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FATTY ACID COMPOSITION OF SEED OILS OF TWELVE *Salvia* SPECIES GROWING IN TURKEY

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Seed oils of 12 Salvia *species collected from different regions in Turkey (*S. albimaculata *Hedge & Hub. –Mor.,* S. candidisima *Vahl.,* S. cedronella *Boiss.,* S. cryptantha *Montbret & Aucher ex Bentham,* S. forskahlei *L.,* S. fruticosa *Miller (Sin.* S. triloba *L. Fil),* S. halophila *Hedge,* S. hypargeia *Fisch. & Mey.,* S. sclarea *L.,* S. tomentosa *Miller,* S. tchihatcheffii *(Fisch. & Mey.) Boiss.,* S. virgata *Jacq.) were obtained by Soxhlet apparatus using hexane. The oil yields were found to be between 2.0% and 20.9%. Fatty acids in the oils were converted to methyl esters and determined by GC/MS in methyl ester form. The main fatty acid components of* S. halophila, S. hypargeia, *and* S. sclarea *are unsaturated oleic, linoleic, and linolenic acids. In others except* S. candidissima, *the dominant acids are oleic, linoleic and palmitic acids.*

Key words: Lamiaceae, *Salvia* seed oils, fatty acids.

Salvia (Lamiaceae) species are used variously as herbal tea or a source of essential oil in various parts of the world [1]. There are 88 species and 98 taxa of *Salvia* recorded in the flora of Turkey. The ratio of endemism of *Salvia* species in Turkey is 51% [2, 3]. *Salvia* species and their essential oils are used in food flavoring, pharmaceuticals, and in perfumery. *Salvia* species have been reportedly used in folk medicine for wound healing and in alleviating stomach, liver, and rheumatism pains and for treating the common cold in the form of infusion and decoction [4]. Antioxidant activities of the seed oils of *Salvia* have been reported. The fatty acid components of the seed oils of these plants are palmitic, palmitoleic, stearic, oleic, linoleic, linolenic, and arachidic acids. These fatty acids are responsible for the antioxidant activity [5].

Previous reports on seed oil fatty acid compositions indicated that the 18:3/18:2 ratio could be used as a taxonomic marker in some subfamilies of the Lamiaceae [6].

The main fatty acid components of the seed oils of *Salvia* species were reported as palmitic, stearic, oleic, linoleic, and linolenic acid [7–15]. Seed oil of *S. sclarea* was reported to be rich in linolenic acid [16] and linoleic acid [17, 18]. The main other components were reported as palmitic, stearic, oleic, and linoleic acids [18]. The ratio of unsaturated fatty acids (93.2–96.1%) is greater than that of saturated fatty acids. This is a typical feature of the seed oils of the family *Lamiaceae* [14].

Among the 12 *Salvia* species, the highest oil yield was obtained from *S. virgata* seeds (20.9%), and *S. hypergeia* seeds gave the lowest oil yield (2.0%) (Table 1).

The content of major fatty acid components varied according to the *Salvia* species studied as follows: linoleic (18.1–61.1%), linolenic (0.4–38.6%), oleic (9.6–31.0%), palmitic (7.4–21.0%), and stearic (2.4–5.8%).

The oil of *S. albimaculata* seeds contained the lowest content of total unsaturated fatty acids (56.7%) while they were the main components in the seed oil of *S. halophila* (87.6%), a xerophytic species.

As to the saturated fatty acid contents in the oils examined, the lowest yield was obtained in the seeds of *S. halophila* (11.9%) and the highest content was encountered in the seeds of *S. tomentosa* (27.7%). The ratio of unsaturated fatty acids to the saturated (U/S ratio) ranged between 2.4 to 7.4.

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TABLE 1. Seed Oil Yields and Collection Sites of *Salvia* species

Species	Collection Area	Oil yield, %
S. albimaculata	Icel: Ermenek to Tekecati, Yumrutepe, 1400 m	3.2
S. candidissima	Eskisehir: Bozdag, 15 km	5.6
S. cedronella	Denizli: Acipayam	3.0
S. cryptantha	Eskisehir	4.7
S. forskahlei	Samsun: Sinop highway near Taflan, 50 km	2.7
S. fruticosa	Aegean region	11.0
S. halophila	Konya: Karakulluk to Eskil, 1 km	20.8
S. hypargeia	Icel: Ermenek-Tekecati, 1500 m	2.0
S. sclarea	Adana (cultivated)	4.0
S. tomentosa	Kutahya: Domanic to Daritepe 6 km, 1275 m	4.6
S. tchihatcheffii	Ankara: Polatli to Sariaba, 720 m	3.9
S. virgata	Kutahya: Eski Karaca village to Domanic	20.9

TABLE 2. Fatty Acid Compositions of 12 *Salvia* species, %

Fatty acids	1	2	3	4	5	6	7	8	9	10	11	12
14:0	0.5	0.3	0.4	0.2	0.3	0.2	0.1	0.1	0.2	0.3	0.4	0.1
15:0	0.1	-	0.2	0.2	0.2	Tr.	Tr.	Tr.	0.1	0.1	-	0.1
16:0	9.7	21.0	15.7	11.8	13.7	12.1	7.4	9.0	11.3	20.9	14.8	13.6
16:1 (7Z)	0.2	-	0.3	0.2	0.3	-	0.1	Tr.	0.2	0.2	-	0.1
16:1 (9Z)	0.2	-	1.0	0.1	0.2	0.2	0.1	0.1	0.1	0.2	-	0.2
17:0	0.1	-	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.2	0.1
18:0	2.4	4.5	3.3	2.8	3.3	5.1	4.2	3.7	4.9	4.9	5.2	5.8
18:1 (9Z)	16.1	21.1	20.5	14.0	9.6	31.0	23.5	20.9	19.4	3.9	22.7	23.6
18:1 (11Z)	0.9	1.0	1.2	1.0	1.5	1.1	1.2	0.9	1.4	1.0	0.7	1.4
18:2	37.2	19.2	49.2	61.1	60.8	47.6	31.4	43.7	18.1	41.0	44.2	44.5
18:3	1.8	20.9	1.8	1.5	2.6	0.6	30.7	19.3	38.6	2.7	1.5	0.4
20:0	0.4	-	0.6	0.9	0.6	0.2	0.1	0.1	0.5	0.7	0.5	0.3
20:1	0.3	-	0.4	0.6	0.3	0.7	0.6	0.5	0.7	0.8	-	0.8
22:0	0.1	-	0.7	0.5	0.3	0.2	Tr.	0.1	0.6	0.5	-	0.1
$\Sigma_{Saturated}$	13.3	25.8	21.1	16.6	18.6	17.9	11.9	13.1	17.8	27.5	21.1	20.1
$\Sigma_{Unsaturated}$	56.7	62.2	74.4	78.5	75.3	81.2	87.6	85.4	78.5	49.8	69.1	71.0
Total	70.0	88.0	95.5	95.1	93.9	99.1	99.5	98.5	96.3	77.3	90.2	91.1
U/S	4.3	2.4	3.5	4.7	4.0	4.5	7.4	6.5	4.3	2.5	3.3	3.5
18:3/18:2	0.05	1.09	0.04	0.02	0.04	0.01	0.97	0.44	2.13	0.07	0.03	0.01

Linoleic acid was the main constituent in the seed oils of *S. albimaculata* (37.2%), *S. cedronella* (49.2%), *S. cryptantha* (61.1%), *S. forskahlei* (60.8%), *S. fruticosa* (47.6%), *S. halophila* (31.4%), *S. hypergeia* (43.7%), *S. tomentosa* (41.0%), *S. tchihatcheffii* (44.2%), and *S. virgata* (44.5%). In the seed oil of *S. candidissima*, oleic acid (21.1%) was the main component followed by palmitic (21.0%), linolenic (20.9%) and linoleic (19.2%). The seed oil of *S. sclarea* contained linolenic acid (38.6%) as the main fatty acid constituent followed by oliec (19.4%) linoleic acid (18.1%).

The genus *Salvia* belongs to the *Nepetoideae* subfamily of the family *Lamiaceae*. The family has been characterized by the occurrence of linolenic, linoleic, and oleic acids in their seed oils. Our results are in accordance with the previous results. Similarly, the occurrence of a high percentage of unsaturated fatty acids was also reported previously as characteristic to the family *Lamiaceae* [19].

This is the first study of the seed oils of *Salvia* species apart from *S. sclarea*. Therefore, a comparison with the previously published data has not been possible. However, in general, our results agree with those of the previously published studies on other members of the family *Lamiaceae* [19].

EXPERIMENTAL

Plant Material. Twelve *Salvia* species were collected from different regions of Turkey in order to determine the fatty acid compositions of their seed oils. The sampling localities and *Salvia* species used in this study are given in Table 1. Voucher specimens are kept at the Herbarium of the Faculty of Pharmacy of Anadolu University, Eskisehir, Turkey.

Extraction and Preparation of Fatty Acids. Seeds were separated from plant material and the purity of the seeds was checked under a stereomicroscope, then crushed in a mortar. Seed oil was extracted with *n*-hexane for 6 hours using a 25 mL capacity Soxhlet apparatus, the solvent was evaporated under reduced pressure using a rotary evaporator at 40°C, and the residue was refluxed with 5 mL of 0.5 N sodium hydroxide solution in methanol for 10 min. Then, 5 mL of 14% BF_3 in methanol solution was added through the condenser and boiled for a further 2 min. The solution was cooled and 5 mL of saturated NaCl solution was added and flask was rotated very gently several times. Additional saturated NaCl solution was added to float the heptane solution into the neck of a 1 mL flask and the upper heptane solution was transferred into a test tube and dried with anhydrous Na_2SO_4. The fatty acid methyl esters were recovered after the removal of solvent under a stream of nitrogen [20]. The fatty acid compositions of the seed oils were determined by GC/MS. Relative percentage amounts of the separated compounds were calculated from total ion chromatograms by a computerized integrator. The mass spectra were also compared with those of reference compounds and confirmed with the aid of retention indices from published sources.

Gas Chromatography/Mass Spectrometry (GC/MS). A Hewlett Packard GCD system with an HP-Innowax fused silica capillary column (60 m × 0.25 f, 0.25 mm) was used with helium as carrier gas (flow rate 1 mL/min). MS were taken at 70 eV. The injection temperature was 250°C and the oven temperature was kept at 60°C for 10 min and programmed to 220°C at a rate of 4°C/min and kept at 220°C for 10 min, then increased to 240°C at a rate of 1°C/min. The split ratio was adjusted to 1:50 and the injection volume was 1 mL. The in-house Baser Library of Essential oil Constituents as well as commercial libraries such as the Wiley-NBS and Mass Finder were used for characterization of the components.

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