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ORIGINAL ARTICLE

Evaluation of the Antioxidant Potency of *Seseli* L. Species (Apiaceae)

Seseli L. Türlerinin (Apiaceae) Antioksidan Potansiyellerinin Değerlendirilmesi

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ABSTRACT

Objectives: In the present study, the antioxidant potency of ethyl acetate (AcOEt) and methanol (MeOH) extracts from the aerial parts of *Seseli* L. species was investigated for the first time.

Materials and Methods: *Seseli* species L. such as *Seseli andronakii* Woronow ex Schischk., *S. campestre* Besser, *S. corymbosum* Boiss. & Heldr., *S. gummiferum* subsp. *gummiferum* Pall. ex Sm., *S. hartvigii* Parolly & Nordt, *S. libanotis* (L.) W.Koch, *S. petraeum* M.Bieb., *S. peucedanoides* (M.Bieb.) Koso-Pol., *S. resinosum* Freyn & Sint., and *S. tortuosum* L. growing in Turkey were collected and evaluated for their antioxidant capacity by using 1.1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging and lipid peroxidation (LPO) inhibition methods.

Results: The highest activities as a scavenger of DPPH radicals were found in the AcOEt extracts of *S. peucedanoides* (M.Bieb.) Koso-Pol (IC_{50}=0.49 mg/mL), and *S. libanotis* (IC_{50}=0.75 mg/mL); α-tocopherol was used as a positive control. On the other hand, in the LPO assay, the highest activities were determined in AcOEt and MeOH extracts (at 5 mg/mL) of *S. tortuosum* and *S. libanotis* (84-94%).

Conclusion: This report gives important information about the antioxidant capacity of *Seseli* L. species. This research on antioxidant capacity proves that the use of some species used in Eastern Anatolia (in salads) is correct. With this screening study performed in *Seseli* L. species growing in Turkey, in the future, it is planned to isolate antioxidant compounds from the most active strains of *Seseli* L.

Key words: Antioxidant, Apiaceae, DPPH, LPO, *Seseli*

ÖZ

Amaç: Bu çalışmada, ilk kez *Seseli* L. türlerinin toprak üstü kısımlarından elde edilen, etil asetat (AcOEt) ve metanol (MeOH) ekstrelerinin antioksidan potansiyelleri araştırılmıştır.

Gereç ve Yöntemler: Türkiye'de yetişen bazı *Seseli* L. türlerinin, *Seseli andronakii* Woronow ex Schischk., *S. campestre* Besser, *S. corymbosum* Boiss. & Heldr., *S. gummiferum* subsp. gummiferum Pall. ex Sm., *S. hartvigii* Parolly & Nordt, *S. libanotis* (L.) W.Koch, *S. petraeum* M.Bieb., *S. peucedanoides* (M.Bieb.) Koso-Pol., *S. resinosum* Freyn & Sint., *S. tortuosum* L., antioksidan kapasiteleri 1,1-difenil-2-pikrilhidrazil (DPPH) radikali süpürme kapasitesi ve lipit peroksidasyonu (LPO) inhibisyon yöntemleri ile değerlendirilmiştir.

Bulgular: En yüksek radikal süpürücü etkinin *S. peucedanoides* (M.Bieb.) Koso-Pol. (IC_{50}=0,49 mg/mL) ve *S. libanotis* (IC_{50}=0,75 mg/mL) EtOAc ekstrelerinde olduğu bulunmuştur; α-tokoferol pozitif kontrol olarak kullanılmıştır. Diğer yandan, LPO deneyinde, en yüksek aktivite *S. tortuosum* ve *S. libanotis* (%84-94)'in EtOAc ve MeOH (5 mg/mL dozda) ekstrelerinde tespit edilmiştir.

Sonuç: Bu çalışmada, *Seseli* L. türlerinin antioksidan kapasitesi hakkında önemli bilgiler elde edilmiştir. Antioksidan kapasiteleri üzerine yapılan bu araştırma ile, bazı türlerin Doğu Anadolu'da gıda olarak (salatalarda) kullanımının doğruluğu bir kez daha gösterilmiştir. Türkiyede yetişen *Seseli* L. türlerinde yapılan bu tarama çalışması ile, gelecekte, antioksidan etki gösteren bileşiklerin en aktif *Seseli* L. türlerinden izole edilmesi planlanmaktadır.

Anahtar kelimeler: Antioksidan, Apiaceae, DPPH, LPO, *Seseli*

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INTRODUCTION

The Apiaceae (previously Umbelliferae) is a well-known family in the plant kingdom with aromatic plants and economically important species.[1] Some members of the family are used as foods, spices, condiments, and ornaments.[2-4] The genus *Seseli* L. belongs to the family Apiaceae and is distributed in Asia and Europe, comprising more than 12 taxa in Turkey, of which 4 are native to the region.[5-8] In addition, new species have recently been discovered.[9-12] Moreover, the latest taxonomy of the type section of the genus *Seseli* has been given based on the molecular data with recently updated names.[13] *Seseli* is an ancient Greek name given to some individual members of the family Apiaceae by Hippocrates.[14] *Seseli* species are mainly rich in coumarins as well as terpenoids, essential oils, etc.[15,16] and have many important pharmacological activities with healing effects such as in inflammation, swelling, rheumatism, pain, and the common cold.[17] On the other hand, the fruit of *S. indicum* has been reported to have anthelmintic, carminative, stomachic, and stimulant properties.[18] *S. sibiricum* is used for blending beverages and as a medicine for livestock in Kashmir.[19] In addition, the fruit of *S. libanotis* is a local remedy for blood pressure control in Pakistan, and its essential oil from the fruit has potent antimicrobial activity.[20] While *S. indicum* exhibited strong insect repellent activity[21] and fungitoxicity,[22] the fruit of *S. tortuosum* is recorded to have emmenagogic and antiflatulent effects.[23] Moreover, the leaves of *S. libanotis* (Kelemkeşir or Kelemenkeşir in Turkish) are consumed as a vegetable in salads in Eastern Turkey.[24]

In Turkey, there are limited studies on *Seseli* species based on coumarins[25-29] and essential oils.[30-34] Previously, antimicrobial,[35] anti-inflammatory, and antinociceptive[36-38] effects have been examined in Turkish *Seseli* species.

The plant kingdom presents secondary plant metabolites (especially polyphenols) as a wide range of natural antioxidants.[39-42] The natural antioxidants in plants are of great interest in natural product science and many herbs have significant antioxidant potency.[43] Antioxidants decrease oxidative stress in cells and are therefore very useful in the treatment of major degenerative diseases.[44] The physiological role of antioxidant agents is to scavenge for free radicals[45,46] in the case of overproduction of these reactive species.[47]

Therefore, in the present study, we aimed to investigate the antioxidant potential of the aerial parts of Turkish *Seseli* species. The species were screened using *in vitro* 1.1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging and lipid peroxidation (LPO) inhibition assays.

MATERIALS AND METHODS

Plant material

Plant materials were collected from different localities in Turkey. All of the *Seseli* L. species were identified by Prof. H. Duman from the Department of Biology, Faculty of Science and Arts, Gazi University, Ankara, Turkey. Voucher specimens were deposited at the Herbarium of the Faculty of Pharmacy of Ankara University and the Herbarium of Gazi University, Ankara, Turkey. The species are listed in Table 1 (ethical committee approval and patient consent were not required).

Extraction of the plants

The extraction method in Fenglin et al.[48] and Báthori et al.[49] was used with some modifications. The aerial parts of each plant material, which were dried and powdered, were prepared according to the procedures described below:

-The ethyl acetate (AcOEt) extract: The plant material (10 g) was extracted with AcOEt at room temperature by a magnetic stirrer (x200 mL) for 24 hour. The extract was evaporated to dryness in a vacuum to give a crude AcOEt extract.

-The methanol (MeOH) extract: After the AcOEt extraction, the plant material (10 g) was extracted with MeOH (80%) at room temperature by a magnetic stirrer (x200 mL) for 24 hour. The extract was evaporated to dryness *in vacuo* to give a crude methanolic extract. The yields of all extracts are given in Table 2.

Table 1. Plant names and collection sites of Turkish *Seseli* L. species

Species	Location	Herbarium no
S. andronakii Woronow ex Schischk	Erzurum, Oltu-Sarıkayalar, 1450-1750 m	ED 1617
S. campestre Besser	İstanbul, Sultanbeyli, Paşaköy c. 500 m	ED 1656
S. corymbosum Boiss. and Heldr.	Antalya-Akseki, Pınarbaşı village 1650-1900 m	AEF 21701
S. gummiferum subsp. *gummiferum* Pall. ex Sm.	Ankara-Hasanoğlan, İdris mountain 1600-1700 m	AEF 21999
S. hartvigii Parolly and Nordt	Antalya-Saklıkent, Bakırlar mountain, 2300-2500 m	AEF 21700
S. libanotis (L.) W.Koch	Ardahan-Posof, 1900 m	ED 1622
S. petraeum M.Bieb.	Gümüşhane, The road to Alemdar village, 1400 m	ED 1644
S. peucedanoides (M.Bieb.) Koso-Polo	Ankara-Hasanoğlan, İdris mountain, 1600-1700 m	AEF 23158
S. resinosum Freyn and Sint.	Bartın-Çakraz, 0-5 m	AEF 21696
S. tortuosum L.	Ankara, Beynam forest, 1400 m	ED 1612

AEF: Herbarium of the Faculty of Pharmacy of Ankara University

Chemicals

Ascorbic acid, thiobarbituric acid (TBA), DPPH, and α-tocopherol were purchased from Sigma Chemical Co (St. Louis, MO, USA).

Antioxidant capacity of the extracts

Radical scavenging capacity (DPPH)

The model of scavenging stable DPPH radicals is a widely used method to evaluate antioxidant activities in a relatively short time compared with other methods. The effect of antioxidants on DPPH radical scavenging is thought to be due to their hydrogen donating ability.[50] The reaction mixture contained 100 µM DPPH in MeOH and different concentrations of the crude extract. Absorbance at 517 nm was measured on a Shimadzu UV-1601 UV-VIS spectrometer at various concentrations (30 min after starting the reaction) at room temperature and the scavenging activity was calculated as the percentage of radical reduction. In our study, samples were dissolved in MeOH (80%) and AcOEt to 10 mg/mL and diluted to various concentrations. The scavenging activity was calculated as the percentage of radical reduction. The values of IC_{50} were determined from a calibration curve for each plant extract. Each experiment was performed in triplicate. IC_{50} values were determined from a calibration curve for each plant extract and α-tocopherol was used as the reference compound.

Assay of lipid peroxidation (LPO)

LPO was determined by a modified version of the method described by Mihara et al.[51] It was measured spectrophotometrically by estimation of the TBA reactant substances (TBARS). Amounts of TBARS were expressed in nmoL malondialdehyde/g tissue. A typical optimized assay mixture containing 0.5 mL of liver homogenate, 0.1 mL of Tris-HCl buffer (pH 7.2), 0.05 mL of 0.1 mM ascorbic acid, and 0.05 mL of 4 mM $FeCl_2$ and 0.05 mL of various concentrations of crude extract or α-tocopherol were incubated for 1 h at 37°C. After incubation, 3.0 mL of H_3PO_4 and 1 mL of 0.6% TBA were added and the resulting mixture was shaken vigorously. The mixture was boiled for 30 minute. After cooling, *n*-butanol was added and the mixture was shaken vigorously. Then the *n*-butanol phase was separated by centrifugation at 3000 rpm for 10 minute. The absorbance of the supernatant was measured at 532 nm against a blank, which contained all reagents except the liver homogenate.

Statistical analysis

Values of experimental results were considered as the mean of at least three determinations (± standard deviation).

RESULTS AND DISCUSSION

The present study deals with the radical scavenging activity (Table 3) and LPO (Table 4) of the AcOEt and MeOH extracts obtained from *Seseli* L. species growing in Turkey such as *Seseli andronakii*, *S. campestre*, *S. corymbosum*, *S. gummiferum* subsp. *gummiferum*, *S. hartvigii*, *S. libanotis*, *S. petraeum*, *S. peucedanoides* (M.Bieb.) Koso-Pol, *S. resinosum*, and *S. tortuosum*. The antioxidant activities of AcOEt and MeOH extracts obtained from the *Seseli* species were investigated by the DPPH scavenging and nonenzymatic rat hepatic microsomal LPO methods. In addition, their antioxidant activities were compared with those of the standard antioxidant α-tocopherol. The DPPH free radical scavenger assay is a simple and basic screening method for the discovery of bioactive substances. Free radicals are species that damage all the components of the body (lipids, proteins, DNA, etc.) and take part in mutations. In this case, antioxidants are important for body protection, helping reduce oxidative damage in the human body, and prevent LPO in foods.[52,53]

Table 2. The yield of extracts from Turkish *Seseli* L. species

Species	AcOEt extract (w/w % mg)	MeOH extract (w/w % mg)
SA	370	154
SA	390	154
SCa	1030	108
SGG	870	128
SH	330	119
SL	270	200
SP	750	118
SPeu	310	100
SR	420	120
ST	570	163

SA: S. andronakii, SH: S. hartvigii, ST: S. tortuosum, SL: S. libanotis, SGG: S.gummiferum subsp. gummiferum, SPeu: S. peucedanoides, SR: S. resinosum, SC: S. corymbosum, SCa: S. campestre, SP: S. petraeum, AcOEt: Ethyl acetate, MeOH: Methanol

Table 3. Inhibitory effects of *Seseli* extracts on DPPH stable radicals

Samples	AcOEt extracts	MeOH extracts
	IC_{50} (mg/mL)	IC_{50} (mg/mL)
Control		
SA	1.91±0.04	0.125±0.003
SH	1.94±0.03	0.225±0.002
ST	1.65±0.02	0.205±0.05
SL	0.75±0.07	0.187±0.002
SGG	3.07±0.04	0.088±0.001
SPeu	0.49±0.1	0.091±0.004
SR	1.18±0.15	0.086±0.001
SC	2.47±0.06	0.253±0.005
SCa	4.27±0.14	0.185±0.008
SP		0.172±0.006
α-Tocopherol	0.013±0.001	

SA: S. andronakii, SH: S. hartvigii, ST: S. tortuosum, SL: S. libanotis, SGG: S. gummiferum subsp. *gummiferum, SPeu: S. peucedanoides, SR: S. resinosum, SC: S. corymbosum, SCa: S. campestre, SP: S. petraeum*, AcOEt: Ethyl acetate, MeOH: Methanol

In our experiments, the results indicated that the extracts of some Turkish *Seseli* species have considerable effects on scavenging DPPH radicals (Figure 1). The AcOEt extract of *S. peucedanoides* (IC_{50}=0.49 mg/mL) and *S. libanotis* (IC_{50}=0.75 mg/mL) showed the most potent radical scavenging capacity (Table 3). These extracts were followed by *S. resinosum* (IC_{50}=1.18 mg/mL), *S. tortuosum* (IC_{50}=1.65 mg/mL), *S. andronakii* (IC_{50}=1.91 mg/mL), *S. hartvigii* (IC_{50}=1.94 mg/mL), *S. corymbosum* (IC_{50}=2.47 mg/mL), *S. gummiferum* subsp. *gummiferum* (IC_{50}=3.07 mg/mL), and *S. campestre* (IC_{50}=4.27 mg/mL) extracts.

The MeOH extracts of *Seseli* species have a higher DPPH radical scavenging effect than AcOEt extracts. The results showed that MeOH extracts of *S. resinosum*, *S. gummifeum* subsp. *gummiferum*, and *S. peucedanoides* have the highest scavenging capacity (IC_{50}=0.086, IC_{50}=0.088, and IC_{50}=0.091, respectively).

The TBA test results showed that MeOH extracts of *Seseli* spp. exhibited potent antioxidant effects (81-96% inhibition at 5 and 10 mg/mL concentrations) when compared to α-tocopherol. The AcOEt and MeOH extracts of *S. tortuosum* have the strongest anti-LPO activity (84-96% inhibition at a dose of 10 mg). The AcOEt and MeOH extracts of *S. campestre*, *S. andronakii*, and *S. gummiferum* subsp. *gummiferum* also exhibited a high anti-LPOeffect in the LPO assay (Table 4).

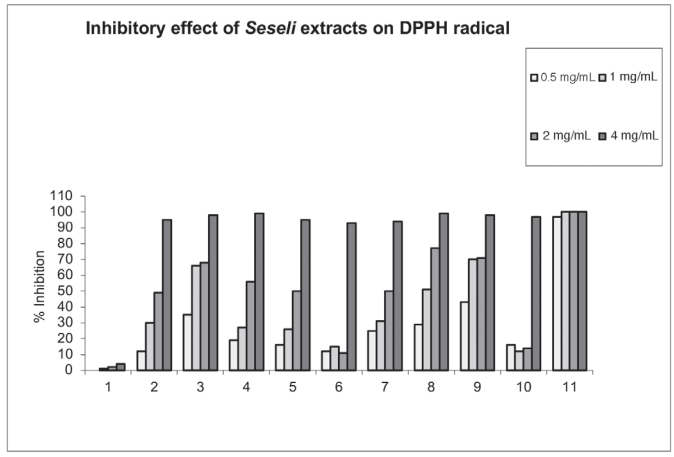

Figure 1. Ethyl acetate extracts of *Seseli* species (1-10) and (11) α-tocopherol at various concentrations

(1) *S. andronakii*, (2) *S. hartvigii*, (3) *S. tortuosum*, (4) *S. libanotis*, (5) *S. gummiferum* subsp. gummiferum, (6) *S. peucedanoides*, (7) *S. resinosum*, (8) *S. corymbosum*, (9) *S. campestre*, (10) *S. petraeum*

Table 4. Antilipid peroxidation effects of *Seseli* extracts[a]

	Concentrations mg/mL	nmol MDA/g tissue	% Inhibition	Concentrations mg/mL	nmol MDA/g tissue	% Inhibition
Control		AcOEt extracts			MeOH extracts	
b			NE[c]			NE[c]
SA	2.5	0.148	34	5	0.027	88
	5	0.045	80	10	0.024	89
SH	2.5	0.084	63	5	0.026	88
	5	0.052	77	10	0.025	89
ST	2.5	0.102	55	5	0.011	95
	5	0.036	84	10	0.009	96
SL	2.5	0.222	1.2	5	0.037	83
	5	0.085	45	10	0.014	94
SGG	2.5	0.085	62	5	0.042	81
	5	0.039	82	10	0.035	84
SPeu	2.5	0.195	13	5	0.021	91
	5	0.129	43	10	0.022	90
SR	2.5	0.144	36	5	0.043	81
	5	0.049	78	10	0.026	88
SC	2.5	0.151	33	5	0.025	89
	5	0.067	70	10	0.018	92
SCa	2.5	0.088	61	5	0.025	89
	5	0.043	81	10	0.02	91
SP	2.5	0.156	31	5	0.028	87
	5	0.058	74	10	0.026	81
α-Tocopherol	0.22	0.009	96	0.22	0.009	96
	0.44	0.003	99	0.44	0.003	99

[a]Each value represents the mean ± standard deviation of 2-4 independent experiments, [b]AcOEt or MeOH only, control for extracts, [c]NE: No effect
SA: S. andronakii, SH: S. hartvigii, ST: S. tortuosum, SL: S. libanotis, SGG: S. gummiferum subsp. *gummiferum, SPeu: S. peucedanoides, SR: S. resinosum, SC: S. corymbosum, SCa: S. campestre, SP: S. petraeum*

In previous studies, the antioxidant potency of MeOH extract of *S. pallasii*, *S. libanotis* subsp. *libanotis*, and *S. libanotis* subsp. *intermedium* (aerial parts and fruits) was determined. *S. libanotis* subsp. *libanotis* showed the strongest antioxidant activity in the DPPH assay.[54] Various extracts in different polarities from the roots, leaves, flowers, and fruit of *S. rigidum* were also studied, and the hexane extract of the root had the best effect among the other plant parts in the DPPH assay.[55,56] In another study, the antioxidant activity of *Seseli rigidum* was evaluated in five extracts in different polarities (water, MeOH, acetone, ethyl acetate, and petroleum ether). The antioxidant effect of the aerial parts of the species was determined *in vitro* using DPPH reagent, and the highest antioxidant activity was expressed in water extract (46.15 µg/mL).[57] Moreover, some of the compounds isolated from the methanolic extracts (80%) of *Seseli diffusum* have been found to have a strong antioxidant effect.[58]

It is known that *Seseli* species contain phenolic compounds consisting mainly of coumarins,[16] which have notable antioxidant potency.[59-61] In addition, mostly oxygenated coumarins are accumulated in the AcOEt fractions, and the glycosides are present in the MeOH extract. The MeOH extract exhibits higher antioxidant activity, which may be explained by the presence of coumarin glucosides as highly polar compounds in the extract. The results show that there seemed to be a good match between the content of the extracts and the antioxidant capacity. Finally, the activity might be due to the polar coumarins of the active *Seseli* species.[52,62]

CONCLUSION

Natural products are generally known to be a good source of active compounds that have potential for the development of new therapeutic agents. The antioxidant properties of the AcOEt and MeOH extracts of *Seseli* species expressed as α-tocopherol equivalent antioxidant capacity were studied using DPPH and LPO assays. These results indicate that plant extracts prevent oxidative damage in normal cells due to their antioxidant properties. The best part of our research was that *Seseli* species growing in Turkey were screened for the first time for their antioxidant capacity. In addition, this research provides a scientific basis for the medicinal use of these plant materials. Therefore, we can conclude from the results of the present study that *Seseli* species may be a potential source of natural antioxidant compounds for the treatment of oxidative degeneration.

Conflicts of interest: No conflict of interest was declared by the authors.

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