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Essential oil Composition of *Salvia officinalis* and *Rosmarinus officinalis*

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ABSTRACT

Secondary metabolites, especially essential oils are of the widely used phyto-chemicals for various purposes. In this regard, numerous studies have been reported on profile of these reputed metabolites in medicinal and aromatic plant (MAPs) species. Of the substantial family of the MAPs, Lamiaceae is of the reputed group with a notable number of plant species. Regarding the species of this group, sage (*Salvia officinalis*) and rosemary (*Rosmarinus officinalis*) are of the well-known and widely-studied species. Herewith the current study, we profiled the essential oil composition in leaves of both species. Accordingly, the analysis revealed that camphene (29.40%), 1,8-cineole (37.26%), camphor (13.48%), borneol (3.69%), trans-caryophyllene (5.42%), and α-thujone (5.78%) were of the predominant compounds identified for *S. officinalis*, whilst camphene (22.45%), 1, 8-cineole (35.36%), linalool (3.67%), camphor (10.80%), cyclohexane,(1-methylethylidene) (3.09%), α-fenchyl alcohol (3.03), 2-cyclohexen-1-one, 2-methyl-5-(1-methylethenyl) (2.12%), and endo-bornyl acetate (4.50%) were of the principal components in leaves of *R. officinalis*.The next studies on the relevant species might be focused on the biological activity of the essential oils.

Keywords: Terpenoids, Secondary metabolites, Volatile oils, *Lamiaceae*

Salvia officinalis ve *Rosmarinus officinalis*'in Uçucu Yağ Bileşimi

ÖZET

Sekonder metabolitler, özellikle uçucu yağlar, çeşitli amaçlar için yaygın olarak kullanılan fitokimyasallardandır. Bu bağlamda, tıbbi ve aromatik bitki türlerinde bilinen bu metabolitlerin profili hakkında çok sayıda çalışma rapor edilmiştir. Çok sayıda önemli bitki türüne sahip olan Lamiaceae önemli tıbbi ve aromatik bitki gruplarındandır. Bu grubun türleriyle ilgili olarak adaçayı (*Salvia officinalis*) ve biberiye (*Rosmarinus officinalis*) bilinen ve üzerinde çokça çalışılan türlerdendir. Bu çalışma ile birlikte her iki türün yapraklarındaki uçucu yağ bileşiminin profilini çıkardık. Buna göre analiz, camphene (%29.40), 1,8-cineole (%37.26), camphor (%13.48), borneol (%3.69), trans-caryophyllene (%5.42), and α-thujone (%5.78) *S. officinalis* için tanımlanan baskın bileşiklerden bazıları iken, *R. officinalis* için tanımlanan camphene (%22.45), 1, 8-cineole (%35.36), linalool (%3.67), camphor (%10.80), cyclohexane,(1-methylethylidene) (%3.09), α-fenchyl alcohol (%3.03), 2-cyclohexen-1-one, 2-methyl-5-(1-methylethenyl) (%2.12), ve endo-bornyl acetate (%4.50) yapraklarındaki ana bileşenler olduğunu ortaya çıkardı. Belirtilmiş olan türlerle ilgili sonraki çalışmalar, uçucu yağların biyolojik aktivitesine odaklanabilir.

Anahtar Kelimeler: Terpenoidler, Sekonder metabolitler, Uçucu yağlar, *Lamiaceae*

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INTRODUCTION

Plants synthesize and accumulate metabolites for their sustainable and proper vegetative and generative development. Those metabolites are mainly sorted into the classes, *viz.* primary metabolites and secondary metabolites. Of those metabolites, primary metabolites are common to all organisms but the secondary metabolites are confined to the plant kingdom and specific to plant species, in general. Considering their functions, primary metabolites are strictly required for the proper growth and development of the plants. However, as reported above, the secondary metabolites are species-specific and not common to all plants, suggesting that the relevant metabolites are not essential for development and productivity of the plants but their assumed protective roles have been postulated in response to the abiotic and biotic environmental conditions (Rhodes, 1994; Pichersky and Gang, 2000; Akula and Ravishankar, 2011; Pagare et al., 2015). Regarding the detailed functions of secondary metabolites against stress factors, comprehensive analysis and deduction have been well-reported (see: Gershenzon, 1984; Mazid et al., 2011; Ahmad et al., 2018; Ashraf et al., 2018; Mahajan et al., 2020; Kulak et al., 2019).

Considering the chemical diversity of secondary metabolites; two major groups are elucidated and the first one is nitrogen-deficient molecules (terpenoids and phenolics) and the later is nitrogen-containing molecules (alkaloid) (Patra et al., 2013). Of these compounds, essential oils are composed of terpenoids and phenylpropanoids.The biosynthesis and regulation of the essential oil are mainly based on the genetic structure of the plants (Rodrigues et al., 2013; Webb et al., 2014). However,their production is also strictly affected and regulated by the environmental conditions (Yavari et al., 2010; Sangwan et al., 2011; Abdelmajeed et al., 2013; Hassiotis et al., 2014).

Regarding the plant species, MAPs are characterized with the secondary metabolites and they are reputed plant species due to their chemical composition for their pharmaceutical and relevant uses (Inoue and Craker, 2014; Bouyahya et al., 2020). Of the plant diversity of this group, Lamiaceae (also known as Mint family) possess 236 genera with anapproximately identified of 7000 species, constituting the largest plant groups of MAPs (Gharib, 2006; Ramasubramania, 2012). Regarding the well-known and reputed species of MAPs, sage (*S. officinalis*) and rosemary (*R. officinalis*) are commonly studied for their chemical composition due to their significant uses in various fields (for sage: Okaiyeto et al., 2021; Ovidi et al., 2021; Jedidi et al., 2021; for rosemary: Lešnik et al., 2021; Nguyen et al., 2021; Ielciu et al., 2021).

Essentialoil of sage is mainly characterized with 1,8-cineole, camphor, α-thujone, β-thujone, borneol, viridiflorol, an dmanool (Raal et al., 2007; Taarit et al., 2010), whilst α-pinene, 1,8-cineol, (+)-camphor, and piperitone are of the reported compounds for rosemary (Gachkar et al., 2007; Hussain et al., 2010). As previously reported in a quite number studies, the essential oil content and their composition are not constant but exhibit plasticity in response to the developmental stage and environmental conditions (Ashraf et al., 2018; Mahajan et al., 2020; Kulak et al., 2019). In this regard, it is common to profile the chemical composition of the same plant species collected from different origins due to possible alterations in the chemical diversity. The studies regarding sage and rosemary essential oil composition are relatively common (Es-sbihi et al., 2021; Göçer et al., 2021 for sage; Jafari-Sales and Pashazadeh, 2021; Soulaimani et al., 2021 for rosemary). According to the postulated opinions regarding the reports of many studies, we can hypothesize that the sage and rosemary plants obtained from Igdir regions may exhibit different chemo-types or diversity of essential oils. In this context, along with the current work, essential oil yield and composition were revealed and then discussed with the former reports, in comparison.

MATERIALS AND METHODS

Plant material

Sage (*Salvia officinalis*) and rosemary (*Rosmarinus officinalis*) were purchased from local spice shops in Igdir province (Turkey). Their scientific identifications were done by Dr. Ramazan Gurbuz and Dr. Muhittin Kulak (Igdir University).

Essential oil extraction

30 g of dried plant samples were subjected to hydro-distillation using Clevenger apparatus for two hours. Then the distillate of oils were separated and preserved at +4 ºC for further chromatographic analysis (Karadağ et al., 2021).

GC-MS analysis of essential oil

For the identification of essential oil compounds, we used Thermo GC/MS Trace Ultra. Regarding GC conditions, DB-5MS column (30m*0, 25 mm*0, 25µm) was employed. Flow rate of carrier gas of helium was 1.0 mL/min. Oven temperature was kept at 40 °C for 1 min and then increased from 40 to 120 °C at a rate of 5 °C/min and waited for 2 min. The relevant temperature was then increased to 240 °C with a rate of 10 °C/min and kept for 3 min.The injection part temperature was set as 240 °C. The mass spectrometer was operated in EI mode at 70 eV. Split ratio was set as 20:1. Mass range 45−450 m/z; scan speed (amu/s): 1000. The components were identified using NIST08, Willey7n.1 and HPCH1607 libraries reference compounds (Celikcan, 2021).

RESULTS AND DISCUSSION

Essential oil compounds identified in sage and rosemary leaves are collectively presented in Table 1, following their elution order on the DB-5MS column as presented in Figure 1 A-B. Herewith, the present findings of the study revealed that camphene (29.40%), 1,8-cineole (37.26%), camphor (13.48%), borneol (3.69%), trans-caryophyllene (5.42%), and α-thujone (5.78%) were of the predominant compounds identified for sage leaves (*S. officinalis*), accounting 95.03% of the total variation of the compounds. In the former reports, Santos-Gomes and Fernandes-Ferreira (2001) reported that α-pinene, camphene, R-thujon, camphor, R-humulene, α-caryophyllene, and viridiflorol were mostly pronounced compounds in the chemical composition of sage leaves, reporting the percentage of camphene (4.22%), 1,8-cineole (6.47%), camphor (19.51%), borneol (0.06%), trans-caryophyllene (not detected), and α-thujone (25.50%). In the study by Raal et al. (2007), 1, 8-cineole (2.7-14.6%), camphor (11.3-29.8%), α-thujone (3.0-26.6%), β-thujone (1.6-12.9%), borneol (1.6-11.8%), and viridiflorol (1.1-15.7%) were revealed to be principal components of sage oils. In their studies, the samples were analyzed from the sage of various sources, *viz.* France, Hungary, Belgium, Russia, Greece, Ukraine, Scotland, Moldavia, Estonia, Estonia, and Estonia. In addition to the profiling the chemical variations of sage samples (Venkatachalam et al., 1984; Delamare et al., 2007; Alizadeh and Shaabani, 2012; Tosun et al., 2014; Khedher et al., 2017), the relevant species were also and widely exposed to the stress factors at aiming to increase or decrease the some desired metabolites for highest quality and to reveal the biosynthesis mechanisms of the concerned compounds (Bettaieb et al., 2009; Taarit et al., 2009; Taarit et al., 2010; Es-sbihi et al., 2020; Kulak et al., 2020).

Considering the essential oil composition of rosemary (*R. officinalis*); the same optimized chromatographic conditions coupled with DB-5MS column were employed. According the analysis, camphene (22.45%), 1, 8-cineole (35.36%), linalool (3.67%), camphor (10.80%), cyclohexane,(1-methylethylidene) (3.09%), α-fenchyl alcohol (3.03), 2-cyclohexen-1-one, 2-methyl-5-(1-methylethenyl) (2.12%), and endobornyl acetate (4.50%) were of the principal components in leaves of rosemary (Table 1, Figure 1-B). Regarding the previous studies, in the study by Hussain et al. (2010), 1,8-cineol (38.5%), camphor (17.1%), α-pinene (12.3%), limonene (6.23%), camphene (6.00%) and linalool (5.70%) were of the identified major compounds. Moreover, Gachkar et al. (2007) reported that the rosemary samples included α-pinene (14.9%), 1,8-cineole (7.43%) and linalool (14.9%). As the case reported for *S. officinalis* exposed to various exogenous treatments, the similar applications were also employed for *R. officinalis* (Kulak, 2019; Abbaszadeh et al., 2020; Kulak, 2020; Mohamadi and Karimi, 2020; Raffo et al., 2020).

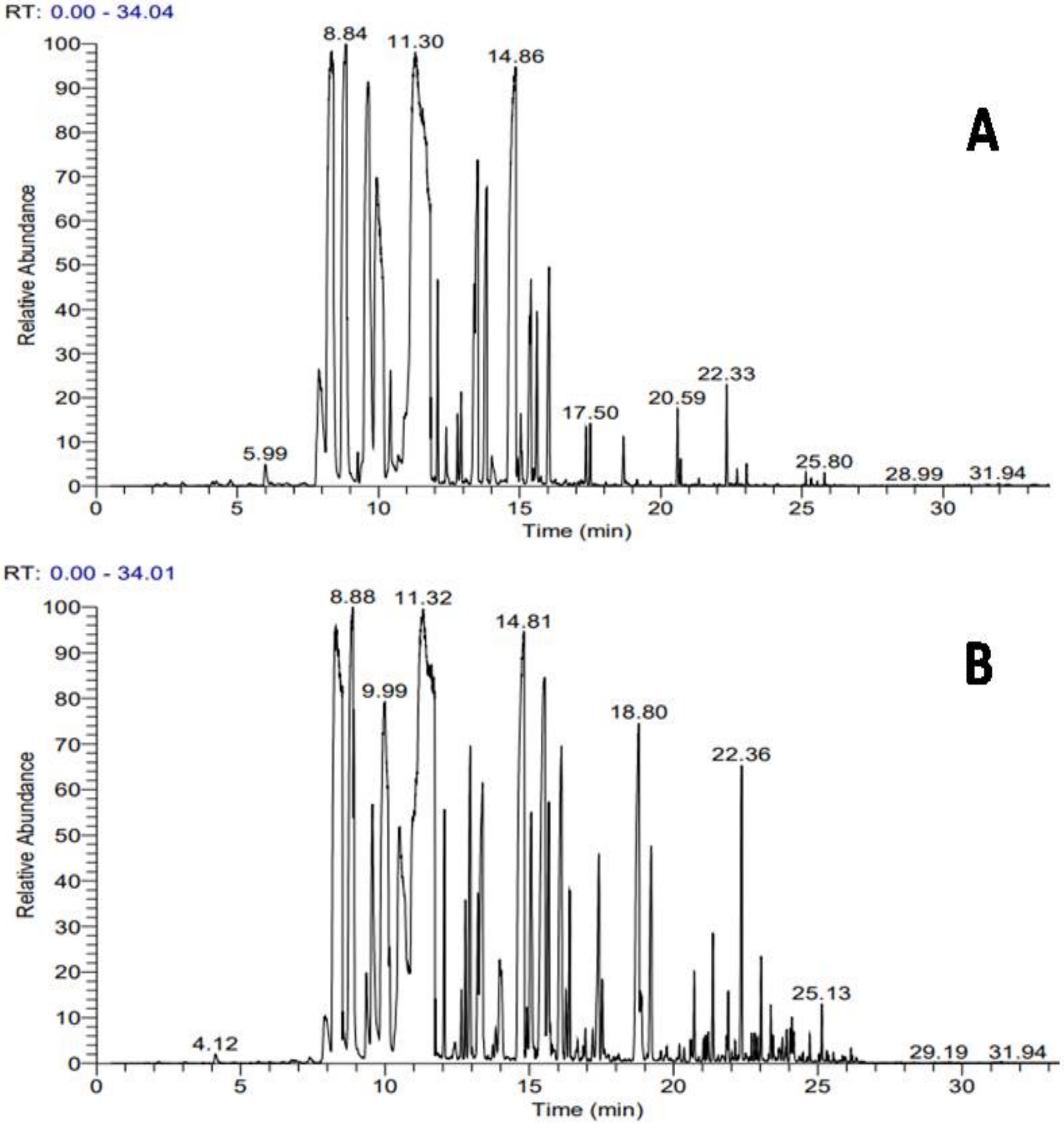

Figure 1: GC-MS chromatogram of **A)** *S. officinalis* and **B)** *R. officinalis*

Table 1. Essential oil compounds of *Salvia officinalis* and *Rosmarinus officinalis*

No	RT	Compounds	CAS	*Salvia officinalis*	*Rosmarinus officinalis*
1	2.15	Hexane	110-54-3	ND	0.02
2	4.76	Hexanal	66-25-1	0.08	ND
3	5.99	Cyclohexane, (1-methylethylidene)-	5749-72-4	0.42	ND
4	7.38	Bornylene	464-17-5	0.07	ND
5	7.38	Cyclohexene	586-62-9	0.07	ND
6	7.39	α-Terpinene	99-86-5	ND	0,06
7	7.39	ç-Terpinene	99-85-4	ND	0.06
8	7.39	4-Terpinenyl acetate	4821-04-9	ND	0.06
9	8.87	Camphene	79-92-5	29.40	22.45
10	11.30	1,8-Cineole	470-82-6	37.26	35.36
11	12.10	ç-Terpinene	99-85-4	1.02	ND
12	13.37	Linalool	78-70-6	ND	3,67
13	13.51	α-Thujone	546-80-5	5.78	ND
14	13.97	Fenchyl acetate	13851-11-1	ND	1.41
15	14.01	α-Campholene Aldehyde	4501-58-0	0.34	ND
16	14.81	Cyclohexanol	2102-62-7	0.13	ND
17	14.84	Camphor	76-22-2	13.48	10.80
18	15.40	1-Borneol	464-45-9	3.69	8.26
19	16.04	α-Terpineol	98-55-5	2.03	ND
20	16.10	Cyclohexane,(1-methylethylidene)-	10482-56-1	ND	3.09
21	16.02	α-Fenchyl alcohol	470-08-6	2.04	3.03
22	16.39	Bicyclo[3.1.1]hept-3-en-2-one, 4,6,6-trimethyl-	80-57-9	ND	1.14
23	16.64	trans-Carveol	1197-07-5	0.04	ND
24	17.08	cis-3-Hexenyl isovalerate	35154-45-1	0.01	ND
25	17.40	2-Cyclohexen-1-one, 2-methyl-5-(1-methylethenyl)-	99-49-0	ND	2.12
26	17.50	Linalyl Acetate	115-95-7	0.35	ND
27	18.05	Z-Citral	106-26-3	0.01	ND
28	18.78	Endobornyl Acetate	76-49-3	0.38	4.50
29	19.21	Phenol, 2-methyl-5-(1-methylethyl)-	499-75-2	0.04	1.46
30	19.64	1-P-Menthen-8-Yl Acetate	80-26-2	0.03	ND
31	20.18	Citronellyl acetate	150-84-5	0.10	ND
32	20.20	α-Copaene	3856-25-5	ND	0.26
33	20.20	cis-Myrtanol	15358-92-6	ND	0.08
34	20.59	α-Terpinenyl Acetate	80-26-2	0.56	ND
35	20.71	Phenol, 2-methoxy-4-(2-propenyl)-	97-53-0	ND	0.44
36	20.87	Geranyl acetate	105-87-3	0.17	ND
37	20.87	Neryl acetate	141-12-8	0.17	ND
38	21.23	(-)-Isoledene	95910-36-4	0.01	ND
39	21.36	α-Copaene	3856-25-5	0.03	0.48
40	21.89	Diphenyl ether	101-84-8	0.01	0.32
41	22.35	trans-Caryophyllene	87-44-5	5.42	1.59
42	22.81	Neryl acetate	3879-26-3	ND	0.08
43	23.37	Naphthalene	30021-74-0	0.01	0.29
44	23.66	Ledene	21747-46-6	0.01	ND
45	23.77	α-Muurolene	31983-22-9	ND	0.17
46	23.91	α-Bisabolene	495-61-4	ND	0.12
47	25.05	(+) spathulenol	77171-55-2	0.00	ND
48	25.32	Veridiflorol	552-02-3	0.06	ND
49	25.30	α-elemene	5951-67-7	ND	0.04
50	30.62	Manool	596-85-0	0.01	ND
51	30.62	Sclareol	515-03-7	0.01	ND
52	33.70	Quercetin 7,3',4'-Trimethoxy	6068-80-0	0.00	ND

ND: Not detected; RT: Retention time

As reported in a quite number of studies, the percentage and in some cases are relatively different in sage leaves (Halbesleben and Wheeler, 2008). The differences might be attributed to the harvesting time (pre-blooming, during blooming, post-flowering) (Ostadi et al., 2020), organs (leaf, stem, flower, and aerial parts) (Açikgöz and Kara, 2020), ecological conditions of the growing area (Jordán et al., 2013), post-harvest processes (packaging, transporting, drying techniques storage, harvest techniques etc.) (Szumny et al., 2010; Jaspal et al., 2021).Those, in an extent, can confirm our hypothesis and targets of the current report because plant system and therefore biosynthesis of metabolites are responsive to the numerous variables as uttered above. We can thereby deduce that the relevant essential oil profiling studies will always be great interest of the phyto-chemists and plant biologists. In order to support our comments or hypothesis; we had a quick a search on web of science (on May 16, 2021) using following criteria "(sage OR Salvia AND essential oil) Refined by: WEB OF SCIENCE CATEGORIES: (PLANT SCIENCES) Time-span: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI." From Web of Science Core Collection, 900 documents were roughly recorded. In the last five years, the number of studies were as 2017 (n=44), 2018 (n=44), 2019 (n=51), 2020 (n=70), and 2021 (n=20; between January and May 16, 2021). The same search was done for rosemary, being about 400 documents for the relevant species with a number of studies 2017 (n=20), 2018 (n=32), 2019 (n=30), 2020 (n=34), and 2021 (n=8; between January and May 16, 2021). The search trend confirms our comments, suggesting that those plants deserve to be investigated for their chemical composition and their uses.

CONCLUSION

Herewith the study, we profiled the essential oil composition of well-known species of Lamiaceae family, such as *S. officinalis* and *R. officinalis*. Considering the compounds, the principal compounds of *S. officinalis* were as camphene, 1, 8-cineole, camphor, borneol, trans-caryophyllene, and α-thujone, whilst camphene, 1,8-cineole, linalool, camphor, cyclohexane, (1-methylethylidene), α-fenchyl alcohol, 2-cyclohexen-1-one, 2-methyl-5-(1-methylethenyl), and endobornyl acetate were of the major compounds in *R. officinalis* oils. The differences were revealed with the previous reports, which were deemed to be consequences of the environmental conditions and post-harvest practices. In the ahead studies, the essential oils samples might be assayed for an array of biological activity tests to associate the compound profile and the possible biological activities.

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