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# The Antioxidant and Antimicrobial Capacities of Phenolic Profiles of Some *Salvia* L. Seeds Grown in Turkey

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**Abstract:** The aim of current study is to show phenolics, antioxidant capacities and antimicrobial activities of seeds of five *Salvia* L. (*S. frigida* Boiss., *S. candidissima* subsp. *candidissima* Vahl., *S. virgata* Jacq., *S. verticillata* L. var. *verticillata* and *S. russellii* Benth.) taxa grown in Turkey. The flavonoid and phenolic acid contents were measured by using HPLC whilst the antioxidant capacities were determined by using different methods. In addition, agar well diffusion method was used to determine the antimicrobial activities of *Salvia* species in this study. It was found that *S. frigida*, *S. verticillata* var. *verticillata* and *S. russellii* have the highest catechin contents and *S. frigida* and *S. verticillata* var. *verticillata* have high rosmarinic acid while *S. frigida*, *S. candidissima* subsp. *candidissima* and *S. verticillata* var. *verticillata* have high vanilic acid. Also, it was determined that *S. frigida* and *S. verticillata* var. *verticillata* have high DPPH radical scavenging activities in 150 and 250 µL while *S. frigida* and *S. verticillata* var. *verticillata* have highest ABTS radical scavenging activity in all concentrations apart from 25 µL for *S. frigida*. Furthermore, *S. frigida* and *S. verticillata* var. *verticillata* have high total phenolic contents. On the other hand, *Salvia* species have similar lipid peroxidation inhibitions. However, the metal chelating activities of *Salvia* species are different. And also, it was demonstrated that *Salvia* taxa have antimicrobial activity.

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## 1. INTRODUCTION

Herbs from the Lamiaceae have been used in traditional medicine for more than 2000 years to treat different diseases such as cancer, diabetes, depression, memory enhancement and infection throughout the world (Shekarchi et al., 2012; Lopresti, 2017). Lamiaceae, contains most popular aromatic plants including marjoram, sage, basil and thyme, have strong antioxidant and antimicrobial activity due to rich in biologically effective components as caffeic

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acid, rosmarinic acid, carvacrol and thymol (Hossain et al., 2010; Khaled-Khodjaa et al., 2014; Skendi et al., 2017). And also, Turkey is accepted as a significant gene center for the Lamiaceae which is represented by 45 genera, 565 species and 735 taxa in Turkey (Dorman et al., 2004; Cetin et al., 2006).

*Salvia*, is the from subfamily Nepetoideae of the Mentheae tribe of the Lamiaceae, which includes 1000 taxa spread out in the different regions of the world (Kahraman, Celep & Dogan, 2009). The name of *Salvia* is originated from Latin "salvare" or "salvus" and is meaning healing due to using folk medicine (Fotovvat et al., 2019). Many *Salvia* species are rich in polyphenol and terpenes and are used as digestive, antiinflammatory, antiseptic, and antioxidant agents (Dent et al., 2017; Gregorczyk-Karolak & Kiss, 2018). Phenolic compounds are in charge of antioxidant capacity in the sage and rosmarinic acid, caffeic acid, chlorogenic acid, vanillic acid, salvianolic acid, luteolin and apigenin are major phenolics in sage (Jasicka-Misiak et al., 2018; Vergine et al., 2019; Katanic-Stankovica et al., 2020).

The genus is represented by 89 species and 95 taxa in flora of Turkey and the endemism of the genus is 45% in Turkey (Kahraman et al., 2018). Generally, the studies about the determination of antioxidant and antimicrobial capacities of sage is related to plant extracts and there are lack of antioxidant capacities in sage seeds. And also the antimicrobial studies is related to plant extracts not seeds. The goal of the current study is to determine phenolic compounds antioxidant capacities and antimicrobial activities of phenolics of seeds in five *Salvia* L. (*S. frigida* Boiss., *S. candidissima* Vahl subsp. *candidissima*, *S. virgata* Jacq., *S. verticillata* L. subsp. *verticillata*., *S. russellii* Bentham) taxa grown in Turkey.

## 2. MATERIAL and METHODS

The plants were collected from natural habitats. The plant samples and seeds were deposited in Firat University Herbarium (FUH). The localities of studied *Salvia* L. taxa were given in Table 1.

**Table 1.** Localities of studied *Salvia* L. Taxa.

| Taxa | Locality |
|---|---|
| *Salvia frigida* Boiss. | Elazig Baskil district, Hacı Mustafa Village, 1850 m |
| *Salvia candidissima* Vahl subsp. *candidissima* | Elazig Baskil district, Hacı Mustafa Village, 1750 m |
| *Salvia virgata* Jacq. | Elazig Baskil district, Bolucuk Village, 1500 m |
| *Salvia verticillata* L. subsp. *verticillata* | Elazig Baskil district, Bolucuk Village, 1490 m |
| *Salvia russellii* Bentham | Elazig Baskil district, Quercus forest around, 1400 m |

### 2.1. Microbial Strain

In this study, fungi (*Candida albicans* FMC 17 and *Candida glabrata* ATCC 66032), dermatophyte (*Trichophyton* sp., *Epidermophyton* sp.) and bacteria [(*Escherichia coli* (ATCC 25922), *Klebsiella pneumoniae* (FMC 5), *Staphylococcus aureus* (COWAN 1), *Bacillus megaterium* (DSM 32)] were used to evaluate the antimicrobial activities of studied *Salvia* taxa.

### 2.3. Extraction Protocol of Phenolics

PREVAIL C18 reversed-phase column (15x4.6 mm, 5 µm, USA) was used and methanol/acetonitrile/water (46/8/46, v/v/v) comprising 1.0% acetic acid is mobile phase (Zu, Li, Fu & Zhao, 2006). Morin, kaempferol, naringenin, quercetin, catechin, naringin, resveratrol, myricetin, rutin and vanillic acid, ferulic acid, rosmarinic acid, cinnamic acid, and caffeic acid were determined. 1.0 mL/min was used as flow rate and l0 µL samples were given as injection volume. Chromatographic conditions were performed at 25°C.

### 2.4. DPPH Radical Scavenging Activity

25, 50, 100, 150 and 250 µL of extracts were treated with 25 mg/L DPPH solved in methanol (4.0 mL). The DPPH radical protocol was performed based on Liyana-Pathiranan and Shahidi (2005)'s method in the current study. The absorbances were measured at 517 nm after the samples were stored in the dark for 30 minutes. 1 µM quercetin was used as reference. The formula (1) was used for the DPPH radical scavenging potential is following:

$$\% \text{ inhibition} = \frac{\text{Ab(control)} - \text{Ab(sample)}}{\text{Ab(control)}} x100 \quad (1)$$

The absorbance of control was represented as Ab(control) and the absorbance of sample was represented as Ab(sample).

### 2.5. ABTS Radical Scavenging Activity

ABTS [2,2-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt] assay was determined according to the Ree et al. (1999) methods. 7 mM ABTS and 2.45 mM potassium persulphate were mixed to form $ABTS^{\bullet+}$ solution. The solution was stored at room temperature approximately 12–16 h. And ABTS was dissolved with water to provide an absorbance of 0.700 ± 0.020. Lastly, three mL of diluted ABTS were mixed with 25, 50, 100, 150 and 250 µL of extract and absorption was determined in the 6 min at 734 nm (Skotti et al., 2014). The formula was used for the DPPH radical scavenging potential is following (2):

$$\% \text{ inhibition} = \frac{\text{Ab(control)} - \text{Ab(sample)}}{\text{Ab(control)}} x100 \quad (2)$$

The absorbance of control was represented as Ab(control) and the absorbance of sample was represented as Ab(sample).

### 2.6. Determination of Total Phenolics

Folin–Ciocalteu method was used to evaluate total phenolics (Singleton et al., 1999). 100 µL extracts were mixed with 3.16 mL of $H_2O$ and 200 µL of Folin– Ciocalteu solution. The samples were stored at room temperature about 3 min. Later, the extracts were treated with anhydrous sodium carbonate (20% w/v) and total phenolic content was observed at 765 nm after two hours in room temperature (Robya et al., 2013). The total phenolic amount was evaluated by using gallic acid equivalents (µgGAE/mg).

### 2.7. Chelating Effects of Ferrous Ions

The chelating activities of samples were evaluated method by Dinis et al. (1994). 50 µL of 2 mM $FeCl_2$ was injected to extracts (50, 100, 250 and 500 µg/mL). 5 mM ferrozine (0.2 mL) mixed with extracts to start the reaction. The extracts were shaken vigorously and stored at room temperature approximately 10 min. The absorbances of samples were measured at 562 nm. The inhibition (%) of ferrozine–$Fe^{2+}$ complex was evaluated based on following formula (3):

$$\% \text{ Chelating activity} = [1 - (\frac{\text{Abs}}{\text{Abc}})] x100 \quad (3)$$

The absorbance of sample was represented as Abs and the absorbance of control was represented as Abc where 100 where $Na_2EDTA$ was used as positive control.

### 2.8. Antioxidant Activity against TBARS

The antioxidant activity of samples was measured according to Shimoi et al. (1994)' method. The samples were prepared by using DMSO (dimethyl sulfoxide). The $Fe^{2+}$ ($FeCl_2.2H_2O$) and hydrogen peroxide were used in the experiments. Also, oleic acid (3.35 mM), linoleic acid (9.01 mM) and linolenic acid (2.30 mM) were used dissolved in DMSO. Sage

extracts, control and Fenton reagent groups were formed. The control group contained 0.5 mL of fatty acid and a buffer (pH=7.4; 0.05 M Tris HCl; 0.2% Tween, 20; 0.15 M KCl) whilst the fenton group contained buffer; hydrogen peroxide (0.01 mM); 0.5 mL of fatty acid and $FeCl_2.2H_2O$ (50 µM) and the extracts comprised $FeCl_2$ (50 µM), 0.25 mL sage extract, 0.5 mL of fatty acid and hydrogen peroxide (0.01 mM). 0.1 mL of a 4% (w/v) BHT was added to all groups to protect the more oxidation and the examples were stored at the 37 °C approximately 24 h. After that, 1 mL of samples from three groups was taken and treated with 1 mL of 0.6% TBA and the samples were stored at 90 °C for 30 min. Finally, 4 mL butan-1-ol was injected to tubes, blended and centrifuged at 4250 rpm for 10 min. The absorbance of the supernatant was measured at 532 nm. MDA standard curves were formed by 1,1,3,3-tetramethoxypropane, and TBARS were written as mg MDA/kg dry matter (Keser et al., 2014).

### 2.9. Antimicrobial Activity

Antimicrobial activities were evaluated agar well diffusion method according to Collins and Lyne (1987)' method. Agar contained Sabouroud Dextrose Agar (Oxoid), Mueller Hinton Agar (Difco) and Malt Extract Agar (Difco) and McFarland standard. And also, bacteria ($10^6$ cells/mL), dermatopyhte and yeast ($10^4$ cells/mL), were found in 100 µL suspension. Phenolics (10 µL) were added to the well after the wells were filled with cork-borer (0.85 cm) and plates. After that, incubation for bacteria was conducted at 37±0.1°C for 24 h and for yeast and dermatophyta fungi were conducted at 25±0.1°C for 72 h. The inhibiton zone was referenced to decide the antimicrobial activity.

### 2.10. Statistical Analysis

All analysis were performed by using SPSS 21.0 packet program. The simple lineer regression model was used to found the correlation between antioxidant capacity (ABTS, DPPH and metal chelating) and total phenolic contents**.** Data obtained from present study represented as mean values ± standard deviation. Also, to evaluate the significance of the observed differences, the least significant difference (LSD) test was used in the antimicrobial activity. The conclusions were expressed as mean ± S.D. $p<0.0001$, $p<0.001$ and $p>0.05$ have been conceived significant when compared to the control group (ampicillin sulbactam, mycostatin). All samples were analysed in triplicate.

## 3. RESULTS and DISCUSSION

Present study showed that myricetin, morin, quercetin, kaempferol, naringenin and resveratrol are low or absent (Table 2). *S. verticillata* subsp. *verticillata* has the highest rutin (114.47±1.25 µg/mg), catechin (583.79±1.27 µg/mg) and naringin (128.8±1.57 µg/mg) contents. In addition, it was demonstrated that *S. frigida* (107.77±2.37 µg/mg) and *S. russellii* (306.88±1.54 µg/mg) have catechin content. And also, this study demonstrated that naringin contents of *S. candidissima* subsp. *candidissima* and *S. virgata* are low (9.27±0.81-9.17±0.57 µg/mg) (Table 2). Literature determined that *Salvia* posses ferulic acid, caffeic acid, chlorogenic acid, o-coumaric acid, p-OH-benzoic acid, protocatechinic acids, rosmarinic acid, apigenin, luteolin, kaempferol and quercetin (Kupeli Akkol et al., 2008; Hamrouni-Sellami et al., 2013; Dincer et al., 2012; Alcantaraa et al., 2019). Similarly, this study showed that studied *Salvia* seeds have vanillic acid, caffeic acid, ferulic acid and rosmarinic acid (Table 2). Whereas, it has been showed that cinnamic acid contents of studied *Salvia* seeds absent or low (Table 2). On the other hand, present study demonstrated that *S. frigida* (16.32±0.85 µg/mg) and *S. candidissima* subsp. *candidissima* (28.57±1.14 µg/mg) posses relatively high ferulic acid content compared to other studied *Salvia* taxa in this study (Table 2). And also, this study found that *Salvia verticillata* subsp. *verticillata* (152.79±1.33 µg/mg), *S. frigida* (107.38±1.51 µg/mg), *S. virgata* (88.24±0.75 µg/mg) have high rosmarinic acid amounts (Table 2). Zengin et al. (2018) found that rosmarinic acid amount of *S. verticillata* is higher than in other *Salvia*

species. Also, Yumrutas et al. (2011) showed that two varities of *S. verticillata* displayed strong antioxidant activity and they indicated that two varieties of *S. verticillata* have especially rich in rosmarinic acid and caffeic acid contents. Literature claimed that *Salvia* is characterized by the rosmarinic acid (Tepe, 2008). Further, Kan, et al. (2007) found that *S. frigida* has the highest rosmarinic acid and caffeic acid contents compare to *S. candidissima, S. virgata* and *S. verticillata*. However, the present study found that the caffeic acid content of *S. frigida* is low (19.71±1.11 µg/mg). In addition, Kan et al. (2007) indicated that *S. virgata* has low rosmarinic acid and caffeic acid contents.

**Table 2.** The results of flavonoid and phenolic acid contents of *Salvia* taxa (µg/mg).

| | | *S. frigida* | *S. candidissima* subsp. *candidissima* | *S. virgata* | *S. verticillata* subsp. *verticillata* | *S. russellii* |
|---|---|---|---|---|---|---|
| Flavonoids | Rutin | 44.37±0.87 | 6.05±0.14 | 14.21±0.24 | 114.47±1.25 | 9.71±0.54 |
| | Myricetin | - | 3.67±0.21 | - | 0.41±0.02 | 0.24±0.05 |
| | Morin | - | 4.84±0.87 | 0.41±0.01 | - | - |
| | Quercetin | 4.87±0.25 | 0.21±0.02 | 0.22±0.04 | - | - |
| | Kaempherol | 0.83±0.79 | 5.47±0.68 | 1.41±0.32 | 1.63±0.2 | 0.39±0.03 |
| | Catechin | 107.77±2.37 | - | - | 583.79±1.27 | 306.88±1.54 |
| | Naringin | 36.78±1.14 | 9.27±0.81 | 9.17±0.57 | 128.8±1.57 | 24.4±0.64 |
| | Naringenin | - | 0.57±0.01 | 0.38±0.01 | - | - |
| | Resveratrol | 0.59±0.02 | - | - | - | - |
| Phenolic acids | Vanillic acid | 64.74±1.21 | 65.4±1.34 | 9.71±0.45 | 84.12±0.97 | 9.27±0.34 |
| | Cinnamic acid | 0.4±0.02 | 0.2±0.01 | 0.2±0.01 | - | 0.2±0.01 |
| | Caffeic acid | 19.71±1.11 | 29.65±0.87 | 31.14±0.79 | 72.94±1.23 | 7.71±0.68 |
| | Ferulic acid | 16.32±0.85 | 28.57±1.14 | 3.27±0.3 | 1.57±0.2 | 1.81±0.1 |
| | Rosmarinic acid | 107.38±1.51 | 28.82±0.86 | 88.24±0.75 | 152.79±1.33 | 17.21±0.89 |

On the other hand, the current study suggested that in general, *S. verticillata* subsp. *verticillata* has high DPPH and ABTS radical scavenging activities (Table 3 and Table 4). Similarly, Yumrutas et al. (2011) indicated that two varieties of *S. verticillata* have exhibited the strongest DPPH radical scavenging. The studied taxa have the highest ABTS radical scavenging activity in 150 and 250 µL whilst studied taxa except for (*S. candidissima* subsp. *candidissima*) posses highest DPPH radical scavenging activity in 250 µL (Table 3 and Table 4). On the contrary, *S. frigida* has lowest DPPH radical scavenging capacity in 25 µL and 50 µL and *S. russellii, S. candidissima, S. virgata* have the lowest DPPH scavenging activity in some concentrations (Table 3). However, Senol et al. (2010) suggested that *S. candidissima, S. virgata* and *S. russellii* have the strongest DPPH radical scavenging activity whilst Orhan et al., (2007) showed that *S. verticillata* has DPPH scavenging capacity are between 68.91±0.21% and 81.1±2.48%. Also, another study by done Orhan et al. (2013) demonstrated that *S. frigida* and *S. verticillata* have strong DPPH radical scavenging.

**Table 3.** The DPPH% results of extracts of *Salvia* L. taxa.

| Taxa | 25 µL | 50 µL | 100 µL | 150 µL | 250 µL |
|---|---|---|---|---|---|
| *S. frigida* | 27.22±0.59 | 16.8±0.56 | 61.7±1.13 | 91.9±1.17 | 93.9±1.41 |
| *S. candidissima* subsp. *candidissima* | 82.14±1.25 | 44.97±0.84 | 13.12±0.58 | 29.4±0.87 | 52.9±1.18 |
| *S. virgata* | 80.11±1.87 | 93.78±1.17 | 43.04±0.97 | 27.8±0.58 | 84.1±1.21 |
| *S. verticillata* subsp. *verticillata* | 65.6±0.97 | 78.9±0.93 | 93.1±1.61 | 94.7±1.29 | 94.1±1.81 |
| *S. russellii* | 14.7±0.59 | 97.59±1.82 | 96.32±1.34 | 36.2±0.97 | 92.7±1.64 |

**Table 4.** The The ABTS% results of extracts of *Salvia* L. taxa.

| Taxa | 25 µL | 50 µL | 100 µL | 150 µL | 250 µL |
|---|---|---|---|---|---|
| *S. frigida* | 53.44±1.12 | 95.68±1.64 | 99.67±1.45 | 98.71±1.12 | 98.14±1.24 |
| *S. candidissima* subsp. *candidissima* | 20.34±0.87 | 41.20±1.12 | 73.62±1.12 | 93.96±1.13 | 98.81±1.11 |
| *S. virgata* | 26.55±0.98 | 41.03±0.91 | 75.34±1.24 | 98.82±0.84 | 98.82±0.97 |
| *S. verticillata* subsp. *verticillata* | 88.44±1.29 | 98.65±1.29 | 98.87±1.14 | 98.57±0.51 | 98.65±0.79 |
| *S. russellii* | 28.10±0.78 | 41.72±0.86 | 90.51±1.57 | 98.79±0.84 | 98.85±0.91 |

Furthermore, it was found that *S. verticillata* subsp. *verticillata* (266.66±0.9 µgGAE/mg) has the highest total phenolic content whilst *S. frigida* has the lowest (76.49±1.06 µgGAE/mg) total phenolic content in the present study (Table 5). Zengin et al. (2018) showed that total phenolic content of *S. verticillata* as 53.52 ± 1.66 mg/g. Also, Tosun et al. (2009) determined the total phenolic content of *S. verticillata*, *S. virgata* and *S. candidissima* as 167.1 mg/g, 101.2 mg/g and 100.3 mg/g, respectively whilst Kupeli Akkol et al. (2008) found that *S. virgata* has 133.8 mg/g total phenolic content. Literature showed that there is a correlation between phenolics and antioxidant activities of *Salvia* species (Tosun et al., 2009). This study showed that there is a strong correlation between total phenolics and DPPH ($r^2$:0.752) and ABTS ($r^2$: 0.764) while there is moderate correlation between total phenolics and metal chelating ($r^2$: 0.305).

**Table 5.** The lipid peroxidation (mg/kg), total phenolic amounts (µgGAE/mg) and metal chelating activities (%) of *Salvia* L. taxa.

| Taxa | Lipid peroxidation | Total Phenolic | Metal Chelating |
|---|---|---|---|
| *S. frigida* | 19.95±0.82 | 160.87±1.72 | 77.84±0.95 |
| *S. candidissima* subsp. *candidissima* | 23.36±0.51 | 76.49±1.06 | 80.48±1.11 |
| *S. virgata* | 22.42±0.78 | 81.92±1.01 | 71.88±0.86 |
| *S. verticillata*. subsp. *verticillata* | 20.87±0.62 | 266.66±0.93 | 45.04±0.84 |
| *S. russellii* | 20.29±0.67 | 94.73±1.24 | 53.51±0.59 |

**Table 6.** The disc diffusion assay results of the antimicrobial susceptibility tests for growing reference microorganisms.

| Reference Microorganisms | Zone of Inhibition values (mm) | | | | | Reference Antibiotics |
|---|---|---|---|---|---|---|
| | *Sf* | *Sc* | *Sv* | *Sver* | *Sr* | |
| *E coli* | 11.00±0.0$^{d}$ | - | - | - | - | 11.66±0.3$^{*}$ |
| *S. aureus* | 11.00±0.0$^{d}$ | 8.33±0.3$^{c}$ | 13.33.±0.3$^{d}$ | 13.33±0.3$^{cd}$ | 13.33±0.3$^{cd}$ | 9.66±0.3$^{*}$ |
| *K. pneumoniae* | 8.33±0.3$^{c}$ | 11.33±0.3$^{d}$ | 13.33±0.3$^{d}$ | 11.33±0.3$^{d}$ | 8.33±0.3$^{c}$ | 11.66±0.3$^{*}$ |
| *B. megaterium* | 14.33±0.3$^{cd}$ | 8.33±0.3$^{c}$ | 8.33±0.3$^{c}$ | 17.33±0.3$^{cd}$ | 13.33±0.3$^{cd}$ | 11.66±0.3$^{*}$ |
| *C. albicans* | 10.66±0.33$^{d}$ | 14.33±0.3$^{cd}$ | - | 16.66±0.33$^{cd}$ | 11.33±0.3$^{d}$ | 11.66±0.3$^{**}$ |
| *C. glabrata* | - | 11.33±0.3$^{d}$ | - | | - | 8.66±0.3$^{**}$ |
| *Epidermophyton* sp. | - | - | - | - | | 8.33±0.3$^{**}$ |
| *Trichopyton* sp. | - | - | - | - | - | 8.33±0.3$^{**}$ |

*Sf*; *S. frigida*, *Sc*; *S. candidisssima*, Sv; *S. virgata*, *Sver*: *S. verticillata*, *Sr*: *S. russellii*. PS; positive control; *ampicillin sulbactam (*) and micostatin (**) 120 µL and 20µg/disc*, Interpretation of zone diameters (mm); Zone of diameter>11 mm (susceptible; $p$<0.0001; cd, $p$<0.001;d), resistant= 8-10 c: $p$<0.01, not susceptible (-) (a: $p$>0.05).

Besides, the current study showed that *S. candidissima* subsp. *candidissima* has the highest metal chelating capacity (80.48±1.11%) and *S. verticillata* subsp. *verticillata* has lowest metal chelating capacity (45.04±0.84%) (Table 5). Senol et al., (2010) found that the methanol extracts of *Salvia* species including *S. candidissima, S. virgata* and *S. russellii* have displayed neligible metal chelating action. However, Seker Karatoprak et al. (2016) suggested that *S. virgata* may be able to protect against complexing free iron (II) ions. Moreover, the lipid peroxidation of studied taxa changed from 19.95±0.82 mg/kg (*S. frigida*) to 23.36±0.51 mg/kg (*S. candidissima* subsp. *candidissima*) in this study (Table 5). Tepe, et al. (2007) indicated that inhibition activity of the linoleic acid of *S. verticillata* subsp. *verticillata* is 74.4±1.29%. Also, Jeshvaghani et al. (2015) found that oxidation of lipid peroxidation was blocked by *Salvia* species including *S. virgata*. Besides, it was indicated that *Salvia* species mostly great protective role against lipid peroxidation study done by Asadi et al. (2010).

Moreover, the present study demonstrated that phenolic contents of *Salvia* L. taxa represented different antimicrobial activities (Table 6). It was showed that *S. verticillata* subsp. *verticillata* represented higher antimicrobial activity against *B. megaterium, C. albicans* and *S. aureus* than other studied *Salvia* taxa. And also, it was found that only *S. frigida* exhibited antimicrobial activity against *E. coli* while only *S. candidissima* subsp. *candidissima* exhibited antimicrobial activity against *C. glabrata*. On the other hand, it was determined that studied *Salvia* taxa don't show antimicrobial activity against *Epidermophyton* sp. and *Trichopyton* sp. (Table 6). It was reported that *Salvia* taxa have potent antimicrobial activity study by done Bayar and Genc (2016). They showed that the methanolic extracts of *S. candidisssima* have significant antifungal capacity (Bayar & Genc, 2018). In another study by done Akin et al. (2010). *S. russellii* is effective against micororganisms. And also, Kunduhoglu et al. (2011) suggested that *S. verticillata* exhibited antimicrobial activity.

## 4. CONCLUSION

The present study demonstrated that the catechin amounts of *S. frigida*, *S. verticillata* subsp. *verticillata* and *S. russellii* are high whilst the the rutin and naringin content of *S. verticillata* subsp. *verticillata* are high. Also, the current study showed that *S. frigida* and *S. verticillata* subsp. *verticillata* have high rosmarinic acid and *S. frigida* (64.74±1.21 µg/mg), *S. candidissima* (65.4±1.34 µg/mg) and *S. verticillata* subsp. *verticillata* (84.12±0.97 µg/mg) have high vanilic acid content. On the other hand, it was found that *Salvia* taxa have high ABTS (in 100, 150 and 250 µL) and DPPH (in 250 µL) except for *S. candidissima* subsp. *candidissima*) radical scavenging activities. Moreover, it was demostrated that *S. frigida* and *Salvia*

*verticillata* subsp. *verticillata* have high total phenolic content. And also, *Salvia* taxa represented antimicrobial activity.

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## Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the author(s).

## Authorship contribution statement

**İrfan Emre:** The methodology (except for antimicrobial activity), the statistical analysis of results (except for antimicrobial results), the writing of original draft. **Murat Kursat:** The collection of plant materials, the nomenclature of plants, the methodology (except for antimicrobial activity). **Sevda Kirbag:** The methodology, the writing of the antimicrobial results. **Pinar Erecevit:** The methodology (antimicrobial activity), the writing of the antimicrobial results. **Mustafa Yunus Emre:** The methodology (except for antimicrobial activity). **Okkes Yilmaz:** The methodology (except for antimicrobial activity; Gas Chromatography and HPLC analysis). **Semsettin Civelek:** The nomenclature of plants.

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