Int. J. Pure Appl. Sci. 9(1);29-37 (2023)

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

Analysis of the Essential Oil Composition, Antimicrobial Activity and Antioxidant Capacity of *Fumaria asepala* Boiss. and *Fumaria schleicheri* Soy.Will. subsp. *microcarpa* Hausskn. from Turkey

Pelin Yilmaz Sancar
Fırat University, Faculty of Science, Department of Biology, Elazığ, Türkiye
peyilmaz@firat.edu.tr
Received date:18.03.2022, Accepted date: 18.11.2022

Abstract

This study aims to determine the antimicrobial and antioxidant activities of essential oil components and methanol extracts of *Fumaria asepala* Boiss. (Akşahtere) and *Fumaria schleicheri* Soy.-Will. subsp. *microcarpa* Hausskn. (Şahtere) species grown in Turkey. While essential oils were isolated by the hydrodistillation method, the analysis of these oils was determined by GC/MS device. According to the results obtained, the main component of the essential oil of *F. asepala* is Phytol (20.74%), followed by Thymol (20.42%), Benzyl Benzoate (15.89%), and Hexahydrofarnesyl acetone (12.92%); It was determined that the main component of the essential oil of *F. schleicheri* subsp. *microcarpa* is Benzyl Benzoate (29.07%), followed by Hexahydrofarnesyl acetone (19.72%), n-Hexadecanoic acid (11.40%) and Phytol (10.04%). The disk diffusion method was used to determine its antimicrobial effects. The above-ground parts of *F. schleicheri* subsp. *microcarpa* showed the best antimicrobial effect against *K. pneumoniae*-ATCC 700603 (25mm), while *F. asepala* showed the best antimicrobial effect against *S. aureus*-ATCC 25923 (24mm) and *K. pneumoniae* (24mm). To determine their antioxidant effects, total antioxidant level (TAS) and total oxidant level (TOS) were determined. It was determined that the TAS value of the methanol extract of *F. schleicheri* subsp. *microcarpa* at a concentration of 1 mg/ml was 2.8314 mmol, and the TOS value of *F. asepala* was 3.1610 mmol at the same concentration. It was determined that the total oxidant levels in both species were high.

Key words: Antimicrobial activity, antioxidant capacity, *Fumaria*, essential oil

Türkiye'den *Fumaria asepala* Boiss. ve *Fumaria schleicheri* Soy.-Will. subsp. *microcarpa* Hausskn. 'nın Uçucu Yağ Bileşenleri ile Antimikrobiyal Aktivitesi ve Antioksidan Kapasitesinin Analizi

Öz

Bu çalışmada, Türkiye'de yetişen *Fumaria asepala* Boiss. (Akşahtere) ve *Fumaria schleicheri* Soy.-Will. subsp. *microcarpa* Boiss. ex Hausskn. (Şahtere) türlerinin uçucu yağ bileşenleri ile metanol ekstrelerinin antimikrobiyal ve antioksidan aktivitelerinin belirlenmesi amaçlanmıştır. Uçucu yağlar hidrodistilasyon yöntemi ile izole edilirken, bu yağların analizi GC/MS cihazı ile belirlenmiştir. Elde edilen sonuçlara göre *F. asepala*'nın uçucu yağının esas bileşeninin Phytol (%20.74) olduğu, bunu Thymol (%20.42), Benzyl Benzoate (%15.89) ve Hexahydrofarnesyl acetone (%12.92)' ın izlediği; *F. schleicheri* subsp. *microcarpa*'nın ise uçucu yağının esas bileşeninin Benzyl Benzoate (%29.07) olduğu ve bunu sırasıyla Hexahydrofarnesyl acetone (%19.72), n-Hexadecanoic acid (%11.40) ve Phytol (%10.04)' ün izlediği saptanmıştır. Antimikrobiyal etkilerini tespit etmek için disk difüzyon yöntemi kullanılmıştır. *F. schleicheri* subsp. *microcarpa*'nın toprak üstü kısımları en iyi antimikrobiyal etkiyi *K. pneumoniae'*e- ATCC 700603 (25mm) karşı gösterirken, *F. asepala* ise en iyi antimikrobiyal etkiyi *S. aureus*-ATCC 25923 (24mm) ve *K. pnuemoniae'e* karşı (24mm) göstermiştir. Antioksidan etkilerini belirlemek için toplam antioksidan seviyesi (TAS) ve toplam oksidan seviyesi (TOS) tespit edilmiştir. *F. schleicheri* subsp. *microcarpa*'nın 1 mg/ml konsantrasyonda metanol ekstresinin TAS değeri 2.8314 mmol olduğu, *F. asepala*'nın TAS değerinin aynı konsantrasyonda 3.1610 mmol olduğu tespit edilmiştir. Her iki türün toplam oksidan seviyelerinin ise yüksek değerlerde olduğu belirlenmiştir.

Anahtar kelimeler: Antimikrobiyal aktivite, antioksidan kapasite, *Fumaria*, uçucu yağ

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

INTRODUCTION

In recent years, the high side effects of synthetic drugs and the search to support treatment with natural products have brought traditional and complementary medicine practices to the fore. It is thought that the use of herbal products rich in biologically active components for this purpose may be an important alternative in reducing high drug costs (Coban et al., 2003; Goncalves and Romano, 2016).

The World Health Organization (WHO) reported that the number of medicinal and aromatic plants used worldwide is approximately 20,000, of which 4,000 are widely used for therapeutic purposes, and around 2,000 medicinal/aromatic plants are traded worldwide, and around 500 in western Europe (Baydar, 2005; Craker et al., 2003).

Turkey; In addition to its geographical structure, it is in an important position in terms of biological richness and is one of the few countries with climatic conditions suitable for the cultivation of medicinal and aromatic plants. Turkey, with its wide area and rich diversity of medicinal and aromatic plants, is in a remarkable position for the trade of these plants. Medicinal and aromatic plants exported from Turkey or demanded in the domestic market are generally collected from the flora of Turkey (Kan, 2005). Plant extracts have been used by humans in traditional medicine for thousands of years. These essential oils obtained from medicinal and aromatic plants have an important market in the world. Among the more than 3000 known essential oils, 300 of them have an important place for the pharmaceutical, agricultural, and food industries, especially; It is used in the cosmetics and perfume industry, in the production of soap, detergent, and toothpaste (Bayaz, 2014).

The genus *Fumaria* L. (Papaveraceae) consists of about 60 species (Pérez-Gutiérrez et al., 2012) and is widespread throughout the European continent, particularly the Mediterranean region and Eastern and Western Europe (Tutin et al., 2010). *Fumaria* species are frequently confused with each other because they have very similar morphological features (Păltinean et al., 2013). Therefore, the identification of species belonging to this genus is based on some specific morphological character, for example, presence or absence of sepals, sepal length, fruit shape, fruit length, fruit stalk, and bracteole length (Păltinean et al., 2013; 2015). Studies have shown that *Fumaria* species are extremely rich sources in terms of alkaloid content. In addition to the alkaloid content, the presence of different types of flavonoids, steroid compounds, and organic acids has been determined (Sousek and Guedon, 1999). Antifungal (Moghtader, 2013), antibacterial (Khamtache- Abderrahima et al., 2016), and anti-inflammatory (Bribi et al., 2016) activities of these species are mentioned in the literature. These activities are especially dependent on the isoquinoline alkaloids found in the plant and protopine is the most common among them (Vrancheva et al., 2012).

This study aims to determine the antimicrobial and antioxidant activities and essential oil composition of two species belonging to the genus *Fumaria* used for medical purposes. This study, while determining the essential oils in the plant, was also aimed to determine the presence and limits of the antioxidant capacity with the antimicrobial effect it shows against some bacteria and fungus species. Thus, it is aimed to contribute to the studies that have been done and will be done about providing raw materials for new therapeutics from plants that naturally grow in Turkey and have medicinal properties. In this study, antioxidant and antimicrobial activities and essential oil content of *Fumaria asepala* Boiss. and *Fumaria schleicheri* Soy.-Will. subsp. *microcarpa* Boiss. ex Hausskn., which were collected from Elazığ province (Turkey) for the first time, were determined.

MATERIAL AND METHODS

Collection of the plant materials

Plant specimens were collected as flowering plants from their natural environment in April 2021 and were brought to the Fırat University Herbarium (FUH) and identified. The collected plants were ventilated and dried in the shade in terms of suitability for the study. Detailed locality information and general view of the samples are given in Table 1 and Figure 1.

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

Table 1. *Detailed location information in studied taxa*

Taxa	Collector	Collection Date	Detailed localities of taxa
Fumaria asepala	PYS- 1005	13.05.2021	B7 Elazığ: Baskil- Sancaklı village inner road, 1410 m. Lat: 38°35'13.061" Lon: 38°55'23.055" (Collected samples show distribution in the same location)
Fumaria schleicheri subsp. *microcarpa*	PYS-1006	13.05.2021	

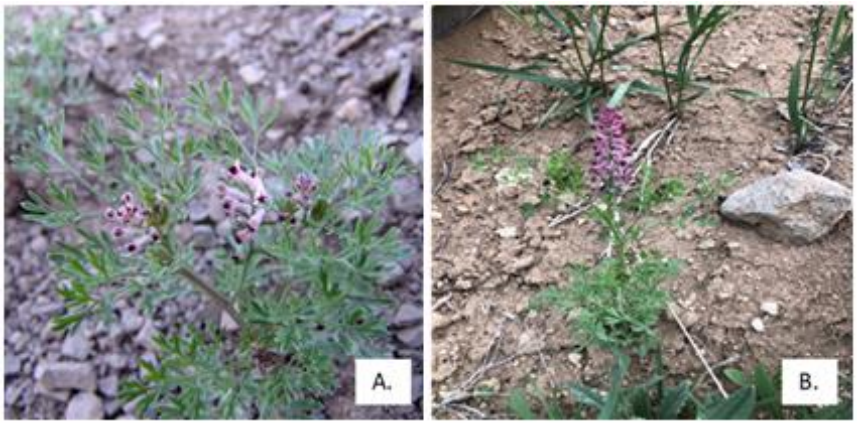

Figure 1. General view of F. asepala (A) and F. schleicheri subsp. microcarpa (B)

Isolation of the Essential Oils

In recent years, drying methods have been used effectively in isothermal and non-isothermal systems in the first step of essential oil studies. In this study, plants were air-dried and the hydrodistillation method was used to obtain oil from dried plants. A total of 250 g of the dried plant was used for the essential oil obtained by using the Clevenger type apparatus for approximately 4 hours. The resulting essential oil was dissolved over anhydrous sodium sulfate and stored at +4°C until analysis (Demirpolat et al., 2017).

Determination of the antimicrobial effect

In this study; Bacteria such as *Staphylococcus aureus* (ATCC 25923), *Klebsiella pneumoniae* (ATCC 700603), *Escherichia coli* (ATCC 25322), *Bacillus megaterium* (DSM32) and *Pseudomonas aeruginosa* (DMS 50071) and *Candida albicans* (FMC17) as fungus were used. Microorganism cultures were obtained from the culture collection of Fırat University, Faculty of Science, Department of Biology, Microbiology Laboratory (Turkey).

Extracts were obtained from the plant samples, which were kept by drying in the open air, after they were powdered in a mortar, 50 g were taken and kept in 100 ml of 96% methanol for 2 days in a shaking oven (Inci et al., 2021).

The antimicrobial activity of the methanol extracts of the samples was determined by the disk diffusion method (Collins and Lyne, 2004). Bacterial strains (*S. aureus, E. coli, K. pneumoniae, P. aeruginosa, B. megaterium*) were inoculated into the nutrient broth (Difco) for 24 hours at 35±1°C, yeast strain (*C. albicans* FMC17 in malt extract-Difco) was incubated at 25±1°C for 48 hours. Culture of the prepared bacteria and yeast in broth, respectively; After being inoculated into MHA and SDA at a rate of 1% (10^6 bacteria/ml, 10^4 yeast/ml) thoroughly shaken, 25 ml were placed in sterile petri dishes with a diameter of 9 cm to ensure homogeneous distribution of the medium. Antimicrobial discs with a diameter of 6 mm impregnated with 100 µl of extracts (1000 µg/disc) were placed lightly on the solidified agar medium (Erecevit Sönmez and Cakilcioglu, 2022).

After keeping the petri dishes prepared in this way for 1.5-2 hours at 4°C, the bacteria inoculated plates were incubated at 37±0.1°C for 24 hours, and the yeast inoculated plate at 25±0.1°C for 72 hours. Standard discs were used for the control

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

(Streptomycin sulfate 10 µg / disc, Nystatin 30 µg/disc). Dimethyl sulfoxide (DMSO) was used for negative control. At the end of the period, the inhibition zones formed on the medium were evaluated in mm.

Determination of total antioxidant and oxidant activity

Total antioxidant status (TAS) and total oxidant status (TOS) of plant extracts were determined with Rel Assay kits (Rel Assay Kit Diagnostics, Turkey). TAS value was expressed as mmol Trolox equiv./L and Trolox was used as the calibrator 15. The TOS value was expressed as µmol H2O2 equiv./L and hydrogen peroxide was used as the calibrator 16.

RESULTS AND DISCUSSION

The analysis of the essential oil obtained by hydrodistillation of the aerial parts of *F. asepala* and *F. schleicheri* subsp. *microcarpa* examined in this study was carried out using the GC-MS technique. As a result of the analysis of this oil obtained, 31 components in *F. asepala* and 26 components in *F. schleicheri* subsp. *microcarpa* were determined in total. While these components constitute approximately 90.36% of the total fat in *F. asepala*, they constitute approximately 91.05% of the total fat in *F. schleicheri* subsp. *microcarpa*. The essential oil yield of the plant was determined as 0.2% (v/w) in *F. asepala* and 0.3% (v/w) in *F. schleicheri* subsp. *microcarpa*. For *F. asepala*, the major components of the essential oil are respectively; Phytol (20.74%), Thymol (20.42%), Benzyl Benzoate (15.89%), and Hexahydrofarnesyl *acetone* (12.92%). For *F. schleicheri* subsp. *microcarpa*; Benzyl Benzoate (29.07%), Hexahydrofarnesyl acetone (19.72%), n-Hexadecanoic acid (11.40%), and Phytol (10.04%). It has been determined that other components in the essential oil are present in small amounts and show qualitative and quantitative changes. Data showing the detailed essential oil components of the plants are given in Table 2.

The antimicrobial effects of methanol extracts of the aerial parts of *F. asepala* and *F. schleicheri* subsp. *microcarpa* are shown in Table 3. Antimicrobial effects of methanol extracts of aerial parts of *F. asepala* and *F. schleicheri* subsp. *microcarpa*; It has been studied against *E. coli, S. aureus, K. pneumoniae, B. megaterium, P. aeuriginosa,* and *C. albicans*. According to the results obtained, the methanolic extract of *F. schleicheri* subsp. *microcarpa* formed 20 mm, 21 mm, 25 mm, 19 mm, 20 mm, and 18 mm inhibition zones against the studied microorganisms, respectively while the methanolic extract of *F. asepala* also formed an inhibition zone of 19 mm, 24mm, 24mm, 16mm, 19mm, and 15 mm, respectively, against the studied microorganisms. In Streptomycin sulfate 10 µg/disc used as a control, it is antimicrobial effect was at different rates against *E. coli* (30mm), *S. aureus* (20mm), *K. pneumoniae* (19mm), *B. megaterium* (25mm), *P. aeuriginosa* (25mm) while Nystatin 30 µg/disc formed a 20mm inhibition zone against *C. albicans*. The aerial parts of *F. schleicheri* subsp. *microcarpa* showed the best antimicrobial effect against *K. pneumoniae*, while *F. asepala* showed the best antimicrobial effect against *S. aureus* and *K. pneumonia.*

The TAS value of the methanol extract of *F. schleicheri* subsp. *microcarpa* at a concentration of 1 mg/ml was calculated as 2.8314 mmol and the TOS value as 11.4030 µmol. The TAS value of the methanol extract of *F. asepala* at the same concentration was determined as 3.1610 mmol and the TOS value as 12.7724 µmol (Table 4).

The results obtained showed that the total antioxidant levels in both species were very good, however, the total oxidant levels were high.

So far, no study available in the scientific literature has provided sufficient data on the antimicrobial and antioxidant activity of *F. asepala* and *F. schleicheri* subsp. *microcarpa* with comprehensive phytochemical analyzes. In this study, we tried to determine the essential oil components and antimicrobial and antioxidant activities of *F. asepala* and *F. schleicheri* subsp. *microcarpa* grown in Turkey for the first time. Phytol (florasol, phytosol), which is a major element in the chemical content of *F. asepala*, is acyclic diterpene alcohol that can be used as a precursor for the production of synthetic forms of vitamin E (Netscher, 2007) and vitamin K_1 (Daines et al., 2003). Thymol (also known as 2-isopropyl-5-methylphenol, IPMP) is a natural monoterpenoid phenol derivative and isomeric to carvacrol, mostly found in thyme oil and as a white crystalline substance with a pleasant aromatic odor and strong antiseptic properties.

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

Table 2. *Constituents of the essential oils from F. asepala and F. schleicheri* subsp. *microcarpa*

No	RT	RI	NAME	*F. asepala*	*F. schleicheri* subsp. *microcarpa*
1.	12.22	965	Hydroperoxide, 1-ethylbutyl	0.86	0.66
2.	18.14	1098	Linalool,	0.60	0.25
3.	12.69	1213	α - terpineol	0.83	0.59
4.	**12.87**	**1295**	**Thymol**	**20.42**	4.78
5.	33.52	1320	E-β-Damascenone	0.57	-
6.	33.80	1324	10,12-Docasadyndioic acid	0.26	-
7.	38.00	1390	trans-β-Ionone	0.65	0.20
8.	41.09	1411	Dodecylamine	-	0.23
9.	43.08	1420	Dodecanoic acid	-	0.48
10.	45.53	1428	14-β-H-Pregna	0.25	0.36
11.	46.48	1501	2-Pentadecanone	0.33	0.54
12.	46.98	1629	14-Methyl-8-hexadecyn-1-ol	1.40	-
13.	47.09	1630	Tetramethyl-2-hexadecen-1-ol	-	0.46
14.	48.03	1643	Phytol acetate	-	0.16
15.	**49.06**	**1760**	**Benzyl Benzoate**	**15.89**	**29.07**
16.	50.53	1804	2-Ethylhexyl salicylate	0.24	1.56
17.	50.98	1820	1-Hentatracontanol	-	0.63
18.	51.16	1824	Isopropyl myristate	0.34	0.45
19.	51.62	1830	Neophytadiene	0.42	-
20.	**51.84**	**1833**	**Hexahydrofarnesyl acetone**	**12.92**	**19.72**
21.	52.98	1844	Phthalic acid	-	0.22
22.	53.39	1854	Homosalate	0.42	0.62
23.	53.76	1858	Heptadecanenitrile	0.78	-
24.	54.10	1905	Malonic acid, 2-butyl decyl ester	0.41	-
25.	54.43	1909	Farnesyl Acetone B	1.95	-
26.	54.63	1912	Hexadecanoic acid, methyl ester	0.29	-
27.	55.19	1920	Tetrapentacontane	0.64	-
28.	55.41	1925	Isopyhtol	-	2.62
29.	55.56	1929	Hexacosane	0.35	-
30.	**55.87**	**1938**	**n-Hexadecanoic acid**	0.69	**11.40**
31.	57.05	1943	1-Decanol, 2-hexyl-	0.29	-
32.	59.75	2000	Oleanitrile	0.50	-
33.	60.18	2060	9-Octadecen-1-ol, (Z)-	1.42	0.28
34.	60.32	2100	Pentacosane	1.69	2.78
35.	60.49	2105	γ-Palmitolactone	2.57	0.25
36.	60.63	2120	Palmitaldehyde, diallyl acetal	-	0.23
37.	60.75	2132	2-Nonadecanol	0.19	-
38.	**60.91**	**2145**	**Phytol**	**20.74**	**10.04**
39.	61.43	2150	Kinome	-	2.47
40.	61.67	2154	(3E,5E,7E)-6-Methyl-8-(2,6,6-trimethyl-1-cyclohexenyl)	1.45	-
Total				**90.36**	**91.05**

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

Table 3. *Antimicrobial effect of F. asepala and F. schleicheri* subsp. *microcarpa*

Microorganism	***Fumaria asepala* (mm)**	***Fumaria schleicheri* subsp. *microcarpa* (mm)**	**Standart (mm)**	**Control**
E. coli	19	20	30 **	
S. aureus	24	21	20 **	
K. pneumoniae	24	25	19 **	
B. megaterium	16	19	25 **	
P. aeuriginosa	19	20	25 **	
C. albicans	15	18	20 *	

**Streptomycin sulfate (10 mg/disc) and *Nystatin (30 mg/disc) were used as standard antibiotic discs. The diameter of the paper discs was 6 mm.

Table 4. *TAS and TOS values of aerial parts of F. schleicheri* subsp. *microcarpa and F. asepala*

	TAS (mmol Trolox equiv./L)	**TOS (µmol H_2O_2 equiv./L)**
F. asepala-MetOH	3.1610	12.7724
F. schleicheri subsp. *microcarpa*-MetOH	2.8314	11.4030

Benzyl Benzoate (29.07%), which is a major element in *F. schleicheri* subsp. *microcarpa*, is an organic compound that is mostly used as a raw material for the treatment of skin diseases and is also known to have an insect repellent effect (Knowles, 1991; Stuart et al., 2009). Another major component, Hexahydrofarnesyl acetone (also known as phytone) (19.72%), is a sesquiterpene (Avoseh et al., 2021; Wei et al., 2016) with antibacterial, anti-nociceptive and anti-inflammatory activities.

When we look at the literature, Ashnagar et al. (2007) investigated the essential oil content of *F. parviflora* Lam., collected from the south of Iran. As a result of the study, the major components in the essential oil were found to be hexadecanoic acid 23.2%, Octadecane 13.2% Farnesyl acetate 8%, α-Cadinol 7.7%. According to the results of our study, hexadecanoic acid was found to be 0.69% in *F. asepala* and 11.40% in *F. schleicheri* subsp. *microcarpa*. In our study, thymol compound, which was found as 20.42% in *F. asepala* and 4.78% in *F. schleicheri* subsp. *microcarpa*, was determined as 0.7% according to Ashnagar et al (2007). It is thought that this difference is due to the difference of the place and time of collection and the plant species. Păltinean et al. (2017) also investigated the chemical composition of some *Fumaria* species (*F. jankae* Hausskn., *F. vailantii* Loisel., *F. schleicheri* Soy.-Will., *F. officinalis* L., *F. rostellata* Knaf, *F. capreolata* L.). According to the results they obtained, it was revealed that *Fumaria* species contain phenolic acids and high amounts of flavonoids. Rutin and isoquercitrin were found as the main compounds in the studied species. Vrancheva et al. (2014) analyzed the primary metabolites of 5 different *Fumaria* species grown in Bulgaria and identified ten carbohydrates, one polyol, ten amino acids, and six organic acids in polar fractions. They stated that these data could be useful in the chemotaxonomic classification of *Fumaria* species. Adhama et al. (2021) revealed that *F. officinalis* has a strong cytotoxic effect against some cell lines. Sofiane and Seridi (2021) looked at the chemical content of *Fumaria capreolata* L. grown in Algeria, and as a result of the phytochemical screening carried out on the above-ground part of the plant, the richness of this plant in terms of secondary metabolites such as alkaloids, catechic tannins, sterols, and terpenes was revealed.

It was determined that methanol extracts of *F. asepala* and *F. schleicheri* subsp. *microcarpa* had an antioxidant effect at a concentration of 1 mg/ml (Table 4). In previous studies, it was determined that *Fumaria* species contain high amounts of phenolic

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

acids and flavonoids (Păltinean et al., 2017). It has been reported that the DPPH radical scavenging effect of different fractions of *F. officinalis* has an IC50 value of 15.74-41.72 µg/mL and total antioxidant levels of 2.40-14.23 mg EAA/g DM (Khamtache-Abderrahim et al., 2016). It was determined that the percent inhibition of the DPPH radical scavenging effect of the ethyl acetate extract of *F. vaillantii* was 83.41% (Ivan et al., 2014). The antioxidant effect of methanol extracts of the aerial parts of *F. officinalis* was reported as 78.93% (Sengül et al., 2009). The IC50 value of the DPPH radical scavenging effect of *F. indica* was calculated as 62.91 µg/ml (Landry et al. 2021). The antioxidant effects of alkaloid extracts of *F. bastardii* and *F. capreolata* were found to be 86% and 45.6% (Maiza et al., 2007). It has been reported that the antioxidant effect of the ethanol extract of *Fumaria capreolata* is 72.35% (Orhan et al., 2012). From the studies, it is thought that *Fumaria* species have antioxidant effects (Sengul et al., 2009; Ivan et al., 2014; Khamtache-Abderrahim et al., 2016; Landry et al., 2021) and this is due to their phenolic acids, flavonoids, and alkaloids (Maiza et al., 2007; Orhan et al., 2007; Păltinean et al., 2017).

When we look at the chemical content of *F. asepala* and *F. schleicheri* subsp. *microcarpa*, it is seen that they have very valuable components. Many of these components have strong antioxidant and antimicrobial effects in the literature. In this study, the efficacy of the methanolic extract of the plant against various pathogenic microorganisms was also tested. According to the test results obtained, it has been observed that it has an antimicrobial effect at certain rates against all tested microorganisms. It is thought that its strong antimicrobial effect is due to these valuable chemical components.

It was determined that methanol extracts of *F. asepala* and *F. schleicheri* subsp. *microcarpa* had antimicrobial effects at different rates (15-25 mm) against the microorganisms used (Table 3). In previous studies, it has been reported that different fractions of *F. officinalis* have antimicrobial effects against *Propionibacterium acnes*, *Acinetobacter calcoaceticus*, *Corynebacterium xerosis* (Khamtache-Abderrahim et al., 2016). It has been determined that *F. vaillantii* forms an inhibition zone in the range of 8-28 mm against A. flavus at different concentrations (Moghtader, 2013). Methanol extracts of the aerial parts of *F. officinalis* formed a 10mm and 15mm inhibition zone against *P. aeruginosa* and *S. aureus*, espectively (Sengul et al., 2009). It has been determined that alkaloid extracts of Fumaria bastardii and *Fumaria capreolata* have antimicrobial effects against *S. aureus, K. pneumoniae, P. aeruginosa*, and *E. coli* (Maiza and Bribi, 2012). Fuyuziphine alkaloid obtained from *F. indica* was used against the development of some fungi that cause diseases in plants and very effective results were obtained (Pandey et al., 2007). It has been reported that *F. vaillantii* and *F. vulgaris* have antimicrobial effects at different rates (8.5-19.5mm) against *S. aureus, B. cereus, E. coli, K. pneumoniae, S. flexneri, E. aerogenes, P. aeruginosa, S. marcescens, P. vulgaris* at a concentration of 480 mg/ml (Jaberian et al., 2013). When the results obtained are compared with previous studies, it is seen that the results show differences (Sengul et al., 2009; Maiza and Bribi, 2012; Moghtader, 2013; Jaberian et al., 2013; Khamtache-Abderrahim et al., 2016). The biochemical contents of *Fumaria* species, the solvents used and the differences in microorganisms affect the antimicrobial results (Kirbag et al., 2013). Stanojević et al (2018) investigated the antioxidant and antimicrobial activity of the aqueous extract of *F. officinalis* in 2018. In their study using 7 different microorganisms, they stated that the plant extract showed the strongest antimicrobial effect, especially against *C. albicans*, and also had high antioxidant activity when they measured the effectiveness using the DPPH method (Stanojević et al., 2018; Karaaslan et al., 2018).

CONCLUSION

In conclusion, as a result of a detailed literature review, it is understood that the genus *Fumaria* is a plant group with high medicinal properties. It is seen that there are quite a lot of studies in the literature using the genus *Fumaria*, and these mostly include antimicrobial, antioxidant, anti-inflammatory, hepatoprotective, antihelminthic, analgesic, essential oil, and cytotoxic studies. However, it is seen that there is no study using *F. asepala* and *F. schleicheri* subsp. *microcarpa* species that we used in our study.

In this study, essential oil components, antimicrobial effects, and antioxidant activities of *F. asepala* and *F. schleicheri* subsp. *microcarpa* were studied for the first time by us and very valuable findings were obtained and brought to the literature.

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

ACKNOWLEDGMENT

The author would like to thanks, Prof. Dr. Semsettin Civelek, Prof. Dr. Sevda Kirbag and Asst. Prof. Azize Demirpolat for their contribution.

CONFLICT OF INTEREST

The Author reports no conflict of interest relevant to this article.

RESEARCH AND PUBLICATION ETHICS STATEMENT

The author declares that this study complies with research and publication ethics.

REFERENCES

Adhama, A., Abedb, R. and Ritsemab, C. (2021). A Reliability Analysis of Rainwater Catchment System. Water Resources, 48(3), 361–367.

Ashnagar, A., Gharib Naseri, N. and Yaghobi, M. (2007). Chemical composition of the essential oil of fumitory plant (*Fumaria parviflora* Lam.) (Fineleaf fumitory) grown in Ahwaz, Iran. Asian Journal of Chemistry, 19(7), 5336-5340.

Avoseh, O. N., Mtunzi, F. M., Ogunwande, I. A., Ascrizzi, R. and Guido, F. (2021). *Albizia lebbeck* and *Albizia zygia* volatile oils exhibit anti-nociceptive and anti-inflammatory properties in pain models. Journal of Ethnopharmacology, 268, 113676.

Bayaz, M. (2014). Esansiyel Yağlar: Antimikrobiyal, Antioksidan ve Antimutajenik Aktiviteleri. Akademik Gıda, 12, 45-53.

Baydar, H. (2005). Tıbbi, Aromatik ve Keyf Bitkileri Bilimi ve Teknolojisi. Süleyman Demirel Üniversitesi Yayınları, Isparta, 113–115.

Bribi, N., Algieri, F., Rodriguez-Nogales, A., Vezza, T., Garrido-Mesa, J., Utrilla, M. U., Contreras, M., Maiza, F., Segura-Carretero, A., Rodriguez-Cabezas, M. E. and Galvez, J. (2016). Intestinal anti-inflammatory effects of total alkaloid extract from *Fumaria capreolata* in the DNBS model of mice colitis and intestinal epithelial CMT93 cells. Phytomedicine, 23: 901–913.

Coban, T., Citoğlu, G., Sever, B. and İscan, M. (2003). Antioxidant activities of plants used in traditional medicine in Turkey. Pharmaceutical biology, 41(8), 608-613.

Collins, C. M. and Lyne, P. M. (2004). Microbiological methods. Oxford University Press Inc, London, 140.

Craker, L. E., Gardner and Z., Etter, S. C. (2003). Herbs in American fields: A horticultural perspective of herband medical plant production in the United Sates. Horticultural science, 38: 977–983.

Daines, A., Payne, R., Humphries, M. and Abell, A. (2003). The synthesis of naturally occurring vitamin K and vitamin K analogues. Current organic chemistry, 7(16), 1625-1634.

Demirpolat, A., Bagci, E. and Doğan, G. (2017). Essential Oil Composition of *Scandix iberica* Bieb. and *Scandix stellata* Banks and Sol. (Apiaceae) from Different Parts, a Chemotaxonomic Approach. Global journal of botanical science, 5(2), 55-62.

Erecevit Sönmez, P. and Çakılcıoğlu, U. (2021). Türkiye'de Yetişen *Centaurea urvillei* DC. subsp. *urvillei*' nin Antibakteriyel ve Antifungal Özelliği. Int. J. Pure Appl. Sci., 7(3), 517-525.

Goncalves, S. and Romano, A. (2016). The medicinal potential of plants from genus *Plantago* (Plantaginaceae). Industrial Crops and Products, 83(1), 213-226.

Inci, S., Eren, A. and Kirbag S. (2021). Determination of antimicrobial and antioxidant activity of *Alchemilla alpina* L. Turkish Journal of Agriculture-Food Science and Technology 9(12), 2260-2264.

Jaberian, H., Piri, K. and Nazari J. (2013). Phytochemical composition and in vitro antimicrobial and antioxidant activities of some medicinal plants. Food chemistry, 136(1), 237-244.

Kan, Y. (2005). Production and consumption potential of medicinal and aromatic plants in Turkey. Pharmacognosy and Phytotherapy Symposium; İstanbul, Proceedings Book, 56–61.

Karaaslan, N. M., Karaaslan, M. G. and Ates, B. (2018). Effects of Some Extraction Solvents on the Antioxidant Properties of Strawberry Fruit. Int. J. Pure and Appl. Sci., 4 (2), 102-109.

Khamtache-Abderrahim, S., Lequart-Pillon, M., Gontier, E., Gaillard, I., Pilard, S., Mathiron, D. and Maiza-Benabdesselam, F. (2016). Isoquinoline alkaloid fractions of *Fumaria officinalis*: Characterization and evaluation of their antioxidant and antibacterial activities. Industrial Crops and Products, 94, 1001-1008.

Kirbag, S., Erecevit, P., Zengin, F. and Guvenc, A. N. (2013). Antimicrobial activities of some *Euphorbia* species. Afr J Tradit Complement Altern Med., 10(5), 305-309.

Knowles, C.O. (1991). 22.4.2 Benzyl Benzoate. In Hayes, Wayland J.; Laws, Edward R. (eds.). Handbook of Pesticide Toxicology, Classes of Pesticides. Academic Press, 3, 1505–1508.

Landry, B. K., Tariq, S., Malik, A., Sufyan, M., Ashfaq, U. A., Ijaz, B. and Shahid, A.A. (2021). *Berberis lyceum* and *Fumaria indica:* in vitro cytotoxicity, antioxidant activity, and in silico screening of their selected phytochemicals as novel hepatitis C virus nonstructural protein 5A inhibitors. Journal of Biomolecular Structure and Dynamics, 25: 1-25.

Maiza, B. F., Khentache, S., Bougoffa, K., Chibane, M., Adach, S., Chapeleur, Y., Max, H. and Laurain-Mattar, D. (2007). Antioxidant activities of alkaloid

IJPAS
ijpas@munzur.edu.tr
ISSN: 2149-0910

Research article/Araştırma makalesi
DOI:10.29132/ijpas.1089824

extracts of tow Algerian species of *Fumaria: Fumaria capreolata* and *Fumaria bastardii.* Records of Natural Products, 1: 28-35.

Maiza, B. F. and Bribi, N. (2012). Antibacterial activity against multi resistant bacteria strains of alkaloid extracts of two Algerian *Fumaria* species. Microbes In Applied Research, 464-468.

Moghtader, M. (2013). In vitro antifungal effects of *Fumaria vaillantii* Loisel. essential oil on *Aspergillus flavus*. Journal of Yeast and Fungal Research, 4: 21–25.

Netscher, T. (2007). Synthesis of Vitamin E, Vitamins & Hormones, Academic Press, 76: 155-202.

Orhan, I., Özçelik, B., Karaoğlu, T. and Şener, B. (2007). Antiviral and antimicrobial profiles of selected isoquinoline alkaloids from *Fumaria* and *Corydalis* species. Zeitschrift für Naturforschung C, 62(1-2), 19-26.

Orhan, I. E., Sener, B. and Musharraf, S. G. (2012). Antioxidant and hepatoprotective activity appraisal of four selected *Fumaria* species and their total phenol and flavonoid quantities. Experimental and Toxicologic Pathology, 64, 205–209.

Păltinean, R., Wauters, J. N., Tits, M., Frédérich, M., Angenot, L., Tămas and M., Crisan, G. (2013). Comparative morphological studies on some species of the genus *Fumaria.* Farmacia, 61: 371–377.

Păltinean, R., Crisan, G., Balica, G., Ielciu, I., Stefănescu, C. and Tămas, M. (2015). Histo-anatomical researches on the vegetative organs of five Romanian *Fumaria* species. Farmacia, 63: 262–266.

Păltinean, R., Mocan, A., Vlase, L., Gheldiu, A. M., Crișan, G., Ielciu, I., Voștinaru, O. and Crișan, O. (2017). Evaluation of Polyphenolic Content, Antioxidant and Diuretic Activities of Six *Fumaria* Species. Molecules, 22(4), 639.

Pandey, M. B., Singh, A.K., Singh, A. K. and Singh, U.P. (2007). Inhibitive Effect of Fuyuziphine isolated from Plant (Pittapapra) (*Fumaria indica*) on Spore Germination of Some Fungi. Mycobiology, 35(3), 157-158.

Pérez-Gutiérrez, M. A., Romero-García, A. T., Salinas, M. J., Blanca, G., Fernández, C. and Suárez-Santiago, V.N. (2012). Phylogeny of the tribe Fumarieae (Papaveraceae s.l.) based on chloroplast and nuclear DNA sequences: Evolutionary and biogeographic implications. American Journal of Botany, 99: 517–528.

Sengul, M., Yildiz, H., Gungor, N., Cetin, B., Eser, Z. and Ercisli S. (2009). Total phenolic content, antioxidant and antimicrobial activities of some medicinal plants. Pakistan Journal of Pharmaceutical Sciences, 22(1), 102-106.

Sofiane, I. and Seridi, R. (2021). Phytochemical profile, total phenolic content and antioxidant activity of ethanolic extract of fumitory (*Fumaria capreolata* L.) from Algeria. European Journal of Biological Research, 11(4), 404-416.

Sousek, J. and Guedon, D. (1999). Alkaloids and organic acids content of Eight *Fumaria* species. Phytochem Anal, 10, 6-11.

Stanojević, L., Zvezdanović, J., Danilović, B., Cvetković, D., Stanojević, J., Ilić, D. and Cakić, M. (2018). The antioxidative and antimicrobial activity of the aqueous earth smoke (*Fumaria officinalis* L.) extract. Advanced Technologies, 7(2), 31-40.

Stuart M. C., Kouimtzi M and Hill SR (eds.). (2009). World Health Organization, WHO Model Formulary
p. 311. hdl:10665/44053. ISBN 9789241547659.

Tutin, T. G., Burges, N. A., Chater, A. O., Edmonson, J. R., Heywood, V. H., Moore, D. M., Valentine, D. H., Walters, S. M. and Webb, D. A. (2010). Psilotaceae to Platanaceae In Flora Europaea. Cambridge University Press, Cambridge, UK, 2(1), 306–311.

Vrancheva, R., Ivanov, I., Marchev, A. and Pavlov, A. (2012). Qualitative and quantitative determination of protopine in *Fumaria* sp. by TLC-densitometry method. Journal of BioScience and Biotechnology, 1, 255–259.

Vrancheva, R. Z., Ivanov, I. G., Aneva, I. Y., Dincheva, I. N., Badjakov, I. K. and Pavlov, A. I. (2014). GC-MS based metabolite profiling of five Bulgarian *Fumaria* species. Journal of BioScience & Biotechnology, 3(3), 195-201.

Wei, G., Kong, L., Zhang, J., Ma, C., Wu, X., Li, X. and, Jiang, H. (2016). Essential oil composition and antibacterial activity of *Lindera nacusua* (D. Don) Merr. Natural Product Research, 30(23), 2704-2706.