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Determination of essential oil components, mineral matter, and heavy metal content of *Salvia virgata* Jacq. grown in culture conditions

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Abstract: Most members of the family Lamiaceae are of considerable importance in areas such as medicine, food, cosmetics, and perfumery, as they are rich in essential oils, aromatic oils, and secondary metabolites. Sage, a member of this family, is the generic name for species of the genus *Salvia*. The genus *Salvia* has approximately 900 species worldwide. There are 99 species of the genus *Salvia* L. in Turkey; 51 of these species are endemic. The local name of *S. virgata* is "yılancık" or "fatmanaotu" in Turkey, and it is used for the treatment of wounds and various skin diseases. In addition, a decoction prepared by using aerial parts of this species is used to prevent blood cancer. In this study, essential oil composition and heavy metal and nutrient element contents (aluminum, cadmium, cobalt, chrome, nickel, phosphorus, potassium, calcium, sulfur, iron, copper, zinc, manganese, boron, and sodium) of *S. virgata* grown in Yozgat, Turkey, under local ecological conditions were determined using standard analytical processes. The essential oil content in the aerial parts of *S. virgata* harvested during full flowering was 0.01% (w/w). The principal constituents of the essential oil were pentacosane (20.09%), caryophyllene oxide (6.90%), phytol (6.83%), spathulenol (6.09%), and nonacosane (5.15%). The highest macro- and micromineral contents were Ca and K, and Fe and Na, respectively. The accumulated concentrations of the three metals found were lower than the maximum allowed for human consumption without health risks.

Key words: GC/MS, heavy metal, mineral content, *Salvia* spp.

1. Introduction

Most members of the family Lamiaceae have considerable importance in areas such as medicine, food, cosmetics, and perfumery, as they are rich in essential oils, aromatic oils, and secondary metabolites. Sage, a member of this family, is the generic name for species in the genus *Salvia*, which has approximately 900 species worldwide (Dweck, 2000). There are 99 species of the genus *Salvia* L. in Turkey; 51 of these species are endemic. Turkey is one of the important gene centers for *Salvia* species (Güner et al., 2012). These species include annual, perennial, and biennial plants in bush form. As important medical plants since ancient times, the leaves, flowers, shoot tips, and partial stems of *Salvia* species are all utilized. In folk medicine, sage leaves are valued for the treatment of many disorders and have been used for their soothing properties, for pain relief and prevention of colds and coughs, for lowering blood pressure, and for sweat-breaking; they have been used as expectorants, disinfectants, and muscle pain relievers, and as a part of midwifery practice (Sarı et al., 2012; Bayram et al., 2016). Consumption of these species as herbal teas is quite common, as well. *Salvia* species appeal to a wide range of consumer groups due to their characteristics, and because they are used in the food, pharmaceutical, and chemical industries their market potential is quite high.

The *S. virgata* species belonging to the genus *Salvia* is a perennial and herbaceous plant that can grow up to 30–100 cm high with an erect and highly branched structure. The leaves are simple, usually scattered on the body, sometimes collected on the base. The flower is a compound cluster. The petals are violet, blue, or mauve, rarely white, and it favors a wide variety of habitats such as shrubland, forests, meadows, low fields, limestone and volcanic rocks, and roadsides (Doğan et al., 2008; Karabacak, 2009; Arslan, 2015). It spreads from sea level up to 2300 m. The blooming period is between May and September. The species spreads through Crimea, the Balkans, Italy, the Caucasus, Northern Iraq, Iran, Afghanistan, and Central Asia and is found all over Turkey (Figure 1) (Karabacak, 2009). The local name of *S. virgata* is "yılancık" or "fatmanaotu" in Turkey, and

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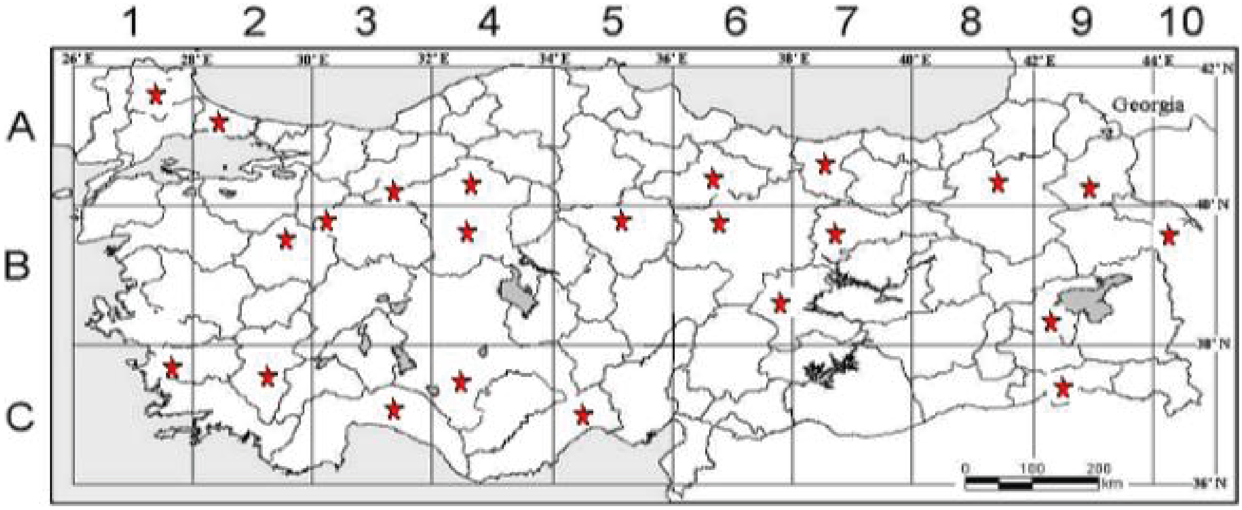

Figure 1. The distribution area in Turkey of *S. virgata* (from www.tubives.com).

it is used for the treatment of wounds and various skin diseases. A decoction prepared with aerial parts of this species is used to prevent blood cancer (Baytop, 1999; Poyraz and Koca, 2006; Sarı et al., 2012). In addition, it is reported that this plant is consumed as a strong tea in Iran (Hatipoğlu et al., 2016) and has several biological activities (antimicrobial, antioxidant, alpha-amylase, GSH-Px, antinociceptive, antiinflammatory, peroxidase, polyphenol oxidase, and acetylcholinesterase activities) (Alizadeh, 2013; Jeshvaghani et al., 2015).

It is crucial to detect the contents of *Salvia* species because the genus is rich and of medical importance. Therefore, a large number of studies have been conducted to determine the essential oil compounds and secondary components of *Salvia* species, and studies are ongoing both in Turkey and in the rest of the world.

The proximity of agricultural lands to cities, distorted urbanization, domestic and industrial wastes, and heavy metals emitted by motor vehicle exhaust and/or chimney fumes negatively affect all living things. In addition, heavy metals taken in high doses through the food chain have a negative effect on human health. The medicinal and aromatic plants that provide us with nutritional trace elements and chemicals of medicinal value are collected from natural and cultivated areas that are exposed to various pollution factors. This situation causes toxic element accumulation in the vegetative organs of plants, especially the leaves of plants. Toxic elements such as lead, cadmium, aluminum, and mercury can cause serious health problems. For this reason, the mineral matter contents of medicinal and aromatic plants should be controlled.

The current study was carried out to detect the essential oil composition and heavy metal and nutrient elements of *S. virgata*, which is locally collected and widely used in Turkey.

2. Materials and methods

2.1. Plant material

Salvia. virgata seeds collected from a natural area were sown into vials containing a 3:1 mixture of peat and soil. The vials in the greenhouse were regularly irrigated with tap water. Seedlings of 10–15 cm in height were planted with 60 × 70 cm spacing in the collection plot during the last week of April 2016. Information on sourcing of plant material used in the research is presented in Figure 2. Some physical and chemical properties and the values of heavy metals in the collection plot are shown in Tables 1 and 2, respectively. Analyses were carried out by the Science and Technology Application and Research Center (Yozgat Bozok University, Turkey).

2.2. Analysis

2.2.1. Determination of essential oil content

After the plants were collected, the aerial parts were allowed to dry in a shady environment not exceeding room temperature. The amount of essential oil in the dried plants was determined by Clevenger distillation device. An average of 50 g of dried plant sample was distilled in 700 mL of water for 3 h. Essential oil values (%, v/w) were calculated as volume over dry matter. The obtained essential oils were placed in dark-colored flasks and stored at 4 °C in a refrigerator until they were analyzed (Oke et al., 2009; Baj et al., 2015).

2.2.2. Gas chromatography–mass spectroscopy analysis (GC/MS)

The compounds of the essential oil were detected with GC/MS (Shimadzu, QP2010 ULTRA) in the Science and

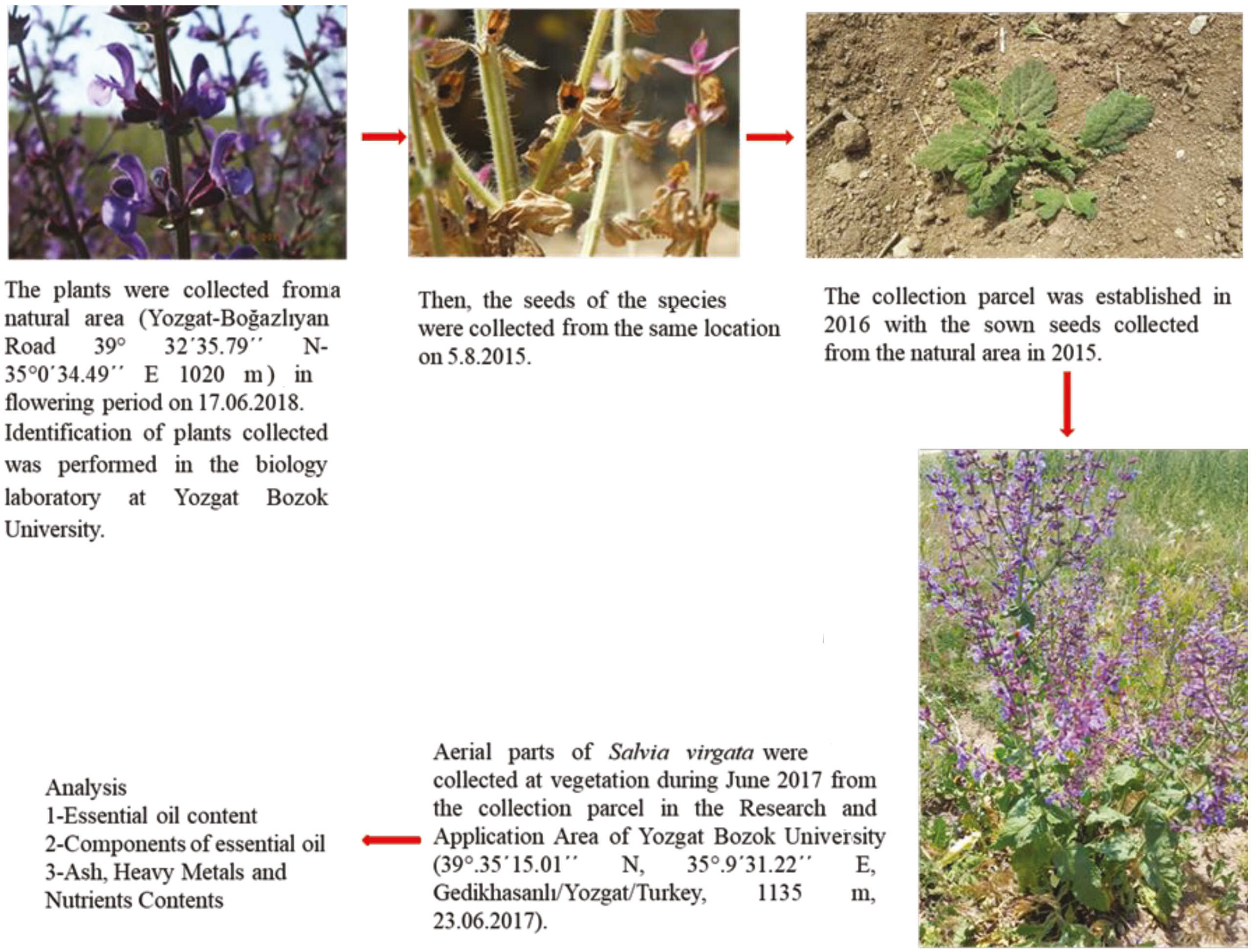

Figure 2. *Salvia virgata* used in this research.

Technology Application and Research Center of Yozgat Bozok University (Turkey). The chromatographic method is given in Table 3. The essential oil compounds were identified by comparing their mass spectra, retention times, and retention indices with the values of reference samples, the FFNSC 1.2 mass spectral library, and the literature (Babushok et al., 2011).

2.2.3. Determination of ash, heavy metal, and nutrient contents

Plant samples were dried in the shade. From each sample, 1 g was weighed and put into a porcelain crucible. The samples were burned at a maximum of 550 °C until gray ash was obtained, and 3 N HCl was added to these samples. Then they were filtered using filter paper (Whatman No. 1), and distilled water was added up to a final volume of 10 mL (Kaçar and İnal, 2010). The heavy metals and nutrients (aluminum, cadmium, cobalt, chrome, nickel, phosphorus, potassium, calcium, sulfur, iron, copper, zinc, manganese, boron, and sodium) in the samples were detected using an iCAP-Qc ICP-MS spectrometer (Thermo Scientific) at the Science and Technology Application and Research Center (Yozgat Bozok University, Turkey). The ICP-MS conditions were as follows: microflow PFA nebulizer, plasma power of 1550 W, quartz cyclonic, Peltier cooled spray chamber, 2.5-mm quartz injector; monitoring of ^{197}Au; argon as the nebulizer gas at 0.98 L min^{-1}; argon as the auxiliary gas at 0.80 L min^{-1}; argon as the cooling gas at 14.00 L min^{-1}; and an analysis time of 60 s. The numerical data calculated by considering plant dry weight are the average of three replications and are presented as mean ± SD. The calibration curve is drawn between 1 ppb and 1 ppm, totaling 11 points (Yetim, 2002; Başaran et al., 2017).

3. Results and discussion

3.1. Compounds and contents of the essential oil

The amount of essential oil in the aerial parts of *S. virgata* collected in full flowering stage was 0.01% (w/w) in our study. Essential oil of 0.48% (w/w) was obtained by steam distillation from herbage of *S. virgata* collected during flowering (July–August) near Tabriz (northwestern Iran)

Table 1. Some physical and chemical properties of the collection plot's soil surface layer (at 0–30 cm).

Properties	Values	Evaluation (Motsara and Roy, 2008)	Properties	Values	Evaluation (Motsara and Roy, 2008)
Texture class	Loamy		K_2O (kg da^{-1})	70.805	High
pH	7.685	Moderately alkaline	Fe (ppm)	1.435	Low
Salinity (%)	0.0305	Salt-free	Zn (ppm)	0.185	Very low
$CaCO_3$ (%)	4.645	Low	Cu (ppm)	0.41	Medium
Organic matter (%)	1.379	Low	Mn (ppm)	3.99	High
N (%)	0.069	Low	Ca (ppm)	7.988	High
P_2O_5 (kg da^{-1})	3.89	Low	Mg (ppm)	221.6	Medium

Table 2. The values of heavy metals detected at 15 cm (A), 30 cm (B), and 45 cm (C) depths of the collection parcel.

Heavy metals (ppm)	Cr			Co			Cu		
	A	B	C	A	B	C	A	B	C
	0.244	0.211	0.216	0.082	0.100	0.074	0.079	0.068	0.052
Permissible limit									
European Union Standards (ppm)[a]	50			150			140		
Republic of Turkey Ministry of Environment and Urbanization Standards (ppm)[b]	100			Not available			100		

[a] Sahoo et al. (2018), [b] www.sgb.gov.tr.

Table 3. Chromatographic method for GC/MS.

GC parameters				MS parameters	
Oven temperature	Rate (°C/min)	Final temperature (°C)	Hold time (min)	Scan rate	50–550 (m/z)
	-	70	1	Interface temperature	250 °C
	20	180	1	Ion source temperature	200 °C
	10	280	10		
Column	Rxi-5ms (30 m × 0.25 mm × 0.25 μm)			MS database:	FFNSC 1.2
Carrier gas	Helium				
Injection temperature		250 °C			
Split ratio		10			
Column flow		1.10 mL/min			

(Sefidkon and Mirza, 1999). Light yellow essential oil (0.57%, w/w) was taken from the dried flowers of *S. virgata* collected from Mazandaran, Iran, in July 2004 (Morteza-Semnani et al., 2005). In another study, the aerial parts of *S. virgata* were gathered from Fars, Iran, at approximately 1700 m, in 2014, and the essential oil yield was 1.6% (v/w) (Golparvar et al., 2017). In another study, the aerial parts of *S. virgata* were collected at 1700 m, before flowering and during 100% flowering stages, in April and June in the Estahban district of Fars Province. The pale yellow essential oils were isolated by hydrodistillation of the aerial parts, and the ratio of essential oil obtained before flowering (0.32%) was lower than in the full flowering stage (0.55%) (Ramakrishna and Ravishankar, 2011). The essential oil content that we obtained in the current study is quite low compared to other studies. Since wild plants are exposed to more stress factors and strict competition than cultivated plants, they keep the secondary metabolite synthesis constantly active. Thus, the effective substance content and diversity of wild-collected drugs are generally higher than those grown in culture conditions (Baydar, 2013). The reason for the low essential oil content in our study may be that the plant samples were not collected from a natural area. In addition, the amount of bioactive substances composed of secondary metabolites varies significantly according to plant organ (morphogenetic variability), life cycles of the plant (ontogenetic variability), and the time of collection (ontogenetic variability) (Ramakrishna and Ravishankar, 2011; Baydar, 2013).

A total of 26 compounds (73.31%) were determined in GC/MS analyses. The identified components in the essential oil are given in Table 4.

The major compounds of the essential oil were pentacosane (20.09%), caryophyllene oxide (6.90%), phytol (6.83%), spathulenol (6.09%), and nonacosane (5.15%). The essential oil composition results from other studies on *S. virgata* are shown in Table 5.

In almost all studies, α- and β-caryophyllene and caryophyllene oxide were some of the principal constituents, but the other main compounds were different. Different main components such as borneol (Hatipoğlu et al., 2016), estregole, and α-amorphene (Yılar et al., 2017) were also recorded in the essential oil of *S. virgata*. In our study, pentacosane was recorded as the highest value component. This component was not detected in previous studies. Pentacosane is one of the major compounds of essential oils obtained from the leaves of *Malus domestica* (Walia, 2012), the dried flowers of *Malva sylvestris* L. (Usami et al., 2013), the aerial parts of *Satureja avromanica* (Abdali et al., 2017), and *Aerva javanica* (Burm.f.) Juss. ex Schult seed (Samejo et al., 2013).

Research has shown that the major compounds of *S. virgata* essential oil have significant biological activity. Pentacosane and nonacosane exhibited antibacterial activity (Mihailovi et al., 2011; Yogesvari et al., 2017). Phytol, an acyclic diterpene alcohol, is used extensively in the synthesis of vitamins E and K1 by the food and cosmetic industries. Phytol, which has antioxidant, anticancer, and cytotoxic activities, has a favorable effect on insulin and enzyme production and blood cholesterol reduction (Yu et al., 2005; Song and Cho, 2015; Kostik and Bauer, 2017). Diterpenes may have anticancer effects when used alone or together with other diterpenes or medicaments having anticancer properties (Islam, 2017). Germacrene D has an antioxidant and cytotoxicity effect on tumor cells (Casiglia et al., 2017), as well as an insecticidal (Bruce et al., 2005; Kiran and Devi, 2007; Casiglia et al., 2017) and a repellent effect (Birkett et al., 2008). Spathulenol has antibacterial activity and a repellent effect (Durán-Peña et al., 2015).

Table 4. The chemical compounds of essential oil from the dried flowering aerial parts of *S. virgata*.

Peak	Compound	RT (min)	RI	Area (%)
1	*β*-Pinene	4.146	1033	0.28
2	Borneol	5.833	1134	0.81
3	Caryophyllene	8.112	1384	1.96
4	*β*-Farnesene	8.218	1428	0.78
5	*α*-Humulene	8.439	1430	1.03
6	Germacrene D	8.686	1458	3.23
7	*β*-Selinene	8.764	1463	0.51
8	Bicyclogermacrene	8.836	1525	1.85
9	Cadinene	9.017	1526	0.44
10	Germacrene B	9.483	1535	0.49
11	Palustrol	9.620	1562	1.52
12	Spathulenol	9.677	1564	6.09
13	Caryophyllene oxide	9.766	1568	6.90
14	*β*-Copaen-4-*α*-ol	9.810	1578	1.16
15	Viridiflorol	9.854	1598	0.94
16	*α*-Humulene epoxide	10.030	1612	1.37
17	Isospathulenol	10.265	1619	3.81
18	*α*-Cadinol	10.415	1662	1.04
19	Valeranone	10.707	1668	1.19
20	Phytol	14.849	2074	6.83
21	Docosane	15.595	2192	0.45
22	Tetracosane	17.388	2381	4.25
23	Pentacosane	18.282	2494	20.09
24	Octacosane	19.965	2773	0.28
25	Squalene	22.325	3066	0.86
26	Nonacosane	23.295	3119	5.15
	Total			73.31

RT: Retention time; RI: retention indices.

Caryophyllene oxide exhibits an antiinflammatory (Chao et al., 2005) and antiviral effect (Frag et al., 2004). When the results obtained from this study are compared with the literature, there are significant differences in the essential oil components. This may be attributed to factors such as the plant part used in the analysis, the development period of the plant, the harvest or collection time, differences in climate and ecological conditions, and the distillation and analysis conditions used (Bingol et al., 2009).

3.2. Ash content

Ash generally indicates the nonorganic part of the plant. Ash is a residue formed by oxides of inorganic substances that are produced as a result of the burning of organic matter. In our study, the ash value of *S. virgata* was 8.48%. In a 2002 study, the ash value was 7.32% in *S. tomentosa* and 9.68% in *S. dichroantha* (Er, 2012). The amount of ash remaining after the burning of plant material changes significantly according to the organ and age of the plant, cultivation techniques, etc. (Vermani et al., 2010).

3.3. Macro- and microminerals and heavy metal content

The proportion of essential plant nutrients, the toxic heavy metals investigated, and Al in the aerial parts of *S. virgata* are shown in Table 6.

Major dietary minerals include calcium, phosphorus, potassium, sulfur, sodium, chlorine, and magnesium; minor elements are iron, cobalt, copper, zinc, manganese, iodine, bromine, and selenium (Yadav et al., 2017). The basic nutrients required for the production of plants are also necessary for the growth and development of all living things (Esetlili et al., 2014). Minerals, which constitute 4%–6% of the human body, are critical in nutrition (Özcan, 2004a, 2004b; Kızıl et al., 2010). A lack or excess of minerals in the human body may be the source of many diseases (Kızıl et al., 2010). *Salvia* species are widely used as an herbal tea and spice. *Salvia* species are rich in both major and minor dietary minerals with nutritional properties. Herbal products can make important contributions towards meeting the daily mineral needs of the human body. Knowing the nutritional content and pharmacological functions of herbal teas is important in determining dosage (Queralt et al., 2005). The findings obtained from this study showed that the highest macro- and micromineral contents are Ca and K, and Fe and Na, respectively. In the literature we found only one study about the mineral content of *S. virgata* (Gezek et al., 2019). However, the mineral contents of different *Salvia* species from other studies are summarized in Tables 7 and 8. As the tables illustrate, the mineral content of *Salvia* species shows wide variation. The mineral composition of *S. virgata* collected from Erzincan Province, Turkey, in 2014 is considerably higher than the values obtained in our study (Gezek et al., 2019). On the other hand,

Table 5. The main components of *S. virgata* essential oil.

Main components (%)	References
β-Caryophyllene (46.6), *β*-caryophyllene epoxide (13.2), fermacrene B (13.9)	Sefidkon and Mirza (1999)
Caryophyllene oxide (34.4), spathulenol (25.6), 1-docosanol (9.3), geranyl acetone (5.6)	Morteza-Semnani et al. (2005)
α-Caryophyllene (24.58–42.54), caryophyllene oxide (10.25–19.88), sabinene (8.64–19.58), 1-octen-3-ol (7.54–8.59), terpinene-4-ol (4.25–6.64), *α*-thujene (3.74–6.46)	Alizadeh (2013)
(E)-Caryophyllene (37.0), caryophyllene oxide (15.2), Phytol (6.1), spathulenol (5.0), germacrene D (4.0), sabinene (3.9)	Moadeli et al. (2013)
Borneol (23.41), trans-pinocarvyl acetate (5.06)	Hatipoğlu et al. (2016)
Caryophyllene oxide (30.23), *β*-caryophyllene (22.63), sabinene (11.82), 1-octen-3-ol (6.64), thujene (6.28)	Golparvar et al. (2017)
β-Pinene (10.74), estregole (22.01), copaene (18.35–22.07), *β*-bourbonene (6.37), isocaryophyllene (13.22–38.21), *α*-caryophyllene (10.88), *γ*-muurolene (6.33), *α*-amorphene (8.38–25.61), eremophilene (12.76), *γ*-cadinene (16.31), germacrene D (5.01–6.01), caryophyllene oxide (6.94–24.82), *γ*-gurjunene (6.78)	Yılar et al. (2017)

Table 6. Essential plant nutrients and heavy metal concentrations of *S. virgata* (ppm).

Macrominerals		Microminerals		Heavy metals	
Ca	102.825 ± 0.42	Fe	2.171 ± 0.02	Al	2.30123 ± 0.023
K	267.273 ± 0.91	Mn	0.650 ± 0.007	Cd	0.00029 ± 0.000
P	33.028 ± 0.30	Zn	0.466 ± 0.009	Co	0.00091 ± 0.000
S	14.280 ± 5.88	Cu	0.165 ± 0.002	Cr	0.00450 ± 0.000
		B	0.603 ± 0.005	Ni	0.00480 ± 0.000
		Na	3.946 ± 0.018		

Table 7. Macromineral concentrations of some *Salvia* species.

Species	Macrominerals				1.1. References
	Ca	K	P	S	
S. officinalis (mg kg^{-1})	16.52	10.70	910		Akgül (1993)
S. officinalis (mg kg^{-1})	23.56				Başgel and Erdemoğlu (2005)
S. officinalis (mg kg^{-1})	1656	810	92		Khalil et al. (2012)
S. officinalis (mg kg^{-1})	11131	11568	672	1714	Özcan (2004)
S. officinalis (%)	1.54	1.92	0.150		Malenčić et al. (2003)
S. glutinosa (%)	1.66	2.97	0.441		
S. reflexa (%)	1.29	3.75	0.215		
S. nemorosa (%)	1.57	1.58	0.248		
S. sclarea (mg kg^{-1})	14582	23582	1750		Szentmihályi et al. (2009)
S. halophile (mg kg^{-1})	12.402	24.171	1.481	1.483	Er et al. (2013)
S. tomentosa (mg kg^{-1})	18.553	14.518	1.385	1.034	
S. heldreichian (mg kg^{-1})	12.855	15.311	1.873	1.625	
S. dichroantha (mg kg^{-1})	17.562	21.861	1.910	2.257	
S. aucheri var. *canescens* (mg kg^{-1})	84.68	13.57	2376.7		Özcan (2004)
S. viridis (%)	2.24	0.79	0.08		Ergün et al. (2010)
S. verticillata L. subsp. *amasiaca* (%)		0.59	0.14		
S. tomentosa (%)	1.12	0.40	0.09		
S. virgata (mg kg^{-1})	18142	24566			Gezek et al. (2019)

Table 8. Micromineral concentrations of some *Salvia* species.

Species	Microminerals						References
	Fe	Mn	Zn	Cu	B	Na	
S. officinalis (mg kg^{-1})	280		50				-
S. officinalis (ppm)	379.27		35.02				Tercan et al. (2016)
S. officinalis (mg kg^{-1})	297.4	32.6	48.4	35.8			Başgel and Erdemoğlu (2005)
S. officinalis (mg kg^{-1})	44	3	6	1		95	Khalil et al. (2012)
S. officinalis (mg kg^{-1})	565	38.8	28.7	4.67	37.8		Özcan (2004)
S. officinalis (ppm)	453.77	39.25	64.46	25.10			
S. glutinosa (ppm)	508.26	49.47	93.75	59.75			Malenčić et al. (2003)
S. reflexa (ppm)	350.54	46.53	18.84	34.18			
S. nemorosa (ppm)	167.62	46.26	34.25	36.70			
S. sclarea (mg kg^{-1})	189.5	9.46	18.32	128.2	16.3	158.9	Szentmihályi et al. (2009)
S. halophile (mg kg^{-1})	214	15.72	22	6.15	36.58		
S. tomentosa (mg kg^{-1})	782	42.42	30.78	4.39	27.97		Er et al. (2013)
S. heldreichian (mg kg^{-1})	179	29.79	23.53	4.99	32.71		
S. dichroantha (mg kg^{-1})	442	38.89	21.91	6.86	45.31		
S. aucheri var. *canescens* (mg kg^{-1})	108.48	12.36	33.27	82.4		474.5	Özcan (2004)
S. viridis (%)						0.21	
S. verticillata L. subsp. *amasiaca* (%)						0.06	Ergün et al. (2010)
S. tomentosa (%)						0.21	
S. virgata (mg kg^{-1})	193.6	25.02	8.921			7096	Gezek et al. (2019)

when considering the results of research conducted with different *Salvia* species, *S. virgata* had low values in terms of microminerals, but it showed average values in terms of macrominerals.

Today, analytical determination of heavy metals in medicinal and aromatic plants is among the most important quality parameters in determining the purity, safety, and efficacy of these plants (Baranowska et al., 2002).When considering the analysis results, the heavy metal content in the aerial parts of *S. virgata* was determined as follows: Al > Ni > Cr > Co > Cd. The limit values for Cd, Cr, and Ni determined by the WHO/FDA are 0.3, 0.02, and 1.63 ppm, respectively (Lone et al., 2003). The amounts of the three metals detected in the current study were lower than the maximum permissible values determined by the WHO/FDA (Figure 3).

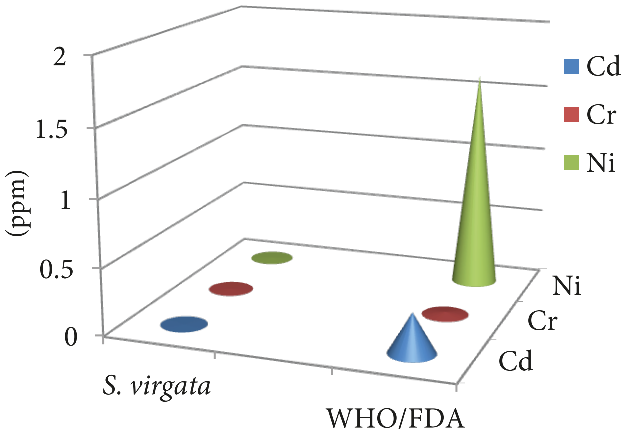

Figure 3. Comparison of Cd, Cr, and Ni levels of *S. virgata* with WHO/FDA limit levels. WHO: World Health Organization; FDA: Food and Drug Administration (USA).

Generally, plants are exposed to heavy metal contamination during growth through water used in irrigation, polluted soils, fertilizers, pesticides, etc., as well as during harvesting and postharvest applications (Dghaim et al., 2015). In our study, only three heavy metals (Co, Cr, and Cu) were detected in the heavy metal analysis of the collection plot. No other heavy metals (Pb, Cd, Ni, Zn, or Hg) were found. It was observed that the heavy metals detected were well below the accepted limit values (Table 2).

The macro- and micromineral and heavy metal contents of the *S. virgata* used in this study are generally consistent with the literature data. Factors such as plant species, growing or cultivating conditions, environmental features, and analytical methods and equipment used all affect the elemental content of plants (Er et al., 2013).

3.4. Conclusions

Numerous studies have been conducted on the chemical components of essential oil in *S. virgata* samples obtained from natural areas. The current study used plants that were obtained from seeds collected from a natural area. The essential oil obtained from the flowering aerial parts of *S. virgata* is rich in some components (pentacosane, caryophyllene oxide, phytol, spathulenol, and nonacosane) exhibiting various biological activities. Although the micronutrient element content of the plant was very low, it contains macronutrients that have positive effects on human health, and toxic heavy metal concentrations did not exceed their respective maximum allowed concentrations. In the literature we found only one study on the elemental content of *S. virgata*. For this reason, our findings are of great importance and will provide a resource for future studies.

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