

Determination of Some Important Properties of *Lavandula Stoechas* (Lavender) Plant for Human Health

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Abstract

Medicinal plants, used in the treatment of many diseases, are natural sources of healing. Due to the phenolic compounds they contain, such as flavonoids, phenylpropanoids, and stilbenes, medicinal plants are used in the treatment of various diseases. In Turkey, the use of this plant for medicinal purposes such as analgesic, antiseptic, wound healing, sedative, expectorant, urinary tract infection relief, eczema wound healing, and strengthening nerves and the heart is widespread. Because of these effects, in this study we examined certain properties of the extracts of *Lavandula stoechas*, grown in our country, in different solvents that are important for human health. The DPPH scavenging capacity of the methanol extract of *L. stoechas* was calculated as 56.345 ± 0.360 µg/mL trolox equivalent, and the TPC value was calculated as 55.356 ± 1.806 mg/g gallic acid equivalent. When we examined the volatile components, the compound groups with the highest amounts were identified as trans-Verbenol in alcohols, α-Campholenal in aldehydes, (-)-Camphor in ketones, Bornyl acetate in esters, and Camphene in terpenes. In our study, the phenolic components catechin, caffeic acid, vanillic acid, p-coumaric acid, gallic acid, and rosmarinic acid were investigated, and rosmarinic acid was the compound detected in the highest amount among both extract results. The antimicrobial effect of *L. stoechas* on *Escherichia coli*, *Staphylococcus aureus*, and *Candida albicans* strains was investigated, and it was found to have an antimicrobial effect only on *Staphylococcus aureus*.

Keywords

Lavandula stoechas,
Rosmarinic acid,
Staphylococcus aureus,
Antioxidant

Lavandula stoechas (Karabaş Otu) Bitkisinin İnsan Sağlığı İçin Önemli Bazı Özelliklerinin Belirlenmesi

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Özet

Birçok hastalığın tedavisinde kullanılan tıbbi bitkiler doğal tedavi kaynaklarıdır. Tıbbi bitkiler içeriğinde yer alan flavonoidler, fenilpropanoidler, stilbenler gibi fenolik maddelerden dolayı farklı hastalıkların tedavisinde kullanılırlar. Bu bitkinin ağrı kesici, antiseptik, yara iyileştirici, yatıştırıcı, balgam söktürücü, idrar yolu iltihabını giderici, egzama yaralarını iyileştirici, sinir ve kalbi güçlendirici gibi tıbbi amaçlarla kullanımı Türkiye’de yaygındır. Bu etkilerinden dolayı bu çalışmada bizde ülkemizde yetişen *L. stoechas* bitkisinin farklı çözücülerdeki ekstraktlarının insan sağlığı açısından önemli bazı özelliklerini inceledik. *L. stoechas* bitkisinin metanollü ekstraktının DPPH giderme kapasitesi 56.345 ± 0.360 µg/mL trolox eş değeri olarak, TPC değeri ise 55.356 ± 1.806 mg/g gallik asit eşdeğeri olarak hesaplanmıştır. Uçucu bileşenlerini incelediğimizde en fazla miktara sahip bileşik grupları alkollerde trans-Verbenol, aldehitlerde α-Campholenal, ketonlarda (-)-Camphor, esterlerde Bornyl acetate ve terpenlerde Camphene olarak tespit edilmiştir. Çalışmamızda kateşin, kafeik asit, vanilik asit, p-kumarik asit, gallik asit ve rosmarinik asit fenolik bileşenleri çalışılmış olup her iki ekstraktlı sonuçlar içerisinde rosmarinik asit en yüksek miktarda tespit edilen bileşik olmuştur. *L. stoechas* bitkisinin *Escherichia coli*, *Staphylococcus aureus* ve *Candida albicans* suşları üzerine antimikrobiyal etkisi incelenmiş sadece *Staphylococcus aureus* üzerine antimikrobiyal etki gösterdiği tespit edilmiştir.

Anahtar kelimeler

Lavandula stoechas,
Rosmarinik asit,
Staphylococcus aureus,
Antioksidan

1. INTRODUCTION

Medicinal plants were used to treat diseases approximately six thousand years ago in countries now known as India, China, and Egypt [1,2]. Traditional treatment methods remain a vital component of basic healthcare for millions of people worldwide, particularly in regions where access to essential medicines is limited. [3,4]. With the increase in industrialization worldwide, more and more people are opting for natural treatment methods to treat their diseases [5,6]. Plants with medicinal properties are used as natural treatment sources to treat many diseases [7]. The reason medicinal plants are preferred for treating many diseases is that they are economical, easily accessible, effective, and have fewer side effects [8,9,10]. Medicinal plants are thought to be used in the treatment of different diseases as they contain phenolic derivatives such as flavonoids, phenylpropanoids, stilbenes, and various active compounds in their structures. These compounds, which have antioxidant properties, can prevent damage caused by reactive oxygen species [11]. These reactive oxygen species are thought to play an important role in the pathogenesis of inflammation-related human diseases [12]. In his book *The Canon of Medicine*, Ibn Sina wrote that a species of *Lavandula*, *Lavandula stoechas*, when boiled and used, is beneficial for joint and rib pain, is useful against diseases such as melancholy and epilepsy, and is a medicinal plant with expectorant and choleric properties. [13].

The genus *Lavandula*, belonging to the Lamiaceae family, is represented by approximately 39 species [14]. Plants belonging to the genus *Lavandula*, which grow naturally in the lower parts of mountains, are endemic to the Mediterranean region. *L. stoechas*, a species of the genus *Lavandula*, is widely found on three continents (Asia, Europe, Africa), especially in the Mediterranean and Balkan countries [15]. The main countries where it is commonly found are Morocco, Algeria, Spain, Greece, France, Italy, Turkey, Saudi Arabia and Iran [16]. This shrub plant, which has irregular, multi-branched stems, has a height of 20 to 60 cm [17]. *L. stoechas*, which has been used for medicinal purposes in Turkey since ancient times, is known among the people by names such as karabaş otu, gargan, keşiş otu, çoban bağırtan, lavanta çiçeği, karahan, Muğla kekigi and yalancı ot çiçeği. Used in countries like Morocco, Algeria, and Tunisia for the treatment of headaches, depression, diabetes, and inflammatory and rheumatic diseases, this plant is also used in our country for medicinal purposes as an analgesic, antiseptic, wound healer, sedative, expectorant, urinary tract infection reliever, eczema wound healer, and nerve and heart strengthener [18,19]. In addition to the use of the flowers of *L. stoechas* as an anti-itch reliever, it is known that consuming the leaves and flowers as a tea is effective against stomach ulcers and cancer [20,21,22]. For centuries, the extract of this plant has been used by the people living in Anatolia as an antimicrobial, anti-vascular, analgesic, sedative, urinary tract infection reliever, heart strengthener, and in the treatment of atherosclerosis [19].

Because of the known medicinal properties of the *Lavandula* genus and the species *L. stoechas*, we

investigated the antioxidant and antimicrobial effects of this plant by extracting its contents in different solvents. In addition to these studies, we determined some of its phytochemical properties by identifying its phenolic content using HPLC and its volatile components using gas chromatography (GC/MS). This study is significant because there are not enough similar studies in the literature showing the difference between extracts of this plant obtained with different solvents.

2. MATERIAL AND METHOD

2.1. Plant Material

The *L. stoechas* plant (Figure 1) used in our study was collected from Muğla province in 2025, and its species identification was made by Assistant Professor Cahit ÇEÇEN.



Figure 1. Flower parts of the *Lavandula stoechas* plant used in our study.

2.2. Study Chemicals

The chemicals used in our study were selected from those with a high degree of purity to ensure repeatability in the event of a problem and to obtain accurate results. These chemicals were obtained from Merck Millipore, Merck EMSURE, ISOLAB and J.T. Baker.

2.3. Preparation of Plant Extract

In our study, we ground the flowering parts of the *L. stoechas* plant in a porcelain mortar and turned them into powder. Afterwards, we placed 10 grams of the powdered seeds into Erlenmeyer flasks and added our solvents (methanol/acetone) in an amount equal to ten times the weight of the plant material. We kept it in an orbital shaker at 100 rpm at room temperature for 24 hours to allow the solvents to penetrate the plant homogeneously. Then, the solvent-plant mixture was filtered using Whatman No:1 filter paper and evaporated using an evaporator until the solvents were completely removed. At the end of this process, the plant extracts adhering to the glass surface were carefully scraped off with a spatula and weighed. They were stored in tubes at +4 °C until the experiments were carried out [23].

2.4. Determination of Antioxidant Properties

The total antioxidant (TAC) property of *L. stoechas* was determined by spectrophotometric analysis of the 1,1-diphenyl-2-picryl hydrazyl (DPPH Sigma-Aldrich, Germany) free radical scavenging capacity. This method was first used by Blois, M. S [24] in 1958 and later developed by Sánchez-Moreno [25] et al. in 1998. The aim of this analysis is to measure the capacity to reduce the stable DPPH free radical as a result of its reaction with antioxidants. When the dark purple DPPH reacts with antioxidants, its color gradually lightens and the absorbance value measured in the spectrophotometer decreases. The radical scavenging capacity of the obtained extract is determined by this change in color.

0.3 mL of plant extracts prepared at different concentrations were taken, 2.7 mL of DPPH was added, and incubated at room temperature in a dark environment for 30 minutes. When the incubation period was complete, absorbance values were measured using a UV-VIS spectrophotometer (Biochrom Libra S70). Trolox was used as a positive control, and each group was studied in three parallels. IC₅₀ values were calculated using the obtained calibration curves to determine the DPPH removal activity and were given as trolox equivalent (TE). Total phenolic content (TPC) was determined using the Folin–Ciocalteu method, similar to the literature [26]. For the TPC analysis of our plant extracts, 100 µL of extract was taken from each sample, 900 µL of pure water was added to it, and then 5 mL of 0.2 N Folin–Ciocalteu reagent was added. This solution was left in the dark for about 8 minutes, then 5 mL of sodium carbonate (Na₂CO₃) was added and vortexed. The absorbance values of the mixtures, which were incubated for 2 hours at room temperature, were measured at the end of the period with a UV–VIS spectrophotometer at a wavelength of 765 nm. The TPC amounts in our study were determined by creating a calibration curve with gallic acid standard solution.

2.5. Volatile Component Analysis

The volatile components of the *L. stoechas* plant were identified using the Shimadzu QP-2020 GC-MS device by means of the Headspace–Solid Phase Microextraction (HS-SPME) method [27]. To determine the volatile components of the plant, 2 grams of the plant were weighed into an SPME vial. This vial was kept at 40 °C for 30 minutes, and an SPME fiber (Supelco, 2 cm) was placed inside the vial and allowed to adsorb for another 30 minutes at 40 °C. After adsorption, the fiber was left to desorb at 250 °C for 5 minutes in the GC-MS injection port. Helium gas was used as the carrier gas and the flow rate was set to 1.05 mL/min. Chromatographic separation was performed using the splitless injection mode. The oven temperature program of the instrument, which was started at 40 °C, was increased by 4°C/min up to 240°C and kept at this temperature for 6 minutes. Isobutyl acetate was used as the internal standard, and the concentration of volatiles was calculated relatively.

2.6. Analysis of Phenolic Compounds

Phenolic compounds of *L. stoechas* were analyzed using High Performance Liquid Chromatography (HPLC) system [28]. Before starting the analysis, the prepared extracts were passed through a 0.45 µm PVDF membrane filter to prevent particle accumulation from affecting the column, and 20 µL of each sample was taken and injected into the Waters Alliance E2695 HPLC system (USA). Separation was performed using a reverse phase C18 column (5 µm, 4.6 × 250 mm; GL Sciences, Tokyo, Japan). *p*-Coumaric acid, Caffeic acid, Vanillic acid, Catechin, Gallic acid and Rosmarinic Acid solutions were used as standards in the analysis of phenolic components. Measurements were taken at a wavelength of 280 nm with a Photodiode Array (PDA) detector (Waters 2996, Milford, MA, USA) and chromatographic data were evaluated with Empower 3 software. The amounts of phenolic compounds we obtained were calculated in mg/kg.

2.7. Determination of Antimicrobial Effects

The antimicrobial effects of *L. stoechas* were tested with a gram-negative bacterial strain (*Escherichia coli* ATCC 25922), a gram-positive bacterial strain (*Staphylococcus aureus* ATCC 25923), and a standard yeast strain (*Candida albicans* ATCC 10231). Bacterial and yeast samples were cultured in sterile Nutrient Broth (Merck), Nutrient Agar (Merck), Sabouraud Dextrose Broth (Merck), and Sabouraud Dextrose Agar (Merck), respectively. As a positive control, Erythromycin 15 µg/disk (Bioanalyse®), Gentamicin 10 µg/disk (Bioanalyse®), Ciprofloxacin 1 µg/disk (Bioanalyse®) and Nystatin 100 µg/disk (Bioanalyse®) discs were used, and as a negative control, DMSO (20%) was used to adjust the concentration of the plant extract. By the disc diffusion method [29], 10 µL of different concentrations (50, 100 mg/mL) of acetone and methanol extracts were applied to sterile blank paper discs with a diameter of 6 mm (Bioanalyse, Ankara, Turkey) and impregnated onto them. For incubation, the bacterial strains were kept in an incubator at 37 °C for 24 hours, while the yeast strain was kept at 30 °C for 48 hours. After the incubation period was completed, the diameters of the resulting inhibition zones were measured.

3. RESULTS AND DISCUSSION

3.1. Antioxidant Capacity

The total antioxidant capacity (TAC) of *L. stoechas* was measured using DPPH radical scavenging activity (RAS) and total phenolic content (TPC) methods. The results obtained are given in Table 1. The total phenolic acid content was calculated according to the gallic acid reference and the R² value was found to be 0.993, and the DPPH scavenging capacity was calculated according to the trolox reference and the R² value was found to be 0.9977.

Table 1. Antioxidant capacity of *Lavandula stoechas* plant

Samples	TPC mg/g	RAS ($\mu\text{g/mL}$)	IC ₅₀ ($\mu\text{g/mL}$)
<i>L. stoechas</i> M	55.356 $\pm$ 1.82 ^a	56.345 $\pm$ 0.360 ^a	46.96
<i>L. stoechas</i> A	21.282 $\pm$ 0.91 ^b	14.435 $\pm$ 0.515 ^b	500.00

M: Methanol, A: Acetone. Values are expressed as mean $\pm$ SD (n = 3). Different superscript letters within the same column indicate significant differences between samples (Anova, Tukey, p < 0.001).

When we examined the RAS and TPC values of *L. stoechas*, it was observed that it had good antioxidant properties.

In the study conducted by Ceylan, Y. et al. in 2015, the DPPH removal capacity of the methanol extract of *L. stoechas* was calculated as 69.31 $\pm$ 1.24 [30], and a value close to the value we obtained in our study (56.345 $\pm$ 0.36) was obtained. In the same study, the total phenolic content of the methanolic extract of *L. stoechas* was measured and it was found to be 105.5 $\pm$ 0.7 mg gallic acid equivalent

(GAE) per gram of dry extract (p < 0.05). In our study, this value was measured as 55.356 $\pm$ 1.806.

In another study, Mushtaq, A. et al. (2018) determined the TPC value of *L. stoechas* extracted in methanol as 285.91 $\pm$ 0.75 mg GAE/g and the DPPH IC₅₀ value as 76.73 $\mu\text{g/mL}$ [31]. In our study, the DPPH IC₅₀ value of the methanol extract was calculated as 46.96 $\mu\text{g/mL}$.

3.2. Volatile Component Analysis

The volatile components of *L. stoechas* were measured chromatographically, and the chromatogram shown in Figure 2 was obtained.

When the volatile components of the flower and leaf parts of *L. stoechas* were analyzed using a GC-MS instrument, a total of 42 compounds were detected. Of these, 10 were alcohols, 2 were aldehydes, 6 were ketones, 6 were esters, 15 were terpenes, and 3 were various other components (Table 2).

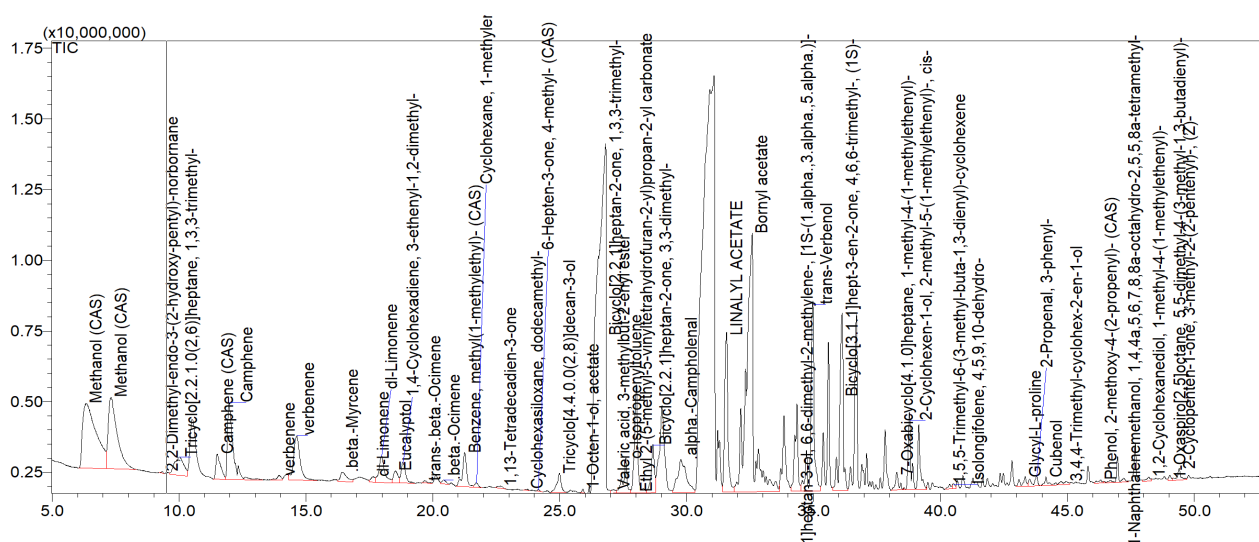


Figure 2. Chromatogram of *Lavandula stoechas* plant obtained from a GC-MS device

Among the volatile components, when we look at the alcohols, methanol has the highest amount with 41.844 mg/kg. In addition, trans-verbenol (18.048 mg/kg), cis-carvyl acetate (10.040 mg/kg) and pinocarveol (2(10)-pinen-3-ol) (7.492 mg/kg) are the most abundant after methanol. When the aldehydes are examined, α -campholenal (7.768 mg/kg) has the highest amount, while among the ketones, the highest proportion compounds are (-)-camphor (80.948 mg/kg) and levo-verbenone (16.526 mg/kg). When we examined the detected ester compounds, we found that Bornyl acetate (51.273 mg/kg), Linalyl acetate (14.090 mg/kg), and Ethyl 2-(5-methyl-5-vinyltetrahydrofuran-2-yl)propan-2-yl carbonate (9.514 mg/kg) were present in high amounts. Among the volatile components, terpenes were the most diverse group, with 15 compounds detected. The five terpenes found in the highest quantities were, in order: Camphene (14.679 mg/kg), Verbenene (8.280 mg/kg), dl-Limonene (4.785 mg/kg), Cyclophenene (4.763 mg/kg), and β -Cymene (4.051 mg/kg). No acidic compounds were detected in this plant.

When we examined other studies on *L. stoechas*, we found that the ketone compound Camphor was found in the highest amount in the study conducted by Mokhtarzadeh, S. et al. in 2019 [32]. Camphor was also the compound found in the highest amount (80.948 mg/kg) among ketones and among all components in our study. Camphor has been shown in various studies to have anti-inflammatory, antimicrobial, antioxidant, antidiabetic and anticancer effects [33].

The compound we detected in the highest amount among the ester components in our study was Bornyl acetate (51.273 mg/kg). This was also among the compounds found in high amounts in the study by Mokhtarzadeh, S. et al. in 2019. Studies have shown that this compound has a beneficial effect in respiratory tract inflammations and an anti-tumor effect [34,35].

Terpenes are the most diverse group of compounds we obtained in our study, and among them, Camphene (14.679 mg/kg) was the most abundant compound. Studies have shown that Camphene has an important effect on health due to its antioxidant and cell-protective effects [36].

Table 2. List of volatile components of *Lavandula stoechas* plant detected by GC-MS device

Compound Name	RT	RI	Amount
ALCOHOLIC			
Methanol	6.332	907	41.844
2,2-Dimethyl-endo-3-(2-hydroxy-pentyl)-norbornane	9.340	1013	0.077
Tricyclo[4.4.0.0(2,8)]decan-3-ol	25.000	1349	2.260
Pinocarveol; 2(10)-Pinen-3-ol	34.359	1633	7.492
trans-Verbenol	34.989	1656	18.048
cis-Caryyl acetate	38.799	1802	10.0400
Cubenol	44.172	2034	0.717
3,4,4-Trimethyl-cyclohex-2-en-1-ol	44.990	2070	0.847
α -Eudesmol	47.260	2171	2.025
Limonen-1,2-diol	48.225	2213	0.495
ALDEHYDES			
α -Campholenal	29.782	1481	7.768
Cinnamaldehyde	43.806	2018	1.214
KETONES			
1,13-Tetradecadien-3-one	22.676	1292	0.343
6-Hepten-3-one, 4-methyl-	24.164	1328	0.106
(-)-Camphor	26.804	1394	80.948
Camphenilone	28.686	1449	4.304
Levoverbenone	36.142	1698	16.526
Jasmone	49.420	2266	1.070
ESTERS			
1-Octenyl acetate	25.922	1372	0.169
Valeric acid, 3-methylbut-2-enyl ester	27.135	1403	0.391
Ethyl 2-(5-methyl-5-vinyltetrahydrofuran-2-yl)propan-2-yl carbonate	28.024	1429	9.514
Linalyl acetate	31.593	1539	14.090
Bornyl acetate	32.576	1571	51.273
Acetegenol	46.328	2130	0.419
TERPENERS			
Cyclofenchene	10.024	1029	4.763
Camphene	11.987	1075	14.679
Verbenene	14.643	1130	8.280
β -Myrcene	16.443	1165	1.627
dl-Limonene	17.985	1194	4.785
1,4-Cyclohexadiene, 3-ethenyl-1,2-dimethyl-	18.827	1211	2.545
trans- β -Ocimene	19.691	1229	0.330
β -Ocimene	20.438	1245	0.469
m-Menthane	21.729	1272	0.408
o-Isopropenyltoluene	27.612	1417	3.547
Limonene epoxide	38.306	1783	1.567
1,5,5-Trimethyl-6-(3-methyl-buta-1,3-dienyl)-cyclohexene	40.360	1868	0.355
Isolongifolene, 4,5,9,10-dehydro-	40.545	1875	0.350
1-Oxaspiro [2,5] oct-5-ene-8,8-dimethyl-4-methylene	49.063	2250	0.367
β -Cymene	21.264	1262	4.051
MISCELLANEOUS			
Eucalyptol	18.542	1205	1.437
Cyclohexasiloxane, dodecamethyl-	23.738	1317	0.077
Glycyl-L-proline	43.361	1998	1.122

3.3. Phenolic Compounds

When we examined the phenolic compound results of *L. stoechas*, we found that the acetone extract contained caffeic acid (0.028 mg/100g), vanillic acid (0.015

mg/100g), and *p*-coumaric acid (0.048 mg/100g). When we examined the methanol extract, the highest amounts were found in rosmarinic acid (1117.248 mg/100g) and catechin (190.217 mg/100g) (Table 3).

Table 3: Amounts of investigated phenolic compounds in *Lavandula stoechas* plant (mg/100g)

Plant Extracts	Catechin	Caffeic acid	Vanillic acid	<i>p</i> -Coumaric acid	Gallic acid	Rosmarinic acid
<i>L. stoechas</i> A	-	0.028	0.015	0.048	-	-
<i>L. stoechas</i> M	190.217	5.559	39.130	5.779	0.893	1117.248

M: Methanol, A: Acetone, -: Not found

In our study, rosmarinic acid was detected in the highest amount among both extracts (1117.248 mg/100g). Rosmarinic acid is generally found in plants such as basil, mint, and rosemary, and studies have shown that it has anticancer and antioxidant effects on health [37]. In addition, the phenolic compound catechin is found in

greater amounts in the methanol solution compared to others. Catechin has been reported to have many effects on health, the main ones being anti-obesity, anti-diabetic, anti-tumor, anti-inflammatory, antioxidant, and antimicrobial effects [38,39,40,41,42]. Vanillic acid, detected in both extracts, is known to have antioxidant

effects and has pharmacological effects of antimicrobial, anti-inflammatory, antioxidant, and inhibition of snake venom activity [43]. *p*-Coumaric acid is a compound with health effects such as anticancer, antimicrobial, antiviral, anti-inflammatory, antimutagenic, antioxidant and immunomodulatory. This compound is found in cereals such as corn, rice, oats, wheat; fruits such as apples, pears, grapes; vegetables such as carrots, potatoes, beans, onions, tomatoes and mushrooms [44]. *p*-Coumaric acid

was detected in both of our extract solutions and was detected in higher amounts in our methanol extract.

3.4. Antimicrobial Tests

The effects of extracts obtained from the *L. stoechas* plant on some bacterial and yeast strains are shown in Table 4.

Table 4. Antimicrobial test results of *Lavandula stoechas* plant

Strains	PC	NC	1M	2M	1A	2A
<i>Escherichia coli</i>	28±0.577	0	0	0	0	0
<i>Staphylococcus aureus</i>	29±0.577	0	18±1.527 ^{a,b}	15±0.577 ^c	20±0.000 ^a	16±0.577 ^{b,c}
<i>Candida albicans</i>	27±0.577	0	0	0	0	0

Values are expressed as mean ± SD (n = 3). Values sharing at least one superscript letter are not significantly different, whereas values with different letters differ significantly (one-way ANOVA followed by Tukey's HSD test, p < 0.05).

1M: Concentration of *L.stoechas* extracted in methanol at 100 mg/mL, 2M: Concentration of *T. occidentalis* extracted in methanol at 50 mg/mL, 1A: Concentration of *L.stoechas* extracted in acetone at 100 mg/mL, 2A: Concentration of *T. occidentalis* in acetone at 50 mg/mL, TE: Not tested
0: Used to indicate no effect.

PC: Positive control, NC: Negative control

When we examined the effects of *L. stoechas* on *E. Coli* gram-negative bacteria, we observed that the positive control formed an inhibition zone with a diameter of 28 mm, while methanol and acetone extracts showed no effect on this bacteria. No zone formation was observed in any of our negative controls.

When we examined the effect of *L. stoechas* plant extracts on *Staphylococcus aureus* bacteria, a Gram-positive strain (Figure 3), it was observed that the positive control

formed an inhibition zone with a diameter of 29 mm, while the 100 mg/mL concentration extracted in methanol formed an inhibition zone of 18 mm, and the 50 mg/mL methanol extract formed an inhibition zone of 15 mm. Looking at our samples extracted in acetone, the 100 mg/mL concentration formed an inhibition zone of 20 mm, while the 50 mg/mL concentration formed an inhibition zone of 16 mm. No inhibition zone formation was observed in any of our negative controls.



Figure 3: Antimicrobial effect of *Lavandula stoechas* plant on *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans* strains

When we examined the effects of *L. stoechas* on the *Candida albicans* yeast strain, we observed that the positive control formed an inhibition zone with a diameter of 27 mm, while methanol and acetone extracts showed no effect, similar to the negative control.

Hickl et al. investigated the antimicrobial effects of extracts of various plants, including *L. stoechas*, in ethyl acetate on different strains in 2024. Three of the strains used in this study are *E. coli*, *S. aureus*, and *C. albicans*, which we also used in our study. When we examined the results, it was found that the ethyl acetate extracts had a lethal effect on *Staphylococcus aureus* bacteria, while they had no effect on the other two bacteria [45]. In our study, *L. stoechas* was extracted in methanol and acetone. When we looked at our results, similar outcomes were obtained, and it was observed that both solvent extracts had an inhibitory effect on *S. aureus* bacteria, but the acetone extract had a greater lethal effect. On the other

two strains, it was observed that neither of the solvents we used showed any antimicrobial effect, as in this study.

When we examined the study conducted by Canlı and his friends in 2019, they investigated the antimicrobial effects of *L. stoechas* plant by extracting it in ethanol on 22 different strains [46]. In this study, it was determined that it showed antimicrobial effects on other strains, including *Staphylococcus aureus* and *Candida albicans* strains, which we used in our study, in addition to *E. coli* and *Klebsiella pneumoniae*.

4. CONCLUSION

In our study, it was determined that the flower and leaf parts of the *L. stoechas* plant we used showed different effects depending on the solvent used for extraction. In particular, extracts obtained from methanol-based solvents were found to have more effective antioxidant

and antimicrobial effects. When we examined the phenolic compounds in our extract obtained from methanol-based solvent, all were detected in varying amounts, while some were undetectable in the plant extracted in acetone. The antimicrobial effect of *L. stoechas*, which was investigated on 3 different strains, was found to have a lethal effect only on *Staphylococcus aureus* bacteria. In our plant, whose volatile components were examined by GC-MS, the most detected substances among alcohols were methanol (41.844 mg/kg), trans-Verbenol (18.048 mg/kg), cis-Carvyl acetate (10.040 mg/kg) and Pinocarveol; While 2(10)-Pinen-3-ol (7.492 mg/kg) was the most abundant among aldehydes, α -Campholenal (7.768 mg/kg) was the most abundant among ketones, (-)-Camphor (80.948 mg/kg) and Levoverbenone (16.526 mg/kg) were the most abundant among ketone compounds, Bornyl acetate (51.273 mg/kg), Linalyl acetate (14.090 mg/kg) and Ethyl 2-(5-methyl-5-vinyltetrahydrofuran-2-yl)propan-2-yl carbonate (9.514 mg/kg) were the most abundant among ester compounds, Camphene (14.679 mg/kg) and Verbenene (8.280 mg/kg) were the most abundant among terpenes.

When we examine the results obtained from our study on the *L. stoechas* plant, it is evident that the plant may have significant health effects due to its lethal effect on *Staphylococcus aureus*, its strong antioxidant properties, and the presence of various bioactive phytochemicals beneficial to health. Therefore, we believe that developing antimicrobial studies of this plant with a wider variety of strains, as well as conducting further studies on its anti-cancer effects and testing on experimental animals, would make a valuable contribution to the literature.

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