*Chemistry of Natural Compounds, Vol. 46, No. 4, 2010*

## BRIEF COMMUNICATIONS

# A COMPARATIVE STUDY OF THE FATTY ACID COMPOSITION AND LIPID CONTENT OF *Salvia sclarea*

**Y. Kara,[1] A. Kocak,[1*] O. B. Citil,[2] and E. Tulukcu[3]**

UDC 547.915:543.544

*Salvia sclarea* L. genus comprises herbaceous, suffructicous, or shrubby perennials, rarely biennial or annual, often strongly aromatic plants. Approximately 900 common *Salvia* species have been recorded throughout the world. The plant grows mainly in mild and hot climates [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 all parts and the whole plant [2]. Some members of this genus are important since they have antibacterial [3], antitumor [4], and antituberculosis activities [5].

*Salvia* is widespread in Turkey, especially in Central Anatolia. According to literature information, the fatty acid compositions of each part of *Salvia* have not been sufficiently investigated. The aim of this study is to determine the fatty acid compositions and ω6/ω3 ratios of *Salvia* grown in Cumra, and to compare each part.

Lipid contents for aerial parts and the whole plant are given in Table 1. The highest percentage of lipid content is 29.38% in seed and the lowest 6.26% in the whole plant. Goren et al. found that the percentage of oil content in the seed of approximately 25 *Salvia* species was 2.0–27.1% [6].

The fatty acid compositions of parts of *Salvia* are presented in Table 2. We identified 32 fatty acids for *Salvia* and evaluated their compositions for each part. The highest fatty acid ratios are as follows; linolenic acid 18:3ω3 (52.03%) in seed, oleic acid 18:1ω9 (22.25%) in seed, palmitic acid 16:0 (16.06%) in leaf, linoleic acid 18:2ω6 (15.83%) in seed, and stearic acid 18:0 (9.07%) in the whole plant. Linolenic and palmitic acids are the most abundant unsaturated and saturated fatty acids in all parts, respectively. The total SFA (saturated fatty acid) composition of the studied species is between 8.60–28.36%, while the PUFA (polyunsaturated fatty acid) composition is 53.41–68.97%.

Palmitic acid is mostly found in leaf and is the major SFA, contributing approximately 41.07–72.56% to the total SFA content. The level of MUFA (monounsaturated fatty acid) depends on the level of oleic acid. The greatest proportion of oleic acid is found in seed oil. Azcan et al. found similar results for other *Salvia* species in seed [2]. EC reported that erucic acid 22:1ω9 in vegetable oils must have a maximum value of 5.0% for human health [7]. In this study, erucic acid was found to be between 0.08 and 4.19% in all parts.

The long-chain ω3 and ω6 fatty acids are commonly called PUFAs. Long-chain ω3 PUFAs cannot be readily synthesized by the human body and are mostly obtained through the diet, and ratios of ω3/ω6 are considered to be important [8–10]. Dyerberg noted that an increase in the ratio of ω3/ω6 PUFA increased the availability of ω3 PUFAs, which are beneficial for human health [11]. The lowest linoleic acid content (5.78%) is found to be in leaf. UFAs (unsaturated fatty acid) constitute a significant component 67.78–91.38% in all parts. Crop with a high ratio of UFAs is desirable for human nutrition [12]. In the report of HMSO, it was suggested that the minimum ratio of PUFA/SFA should be 0.45 [13]. In this study, this ratio is found to be a minimum of 1.88% in leaf. Nutritionists have suggested that ω3 fatty acids should be present in higher amounts in human diet. Therefore, they reported that the ω6/ω3 ratio had to be below 4.0 for human health [13]. In the present study, the ω6/ω3 ratio is found to be a maximum of 0.49% in flower.

1) Department of Chemistry, Faculty of Science, Selcuk University, 42075 Konya, Turkey, fax: +903322410106, e-mail: akocak42@gmail.com; 2) Department of Animal Nutrition and Nutritional Disorders, Faculty of Veterinary Medicine, Selcuk University, 42075 Konya, Turkey; 3) Technical Vocational School of Higher Education, Program of Medical Aromatic Plants, Selcuk University, 42500 Konya, Turkey. Published in Khimiya Prirodnykh Soedinenii, No. 4, pp. 516–518, July–August, 2010. Original article submitted January 20, 2009.

 0009-3130/10/4604-0612 

TABLE 1. Lipid Contents of *Salvia sclarea*

| Parts of *Salvia sclarea* | Lipids, % wet weight basis | Parts of *Salvia sclarea* | Lipids, % wet weight basis |
|---|---|---|---|
| Leaf | 9.42 | Seed | 29.38 |
| Flower | 7.04 | Total* | 6.26 |

*Total is the lipid content of the whole plant.

TABLE 2. Aerial Part Variations of Total Fatty Acid Composition of *Salvia sclarea*

| Fatty acids | Leaf | Flower | Seed | Total |
|---|---|---|---|---|
| 8:0** | 0.00±0.00 | 0.00±0.00 | 0.01±0.01 | 0.00±0.00 |
| 9:0 | 0.00±0.00$^{c}$ | 0.27±0.20$^{a}$ | 0.00±0.00$^{c}$ | 0.15±0.15$^{b}$ |
| 10:0 | 0.00±0.00$^{b}$ | 0.06±0.04$^{a}$ | 0.00±0.00$^{b}$ | 0.06±0.07$^{a}$ |
| 11:0 | 0.00±0.00$^{b}$ | 0.09±0.09$^{a}$ | 0.00±0.00$^{b}$ | 0.05±0.06$^{a}$ |
| 12:0 | 0.09±0.04$^{a}$ | 0.03±0.02$^{b}$ | 0.00±0.00$^{c}$ | 0.08±0.04$^{a}$ |
| 13:0 | 0.36±0.18$^{a}$ | 0.04±0.04$^{b}$ | 0.05±0.01$^{b}$ | 0.16±0.16$^{b}$ |
| 14:0 | 4.83±2.89$^{a}$ | 0.86±0.60$^{b}$ | 0.02±0.01$^{b}$ | 4.11±2.93$^{a}$ |
| 15:0 | 0.64±0.20$^{a}$ | 0.10+0.12$^{c}$ | 0.00±0.00$^{c}$ | 0.37±0.25$^{b}$ |
| 16:0 | 16.06±2.15$^{a}$ | 11.37±4.93$^{b}$ | 6.24±0.26$^{c}$ | 11.40±4.85$^{b}$ |
| 17:0* | 1.01±0.39$^{a}$ | 0.63±0.86$^{ab}$ | 0.05±0.03$^{b}$ | 1.17±0.87$^{a}$ |
| 18:0 | 5.37±0.41$^{b}$ | 6.48±0.67$^{b}$ | 1.86±0.09$^{c}$ | 9.07±3.51$^{a}$ |
| 20:0** | 0.00±0.00 | 0.00±0.00 | 0.00±0.01 | 0.00±0.00 |
| 21:0* | 0.00±0.00$^{b}$ | 0.71±0.81$^{ab}$ | 0.13±0.03$^{b}$ | 1.14±1.23$^{a}$ |
| 24:0 | 0.00±0.00$^{b}$ | 0.00±0.00$^{b}$ | 0.24±0.08$^{a}$ | 0.00±0.00$^{b}$ |
| ∑SFA | 28.36 | 20.64 | 8.60 | 27.76 |
| 14:1 ω5 | 0.44±0.14$^{a}$ | 0.03±0.02$^{c}$ | 0.01±0.01$^{c}$ | 0.18±0.20$^{b}$ |
| 16:1 ω7* | 0.30±0.10$^{ab}$ | 0.20±0.30$^{bc}$ | 0.07±0.03$^{c}$ | 0.44±0.33$^{a}$ |
| 18:1 ω9 | 5.89±2.01$^{c}$ | 10.01±3.78$^{b}$ | 22.25±1.86$^{a}$ | 9.16±3.28$^{b}$ |
| 20:1 ω9 | 4.60±1.33$^{a}$ | 0.60±0.16$^{c}$ | 0.00±0.00$^{c}$ | 2.55±2.09$^{b}$ |
| 22:1 ω9 | 0.52±0.44$^{bc}$ | 4.19±2.51$^{a}$ | 0.08±0.05$^{c}$ | 2.09±2.25$^{b}$ |
| 24:1 ω9 | 2.62±1.66$^{a}$ | 1.30±0.30$^{b}$ | 0.00±0.01$^{c}$ | 2.21±1.06$^{ab}$ |
| ∑MUFA | 14.37 | 16.33 | 22.41 | 16.63 |
| 16:2 ω4** | 0.00±0.00 | 0.00±0.00 | 0.00±0.05 | 0.03±0.05 |
| 18:2 ω6 | 5.78±1.58$^{c}$ | 8.49±4.03$^{b}$ | 15.83±0.73$^{a}$ | 7.89±2.79$^{bc}$ |
| 18:3 ω3 | 33.35±1.50$^{b}$ | 29.37±1.52$^{b}$ | 52.03±2.23$^{a}$ | 28.45±9.65$^{b}$ |
| 20:2 ω6 | 0.00±0.00$^{b}$ | 0.00±0.00$^{b}$ | 0.08±0.03$^{a}$ | 0.00±0.00$^{b}$ |
| 20:3 ω6 | 4.23±0.77$^{b}$ | 8.21±4.96$^{a}$ | 0.21±0.08$^{c}$ | 5.69±3.43$^{ab}$ |
| 20:4 ω6 | 0.00±0.00$^{b}$ | 0.00±0.00$^{b}$ | 0.10±0.04$^{a}$ | 0.00±0.00$^{b}$ |
| 20:5 ω3 | 0.91±0.24$^{b}$ | 3.66±3.32$^{a}$ | 0.05±0.04$^{b}$ | 3.23±2.44$^{a}$ |
| 22:2 ω6* | 1.62±0.84$^{a}$ | 1.43±1.40$^{a}$ | 0.25±0.06$^{b}$ | 1.02±1.14$^{ab}$ |
| 22:3 ω3** | 0.00±0.00 | 0.38±0.52 | 0.19±0.07 | 0.13±0.25 |
| 22:4 ω6 | 0.99±0.15$^{b}$ | 2.46±0.56$^{a}$ | 0.02±0.07$^{c}$ | 1.26±0.96$^{b}$ |
| 22:5 ω3 | 6.24±0.09$^{a}$ | 8.69±4.05$^{a}$ | 0.07±0.03$^{b}$ | 6.61±3.03$^{a}$ |
| 22:6 ω3** | 0.29±0.59 | 0.34±0.17 | 0.14±0.03 | 0.26±0.22 |
| ∑PUFA | 53.41 | 63.03 | 68.97 | 54.57 |
| Unknown | 3.86 | – | 0.02 | 1.04 |
| ∑ω3 | 40.79 | 42.44 | 52.48 | 38.68 |
| ∑ω6 | 12.62 | 20.59 | 16.49 | 15.86 |
| ∑ω3/ω6 | 3.23 | 2.06 | 3.18 | 2.44 |
| ∑ω6/ω3 | 0.31 | 0.49 | 0.31 | 0.41 |

The highest value in the same line is denoted by a, the lowest value is denoted by c, and the value between a and c is denoted by b. If the value is denoted ab (or bc), it is found in the range of a and b (or b and c). $P < 0.01$; *$P < 0.05$, **insignificant. Total is the lipid content of the whole plant.

The town of Cumra is located at between 33–34 north altitude and 37–38 east longitude with a surface area of 2320 $km^2$. Cumra is where the first irrigation projects (Konya Plain Project) were applied. The study area is about 47 km from the center of Konya. The Toros mountains start 20 km away from the south of Cumra, which yields a total area of 1085.6 $km^2$. Nine *Salvia* plant samples were collected from different areas of Cumra in order to determine the fatty acid compositions for leaf, flower, seed, and the whole plant. The samples were taken by cutting at a height of 10 cm above the soil level, cleaned with water, dried in a shaded area, and powdered. All the reagents were analytical grade and used without further purification.

**Lipid Content**. Each powdered part (5 g) was extracted using a Soxhlet apparatus with diethyl ether for 6 hours. After completing the extraction, the solvent was evaporated under reduced pressure. Then, the lipid content of each part was determined according to previously reported method [14].

**Fatty Acid Analysis**. The each part (about 5 g) was extracted with chloroform–methanol mixture (2:1, v/v) [15]. The fatty acids were converted to their methyl esters using the standard boron trifluoride-methanol method [16]. The resultant fatty acid methyl esters were separated and stored at –20°C. At the beginning of each analysis, the samples were allowed to equilibrate to room temperature and analyzed by gas liquid chromatography (Shimadzu 15-A), equipped with a dual flame ionization detector and a 1.8 m × 3 mm internal diameter packed glass column containing GP 10 % SP-2330 on 100/120 Chromosorb WAW, Cat. No: 11851. Column temperature was 190°C for 31 min, which then rose progressively at 30°C/min up to 220°C, where it was maintained for 10 min at 220°C. Carrier gas was nitrogen (2 mL/min). The injector and detector temperatures were 225 and 245°C, respectively. Conditions were chosen to separate fatty acids of carbon chain length from 8 to 24. The fatty acids were identified by comparison of their retention times with known external standard mixtures (Alltech) and quantified by a Shimadzu C-R4A integrator, and the results were expressed as percentage distribution of fatty acid methyl esters. Each of the experiments was repeated three times.

**Statistical Analysis**. Nine plant samples were analyzed for each part of *Salvia*, and each part was analyzed in triplicate. The average results of peak area are expressed as means ± SD. The statistical analysis of the percentages of fatty acid was tested by analysis of variance (ANOVA), and comparisons between mean values were performed using Duncan′s test. Differences between means were reported as significant if $P < 0.05$.

## ACKNOWLEDGMENT

This study was financed by Selcuk University Scientific Research Foundation (SUBAP: 06201038).

## REFERENCES

1. F. Senatore, N. A. Arnold, F. Piozzi, and C. Formisano, *J. Chromatogr. A,* **1108**, 276 (2006).
2. N. Azcan, A. Ertan, B. Demirci, and K. H. C. Baser, *Chem. Nat. Comp.,* **40**, 218 (2004).
3. A. Ulubelen, N. Tan, U. Sonmez, and G. Topcu, *Phytochemistry*, **47**, 899 (1998).
4. G. Topcu, N. Tan, G. Kokdil, and A. Ulubelen, *Phytochemistry*, **45**, 1293 (1997).
5. A. Ulubelen, G. Topcu, and J. Bozok-Johanson, *Nat. Prod.,* **60**, 1275 (1997).
6. A. C. Goren, T. Kilic, T. Dirmenci, and G. Bilsel, *Biochem. Syst. Ecol.,* **34**, 160 (2006).
7. EC, 1980. Council Directive 80/891/EEC, Official Journal L, p. 254.
8. C. Alasalvar, K. D. A. Taylor, E. Zubcov, F. Shahidi, and M. Alexis, *Food. Chem.,* **79**, 145 (2002).
9. G. J. M. Coetzee and L. C. Hoffman, *S. Afr. J. Anim. Sci.,* **32**, 175 (2002).
10. G. M. Pigott and B. W. Tucker, *Food. Rev. Int.,* **3**, 105 (1987).
11. J. Dyerberg, *Nutr. Rev.,* **44**, 125 (1986).
12. J. L. Guil-Guerrero and I. Rodriguez-Garcia, *Eur. Food. Res. Technol.,* **209**, 313 (1999).
13. HMSO, UK, 1994. Nutritional Aspects of Cardiovascular Disease (report on health and social subjects No. 46) London.
14. AOAC, 1990, *Official Method of Analysis*, 15th Ed., Assoc. Off. Analyt. Chemists, Arlington, VA, USA.
15. J. Folch, M. Lees, and G. H. Sloane Stanley, *J. Biol. Chem.,* **226**, 497 (1957).
16. C. W. Moss, M. A. Lambert, and W. H. Merwin, *Appl. Microbiol.,* **28**, 80 (1974).