

Exploring the Antioxidant and Antimicrobial Potential of Some Scandix Species

Scandix Türlerinin Antioksidan ve Antimikrobiyal Potansiyelerinin Araştırılması

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Abstract

The use of plant-based preparations is an ancient practice that has persisted from the past to the present. In particular, their use as antimicrobial and antioxidant agents has been increasingly common. This study aims to determine the antimicrobial and antioxidant effects of methanol extracts of the aerial parts of 5 *Scandix* species (*S. iberica*, *S. stellata*, *S. pecten veneris*, *S. macrorhyncha* and *S. balansae*) collected from Türkiye. The antimicrobial effects of the methanol extracts were detected by using the disk diffusion method. Antioxidant activity also were evaluated by measuring total antioxidant capacity, total oxidant status, and DPPH radical scavenging activity. The methanolic extract of *Scandix* species has inhibited the growth of the microorganisms at the 14.6 to 35.3 mm ratio. TAS values ranged from 2.0 to 3.4 mmol, while TOS values ranged from 15.1 to 23.7 µmol. It was observed that the DPPH radical scavenging effects increased with rising concentrations. The results will contribute to the evaluation of the potential of these species as natural antimicrobial and antioxidant compounds in the food, cosmetic or pharmaceutical industries.

Öz

Bitkisel preparatların kullanımı geçmişten günümüze kadar devam eden eski bir uygulamadır. Özellikle antimikrobiyal ve antioksidan ajan olarak kullanımı giderek yaygınlaşmaktadır. Bu çalışmada, Türkiye'den toplanan 5 *Scandix* türünün (*S. iberica*, *S. stellata*, *S. pecten veneris*, *S. macrorhyncha* and *S. balansae*) toprak üstü kısımlarının metanol ekstraktlarının antimikrobiyal ve antioksidan etkileri belirlenmesi amaçlanmaktadır. Metanol ekstraktlarının antimikrobiyal etkileri disk difüzyon yöntemi kullanılarak tespit edilmiştir. Antioksidan aktivite ayrıca toplam antioksidan kapasite (TAS), toplam oksidan durum (TOS) ve DPPH radikal süpürücü aktivitesi ölçülerek değerlendirilmiştir. Scandix türlerinin metanol ekstraktının mikroorganizmaların büyümesini 14.6 ila 35.3 mm oranında engellediği tespit edilmiştir. TAS değerleri 2.0 ila 3.4 mmol arasında değişirken, TOS değerleri 15.1 ila 23.7 µmol arasında değişmiştir. DPPH radikal süpürücü etkilerinin artan konsantrasyonlarla arttığı gözlemlenmiştir. Elde edilen sonuçlar, *Scandix* türlerinin gıda, kozmetik veya ilaç endüstrilerinde doğal antimikrobiyal ve antioksidan bileşikler olarak kullanım potansiyelinin değerlendirilmesine katkıda bulunacaktır.

INTRODUCTION

Plants have historically held a key place in human life (Mehrnia et al. 2021), serving not only in culinary arts, medicine, cosmetics, and perfumery but also as natural coloring and flavoring agents in traditional health practices (Iqbal et al. 2021). Particularly in recent years, with the appearance of the SARS-CoV-2 virus, the demand for plants has steadily grown (Caspani 2020, Vandebroek et al. 2020).

The Apiaceae family, which is one of the flowering plants, includes 300-455 genera and 3000-3700 species. They are very rich in secondary metabolites. Synthesis of essential oils and oleoresins secreted in schizogen channels in root, stem, leaf and flower parts is a characteristic feature of this family (Constance 1971, Davis 1972, Heywood 1972, Pimenov 1993). They have a unique flavor with these essential oils obtained from their fruits and leaves (Demirpolat et al. 2018). They are cosmopolitan and abundant in temperate regions, especially in the northern hemisphere. However, they are rare in the tropics (Berenbaum 1990, Downie et al. 2000).

Certain species within the Apiaceae family are recognized for their medicinal applications, alongside their roles as spices and flavor enhancers (Trifan et al. 2021). Studies have shown that both the aerial and root parts of these plants contain essential oil compounds (Heinrich et al. 2017, Trifan et al. 2021) and exhibit antimicrobial, antioxidant, cytotoxic, hypoglycemic, immunomodulatory, and anti-inflammatory properties (El-Soud et al. 2011, Pandey et al. 2012, Yousofi et al. 2012, Heinrich et al. 2017, Trifan et al. 2021, Saeed et al. 2024). Consequently, plant-based medicines are valued as effective resources for treating various illnesses due to these biologically active compounds (Wahab et al. 2018). In light of antibiotic resistance in harmful microorganisms, the use of plant extracts as antimicrobial agents is especially noteworthy. Furthermore, natural antioxidants known for inhibiting free radical formation in the body are advantageous over synthetic options, as they neutralize free radicals without introducing toxic or mutagenic side effects (Glumac et al. 2017, Kahraman et al. 2019, Aati et al. 2022). Thus, plant-derived compounds with strong antioxidant properties play a critical role in antioxidant supplementation.

Scandix species are plants belonging to the Apiaceae family and are generally native to the Mediterranean climate. These species are especially rich in essential oil compounds and are remarkable for their medicinal and aromatic properties. This genus includes 20 species 15 of these are mostly limited to the Mediterranean Region (Kubeczka 1982, Demirpolat et al. 2019). *Scandix* species have been used for medicinal purposes such as genital disorders, liver protection (Tetik et al. 2013). It has been reported that *Scandix pecten-veneris*, commonly known as ‘mad coriander’, which is widespread in Eurasia, extending to England in the west and Denmark in the north in Europe, and also found in some parts of Türkiye, is used against infectious diseases in traditional medicine (Wahab et al. 2018). However, the fact that the medical effects of some species have not yet been studied makes this study important.

For this purpose, it was aimed to determine the antimicrobial and antioxidant activities of the methanolic extract of some *Scandix* species (*S. iberica*, *S. stellata*, *S. pecten-veneris*, *S. macrorhyncha*, *S. balansae*) from the Apiaceae family and to discuss the the results with the other studies to evaluate the medicinal importance of the plant species.

MATERIALS AND METHODS

Material

Scandix species (*Scandix iberica*-FUH1003, *Scandix stellata*-FUH1004, *Scandix pecten-veneris* FUH1005, *Scandix macrorhyncha* FUH1016, *Scandix balansae* FUH1018; Demirpolat) collected from natural habitats in Türkiye, in May. The voucher specimen for has been deposited in the FUH.

Methods

Antimicrobial Activity

The antimicrobial activity of methanolic extracts of the plants was determined against some bacteria (*Escherichia coli* ATCC25922, *Klebsiella pneumoniae* ATCC700603, *Bacillus megaterium* DSM32, *Staphylococcus aureus* COWAN1, *Pseudomonas aeruginosa* DMS50071) and yeasts (*Candida albicans* FMC17 and *Candida glabrata* ATCC 66032) by disk diffusion method (Collins et al. 2004). Bacteria were incubated in Nutrient Broth at $35 \pm 1^\circ\text{C}$ for 24 h and yeasts in Malt Extract Broth at $25 \pm 1^\circ\text{C}$ for 48 h. The prepared cultures were inoculated into Müeller Hinton Agar and Sabouraud Dextrose Agar at 10^6 bacteria/ml and 10^4 yeasts/ml, respectively, and 25 ml was added to sterile petri dishes after shaking well. Homogeneous distribution of the medium was ensured. Extract impregnated (1000 µg) 6 mm diameter disks were placed on the solidified agar. The plates were kept at 4°C for 1.5-2 h and incubated at $37 \pm 0.1^\circ\text{C}$ for 24 h for bacteria and

25 ± 0.1°C for 72 h for yeasts. Standard antibiotic discs for bacteria (Streptomycin sulfate 10 µg/disc) and yeasts (Nystatin 30 µg/disc) were used as controls. Inhibition zones were measured in mm after incubation.

Antioxidant Activity

TAS and TOS values of the samples were determined by Rel Assay kits. TAS value was expressed as mmol Trolox equiv./L and Trolox was used as a calibrator (Erel 2004). TOS value was expressed as µmol H₂O₂ equiv./L and hydrogen peroxide was used as a calibrator (Erel 2005). The antioxidant activity of the methanol extract of the plants was determined according to the DPPH radical scavenging capacity method (Cuendet et al. 1997, Kirby et al. 1997). The solution prepared in methanol at an extract concentration of 1 mg/ml was diluted 4 times and then DPPH calibration curve was obtained. After 40 µl of the solution was taken and 160 µl of DPPH solution was added and mixed, samples were kept in the dark for 30 minutes. Butylated hydroxyanisole (BHA) and methanol were used as controls. At the end of the time, the absorbance of each mixture was read at 570 nm in a spectrophotometer and inhibition levels were calculated as %; I (%) = (A control - A sample / A control) x 100.

Statistical Analysis

SPSS Statistics (Version 22) was used to perform the statistical analysis and generate the figures. Analysis of variance (ANOVA) and Student's t-test were performed, and p<0.01 was considered significant.

RESULTS AND DISCUSSION

The antimicrobial results of methanol extracts of plants against the microorganisms used are given in Table 1. It was determined that the Scandix methanolic extract has inhibited the growth of the bacteria at different ratios. In the results obtained, it was determined that the antimicrobial effects of *S. iberica* against *E. coli*, *P. aeruginosa*, *K. pneumoniae*, *B. megaterium*, *S. aureus*, *C. albicans* and *C. glabrata* were 27.6mm, 17.6mm, 22.3mm, 16.3mm, 23.5mm, 17.6mm and 20.3mm, respectively. Inhibition zones of *S. stellata* against the same microorganisms were determined as 35.3mm, 18.6mm, 23.6mm, 17.3mm, 25.3mm, 19.3mm and 20.3mm, respectively. The antimicrobial effects of *S. pecten-veneris* methanol extract against *E. coli*, *P. aeruginosa*, *K. pneumoniae*, *B. megaterium*, *S. aureus*, *C. albicans* and *C. glabrata* were found to be in the range of 18.6-32.3mm. It has been stated that *S. macrorhyncha* and *S. balansae* extracts significantly inhibited the growth of the microorganisms used (inhibition zones 14.6-30.6 mm) (Table 1).

Table 1. Inhibition zones of methanol extracts of *Scandix* sp. against some microorganisms (mm)

	<i>S. iberica</i>	<i>S. stellata</i>	<i>S. pecten-veneris</i>	<i>S. macrorhyncha</i>	<i>S. balansae</i>	Control
<i>E. coli</i>	27.6 ± 0.6 ^c	35.3 ± 0.6 ^a	32.3 ± 0.6 ^b	26.3 ± 0.6 ^c	25.3 ± 0.6 ^c	20.3 ± 0.6 ^d
<i>P. aeruginosa</i>	17.6 ± 0.6 ^c	18.6 ± 0.6 ^b	20.3 ± 0.6 ^a	16.7 ± 0.6 ^c	20.3 ± 0.6 ^a	20.3 ± 0.6 ^a
<i>K. pneumoniae</i>	22.3 ± 0.6 ^b	23.6 ± 0.6 ^b	18.7 ± 0.6 ^c	25.7 ± 0.6 ^a	21.3 ± 0.6 ^b	25.7 ± 0.6 ^a
<i>B. megaterium</i>	16.3 ± 0.6 ^d	17.3 ± 0.6 ^c	19.7 ± 0.6 ^b	14.3 ± 0.6 ^d	16.7 ± 0.6 ^{cd}	25.7 ± 0.6 ^a
<i>S. aureus</i>	25.3 ± 0.6 ^d	25.3 ± 0.6 ^c	30.3 ± 0.6 ^a	28.7 ± 0.6 ^b	30.3 ± 0.6 ^a	25.7 ± 0.6 ^c
<i>C. albicans</i>	17.6 ± 0.6 ^b	19.3 ± 0.6 ^a	18.3 ± 0.6 ^{ab}	18.7 ± 0.6 ^a	16.3 ± 0.6 ^b	17.3 ± 0.6 ^{ab}
<i>C. glabrata</i>	20.3 ± 0.6 ^a	20.3 ± 0.6 ^a	20.7 ± 0.6 ^a	20.3 ± 0.6 ^a	19.3 ± 0.6 ^a	17.3 ± 0.6 ^b

According to the study results, the methanol extract of *S. stellata* showed the highest antimicrobial effect (35.3 mm) against *E. coli* at a concentration of 1 mg/ml (Table 1). *S. pecten-veneris* methanolic extracts formed an inhibition zone of 7.5-25.2 mm against *C. albicans* and *C. glabrata* at concentrations of 50-500 µg/mL. It was reported that the same extract at 500 µg/mL concentrations formed a 10.5-47.5 mm inhibition zone against *S. aureus*, *B. subtilis*, *P. aeruginosa*,

K. pneumoniae (Sharifi-Rad et al. 2016). The antimicrobial effects of *S. pecten-veneris* methanolic extracts against *E. coli*, *S. thyphi*, *S. pneumoniae*, *P. vulgaris*, *S. aureus*, *B. subtilis* and *C. albicans* were found to be 18, 20, 16, 15, 22, 16 and 30 mm, respectively (Wahab et al. 2018). Since there is no other study on the subject, parallel results emerge when we compare the genus *Scandix* with the closely related genus *Ferula*. Chloroform extract of aerial parts of *Ferula caspica* showed antimicrobial activity against *Enterococcus faecalis* and *Staphylococcus aureus* at concentrations of 32 and 64 µg/mL, respectively (Kahraman et al. 2019). It has been reported that essential oils obtained from the aerial parts of *Ferula orientalis* have antimicrobial effects against *S. aureus* and *C. albicans* strains, and have no antimicrobial activity against *E. coli* (Karakaya et al. 2019). It was determined that the inhibition zones of essential oils obtained from the aerial parts of *Anethum graveolens* against *S. aureus*, *Bacillus licheniformis*, *Listeria innocua*, *Enterobacter xiangfangensis* and *C. albicans* ranged from 7 to 23 mm (Aati et al. 2022). The results compared with previous studies, it can be said that the antimicrobial results changed depending on the plant extract used, the bioactive components of the plants, which parts of the plant were used, the solvent and the microorganisms used.

In the antioxidant capacity of the methanolic extracts of *Scandix* species studied, TAS and TOS values of methanol extracts of *S. iberica*, *S. stellata*, *S. pecten-veneris*, *S. macrorhyncha* and *S. balansae* are given in Table 2. TAS values of extracts of these species were determined as 2.9 mmol, 3.4 mmol, 3.2 mmol, 3.1 mmol and 2.0 mmol, respectively. TOS values of the same species were determined in the range of 15.1-23.7 µmol. Although TAS values of *Scandix* species were good, TOS values were found to be high (Table 2).

Table 2. TAS and TOS values of methanol extracts of *Scandix* sp.

	TAS (mmol Trolox equiv./L)	TOS (µmol H ₂ O ₂ equiv./L)
<i>S. iberica</i>	2.3 ± 0.6 ^{ab}	17.0 ± 0.0 ^c
<i>S. stellata</i>	3.3 ± 0.6 ^a	23.3 ± 0.6 ^a
<i>S. pecten-veneris</i>	3.0 ± 0.0 ^{ab}	19.7 ± 0.6 ^b
<i>S. macrorhyncha</i>	3.3 ± 0.6 ^a	18.3 ± 0.6 ^{bc}
<i>S. balansae</i>	2.0 ± 0.0 ^b	15.3 ± 0.6 ^d

Inhibition percentages of radical scavenging effects of methanol extracts of *S. iberica*, *S. stellata*, *S. pecten-veneris*, *S. macrorhyncha* and *S. balansae* are given in Table 3. It was observed that the rate of inhibition of the radical scavenging effects of extracts of *Scandix* species increased depend on increasing concentrations. The highest antioxidant effect was found in the methanol extract of *S. pecten-veneris* at a concentration of 1000 µg/mL (Table

Table 3. Percent inhibition of the DPPH radical of methanol extracts of *Scandix* sp.

	<i>S. iberica</i>	<i>S. stellata</i>	<i>S. pecten-veneris</i>	<i>S. macrorhyncha</i>	<i>S. balansae</i>
BHA	87.3 ± 0.6 ^a	87.3 ± 0.6 ^a	87.3 ± 0.6 ^a	87.3 ± 0.6 ^a	87.3 ± 0.6 ^a
MetOH	2.3 ± 0.6 ^a	2.3 ± 0.6 ^a	2.3 ± 0.6 ^a	2.3 ± 0.6 ^a	2.3 ± 0.6 ^a
1000 µg/mL	56.7 ± 0.6 ^d	67.3 ± 0.6 ^b	71.3 ± 0.6 ^a	60.3 ± 0.6 ^c	68.7 ± 0.6 ^b
500 µg/mL	50.0 ± 0.0 ^c	65.3 ± 0.6 ^a	64.3 ± 0.6 ^a	60.7 ± 1.2 ^b	64.3 ± 0.6 ^a
250 µg/mL	44.3 ± 0.6 ^c	55.3 ± 0.6 ^b	25.3 ± 0.6 ^e	57.3 ± 0.6 ^a	30.0 ± 0.0 ^d
125 µg/mL	27.0 ± 0.0 ^b	39.3 ± 0.6 ^a	9.3 ± 0.6 ^d	27.3 ± 0.6 ^b	25.3 ± 0.6 ^c

In the results obtained in the study, while the best total antioxidant level was detected in *S. stellata* (3.4 mmol) (Table 3), the highest DPPH radical scavenging effect was detected in the extract of *S. pecten-veneris* (Table 3). In the previous study, % inhibitions of *S. pecten-veneris* methanolic extracts for concentrations of 100, 200, 300, 600 and 900 µg/mL were reported as 3.5, 16.42, 34.62, 44.56 and 77.49, respectively (Sharifi et al. 2016). Antioxidant effects have been investigated in studies conducted on some plants belonging to the *Scandix* genus. The methanol extract of *S. pecten-veneris* has been shown to have strong antioxidant properties. In addition, extracts of this plant have the capacity to inhibit lipid peroxidation thanks to their high content of phenolic compounds that support antioxidant activity (Ceylan et al. 2024).

The crude methanolic extract of *S. pecten-veneris* showed 40% antioxidant activity against DPPH at a concentration of 1 mg/mL (Wahab et al. 2018). *Scandix australis* extracts were determined to have less than 20% antioxidant effect against oxidative DNA damage induced by hydrogen peroxide at a concentration of 10 µg/mL. (Kapiszewska et al. 2005). The radical scavenging activity percentage of *Pimpinella anisum* essential oils at 50 µL/mL concentration was determined as 77.58% (El-Sayed et al. 2022). In order to obtain pollen with high total phenolics, it was suggested that beekeeping should be carried out in regions where flowers such as *Scandix* are found in beekeeping thanks to their antioxidant properties. In this way, he stated that it could become a functional food product to be evaluated in the future (Anik and Vardar 2024). In the literature review, it is seen that antioxidant studies of *S. iberica*, *S. stellata*, *S. pecten-veneris*, *S. macrorhyncha* and *S. balansae* are insufficient, but some species belonging to Apiaceae have antioxidant effects. It was determined that the antioxidant effect results may vary depending on the species, method used, bioactive components contained in the plant and concentrations.

CONCLUSION

Previous studies reveals a notable lack of studies on the antimicrobial and antioxidant effects of *S. iberica*, *S. stellata*, *S. pecten-veneris*, *S. macrorhyncha*, and *S. balansae* extracts. The results obtained in this study are therefore highly significant in terms of their contribution to the scientific literature. It was determined that the methanol extracts of these *Scandix* species exhibited substantial antimicrobial effects. These findings suggest that *Scandix* species could be considered potential candidates for antimicrobial and antioxidant applications.

The findings of this study provide an important foundation for further detailed investigation of the bioactive properties of *Scandix* species. Additionally, further research could include extractions with different solvents to validate the antimicrobial and antioxidant effects of these species, testing against more microorganism strains, and exploring the mechanisms of action at the molecular level. Moreover, toxicity, efficacy, and bioavailability studies could be conducted to examine the potential therapeutic effects of these species. Such studies would contribute to evaluating the potential of *Scandix* species for use as natural antimicrobial and antioxidant compounds in the food, cosmetic, or pharmaceutical industries.

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