then added to a 2-L balloon flask, and mixed with 1 L of distilled water. The balloon flask was attached to the Clevenger apparatus under the heating mantle. The condenser of the Clevenger apparatus was insulated with cotton and aluminum foil to increase working efficiency. Finally, the volatile oil was dehydrated by anhydrous sodium sulfate and stored at 6°C.

Analysis of the Volatile Oil

The constituents of the EO were qualitatively and quantitatively identified by gas chromatography/mass spectrometry-flame ionization detector (GC/MS-FID; ThermoQuest Trace, UK). The fused-silica capillary column used for analysis was a capillary column (DB-5, 60 m, J & W Scientific®). The temperatures of the column were programmed from 60°C to 250°C (rate of 5 °C/minute), and the holding time was set at the 250°C for 10 minutes. The flow rate of the nitrogen gas as a mobile phase was 1 mL/min in the GC/FID, and the temperature of the injector and the detector was 250°C and 300°C, respectively. In the GC/MS analysis, the flow rate of the mobile phase (helium gas) was 1 mL/min, and the temperature of the interface and ion source was 240°C and 205°C, respectively. Moreover, the ionization energy was 70 eV, and the scan range for mass was 45-456 M/Z. Different parameters such as retention time, retention indices, MS spectra, and GC/MS libraries (Figure 1) were used to identify the constituents (12).

Preparation of the Extracts

For the preparation of the extract by the maceration method, 100 g of the *P. chenur* Mozaff were ground and then soaked in 0.5 L of chloroform with shaking at room temperature for three days. The obtained extract was concentrated using a rotary evaporator at 50°C. This procedure was performed three times. Furthermore, the methanolic extract was obtained by the same procedure. The obtained extracts were evaporated and stored at 4°C.

Antibacterial Activity

The antibacterial activity of *P. chenur* Mozaff volatile oils was evaluated against the standard strains of bacteria (6 gram-positive and 3 gram-negative bacteria) by comparison with standard antibiotics (tetracycline, gentamicin, and ampicillin) using the disc diffusion method by measuring the inhibitory zone in the agar Mueller-Hinton medium

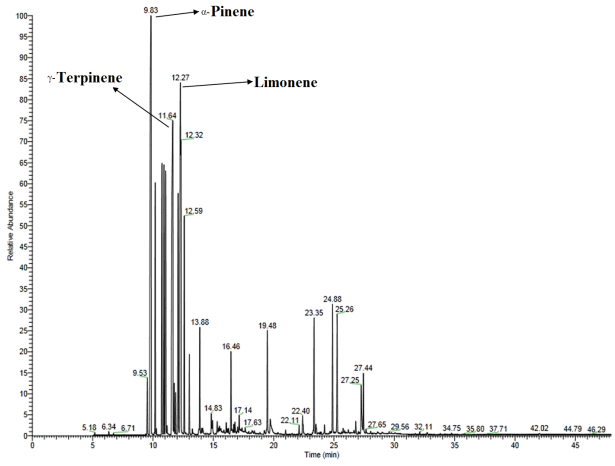

Figure 1. GC-MS Chromatogram of *Peucedanum chenur* Mozaff Essential Oil (Aerial Parts). *Note*. GC-MS: Gas *chromatography*-mass spectrometry

and by minimum inhibitory concentration determination using the broth microdilution assay according to the method of Abdali et al. All analyses were performed in triplicates (13). The standard bacteria included *Bacillus pumilus* (PTCC 1274), *Bacillus subtilis* (ATCC 465), *Staphylococcus aureus* (ATCC 25923), *Bacillus cereus* (PTCC 1015), *Klebsiella pneumoniae* (ATCC 10031), *Enterococcus faecalis* (ATCC 29737), *Escherichia coli* (ATCC 25922), *Staphylococcus epidermidis* (ATCC 12228), and *Pseudomonas aeruginosa* (ATCC 85327).

Determination of Total Phenolic and Flavonoid Content

The total phenolic content was determined using the Folin-Ciocalteu method. Gallic acid was used as the standard, and the calibration curve was plotted after measuring the absorbance of different concentrations. A different concentration of the sample was prepared by dilution in methanol. In addition, 30 µL of the sample was mixed with 300 µL of the Folin-Ciocalteu reagent, and then, 200 µL of sodium carbonate was added to the solution, and finally, the absorbance was measured at 765 nm again.

The total flavonoid content of the extract was expressed as mg of quercetin equivalent per gram of the dry sample. A different concentration of the sample was provided by dilution in methanol. Next, 30 µL of the sample was mixed with 200 µL of sodium nitrite (1 M) and 200 µL of aluminum chloride. Eventually, after one hour, the absorbance was measured at 415 nm again. According to Quercetin as a standard reference, various concentrations were prepared, and the absorbance was recorded at 415 nm. All measurements were performed three times (14).

2,2-Diphenyl-1-picryl-hydrazyl-hydrate (DPPH) Radical Scavenging Activity

The antioxidant activity of the EO was assayed by the method of Dastan et al using ascorbic acid instead of BHT as the standard antioxidant. In this assay, various concentrations of ascorbic acid (1.25-250 µg/mL) were added to the DPPH solution (0.15 mM). The mixture was kept at room temperature for 60 minutes (a dark place with shaking), and then the absorbance was recorded at 517 nm (15).

Phytochemical Analysis

The initial phytochemical analyses of *P. chenur* Mozaff extracts were evaluated using standard methods employed by Ugochukwu et al (16) and Kumar Bargah (17). Further phytochemical analyses of *P. chenur* Mozaff extracts were evaluated using HPLC. The methanolic extract and standard compounds were analyzed using RP-HPLC-DAD equipped with a C18 reversed-phase column (25 cm × 4.6 mm, 3 µm) at 27˚C. The flow rate was 1 mL/min, and the injection volumes were 20 µL of the sample. The applied method (water (A) and HPLC grade methanol (B)) included 0-10 minutes (30% B), 10-30 minutes (30-60% B), 30-55 minutes (60-100% B), and 55-65 minutes (100% B). The wavelength range of the device was also set from 200 to 400 nm. After the injection of the methanolic extract into the HPLC system, the extract chromatogram was compared with the existing standards, retention time, and both 2D and 3D UV spectra in order to identify the phenolic compounds. The amounts of the identified phenolic compounds in the extracts were determined using the calibration curve obtained from the standards. Finally, the amounts of compounds were expressed as µg/g of the dry extract, and ChemStation software was applied for data analysis.

Results and Discussion

The volatile oil obtained from *P. chenur* Mozaff was a thick and yellow liquid with a 0.5 (w/w) yield. The volatile oil components were identified and quantified by GC/MS-FID. A total of 94.7% of the EO components, including 36 different compounds, were identified (Table 1 and Figure 1). The main constituents of the EO were α-pinene (17.26), limonene (14.67), γ-terpinene (14.11), β-pinene (5.79), and sabinene (5.69), belonging to monoterpene hydrocarbons (Figure 2).

Studies on the plants of the genus *Peucedanum* have also shown that the major constituents of the volatile oil of most species in this genus are monoterpene hydrocarbons, and in many species such as *officinal*, *alsaticum, oreoselinum, austriacum, palimbioides, scoparium*, and *cervaria*, the main compound is α-pinene (1).

Additionally, the quality and efficiency of the extraction of volatile oils vary in different studies, which can be affected by several factors such as the parts of the applied plant, environmental factors, harvest season, the genetic and intrinsic factors of the plant, the geographical location of the plant, plant storage conditions after collection, and the method used for the extraction of the EO. In a study performed by Masoudi et al on *P. scoparium*, the EO yield

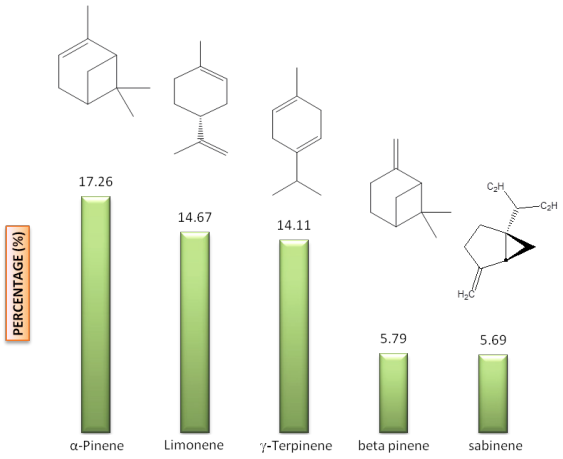

Figure 2. The Main Compounds of the *Peucedanum chenur* Mozaff Essential Oils

Table 1. The Chemical Composition of the Essential Oil From the Aerial Parts of *Peucedanum chenur* Mozaff

No.	Compounds	Area% (±SD[c]) n = 3	RI[a]	RI[b]
1	α-thujene	1.2 ± 0.1	920	924
2	α-pinene[d]	17.3 ± 1.2	932	932
3	Camphene[d]	4.0 ± 0.2	946	946
4	Sabinene	5.7 ± 0.4	968	969
5	β-pinene	5.8 ± 0.5	974	974
6	β-myrcene	4.8 ± 0.3	983	988
7	Dehydro-1,8-cineole	0.1 ± 0.0	985	988
8	γ -terpinene	14.1 ± 0.9	1001	1002
9	δ-3-carene	0.7 ± 0.0	1005	1008
10	α-terpinene	0.6 ± 0.0	1009	1014
11	ρ-cymene	5.3 ± 0.4	1017	1020
12	Limonene	14.7 ± 0.7	1023	1024
13	(z)-β-ocimene	3.6 ± 0.2	1035	1032
14	γ-terpinene	1.2 ± .01	1051	1054
15	*cis*-sabinene hydrate	0.1 ± 0.0	1060	1065
16	Terpinolene	1.8 ± 0.1	1082	1086
17	Linalool	0.1 ± 0.0	1089	1095
18	*cis*-ρ-menth-2-en-1-ol	0.4 ± 0.0	1115	1118
19	α-campholenal	0.3 ± 0.0	1119	1122
20	*cis*-verbenol	0.3 ± 0.0	1139	1137
21	*trans*-verbenol	0.2 ± 0.0	1143	1140
22	pinocarvone	0.3 ± 0.0	1159	1160
23	terpinen-4-ol	1.6 ± 0.1	1173	1174
24	Cryptone	0.2 ± 0.0	1181	1183
25	α-terpineol	0.3 ± 0.0	1185	1186
26	Myrtenal	0.1 ± 0.0	1193	1195
27	β-bourbonene	0.5 ± 0.0	1392	1387
28	(E)-caryophyllene	2.1 ± 0.1	1425	1417
29	γ-elemene	0.3 ± 0.0	1435	1434
30	α-humulene	0.2 ± 0.0	1458	1452
31	germacrene D	2.1 ± 0.1	1490	1484
32	Bicyclogermacrene	2.1 ± 0.2	1505	1500
33	δ-cadinene	0.1 ± 0.0	1525	1522
34	Germacrene B	0.2 ± 0.0	1564	1559
35	Spathulenol	1.4 ± 0.1	1585	1577
36	Caryophyllene oxide	1.1 ± 0.1	1593	1582
	Monoterpene hydrocarbons	80.9		
	Oxygenated monoterpenes	3.8		
	Sesquiterpene hydrocarbons	7.5		
	Oxygenated sesquiterpenes	2.5		
	Total identified	94.7		

[a] Retention indices calculated from the homologous series C6-C30; [b] Retention indices according to RI references; [c] Standard deviation for three replications; [d] The identification was also confirmed by co-injection with standard.

was 0.47% w/w (18). In another study on *P. petiolare*, Rustaiyan et al reported a volatile oil yield of 0.85% w/w (19). Studies on the other species of the genus *Peucedanum* also revealed the EO extraction yields from the aerial parts ranging from 0.02-0.64% v/w (1).

Based on the analysis of the volatile oil of *P. austriacum*, the volatile oil of the leaves differed from that of the fruit. The major constituents in the volatile oil of the leaves were sesquiterpenoids. Further, caryophyllene oxide (23.1%), germacrene D (12.2%), and (E)-caryophyllene (10.2%) were the major compounds. However, in the volatile oil obtained from the fruit, monoterpenoids formed the major part of the volatile oil, and β-phellandrene (45.2%) and α-pinene (10.1%) were the main compounds (20). Furthermore, in *P. officinale*, the efficiency and the number of the compounds in the volatile oils obtained from the flowers, stems, leaves, and roots of the plant were different, while monoterpenes were the main components in all parts of the plant (21).

According to studies on the EOs of the other *Peucedanum* species, α-pinene is the main compound in 7 species, including *officinal, austriacum, oreoselinum, alsaticum, scoparium, palimbioides*, and *longifolium*, while limonene is the main compound in 4 species, including *zenkeri, alsaticum, officinal*, and *cervaria*. On the other hand, γ-terpinene is not the main compound in these 11 species. However, the results of these investigations can be used in the chemotaxonomy of the plants of the genus *Peucedanum* (1,19).

The most prominent feature of the EO of *P. chenur* Mozaff, compared with those of the other mentioned species, is the presence of γ-terpinene, along with limonene as the main constituents. Furthermore, the anti-tumor effects of limonene (22) and the anti-inflammatory effects of γ-terpinene (23) have been proven in previous studies. Hence, the *P. chenur* Mozaff plant can be considered in anti-tumor and anti-inflammatory studies, and further pharmacological studies on the EO of the plant should be conducted in this regard.

The results obtained from the initial phytochemical analyses of the *P. chenur* Mozaff extracts (Table 2)

Table 2. The Results of Phytochemical Analysis of the *Peucedanum chenur* Mozaff Extract

Phytochemical Constituents	Methanol Extract	Chloroform Extract
Flavonoids	+++	-
Phenols	+++	-
Alkaloids	+	+
Proteins	-	-
Terpenoids	+	+
Steroids	+	+
Saponins	-	-
Anthraquinones	-	-
Amino acids	++	-
Tannins	++	+
Glycoside	-	-

Note. +++: Strongly present, ++: Moderately present; +: Slightly present; -: Absent; *P. chenur*: *Peucedanum chenur*.

indicated the presence of different compounds such as steroids, tannins, alkaloids, phenols, flavonoids, terpenoids, and amino acids in this plant, which can be considered the source of pharmacological effects in the plant. Various compounds such as coumarins, amines, glycosides, flavonoids, phenolic acids, and diterpenes have been reported to exist in the *Peucedanum* species in previous studies. For example, the presence of flavonoids, diterpenes, saponins, alkaloids, and phenolic compounds in the plant has been detected in a phytochemical study conducted on *P .beluchistanicum* (24).

The antioxidant capacity of the volatile oil of *P. chenur* Mozaff was determined by the DPPH free radical scavenging method, and a half maximal inhibitory concentration value of 122 ± 2.1 (µg/mL) was obtained accordingly. The amount of the total phenolic of the *P. chenur* Mozaff extract was 0.32 ± 0.07 mg of gallic acid equivalents per gram of the sample. Further, the amount of the total flavonoid for the *P. chenur* Mozaff extract was 0.97 ± 0.09 mg of quercetin equivalent per gram of the sample.

The application of plants containing phenolic compounds has been increasing in various food and pharmaceutical industries. The phenolic compounds in these plants have a variety of biological effects, including antioxidant, anti-cancer, and anti-cardiovascular disease effects (11). In a study performed by Tepe et al on the antioxidant capacity of *P. longifolium* and *P. palimbioides* using the beta-carotene-linoleic acid method, both species exhibited high antioxidant capacity (25).

The antibacterial activity results of the *P. chenur* Mozaff volatile oil are provided in Table 3. α-pinene and β-pinene are the major components of the *P. chenur* Mozaff volatile oil and exhibit considerable antibacterial effects, thus the volatile oil obtained from *P. chenur* Mozaff was expected to show antibacterial activities. The antibacterial test results demonstrated that the growth inhibition zone diameter for *B. cereus* and *K. pneumoniae*, as well as *S. aureus* and *E. coli* was 17 mm and 18 mm, respectively, indicating the significant antibacterial activity against these strains. Consequently, the volatile oil represented the greatest growth inhibitory effect on *S. aureus* and *E. coli*. However, the EO exhibited the weakest activity on *P. aeruginosa*. In the case of Gram-negative *P. aeruginosa* bacteria, it should be noted that gram-negative bacteria are more resistant species owing to their structural characteristics, thus the prevalence of resistant infections triggered by these bacteria has caused serious concern worldwide, especially *P. aeruginosa*, also known as multidrug-resistant bacteria in other studies (26).

Leite et al aimed at inhibiting the growth of Gram-positive bacteria causing infective endocarditis, confirmed the inhibitory effects of α-pinene and β-pinene on the growth of *S. aureus, S. pneumoniae, S. epidermidis*, and *S. pyogenes* (27). Alavi et al revealed that the volatile oil of *P. ruthenicum* fruits showed antibacterial activity against *S. epidermidis, S. aureus*, and *B. cereus* bacteria. However, it had no antibacterial effect on Gram-negative bacteria, including *P. aeruginosa*, *E. coli*, and *S. typhi,* (28). Moreover, Olga et al focused on the antibacterial activity of *P. austriacum* EOs. According to their results, the EO possessed moderate antibacterial activity on *B. subtilis* and *S. aureus* strains, whereas it had weak antibacterial activity against *P. aeruginosa*. Similarly, the volatile oil had no antibacterial activity on *E. coli* and *Salmonella typhimurium* (20).

Regarding the confirmation of the presence of phenolic compounds by phytochemical analyses, the *P. chenur* Mozaff was then analyzed by the high-performance liquid chromatography-photodiode array detector, and five phenolic compounds were identified and quantified, including rutin, caffeic acid, naringenin, apigenin, and quercetin (12243, 8855, 2560, 873, and 230 µg/g of the extract, respectively, Table 4). It should be noted that these compounds were first identified and quantified in *P. chenur* Mozaff (Figures 3 and 4). The phenolic compounds that play an important protective role in plants as secondary metabolites also have a significant effect on human health. For example, rutin has been shown to increase vascular resistance and decrease edema and blood pressure. Additionally, caffeic acid and quercetin have antifungal and antibacterial effects, respectively (27,28).

Table 3. In Vitro Antibacterial Activity of *Peucedanum chenur* Mozaff Essential Oil

Microorganisms									
Sample	***Bacillus pumilus***	***Bacillus subtilis***	***Staphylococcus aureus***	***Bacillus cereus***	***Klebsiella pneumoniae***	***Enterococcus faecalis***	***Escherichia coli***	***Staphylococcus epidermidis***	***Pseudomonas aeruginosa***
Essential oil	12 [a] (15) [b]	12 (>15)	18 (7.5)	17 (7.5)	17 (7.5)	12 (15)	18 (7.5)	12 (>15)	-
Tetracycline[c]	nt	21 (3.2)	20 (3.2)	nt	Nt	Nt	- (nt)	34 (1.6)	Nt
Gentamicin[d]	nt	- (nt)	- (nt)	nt	Nt	Nt	23 (3.2)	- (nt)	Nt
Ampicillin[e]	15 (15)	14 (15)	13 (15)	nt	Nt	Nt	12 (15)	19 (15)	Nt

[a] Zone of inhibition (in mm) includes diameter of the disc (6 mm), [b] Minimum inhibitory concentration values as mg/mL, (–): Inactive, (7-13): Moderately active, (>14): Highly active; nt: Not tested, [c] Tested at 30 µg/disc; d: Tested at 10 µg/disc; [e] Tested at 10 µg/disc.

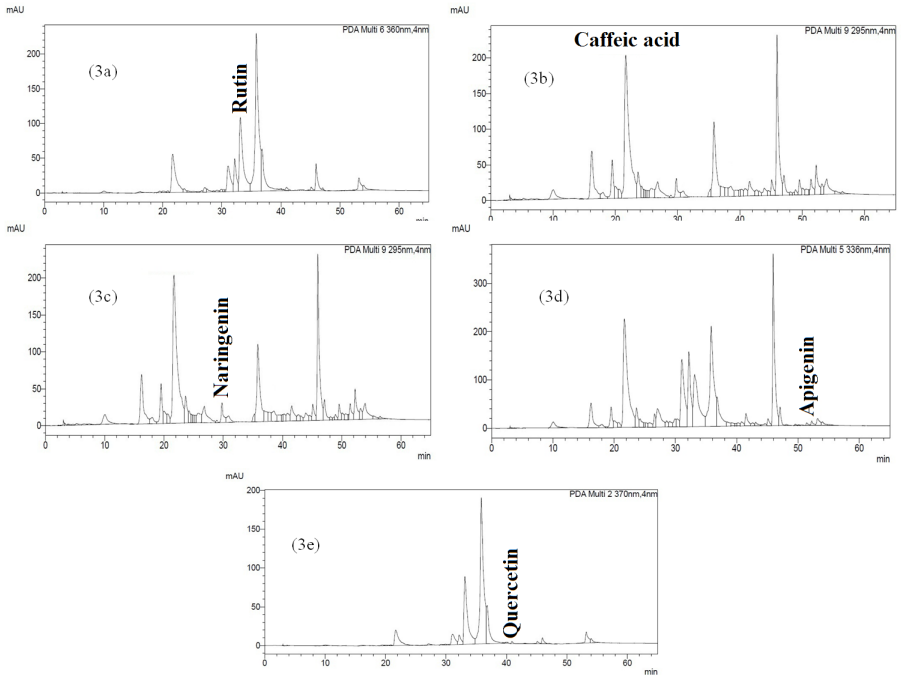

Figure 3. The HPLC of the Methanolic Extract of *Peucedanum chenur* Mozaff. 3a: HPLC peak of rutin in methanolic extract of p. chenur at 360 nm. 3b: HPLC peak of caffeic acid in methanolic extract of p. chenur at 295 nm. 3c: HPLC peak of Naringenin in methanolic extract of p. chenur at 295 nm. 3d: HPLC peak of Apigenin in methanolic extract of p. chenur at 336 nm. 3e: HPLC peak of Quercetin in methanolic extract of p. chenur at 370 nm.
. *Note*. HPLC: High-performance liquid chromatography

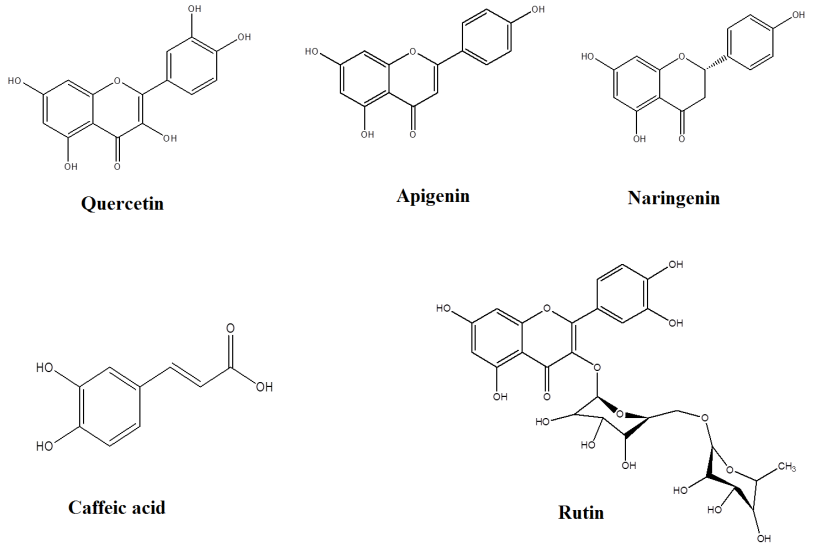

Figure 4. Structures of the Phenolic Compounds in the Methanolic Extract of *Peucedanum chenur* Mozaff

Table 4. Phenolic Compounds From the Methanolic Extract of *Peucedanum chenur* Mozaff

Phenolic Compounds	Concentration (µg/g Extract) n = 3	RSD%	Absorbance Wavelength (nm)	RT (min)	LOD (µg/L)	LOQ (µg/L)
Quercetin	230	1.2	370	41	20	50
Ferulic acid	nd	1.1	320	30	5	25
Gallic acid	nd	1.9	270	6	500	1000
Apigenin	873	1.5	336	52	200	500
Benzoic acid	nd	1.4	250	28	5	25
Caffeic acid	8855	1.9	300	22	50	100
Rutin	12243	2.2	360	33	20	50
Naringenin	2560	1.7	290	30	50	200

RST: Relative standard deviation; LOD: Limit of detection; LOQ: Limit of quantification; RT: Retention time; nd: Not detected.

Concerning studies performed on the other species of the genus *Peucedanum*, the caffeic acid compound was first identified by Bartnik et al in *P. tauricum* Bieb (29). In an earlier study, Kuzmanov et al managed to identify quercetin in *P. ruthenicum* (30). Subsequently, Alavi et al investigated the phenolic compounds of the aerial parts of *P. ruthenicum* and identified rutin, quercetin, and caffeic acid (31).

Conclusion

This study was performed to first evaluate the chemical constituent and biological effects of the *P. chenur* Mozaff. According to the obtained results, the *P. chenur* Mozaff volatile oil was a rich source of the α-pinene, limonene, and γ-terpinene compounds. Furthermore, the plant extract contained phenolic compounds such as rutin, caffeic, acid, and naringenin. Due to different applications and biological effects of these compounds reported in previous investigations, further studies should examine the volatile oil and extract constituents. Moreover, the broad range of compounds, as well as the antibacterial and antioxidant activities of *P. chenur* Mozaff demonstrated the potential of this plant for the application in pharmaceutical and food industries.

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Competing Interests

The authors declare that there is no conflict of interests in this study.

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