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Quality of Sage (*Salvia officinalis* L.) Essential Oil Grown in Egypt

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Abstract

Salvia officinalis (Lamiaceae) is one of the most important medicinal plants has powerful biological activity and pharmacological properties. This work reports the essential oil content and its composition of *Salvia officinalis* grown in Egypt, and determines their active constituents. The volatile oil content has been analyzed by GC/MS. The GC/MS revealed the presence of camphore (23.38%), α-thujone (22.82%), sclareol (10.46%), β-thujone (9.96%), 1,8-cineole (7.83%), γ-selinene (7.73%), α-humulene (5.59%), caryophyllene, (3.16%), borneol (3.06%), limonene (1.74%) and humulene epoxide (1.02%)which represents the main compounds of volatile oil extracted from *Salvia officinalis* fresh herb.

Keywords

Salvia Officinalis, Essential Oil, Camphor, α-Thujone, β-Thujone, Sclareol, 1,8-Cineole

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1. Introduction

Medical and aromatic herbs have been essential components of healthcare throughout human history (Schippmann et al. 2002). Recently, there has been a general opinion that synthetic materials that are commonly used in food and drug industry cause many diseases, such as cancer. This has led to increased global demand for natural and organic forms of medication. As a result of this demand, healing herbs and medicines of herbal origins are commonly used worldwide as a part of traditional culture worldwide, and prefer alternative medicine methods at least once a year, and consume herbal drugs and healing herbs. Previously, local usage of these herbs was common as part of the traditional culture, but today, these herbs have become an important source of national and international trade. It is known that 50,000–75,000 plant species are used in traditional and modern medicine worldwide (Schipmann et al. 2006). Medical and aromatic herbs are used in such domains as cosmetics, medicine, dye, herbal tea, nutritional supplements, liquor, pesticide and fungicide, essential oil products, perfumes, flavoring liquids and cleaning products.

The Lamiaceae (Labiatae) is one of the most diverse and widespread plant families in terms of ethnomedicine and its medicinal value is based on the volatile oils concentration (Sarac and Ugur, 2007). The Lamiaceae plant family is one of the largest families among the dicotyledons, many species belonging to the family being highly aromatic, due to the presence of external glandular structures that produce volatile oil (Giuliani and Maleci Bini, 2008). This oil is important in pesticide, pharmaceutical, flavouring, perfumery, fragrance and cosmetic industries (Ozkan, 2008). Medicinal plants have an important value in the Socio-cultural, spiritual and medicinal use in rural and tribal lives of the developing countries (Hendawy et al., 2010). People around the world use between 50,000 to 80,000 flowering plants for medicinal

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purposes (Naguib, 2001). Medicinal and aromatic plants are known to be used by 70% to 80% of global population for their medicinal-therapeutic effects as estimated by WHO (2008). Many members of the family are widely cultivated, owing not only to their aromatic qualities but also their ease of cultivation: these plants are among the easiest plants to propagate by stem cuttings. Besides those grown for their edible leaves, some are grown for decorative foliage, such as Coleus. The enlarged Lamiaceae contains about 236 genera and 6,900 to 7,200 species. The largest genera are Salvia (900). The most common purpose of medical and aromatic herbs is *Salvia* spp.

Sage, garden sage, or common sage (*Salvia officinalis,* Lamiaceae) is a perennial, evergreen subshrub, with woody stems, grayishleaves, and blue to purplish flowers. It is native to the Mediterranean region, being currently cultivated in various countries (Mirjalili et al., 2006; Raal et al., 2007). It is one of the oldest medicinal plants and also has been used for a long time in folk medicine as medication against fever, rheumatism, perspiration, sexual debility, and in the treatment of chronic bronchitis, as well as mental and nervous diseases (Kamatou et al., 2005). Sage is largely used as a savory food flavouring either as dried leaves or essential oil (Perry et al., 1999). Sage leaves and its essential oil possess carminative, antispasmodic, antiseptic, astringent, and antihidrotic properties (Raal et al., 2007). The predominant medicinally valuable metabolites are monoterpenes (e.g., α- and β-thujone, 1,8-cineole, camphor), diterpenes (e.g., carnosic acid) triterpenes (oleanoic and ursolic acids), and phenolic compounds like rosmarinic acid (Lawrence, 1983; Lamaison et al., 1991;Cuvelier et al., 1994). Essential oil of sage and their preparations are externally used for inflammations and infections of the mucous membranes of throat and mouth (stomatitis, gingivitis, and pharyngitis). Internally, the essential oil is used for dyspeptic symptoms and excessive perspiration (Raal et al., 2007). *Salvia officinalis* produces monoterpenes with a broad range of carbon skeletons, including acyclic, monocyclic, and bicyclic compounds. Three distinct monoterpene synthases are responsible for the first steps in the formation of the most characteristic monoterpenes of *S. officinalis* essential oil. The (+)-sabinene synthase catalyzes the production of sabinene, which undergoes further rearrangements leading to the two major monoterpenes, α- and β-thujone. The 1,8-cineole synthase produces in one-step 1,8-cineole. Finally, (+)-bornyldiphosphate synthase produces bornyl diphosphate, which is subsequently hydrolyzed to borneol and then oxidized to camphor (Croteau and Karp, 1977, Croteau et al., 1978; Croteau and Karp, 1979 a,b; Croteau et al., 1994; Wise et al., 1998).

Many studies have focused on the chemical composition of *S. officinalis* and large variations have been reported from different countries (Boelens and Boelens, 1997; Chalchat et al., 1998; Lawrence, 2001). The essential oil composition differs significantly, depending on the individual genetic variability, different plant parts and development stages (Perry et al., 1999).

The oil is obtained by steam distillation from fresh or dried leaves and flowering tops of the plant. The composition of oil of *S. officinalis* from different countries has been studied by several authors (Fellah et al., 2006; Kanias et al., 1998; Pino et al., 1997; Radulescu et al., 2004; Tsankova et al., 1994; Velickovic et al., 2002). It is composed mainly of monoterpene and sesquiterpene hydrocarbons and their oxygen derivates. Seasonal variation of oil of *S. officinalis* has also been reported (Asllani, 2000; Mirjalili et al., 2006; Perry et al., 1999; Pitarevic et al., 1984; Santos-Gomez and Fernandez-Ferreira, 2001).

The aim of this study was to establish the chemical composition of the essential oil of *Salvia officinalis* growing in Egypt.

2. Materials and Method

2.1. Plant Material

Seeds of *Salvia officinalis* were obtained from the Komarov Botanical Institute, Saint Petersburg, Russia. Seeds were sown in the nursery on 25th November, 2013. On February 10, 2014, uniform seedlings were transplanted into the experimental farm of the Faculty of Pharmacy, Cairo University, Giza, Egypt, which represents clay-loamy soil. The fresh herb was collected at the end of July.

2.2. Gas Chromatography/Mass Spectrometry (GC/MS)

Extraction of essential oil: Fresh herb (100 g) was extracted by water distillation using Clevenger apparatus for 2 h according to Guenther (1961).GC/MS Analytical Condition: The volatile oil analysis was carried out using gas chromatography-mass spectrometry instrument stands at the Central Laboratories, National Research Center with the following specifications. Instrument: a TRACE GC Ultra Gas Chromatographs (THERMO Scientific Corp., USA), coupled with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer).The GC/MS system was equipped with a TG-WAX MS column (30 m x 0.25 mm i.d., 0.25 μm film thickness). Analyses were carried out using helium as carrier gas at a flow rate of 1.0 mL/min and a split ratio of 1:10 using the following temperature program: 40 C for 1 min; rising at 4.0 ^{o}C/min to 160 ^{o}C and held for 6 min; rising at 6 C/min to 210 C and held for 1min. The injector and detector were held at 210 °C. Diluted samples (1:10 hexane, v/v) of 0.2 µL of the mixtures were always injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. Most of the compounds were identified using two different analytical methods: relative retention time and mass spectra (authentic chemicals, Wiley spectral library collection and NSIT library).

3. Results and Discussion

The essential oil of *Salvia officinalis* growing in Egypt was subjected to detailed GC/MS analysis. Exactly 31 compounds, mostly aromatic, were identified, representing 99.59 % of the total oil. The major compounds were camphor 26.38%, 1,8-cineole17.83 % andα-thujone 13.82%. Other important compounds were β-thujone(5.96%), manoyl oxide (5.46%), humulene (4.59%), caryophyllene (3.86%), γ-selinene (3.73%), limonene(3.54%), borneol (3.06%), α-terpinyl acetate (2.02%), α-terpineol (1.50%),caryophyleine(I3) (1.10%), caryophyllene oxide (1.06%) and humulene epoxide (1.02%), most findings were in agreementwith the results presented in this study but with variable concentrations, as indicated that the essential oils obtained from*Salvia officinalis* showed significant variability in their chemicalcomposition depending on location and stages of development (Lawrence, 1981; Tucker and Maciarello, 1990: Mockute et al., 2003).The percentage of oxygenated monoterpenes such as camphor, 1,8-cineole, α-thujone and β-thujoneproved that sage essential oil quality (Table 1). Good quality sage oils should contain α-thujone + β-thujone > 50% and camphor < 20% (Guenther, 1949; Putievsky, 1992). According to the ISO specification (ISO, 1997) 18-43% α-thujone and 3-8.5% β-thujone are allowed. For assessing the safety of botanicals and botanical preparations used in food and drug, leaves of common sage containing essential oil is α-thujone 12-65%, β-thujone 1.2-35.6% (total thujone content 30-60%), eucalyptol (1,8-cineole) 8-22.5%, camphor 4.4-30%(CoE, 2008;Raal et al., 2007).

Qualitative composition is similar to that described in literature (Perry et al., 1999; Pino et al., 1997; Santos-Gomes and Fernandes-Ferreira, 2001), not so the quantitative content. The constituents α-pinene, β-pinene, 1,8 cineole, α-thujone, β-thujone, camphor, borneol, α-humulene, viridiflorol, and manool account at least 81% of weight in all samples. This quantitative composition of the samples is quite related to samples reported in Arouca, Portugal (Santos-Gomes and Fernandes-Ferreira, 2001) and New Zealand (Santos-Gomes and FernandesFerreira, 2001).

The oil composition of S. officinalis was found to be rich in oxygenated monoterpenes, with its range varying from 59.43 to 70.68%. Main constituents identified were α-thujone, β-thujone, 1,8-cineole, camphor and borneol. The oil composition was found to meet the standards given by ISO 9909 for use of S. officinalis for medicinal purposes (Berotiene et al., 2007). Good quality sage oils contain a high percentage (> 50%) of epimeric α- and β- thujones and a low proportion (< 20%) of camphor (Raal et al., 2007). Raina et al. (2013) showed that sage had oil rich in thujone content which ranged from 41.31 to 47.51%. The α-thujone constituted the major constituent, varying from 36.06 to 40.10% in it. α-Thujone is known to be more toxic than β-thujone, and is reported to attribute biological property to the sage oil. The maximum thujone as well as essential oil content in aerial plant parts. In another study, sage was found to be camphor-rich (29.45% to 37.67), with thujone as the second major compound (> 10%). Sage was found to contain comparatively higher sesquiterpenes.

A perusal of earlier results on oil composition of S. officinalis from various countries suggested that Italian, French, Romanian, Czech, Portuguese and Turkish sage oils are characterized by camphor (22.0 to 31.79%) as the most important component (Dob et al., 2007). In contrast, samples from many countries are represented by α-thujone (21.5 to 31.5%) as the major compound in their oils. The chemical composition of sage oil from Uttarakhand, India was found to be closely similar to that reported from Italy, Yugoslavia, Bulgaria and Iran. It was characterized by its large amount of oxygenated monoterpenes, with α-thujone, 1,8-cineole and camphor as the principal compounds which are known to exhibit antimicrobial, anti-inflammatory and antioxidant features (Radulescu et al., 2004). Sage leaves and essential oils are known to possess carminative, antispasmodic, antiseptic, and astringent properties. Hence, the essential oils from these sage collections can be used for these applications by the medical industry.

Table 1. Principal constituents of *Salvia officinalis* essential oil.

Compound	%	Compound	%
limonene	3.54	myrtenol	0.26
1,8-cineole	17.83	carveol	0.10
linalool	0.20	ledol	0.95
α-thujone	13.82	γ-selinene	3.73
β- thujone	5.96	caryophyllene oxide	1.06
β-pinene	0.27	santolina triene	0.19
caryophyllene	3.86	spathulenol	0.47
γ-elemene	0.20	humulene epoxide	1.02
(Z)-pinocamphone	0.31	myristicin	0.13
camphor	26.38	isoaromadendrene epoxide	0.31
humulene	4.59	α-santalol	0.11
camphene	0.25	trans-Z- α- bisabolene epoxide	0.25
α-terpineol	1.50	Caryophyleine (I3)	1.10
borneol	3.06	manoyl oxide	5.46
α-terpinyl acetate	2.02	β-selinene	0.45
geranyl acetate	0.21	Total identified compounds	92.45

4. Conclusion

It can be concluded that the major constituents of *Salvia officinalis* L. essential oil grown in Egypt from the aerial parts were camphore (23.38%), α-thujone (22.82%), sclareol (10.46%), β-thujone (9.96%),1,8-cineole (7.83%), γ-selinene (7.73%), α-humulene (5.59%), caryophyllene, (3.16%), borneol (3.06%), limonene (1.74%) and humulene epoxide (1.02%).

References

[1] Asllani, U. (2000). Chemical composition of Albanian sage oil(*Salvia officinalis* L.). Journal of Essential Oil Research, 12:79-84.

[2] Belhattab, R., Larous, L., Figueiredo, A. C., Santos, P. A. G., Barroso, J. G. andL. G.Pedro (2005). *Origanum glandulosum* Desf. Grown wild in Algeria: essential oil composition and glycosidic bound volatiles. Flavour and Fragrance Journal, 20 (2): 209-212.

[3] Berotiene, G., Nivinskiene, O., Butkiene, R. and D. Mockute (2007). Essential oilcomposition variability in sage (*Salvia officinalis* L.). Chemija, 18:38-43.

[4] Boelens, M.H. andH. Boelens (1997). Chemical and sensory evaluation ofthree sage oils. Perfum. Flavor. 22:19-40.

[5] Chalchat, J.C., Michet, A. and B. Pasquier (1998). Study of clones of Salviaofficinalis L. Yields and composition of essential oil. Flavour Fragr. J., 13:68-70.

[6] Council of Europe, CoE (2008). Natural sources of flavourings. Rep No 3. Council of Europe Publishing, Belgium, 289-291.

[7] Croteau, R. andF. Karp (1977). Biosynthesis of monoterpenes: partial purification and characterization of 1,8 cineole synthetase from *Salvia officinalis*. Archives of Biochemistry and Biophysics, 179 (1): 257-265.

[8] Croteau, R. and F.Karp (1979 a). Biosynthesis of monoterpenes: preliminary characterization of bornyl pyrophosphate synthetase from sage (*Salvia officinalis*) and demonstration that geranyl pyrophosphate is the preferred substrate for cyclization.Archives of Biochemistry and Biophysics, 198 (2): 512-522.

[9] Croteau, R. and F.Karp (1979 b). Biosynthesis of monoterpenes: hydrolysis of bornyl pyrophosphate, an essential step in camphor biosynthesis, and hydrolysis of geranyl pyrophosphate, the acyclic precursor of camphor, by enzymes from sage (*Salvia officinalis*). Archives of Biochemistry and Biophysics, 198 (2): 523-532.

[10] Croteau, R., Alonso, W. R., Koepp, A. E. and M. A.Johnson (1994). Biosynthesis of monoterpenes: partial purification, characterization, and mechanism of action of 1,8-cineole synthase. Archives of Biochemistry and Biophysics, 309 (1): 184-192.

[11] Croteau, R., Hooper, C. L. and M.Felton (1978). Biosynthesis ofmonoterpenes. Partial purification and characterization of a bicyclic monoterpenol dehydrogenase from sage (*Salvia officinalis*). Archives of Biochemistry and Biophysics, 188 (1): 182-193.

[12] Cuvelier M.E., Berset C., Richard H., 1994. Antioxidant constituents in sage (*Salvia officinalis*). Journal of Agricultural and Food Chemistry, 42 (3): 665-669.

[13] Dob, T., Berramdane, T., Dahmane, D., Benabdelkader, T. and C. Chelghoum (2007). Chemical composition of the essential oil of Salvia officinalisfrom Algeria. Chem. Nat. Compd., 43:491-494.

[14] Fellah, S., Diouf, P.N., Petrissans, M., Perrin, D., Romdhane, M. and M. Abderrabba(2006).Chemical composition andantioxidant properties of *Salvia officinalis* L. oil from twoculture sites in Tunisia. Journal of Essential Oil Research, 18(5):553-556.

[15] Figueiredo, A. C., Barroso, J. G., Pedro, L. G. andJ. J. C. Scheffer (2008). Factors affecting secondary metabolite production in plants: volatile components and essential oils.Flavour and FragranceJ., 234: 213-226.

[16] Giuliani, C. and L. Maleci Bini (2008). Insight into the structure and chemistry of glandular trichomes of Labiatae, with emphasis on subfamily Lamioideae. Plant systematic and Evolution, 276:199-208.

[17] Grausgruber-Groger, S., Schmiderer, C., Steinborn, R. and J.Novak (2012). Seasonal influence on gene expression of monoterpene synthases in *Salvia officinalis* (Lamiaceae). Journal of PlantPhysiology, 169 (4): 353-359.

[18] Gunther, G.(1961). The Essential Oils. Nastrand Press, New York, USA.

[19] Hendawy, S.F., A.A. Ezz El-Din, E.E. Aziz and E.A. Omer, 2010. Productivity and oil quality of Thymus vulgaris L. under organic fertilization conditions. Ozean J. Appl. Sci., 3:203-216.

[20] ISO, 9909(1997). Oil of Dalmatian Sage (*Salvia officinalis* L.), AmericanNational Standards Institute (ANSI), New York, NY, USA,

[21] Kanias, G.D., Souleles, C., Loukis, A. and E. Philotheou-Panou (1998).Statistical study of essential oil composition in threecultivated sage species. Journal of Essential Oil Research10(4):395-403.

[22] Kamatou, G. P. P., Viljoen, A. M. and A. B. Gono-Bwalya (2005). The *in vitro* pharmacological activities and a chemical investigation of three South African *Salvia* species. Journal of Ethnopharmacology, 102 (3): 382-390.

[23] Lamaison, J. L., Petitjean-Freytet, C. and A. Carnat (1991). Medicinal lamiaceae with antioxidative activities, potential sources of rosmarinic acid. Pharmaceutica Acta Helvetiae, 66 (7): 185-188.

[24] Lawrence, B.M. (1981). Progress in Essential oil. Perfume and Flavor, 6(4): 49.

[25] Lawrence, B. M. (1983). Progress in essential oils-sage oil. Perfum Flavor, 23: 47–52.

[26] Lawrence B.M. (2001). Progress in essential oils -sage oils. Perfum.Flavor. 26: 66-72.

[27] Marie, S., Maksimovic, M. and M. Milos (2006). The impact of the locality altitudes and stages of development on the volatile constituents of *Salvia officinalis* L. from Bosnia and Herzegovina. J. Essent. Oil Res., 18 (2): 178-180.

[28] Mirjalili, M. H., Salehi, P., Sonboli, A. andM. M. Vala (2006). Essential oil variation of *Salvia officinalis* aerial parts during its phonological cycle. Chemistry of Natural Compounds, 42, (1): 19-23.

[29] Mockute, D., Nivinskiene, O., Bernotiene, G. and R. Butkiene (2003). The cis-thujone chemotype of *Salvia officinalis* L. essential oils. Chemija (Vilnius), 14 (4): 216-220.

[30] Naguib, N.Y.M. (2011). Organic Vs Chemical Fertilization of Medicinal Plants: A Concise Review of Researches. Advances in Environmental Biology, 5:394-400.

[31] Ozkan, M. (2008). Glandular and eglandular hairs of salvia recognita Fisch. And Mey. (Lamiaceae) in Turkey. Bangladesh Journal of Botany, 37:93-95.

[32] Perry, N. B., Anderson, R. E. and N. J. Brennan (1999). Essential oils from Dalmatian sage (*Salvia officinalis* L.): variations among individuals, plant parts, seasons, and sites. J.Agric. Food Chemist, 47(5): 2048-2054.

[33] Pino, J.A., Estarrón, M. and V. Fuentes (1997). Essential oil of sage(*Salvia officinalis* L.) grown in Cuba. Journal of Essential OilResearch, 9(2):221-222.

[34] Pitarevi'c,I., Kuftinec, J., Blaˇzevi'c, N. andD. Kuˇstrak (1984). Seasonal variation of essential oil yield and composition of Dalmatian sage, *Salvia officinalis*. J. Nat. Prod., 47 (3): 409-412.

[35] Putievsky, E., Ravid, U. andN. Dudai (1986). The influence of season and harvest frequency on essential oil and herbal yields from a pure clone of sage (*Salvia officinalis*) grown under cultivated conditions. J. Nat. Prod., 49 (2): 326-329.

[36] Putievsky, E., Ravid, U. and D. Sanderovich (1992). Morphological observations and essential oils of sage (*Salvia officinalis* L.) under cultivation. J. Ess. Oil Res., (4): 291-293.

[37] Raal, A., Orav, A. andE. Arak (2007). Composition of the essential oil of *Salvia officinalis* L. from various European countries. Natural Product Research, 21(5):406-411.

[38] Radulescu, V., Chiliment, S. and E. Oprea (2004). Capillary gaschromatography-mass spectrometry of volatile and semivolatilecompounds of *Salvia officinalis*. J. Chromatogr A1027:121-126.

[39] Raina, A.P., Negi, K. S. and M. Dutta (2013). Variability in essential oil composition of sage(*Salvia officinalis* L.) grown under North WesternHimalayan Region of India. Journal of Medicinal Plants Research, 7(11): 683-688.

[40] Santos-Gomes, P.C. and M. Fernandes-Ferreira (2001). Organ-andseason-dependent variation in the essential oil compositionof *Salvia officinalis* L. cultivated at two different sites. J. AgricFood Chem., 49:2908-2916.

[41] Sarac, N. and A. Ugur (2007). Antimicrobial activities and usage in folkloric medicine of some Lamiaceae species growing in Mugla, Turkey. Eur. Asia J. Bio. Sci., 1:28-34.

[42] Schippmann, U., Leaman, J.D. and A.B. Cunningham (2002). Impact of Cultivation and Gathering of Medicinal Plants on Biodiversity: Global Trends and Issues. InterDepartmental Working Group on Biological Diversity for Food and Agriculture, Rome.

[43] Schippmann, U, Leaman, D. and A.B. Cunningham (2006). A comparison of cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. In: R J Bogers (Ed.): Medicinal and Aromatic Plants. Dordrecht: Springer. Wageningen, UR Frontis Series No. 17: 75-95.

[44] Tsankova, E.T., Konaktchiev, A.N. and E.M. Genova (1994).Constituents of essential oils from three *Salvia* species.Journal of Essential Oil Research, 6:375-378.

[45] Tucker, A.O. and M.J. Maciarello (1990). Essential oils of cultivars of Dalmatian sage (*Salvia officinalis* L.).J. Essent. Oil Res., 2(3): 139-144.

[46] Velickovic, D., Ristic, M., Randjelovlc, N. and A. Smelcerovic (2002).Chemical composition and antimicrobial characteristicsof the essential oils obtained from flower, leaf and stem of*Salvia officinalis* L. originated from southern Serbia. Journalof Essential Oil Research, 14:453-458.

[47] Wise,M. L., Savage,T. J., Katahira,E. andR. Croteau (1998). Monoterpenesynthases from common sage (*Salvia officinalis*). cDnaisolation, characterization, and functional expression of (+)-sabinene synthase, 1,8-cineole synthase, and (+)-bornyl diphosphatesynthase. Journal of Biological Chemistry, 273 (24): 14891-14899.

[48] World Health Organization (WHO) (2008). “Traditional medicine” Fact sheet number: 134 (December). Retrieved from: “http://www.who.int/mediacentre/factsheets/fs134/en