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Original Article

GS/MS analysis and the antioxidant and antimicrobial properties of *Salvia potentillifolia* (Boiss. & Heldr.) ex Bentham

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ABSTRACT

Background and Aims: Sage is traditionally used as an herbal tea in Türkiye. In this study, the phenolic composition and biological potential of *Salvia potentillifolia* (Boiss. et Heldr.) ex Bentham (Lamiaceae) were determined.

Methods: The essential oil constituents of *S. potentillifolia* were determined using gas chromatography/mass spectrometry (GC/MS). The in vitro antioxidant properties of the methanol extract of *S. potentillifolia* were tested spectrophotometrically using phosphomolybdenum assay, 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging, hydrogen peroxide (H_2O_2) scavenging, β-carotene bleaching inhibition, Fe^{2+} chelating, reducing power, ferric ions reducing activity (FRAP), and cupric ion reducing activity (CUPRAC) assays. The total phenolic and flavonoid contents of the methanol extract were determined. The antimicrobial effects of the methanol extract and essential oil were detected against 12 bacteria, 1 yeast, and 2 aflatoxigenic fungi strains using agar-well diffusion and the micro-well dilution methods.

Results: Fifty compounds were detected in the essential oil. The major oil component was eucalyptol. It was followed by carvacrol, β-pinene, borneol, camphor, α-terpineol, 4-terpineol, bornyl acetate, and caryophyllene. The methanol extract of *S. potentillifolia* had effective DPPH radical scavenging, Fe^{3+} reducing, and Cu^{2+} reducing activities while exerting weak H_2O_2 scavenging and Fe^{2+} chelating activities. The methanol extract had weak antibacterial activity, whereas the essential oil had moderate antibacterial activity. The methanol extract had no antifungal potency against the tested aflatoxigenic fungi.

Conclusion: The methanol extract of *S. potentillifolia* is a natural antioxidant resource, whereas the essential oil may be a natural antibacterial agent. It is believed that the results of this study will contribute to the recently increasing research on the use of natural antioxidant and antimicrobial compounds as an alternative to synthetic compounds in various industrial fields, such as food, pharmacy, and medicine.

Keywords: Antimicrobial, Antioxidant, Essential oil, *Salvia potentillifolia*

INTRODUCTION

The genus *Salvia* is the largest member of the Lamiaceae family (Kivrak, Göktürk, Kivrak, Kaya, & Karababa, 2019). There are 115 *Salvia* (sage) taxa growing in Türkiye, 63 taxa of which are endemic (54.7%) (Celep & Doğan, 2023). Some members of the *Salvia* genus are used in the pharmaceutical, cosmetic, perfume, and pharmaceutical industries (Kelen & Tepe, 2008; Kivrak et al., 2009; Kivrak, Göktürk, Kivrak, Kaya, & Karababa, 2019). It has been sold commercially as a spice to flavour meats (Kivrak et al., 2009; Sepahvand et al., 2014).

It has been used for the treatment of diseases, including epilepsy, colds, bronchitis, and tuberculosis (Kivrak et al., 2019), wounds, insomnia, skin infections, headache, cerebral ischemia, memory disorders (Sepahvand et al., 2014), stomach ache, headache, wounds, skin infections, colds (Kivrak et al., 2009), diarrhea, gonorrhea, hemorrhoids and eye diseases (Kelen & Tepe, 2008).

It has been used for medical purposes since ancient times and has different traditional uses (Gürdal, Yeşil, Akalın, & Tan, 2019). Many Salvia species have antimicrobial, antioxidant, antiviral, antitumoral, antidiabetic, antifungal, hypoglycaemic, and anticarcinogenic effects (Aghaei Jeshvaghani, Rahimmalek, Talebi, & Goli, 2015; Kivrak et al., 2019). Their secondary metabolites exhibit many pharmacological activities, such as antiplatelet, antiproliferative, and anticancer ef-

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fects, larvicidal and antimicrobial activities, antioxidant, acetyl- and butyrylcholinesterase inhibition, and antinociceptive and anxiolytic effects (Hao et al., 2015).

Salvia plants have various therapeutic secondary metabolites, such as terpenes, phenolics (Hao et al., 2015; Kelen & Tepe, 2008), diterpenoids, sesquiterpenoids, and phenolic acids (Al-Qudah, Al-Jaber, Abu ZArga, & Abu Orabi, 2014). Endemic *S. potentillifolia* called as "Adacayı" or "Salba" in Muğla, Türkiye and has been used as a folkloric drug, rarely as a tea (Kivrak et al., 2009). It is used to treat cold and flu in Türkiye (Gürdal et al., 2019).

The composition and antimicrobial properties of essential oil of *S. potentillifolia* were previously reported by Köse, Öngüt, & Yanıkoğlu (2013). The antioxidant and antimicrobial properties of essential oil and ethanol extracts obtained from *S. potentillifolia* collected in Burdur were previously reported (Kivrak et al., 2009). The same researchers recorded the phenolic compositions of *S. potentillifolia* extracts collected in Burdur by UPLC-ESI-MS/MS (Kivrak et al., 2019). Additionally, their antioxidant activities had been previously determined (Kivrak et al., 2019; Özek, 2017). However, as far as our literature survey was able, the antioxidant activity of the methanol extract of *S. potentillifolia* had not previously been determined by hydrogen peroxide scavenging, FRAP, and CUPRAC assays. In addition, the antimicrobial activity of the methanol extract was not previously determined. Therefore, this research aimed to identify the polyphenol compounds of *S. potentillifolia* essential oil and to determine the antioxidant and antimicrobial activity of the methanol extract.

MATERIALS AND METHODS

Plant

The aerial parts of *S. potentillifolia* were collected from Antalya (Elmalı-Sedir Research Forest Entrance), the southern Anatolia region of Türkiye in July 2015 (36°35'31"K-29°58'22"D, 1240 m) and stored at the Herbarium of the Biology Department at Erciyes University (Voucher no.: Aksoy 2522).

Extraction

The plant was dried at room temperature and pulverized into powder. The ground material was extracted using a Soxhlet-type extractor with methanol. The extract was filtered through filter paper and then evaporated at 40 °C. The yield of the methanol extract was calculated and stored at 4 °C (Albayrak, Aksoy, Sagdic, & Hamzaoglu, 2010).

Essential oil

The plant was hydrodistilled for 3 h using a Clevenger-type distillation apparatus. The obtained essential oil was dried in anhydrous sodium sulphate and stored at 4 °C until use (Albayrak & Aksoy, 2019).

Estimation of total phenol and flavonoid contents

Folin-Ciocalteu and $AlCl_3$ colorimetric assays were performed to examine the total phenolic and flavonoid content of the methanol extract as detailed in our previous work (Albayrak et al., 2010). The results of total phenolic and flavonoid contents are expressed as milligrams of gallic acid equivalents (GAE) and quercetin equivalents (QE)/g extract, respectively.

Analysis of essential oil content

The essential oil composition was detected by gas chromatography/mass spectrometry/quadrupole detection analysis using a Shimadzu QP 5050 system, as detailed in our previous work. The composition (%) was computed from the GC peak areas without any correction factors (Albayrak & Aksoy, 2019).

Antioxidant activity

The antioxidant activity of the methanol extract of *S. potentillifolia* was spectrophotometrically evaluated using several methods, including phosphomolybdenum, DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging, H_2O_2 scavenging, β-carotene bleaching inhibition, Fe^{2+} chelation, reducing power, ferric reducing antioxidant power (FRAP), and cupric ion reducing activity (CUPRAC) assays. Total antioxidant activity was presented as mg of ascorbic acid equivalents (AAE) /g extract. The ability of the extracts to scavenge DPPH was examined as a percentage of inhibition. IC_{50} (concentration necessary to scavenge 50% DPPH) value was calculated. BHT (Butylated hydroxytoluene) was used as a reference (Albayrak & Aksoy, 2019).

The ability of the extract to prevent bleaching of β-carotene was studied (Cao et al., 2009), and the results are presented as percentage inhibition. The percentages of H_2O_2 scavenging by the extract and gallic acid, BHT and BHA (Butylated hydroxylanisole) standards were calculated. IC_{50} value was determined. The FRAP results for the extract and L- ascorbic acid were expressed as mmol/L of Fe^{2+}. The reducing activity was compared with that of BHT, and the results are presented as absorbance values at 700 nm. Increasing the absorbance of the solution indicates a higher reduction potential. The chelating ability was compared with ethylene diamine tetra acetic acid (EDTA). The inhibition of ferrozine-Fe^{2+} complex formation was determined (Albayrak & Aksoy, 2019).

Determination of antimicrobial activity

Aeromonas hydrophila ATCC 7965, *Bacillus cereus* ATCC 11778, *Escherichia coli* ATCC 25922, *Klebsiella pneumo-*

niae ATCC 13883, *Listeria monocytogenes* 1/2B, *Proteus mirabilis* ATCC 25933, Methicillin-resistant *Staphylococcus aureus* ATCC 43300 (MRSA), *Streptococcus pneumoniae* ATCC 10015, *Salmonella enteritidis* ATCC 13076, *Salmonella typhimurium* NRRLE 4463, *Yersinia enterocolitica* ATCC 1501, *Candida albicans* 10231, *Aspergillus parasiticus* DSM 5771, and *Aspergillus flavus* NRRL 3357 were used as test organisms.

Antimicrobial activity test was performed in accordance with the criteria of the Clinical and Laboratory Standards Institute (CLSI, 2020). Agar-well diffusion and the micro-well dilution method, which were described in our earlier study, was carried out for the extract at 30 mg/mL (Albayrak & Aksoy, 2019).) For the essential oil, a disc diffusion assay, which was described in our previous study, was used (Albayrak & Aksoy, 2019). The growth inhibition zones were recorded in millimeters. Tetracycline (10 mg/mL), natamycin (30 mg/mL), ampicillin (AMP, 10 µg/disk), kanamycin (K, 30 µg/disk), and penicillin (P, 10 µg/disk) were selected as standards.

To determine the minimum inhibitory concentration (MIC) values, the extract and essential oil were prepared at 30 mg/mL and 2000 µg/mL in 10% dimethylsulfoxide (DMSO). Then, two-fold dilutions were made in the medium. The minimum inhibitory concentration (MIC) was recorded as the lowest sample concentration that prevented visible growth after the incubation period. In the MIC method, the concentrations exhibiting complete absence of visual growth were determined, and 0.1 mL of each culture broth was transferred on to the agar plates. Minimum bactericidal concentration (MBC) and minimum fungicidal concentration (MFC) were recorded as the lowest concentration at which zero or only one colony was observed on the agar surface.

RESULTS AND DISCUSSION

The hydrodistillation of *S. potentillifolia* yielded a light yellowish oil with a yield of 0.15% (v/w). The phenolic constituents of the essential oil of *S. potentillifolia* were determined by GC/MS. Fifty compounds representing 100.00% of the total oil were determined (Table 1). The major compound was eucalyptol (%23.01). It was followed by carvacrol (6.45%), β-pinene (6.01%), borneol (5.48%), camphor (4.69%), α-terpineol (4.04%), 4-terpineol (3.93%), bornyl acetate (3.92%), caryophyllene (3.92%), caryophyllene oxide (3.84%), α-pinene (3.81%), linalool (3.37%), cymol (2.58%), γ-terpinene (2.55%), α-terpinyl acetate (1.79%), β-myrcene (1.78%), myrtenyl acetate (1.70%), α-humulene (1.60%), *δ*-cadinene (1.44%), germacrene (1.32%), humulene oxide (1.12%) and β-bourbonene (1.01%).

Several authors have reported on the essential oil compositions of Salvia species (Hatipoglu et al., 2016; Wang et al., 2023). Apart from some chemical variations, eucalyptol, camphor, borneol and α, β-pinene are usually main components of *Salvia* essential oils. The essential oil constituents of *S. potentillifolia* (Burdur, Türkiye) was previously analyzed and α, β-pinenes were found as major compounds (Kivrak et al., 2009). Our findings are similar to those obtained for *S. officinalis* (Hayouni et al., 2008; Longaray Delamare, Moschen-Pistorello, Artico, Atti-Serafini, & Echeverrigaray, 2007) and *S. libanotica* (Farhat et al., 2001) oil containing 1,8-cineole, camphor, borneol and α, β-pinene as main compounds. Similarly, 1,8-cineole was found as the main component of *S. aucheri* var. *aucheri* (30.5%), *S. aramienesis* (46.0%) (Kelen & Tepe, 2008), and *S. hydrangea* EO (2.1%) (Kotan et al., 2008). The major components of *S. officinalis* essential oils were determined as α-thujone, camphor, and borneol (Russo et al., 2013). According to these results, there was a significant variation in the content and yield of essential oil among the studied *Salvia* species. The reasons for these variations may be the differentiation of species, geographical, climatic, seasonal, and experimental conditions (Herraiz-Peñalver et al., 2010).

The percent yield of the methanol extract of *S. potentillifolia* was 17.20% (w/w). The total phenolic and flavonoid contents of the methanol extract were 52.20 ± 0.6 mg GAE/g and 9.90 ± 0.0 mg QE/g extract, respectively. It has been previously recorded the total phenolic and total flavonoid contents of the methanol, hexane, ethylacetate, and water extracts obtained from *S. potentillifolia* as range from 49.2 to 62.4 µg pyrocatechol equivalents (PEs)/mg and from 35.1 to 292.2 µg quercetin equivalents (QEs) /mg, respectively. The total phenolic content of the methanol extract of *S. potentillifolia* was found as 168.5 µg QEs/mg (Kivrak et al., 2019). This value is much higher than the value obtained for the methanol extract of *S. potentillifolia* evaluated here. The total phenolic and total flavonoid contents of the methanol extracts of different Salvia species were found as 38-326 mg gallic acid/g and 91-253 mg (+)-catechin/g, respectively (Asadi et al., 2010). The total phenolic and total flavonoid contents of the methanol extract of *S. spinosa* were 377.6 mg GAE/g and 134.8 mg QE/g, respectively (Bahadori et al., 2015). The total phenolic content of the methanol extract of *S. eremophila* was found as 101.25 µg GAE/mg (Ebrahimabadi, Mazoochi, Kashi, Djafari-Bidgoli, & Batooli, 2010). The total phenolic contents were found as 67.67-72.02 mg GAE/g for *S. argentea* extracts and 112.93-161.37 mg GAE/g for *S. officinalis* extracts (Farhat et al., 2013).

To determine of antioxidant effects of the extracts should be used many methods which have several mechanisms (Aruoma, 2003). Thus, several biochemical methods were carried out to evaluate properties of the extract in this work: phosphomolybdenum, DPPH, FRAP, CUPRAC, β-Carotene bleaching, hydrogen peroxide scavenging, and chelating activity methods.

The total antioxidant activity of the methanol extract was determined to be 301.78 ± 0.6 mg AAE/g extract. In the

Table 1. Compositions of essential oil from *S. potentillifolia*

Compounds	RT[b]	%	Compounds	RT[b]	%
α-thujene[a]	5.694	0.25[c]	Bornyl acetate	24.392	3.92
α-pinene	5.942	3.81	(-)-trans-Pinocarvyl acetate	25.123	0.18
Camphene	6.466	0.66	Carvacrol	26.092	6.45
Sabinene	7.254	0.57	Myrtenyl acetate	26.951	1.70
β-Pinene	7.460	6.01	α-Terpinyl acetate	28.504	1.79
β -Myrcene	7.884	1.78	α-Copaene	30.224	0.39
α- Terpinene	9.037	0.62	β - Bourbonene	30.698	1.01
Cymol	9.404	2.58	β - Elemene	31.209	0.08
Eucalyptol (1,8-cineole)	**9.787**	**23.01**	Caryophyllene	32.967	3.92
γ-Terpinene	10.995	2.55	α-Humulene	35.204	1.60
α -Terpinolene	12.369	0.44	β - Farnesene	35.442	0.54
Linalool	13.296	3.37	β - Cadina-1(6),4-diene	36.336	0.18
Nonanal	13.440	0.24	Germacrene	36.839	1.32
α- Thujone	14.071	0.26	β-Cubebene	37.457	0.20
α- Campholenal	14.574	0.28	β -Selinene	37.874	0.33
trans-Pinocarveol	15.460	0.84	γ-Cadinene	38.900	0.20
Camphor	15.707	4.69	sesquisabinene hydrate	39.107	0.52
p-Mentha-1,5-dien-8-ol	16.046	0.09	δ-Cadinene	39.304	1.44
Pinocamphone	16.495	0.25	Elemol	41.192	0.37
Pinocarvone	16.592	0.51	Caryophyllene oxide	42.922	3.84
Borneol	17.397	5.48	Guaiol	44.033	0.16
4-Terpineol	17.921	3.93	Humulene oxide	44.549	1.12
Cymen-8-ol <para->	18.432	0.23	α -Longipinene	45.768	0.43
Myrtenal	18.626	0.67	α- Muurolol	46.640	0.39
α -Terpineol	18.915	4.04	β-Eudesmol	47.280	0.76
			Total		**100**

[a] Compounds listed in order of elution from the FFAP MS column.
[b] Retention time (as minutes).
[c] The percentage composition was computed from the GC peak areas. Bold type indicates major components.

β- carotene bleaching method, the β- carotene is prevented from losing its orange colour in the presence of antioxidants by quenching the linoleate-free radicals formed in the solution (Jayaprakasha, Singh, & Sakariah, 2001). The inhibition values of the methanol extract, butylated hydroxytoluene, and butylated hydroxyanisole at 1 mg/mL were 31.48%, 84.26%, and 94.33%, respectively. The extract showed weaker inhibitor activity than BHT and BHA.

The methanol extract exhibited concentration-dependent DPPH radical scavenging activity (Figure 1). The percentage inhibition of the extract was 15.69%, 37.13%, 69.24%, 91.18, and 92.02% at 0.1, 0.25, 0.5, 1, and 2 mg/mL concentrations, respectively. At 1 and 2 mg/mL, the extract exhibited a high inhibitory effect similar to that of BHT (91.47% and 92.15% at 1and 2 µg/mL, respectively). The IC_{50} was calculated as 11.63 µg/mL. The BHT level was 3.35 µg/mL. Low IC_{50} and high DPPH scavenging percentages indicate high antioxidant activity.

There are many studies on the DPPH scavenging potential of different *Salvia* species. The ethanol extract of *S. potentillifolia* collected from Burdur, Türkiye showed high DPPH inhibitor (IC_{50}= 69.4 µg/mL) and β-carotene bleaching inhibitor (75.4 % at 80 µg/mL) activity (Kivrak et al., 2009). The same researchers reported that ethyl acetate extracts of *S. halophila* showed DPPH scavenging activity with IC_{50}= 248.4 µg/mL and β-carotene bleaching inhibitor effect (IC_{50} = 26.1 µg/mL, respectively (Kivrak et al., 2019).

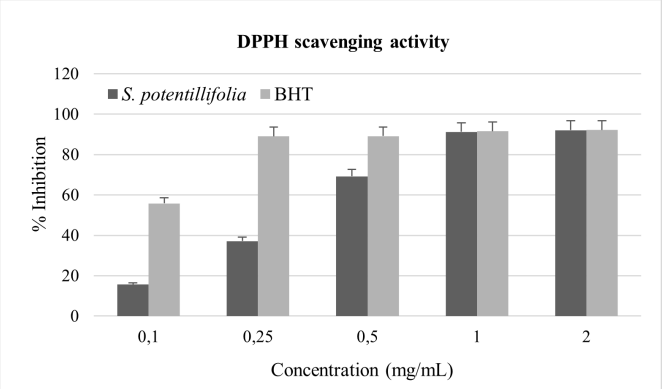

Figure 1. DPPH scavenging activity of *S. potentillifolia* methanol extract

The methanol extract of *S. eremophila* was reported to be an antiradical (IC_{50} = 35.19 µg/mL) and β-carotene bleaching inhibitor (72.42%) agent (Ebrahimabadi et al., 2010). The methanol extract of *S. brachyantha* exerted antioxidant, DPPH scavenging effect (IC_{50}= 46.72 µg/mL) and β-carotene inhibitor effect (69.45%) (Esmaeili & Sonboli, 2010). When the results are compared, it is seen that the methanol extract of *S. potentillifolia* had higher DPPH inhibitor activity (IC_{50} = 11.63 µg/mL) and the lower β-carotene bleaching inhibitor activity than the methanol extracts of *S. eremophila* and *S. brachyantha*. In another study, IC_{50} values of the methanol extracts obtained from *S. virgata, S. nemorosa, S. officinalis, S. sclarea, S. per-*

sica, S. reuterana, and *S. cereal* were in the range of 198 to 1810 µg/mL (Aghaei Jeshvaghani et al., 2015). IC_{50} value of the methanol extract of *S. potentillifolia* was lower than that of these *Salvia* species and thus had higher DPPH scavenger activity. It has been reported that the methanol extract of *S. spinosa* displayed high DPPH scavenging potency with IC_{50} =116.4 µg/mL (Bahadori et al., 2015). However, this IC_{50} was higher than that of *S. potentillifolia*.

Cu^{2+} reducing potentials of the extract and trolox are presented as absorbance values in Fig. 2. Cu^{2+} reducing activity of the extract was concentration-dependent. As shown in Figure 2, *S. potentillifolia* extract had strong CUPRAC activity. The absorbance values of the methanol extract at 450 nm ranged from 0.017 to 3.07 at 0.6-3 mg/mL. The absorbance value of the methanol extract (2.87) was the higher than trolox (2.85) at 1 mg/mL.

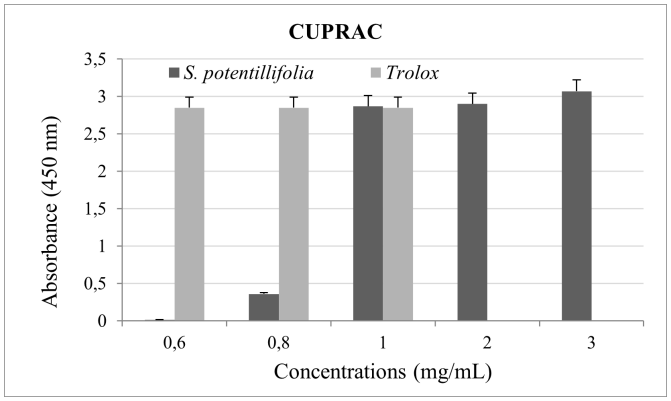

Figure 2. Cu^{2+} reducing activity of *S. potentillifolia* methanol extact

The result indicated that the methanol extract of *S. potentillifolia* had moderate reducing power at 2.28 mM Fe (II)/L compared with L-ascorbic acid (4.52 mM Fe (II)/L) in the FRAP assay. The FRAP values of the methanol extracts obtained from different *Salvia* species were in the range of 81.56 to 197.33 mM Fe(II)/mg (Farhat et al., 2013). Based on this study, it can be concluded that the total phenolic content, composition, and antioxidant capacity of *Salvia* samples collected from different regions may vary.

The methanol extract of *S. potentillifolia*, BHT, BHA, and gallic acid exhibited 34.09%, 76.97%, 64.73%, and 137.61% hydrogen peroxide scavenging activity, at 50 µg/mL, respectively (Figure 3). IC_{50} values were 78.63, 31.09, 23.16 and 17.62 µg/mL, respectively. According to the results, the methanol extract has a weak scavenging potential. The hydrogen peroxide scavenging effect of the methanol extract and standards increased in the order of the methanol extract< BHT< BHA< gallic acid. Similarly, Zhao, Xiang, Ye, Yuan, & Guo, (2006) determined that the extract of *S. miltiorrhiza* has high DPPH scavenging activity but low hydrogen peroxide scavenging activity.

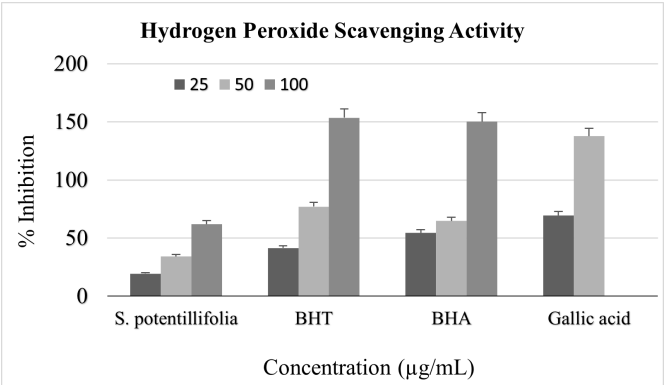

Figure 3. H_2O_2 scavenging effect of *S. potentillifolia* methanol extract

As shown in Figure 4, *S. potentillifolia* extract showed strong reducing power compared with BHT. The reducing activity of *S. potentillifolia* extract and BHT increased with increasing concentrations. *S. potentillifolia* extract has a higher powerful reducing ability than BHT at concentrations of 2.50, 5.0, and 10.0 mg/mL concentrations. The results demonstrated that *S. potentillifolia* extract has high electron-donor properties and thus can terminate very harmful radical chain reactions. The ethanol extract of *S. potentillifolia* has been reported to have high reducing power in a previous study (Kivrak et al, 2009).

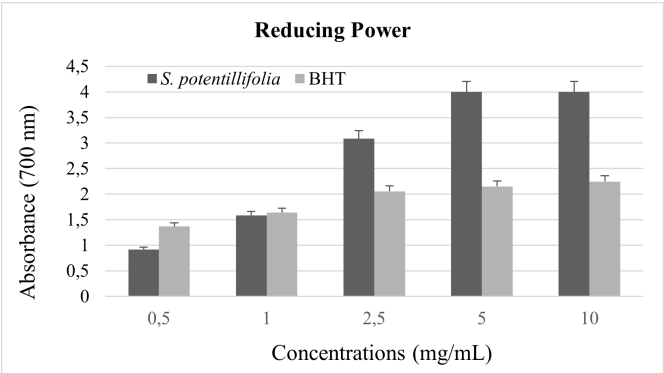

Figure 4. Reducing power of *S. potentillifolia* methanol extract

S. potentillifolia extract showed weak ferrous ion (Fe^{2+}) chelating activity. *S. potentillifolia* extract exhibited 16.25 ± 0.3% chelation of ferrous ions at 5 mg/mL. The value for EDTA was found to be 99.45 ± 0.0% at the same concentration. Similarly, the metal chelation activities of methanolic extracts obtained from five different *Salvia* species were reported to be between 37.35% and 76.25% (Kursat et al., 2023). Phenolic compounds are potential free radical terminators, scavengers, metal chelators, and inhibitor of lipoxygenase (Asadi et al., 2010). Because of differences in experimental methods , standards, and collection locations, it is difficult to compare different species (Aghaei Jeshvaghani et al., 2015).

Table 2. Antimicrobial activities of the methanol extract and essential oil of *S. potentillifolia* (mm, inhibition zones)

Bacteria	Extract (30 µg/mL)			Essential oil			Tetracycline			Ampicillin	Kanamycin	Penicillin
	mm	MIC (µg/mL)	MBC (µg/mL)	mm	MIC (µg/mL)	MBC (µg/mL)	mm	MIC (µg/mL)	MBC (µg/mL)	mm	mm	mm
A. hydrophila	7.0	6.25	12.5	9.0	0.5	1.0	27	<3.9	125	32	19	37
Y. enterocolitica	-	-	-	-	-	-	23	<3.9	125	-	10	-
S. typhimurium	-	-	-	-	-	-	15	62.5	125	11	11	10
L. monocytogenes	-	-	-	10	0.5	0.5	29	<3.9	<3.9	-	-	15
E. coli	-	-	-	-	-	-	24	<3.9	125	8	11	7
K. pneumoniae	10	0.78	0.78	27	0.25	0.5	48	15.6	15.6	23	7	33
S. aureus (MRSA)	-	-	-	-	-	-	25	<3.9	125	-	-	-
P. mirabilis	-	-	-	-	-	-	19	31.5	125	7	14	12
B. cereus	10	6.25	12.5	9.0	0.25	1.0	27	<3.9	<3.9	-	15	11
S. pneumoniae	13	6.25	6.25	9.0	0.5	0.5	24	7.8	7.8	-	-	13
S. enteritidis	-	-	-	-	-	-	25	<3.9	62.5	9	10	10
Yeast							**Natamycin**	**MIC (µg/mL)**	**MFC (µg/mL)**			
C. albicans	-	-	-	-	-	-	23	<3.9	62.5	-	-	-
Moulds												
A. flavus	-	-	-	7	0.06	1.0	17	7.8	>250	-	-	-
A. parasiticus	-	-	-	-	-	-	15	15.6	>250	-	-	-

-: not detected

The antioxidant properties of *Salvia* genus and *S. potentillifolia* were determined using many assays recorded in many reports. However, as far as our literature survey could ascertain, the FRAP and CUPRAC potencies, H_2O_2 scavenging, iron reducing power, and Fe^{2+} chelating potency of *S. potentillifolia* have not been previously reported.

Table 2 gives summary of the findings of the antimicrobial properties of the methanol extract and essential oil of *S. potentillifolia* against 12 bacteria, one yeast and two moulds. The methanol extract of *S. potentillifolia* exhibited weak antibacterial activity (Table 2). The extract had an effect only against *A. hydrophila, K. pneumoniae, B. cereus,* and *S. pneumoniae* with inhibition zones and MIC values in the range of 7.0-13 mm and 0.78-12.5 mg/mL, respectively. No activity against *C. albicans, A. flavus*, and *A. parasiticus* was exerted by the methanol extract. Essential oil had moderate antibacterial activity against all tested bacteria, along with 0.25-1.0 mg/mL MIC and MBC. The essential oil had no inhibitory effect against *Y. enterocolitica, S. typhimurium, E. coli*, methicillin-resistant *S. aureus, P. mirabilis*, and *S. enteritidis*, whereas it showed antibacterial activity against *A. hydrophila* (9.0 mm, inhibition zone), *L. monocytogenes* (10.0 mm), *K. pneumoniae* (27 mm), *B. cereus* (9.0 mm), and *S. pneumoniae* (9.0 mm). *B. cereus* and *K. pneumoniae* were the most sensitive (MIC=0.25 mg/mL) to the essential oil. Essential oil showed weak antifungal activity against aflatoxigenic *A. flavus* (7.00 mm, MIC = 0.06 mg/mL and MFC = 1.0 mg/mL). Essential oil was more effective against *L. monocytogenes, K. pneumoniae*, and *S. pneumoniae* than ampicillin and kanamycin.

The antimicrobial potency of the essential oils of *S. potentillifolia* and its ethanol extract was previously investigated. Contrary to our results, the essential oil and ethanol extract of *S. potentillifolia* was reported to have antibacterial effects against *S. enteritidis, E. coli, Y. enterocolitica, S. aureus* (MIC= 26.5-67.5 µg/mL) and anticandidal activity against *C. albicans* (MIC= 18.5-27.5 µg/mL). When the results are compared, it can be said that ethanol extract of *S. potentillifolia* is more effective than its methanol extract against K. pneumoniae and B. cereus (Kivrak et al., 2009). In a previous study, it was reported that *S. potentillifolia* has anticandidal activity (Celik, Ergin, Arslan, & Kartal, 2010). S. hydrangea essential oil exhibits considerable antifungal activity and a wide spectrum of antibacterial activity (Kotan et al., 2008). Similar results were obtained by Delamare (2007), who showed that the essential oils of *S. officinalis* and *S. triloba* exhibited inhibitory effect on *B. cereus* and *A. hydrophila* (Longaray Delamare et al., 2007). Contrary to our results, the methanol extract and essential oil of *S. spinosa* had effects against *E. coli, S. aureus*, and *C. albicans,* but were not active against *K. pneumoniae* (Ebrahimabadi et al., 2010). The essential oil of *S. sclareoides* strongly prevented *K. pneumoniae, S. aureus,* and *L. monocytogenes*, except for *P. aeruginosa* and *C. albicans* (Sepahvand et al., 2014). Thus, the compositions and biological activities of the essential oils of different *Salvia* species may change (Hayouni et al., 2008). Furthermore, as far as our literature survey could be determined, there were any findings regarding the antimicrobial activity of the methanol extract of *S. potentillifolia*. The phenolic content of essential oils may change due to many factors.

CONCLUSION

The main content of the essential oil of *S. potentillifolia* was eucalyptol (%23.01) determined by gas chromatography–mass spectrometry. The methanol extract of *S. potentillifolia* was found to have strong antioxidant potential. The present results also showed that the methanol extract and essential oil of *S. potentillifolia* exhibited from weak to moderate antimicrobial activity. Based on the obtained results, it can be evaluated as a natural source in the pharmaceutical and food industries. Therefore, further *in vivo* studies on antioxidant activity and action mechanisms are required. The results of this study support its therapeutic use in folk medicine.

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