Fatty acid composition of stems, leaves, flowers, and seeds of some medicinal plants

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Medicinal plant species are economically important and have many uses. In this research, the stem, leaves, flowers, and seeds of some medicinal plant species such as *Lavandula intermedia, Satureja hortensis* and *Ocimum basilicum* were analysed. The fatty acid compositions of these three different species were determined by gas chromatography of methyl esters of fatty acids. The stem, leaf, flower, and seed oils of *L. intermedia* contain 44.72%, 45.11%, 29.89% and 8.55% palmitic acid and 16.18%, 23.21%, 34.76% and 39.76% linolenic acid, respectively, as the main component fatty acids, while the stem, leaf, flower and seed oils of *S. hortensis* contain 23.11%, 11.76%, 13.32% and 6.26% palmitic acid and 31.70%, 51.74%, 47.97% and 43.79% linolenic acid, respectively, as main component fatty acids. On the other hand, stem, leaf, flower, and seed oils of *O. basilicum* contain 44.72%, 45.11%, 29.89% and 8.55% palmitic acid and linolenic acid 16.18%, 23.21%, 34.76% and 39.76%, respectively, as main component fatty acids.

Keywords: *Satureja hortensis*, *Ocimum* basilicum, *Lavandula intermedia*, aerial parts, fatty acid

1. INTRODUCTION

The physical and chemical properties of the oils contained in the plants determine the composition of the fatty acids they contain. The fatty acid compositions of plants are constantly changing depending on many factors. The quality of the oil, its nutritional and processing values are largely dependent on its fatty acid composition. Knowing the fatty acid compositions of plants enables the production of oils according to their intended use [1]. The oils contained in the plants are not only a high energy source, but also have very important roles in nutrition and health depending on the properties of fatty acids. It is known that saturated fatty acids cause cardiovascular diseases and weight gain, while unsaturated fatty acids generally have positive effects on human health [2].

Medicinal and aromatic plants are widely used in these areas due to their potential to be a vegetable oil, functional food, drug active ingredient and cosmetic product. Among the medicinal and aromatic plants, lavender, thyme, and basil are from the Lamiaceae family and are among the plants used for these purposes [3]. Several studies have reported the fatty acids composition of some medicinal plant of Lamiaceae family such as: *Satureja*, *Thymus* and *Origanum* [4], *Salvia taxa* [5, 6, 7], *Ocimum basilicum* [8], *Lavandula* and *Salvia* [9]. The aim of this study was to determine the fatty acid composition of stems, leaves, flowers, and seeds of some medicinal plants in the eastern region of Anatolia. This is the first study to analyse four different parts of three different plants for fatty acids in Turkey, therefore it has an original value.

2. MATERIALS AND METHODS

2.1. PLANT MATERIAL

L. intermedia was planted at a 100 cm distance between rows and a 40 cm distance between rows in 1 da on 2nd June 2020, *S. hortensis* was cultivated at a 40 cm distance row and 20 cm distance row in 1 da on 8th May 2020, and *O. basilicum* was planted at a 40 cm distance row and 40 cm distance row in 1 da on 22nd May 2021. In the flowering stage of each of the three mentioned plants the stems, leaves, flowers, and seeds were gathered collected from bee pasture in the Bingol province of Turkey between June and September 2021 after a sufficient maturity of plant seeds and prepared for analysis.

2.2. METHODS

2.2.1. Oil extraction and fatty acid methylation

Oil of the dried sample and derivatisation of fatty acids were extracted by revising the method of Hara and Radin (1978). At first, one g of plant samples was weighed. 5 ml of hexane/isopropanol (3:2) was added and vortexed. Then it was centrifuged at 4500 rpm for 10 minutes, and the upper part of the obtained material was filtered and transferred to test tubes and vortexed by adding 2.5 ml of 2% methanolic sulfuric acid. This mixture was kept at 50°C for 15 hours for methylation to occur, and after 15 hours, the tubes were removed and cooled at room temperature, and 2.5 ml of 5% NaCl was added and vortexed. In the next step, the fatty acid methyl esters formed in the tubes were extracted with 2.5 ml of hexane and the hexane phase was taken from the top with a Pasteur pipette and treated with 2.5 ml of 2% Na2CO3. After the above phase, the obtained material was taken and placed in test tubes, the mixture containing methyl esters was evaporated by nitrogen at 45°C. This procedure was carried out in three replications on all three plant materials. Finally, the fatty acids in test tubes were dissolved with 1 ml of hexane and taken into vials and stored in the GC-MS device.

2.2.2. Fatty acid and analysis

Extracted oil of the dried sample and derivatisation of fatty acids were separated and quantified by gas chromatography and flame ionisation detection (Agilent brand 7890A model GC, 5975C model MS) coupled to a glass GC 10 software computing recorder in three replications. Chromatography was performed with a capillary column (60 m × 250 µm × 0.15 µm, J&W 122-7061) using nitrogen as a carrier gas (flow rate 34 ml/min). Chromatographic conditions: it started at 50°C, where it stood for 2 minutes and reached 200°C at a rate of 20°C/min and then accelerated to 230°C at 5°C /min where it stood for 30 minutes. Total analysis time was 55.5 min. MS results were determined by comparing the Whaley and NIST libraries in the device's memory.

3. RESULTS AND DISCUSSION

The stem, leaves, flowers, and seeds of some medicinal plants contain palmitic and stearic acids as the major component fatty acids, among the saturated acids, with small amounts of lauric, myristic, pentadecanoic, margaric, arachidic, heneicosanoic, behenic, tricosanoic, and lignoceric acids. The major unsaturated fatty acids found in the stem, leaves, flowers, and seeds of some medicinal plant oils were oleic, linoleic and liolenic acids. Pentadecenoic, hexadecatrienoic, margoleic, eicosenoic, eicosapentaoic, and docosaenoic acids were below 1%.

In this study, the average of total saturated fatty acids of the stem, leaves, flowers, and seeds of three medicinal plants were between 10.08 and 69.55% in three replications, while the average amount of total unsaturated fatty acids were between 30.45 and 89.92% in three replications. In all three plants, the highest saturated fatty acids were obtained from the plant stems, while the lowest saturated fatty acids were obtained from the plant seeds. Total percentage of saturated fatty acid of stem, leaf, flower, and seed of lavender were 69.55, 64.03, 45.77 and 10.08 respectively. Also, the total percentage of unsaturated fatty acid of lavender stem, leaf, flower, and seed were 30.45, 35.97, 54.23 and 89.92 respectively. Total percentage of saturated fatty acid of stem, leaf, flower, and seed of thyme were 41.71,16.24,18.22 and 11.68, respectively. Also, the total percentage of unsaturated fatty acid of thyme stem, leaf, flower, and seed were 58.29, 83.76, 81.78 and 88.34 respectively. Total percentage of saturated fatty acid of stem, leaf, flower, and seed of basil were 53.31, 38.12, 39.35 and 20.23 respectively. Also, the total percentage of unsaturated fatty acid of basil stem, leaf, flower, and seed were 46.69, 61.87, 60.65 and 79.79, respectively (Tab. I).

According to this study lauric acid was detected only in the leaves and stems of thyme and in the leaves of basil at a rate of 3.77%, 0.05% and 0.20%, respectively. Myristic acid obtained from stems, leaves, flowers, and seeds of some medicinal plants varied between 0.07% and 4.33%. The highest myristic acid was detected in lavender leaves, while the lowest myristic acid was detected in thyme seeds. Pentadecanoic acid was detected in other plant parts of thyme, lavender, and basil, except for the stem of thyme, stem, and leaves of basil, and varied between 0.03% and 0.53%. While some researchers have reported that lauric, myristic and pentadecanoic acids in Thymus capitatus were 0.703, 0.100 respectively [7], some researchers reported that lauric, myristic and pentadecanoic acids in some Lamiaceae taxa leaves were 0.05-0.14%, 0.23-1.46% and 0.17-0.59%, respectively [4]. In a study conducted in Pakistan, lauric acid was 0.85% and myristic acid was 0.36% in basil seeds [12]. In a study conducted in Tunisia, it was reported that myristic acid in basil leaves varied between 0.1-0.2% [8]. On the other hand, in a

Table I - Fatty acids of the stem, leaves, flowers and seeds of some medicinal plants

	Lavender					Thyme					Basil			
	Stem	**Leaf**	**Flower**	**Seed**		**Stem**	**Leaf**	**Flower**	**Seed**		**Stem**	**Leaf**	**Flower**	**Seed**
C 12:0	-	-	-	-		3.77	0.05	-	-		-	0.20	-	-
C 14:0	4.33	2.73	1.41	0.21		0.58	0.49	0.49	0.07		0.75	2.27	1.24	0.20
C 15:0	0.53	0.52	0.47	0.04		-	0.06	0.11	0.03		-	-	0.51	0.04
C 16:0	44.72	45.11	29.89	8.55		23.11	11.76	13.32	6.26		36.28	25.37	24.69	10.54
C 17:0	0.42	0.46	0.98	0.32		-	0.39	0.49	0.22		-	0.32	1.85	0.26
C 18:0	17.54	14.13	10.50	0.02		9.73	2.92	3.18	4.74		14.41	6.41	7.35	8.24
C 20:0	1.15	1.08	1.47	0.33		1.24	0.40	0.40	0.18		1.87	2.68	2.85	0.49
C 21:0	-	-	0.23	0.24		-	-	-	-		-	-	-	0.15
C 22:0	0.86	-	0.49	0.13		3.28	0.17	0.23	0.07		-	0.87	0.86	0.15
C 23:0	-	-	-	0.13		-	-	-	0.05		-	-	-	0.07
C 24:0	-	-	0.33	0.11		-	-	-	0.06		-	-	-	0.09
∑TSFA	**69.55**	**64.03**	**45.77**	**10.08**		**41.71**	**16.24**	**18.22**	**11.68**		**53.31**	**38.12**	**39.35**	**20.23**
C 15:1	-	-	-	-		-	-	-	0.02		-	-	-	-
C 16:1	1.35	1.41	0.74	0.61		-	0.36	0.46	0.17		-	1.88	0.38	0.65
C 16:3	-	-	-	0.02		-	-	-	-		-	-	-	-
C 17:1	-	-	-	0.04		-	-	-	0.02		-	-	-	0.02
C 18:1	7.35	6.12	8.72	24.41		7.49	8.37	7.98	11.46		6.84	6.41	6.21	14.07
C 18:2	5.57	5.23	10.01	18.76		19.10	23.04	22.60	27.40		15.11	9.91	19.92	23.02
C 18:3	16.18	23.21	34.76	39.76		31.70	51.74	47.97	43.79		24.74	43.68	33.74	36.43
C 20:1	-	-	-	0.56		-	0.10	-	0.22		-	-	0.40	0.15
C 20:2	-	-	-	-		-	0.05	-	0.14		-	-	-	-
C 20:3	-	-	-	5.70		-	0.10	2.77	5.08		-	-	-	5.41
C 22:1	-	-	-	0.06		-	-	-	0.02		-	-	-	0.02
∑TUSFA	**30.45**	**35.97**	**54.23**	**89.92**		**58.29**	**83.76**	**81.78**	**88.34**		**46.69**	**61.87**	**60.65**	**79.79**

C12:0 Lauric acid; C14:0 Myristic acid; C15:0 Pentadecanoic acid; C15:1 Pentadecenoic acid; C16:0 Palmitic acid; C16:1 Palmitoleic acid; C16:3 Hexadecatrienoic acid; C17:0: Margaric acid; C17:1 Margoleic acid; C18:0: Stearic acid; C18:1 Oleic acid; C18:2 Linoleic acid; C18:3 Linolenic acid; C20:0 Arachidic acid; C20:1 Eicosenoic acid; C20:2 Eicosapentaoic acid; C20:3 Eicosatrienoic acid; C21:0 Heneicosanoic acid; C22:0 Behenic acid; C22:1 Docosaenoic acid; C23:0 Tricosanoic acid; C24:0: Lignoceric acid; TSFA: Total saturated fatty acid; TUSFA: Total unsaturated fatty acid

study conducted in Sudan, myristic acid was found to be 0.11% and pentadecanoic acid was 0.04% in basil seeds [13].

Palmitic, stearic and arachidic acids, among the saturated fatty acids, were between 6.26-45.11%, 0.02-17.54% and 0.18-2.85%, respectively. The highest palmitic acid was obtained in the lavender leaf, the highest stearic acid was obtained in the lavender stem, and the highest arachidic acid was obtained in the basil flower. On the other hand, the lowest palmitic and arachidic acids were obtained in the thyme seeds, while the lowest stearic acid was detected in the lavender seeds. In a study on the chemical composition of some plants, palmitic and stearic acids of thyme were 2.91% and 0.77%, respectively, while palmitic and stearic acids of lavender were 5.83% and 1.53%, respectively [14]. In a study conducted to determine the fatty acid profiles of some *L.* species, it was reported that palmitic acid varied between 4.3-5.4%, stearic acid between 1.2-1.6% and arachidic acid between 0.1-0.2% [15]. While some researchers determined palmitic, stearic and archidic acids in basil leaves as 01.-0.2, 2.0-2.8 and 0.5-0.6%, respectively [8], some researchers found the same fatty acids in thyme as 1.196, 0.832 respectively [7]. On the other hand, in studies on basil seeds, palmitic, stearic and arachidic acids were reported as 6.8-8.8, 2.0-2.8 and 0.2% in Canada [16], 8.0-9.2, 3.6-3.8 and 0.2-0.3% in India [17], 1.6-7.5, 0.7-3.8 and 0.3% in Malaysia [18], 4.9, 2.5 and 0.25% in Iran [19]. Palmitic and stearic acids of basil were determined as 5-13% and 2-3% [20], and as 13.38% and 6.55% in Sudan [13], as 9.70% and 5.45% in Pakistan [12], and 6.23-10.16% and 2.97-4.88% in Iran [21]. It was reported that palmitic, stearic and arachidic acids of some Lamiaceae taxa were determined as 13.49-27.71%, 1.26-3.99% and 0.66-3.20%, respectively [4].

Margaric acid was detected in other plant parts of thyme, lavender, and basil except the stems of thyme and basil, while behenic acid was seen in other plant parts of thyme, lavender and basil except lavender leaves and basil stems. While the highest margaric acid observed in the flower of thyme with 1.85%, the highest behenic acid was detected in the leaf of basil with 0.87%, the lowest margaric and behenic acids were obtained in the seeds of thyme with 0.27% and 0.07%, respectively. Margaric and behenic acids were 0.015 and 0.002 g/kg of essential oil, respectively, in *Thymus capitatus* [7], while margaric and behenic acids were 0.65% and 0.17%, respectively, in *O. basilicum* seeds [13]. On the other hand, margaric and behenic acids of some Lamiaceae taxa were determined as 0.26-0.47% and 12.39-18.55%, respectively [4].

Heneicosanoic acid was detected only in lavender flowers and seeds and basil seeds, lignoceric acid in lavender, thyme and basil seeds and lavender flower, and tricosanoic acid only in lavender, thyme, and basil seeds. In the study examining the fatty acid profile of *Thymus capitatus*, lignoceric acid was 0.001 g/kg of essential oil [7], while in the study examining the fatty acid composition in *O. basilicum* seeds, heneicosanoic, tricosanoic and lignoceric acids it was 0.14%, 0.07% and 0.13%, respectively [13].

Pentadecenoic acid was found only in thyme seeds, while hexadecatrienoic acid was detected only in lavender seeds. On the other hand, margoleic acid exıstedonly in lavender, thyme, and basil seeds. It was reported that pentadecenoic acid of *Origanum* species was determined at 0.10-0.18% [4]. Palmitoleic acid was in other plant parts of lavender, thyme, and basil, except for the stems of thyme and basil, and varied between 0.17% and 1.88%. Palmitoleic acid was determined at 0.2-0.3% in basil seeds [16], 0.1-0.4% in some *L.* species [15], 0.4-0.5% in basil leaves [8], 0.2% in herb and seed of *O. basilicum* [17], 0.1% in seeds of *O. basilicum* [18], 0.30-1.70% in some Lamiaceae taxa [4], 0.07% in basil seeds [19], 0.022 g/kg of essential oil in *Thymus capitatus* [7] and 0.78% in *O. basilicum* seeds [13].

The main unsaturated acids in the oils of stems, leaves, flowers, and seeds of some medicinal plants are oleic, linoleic, and linolenic acids. The highest oleic acid content was in lavender seeds (24.41%) and the lowest in lavender leaves (6.12%). Linolenic acid was richer than linoleic acid in the oils of stems, leaves, flowers, and seeds of all medicinal plants. Linoleic acid was in the highest concentrations in the leaf, flower, and seed oil of thyme. The linoleic acid content was highest in the seeds of thyme (27.40%) but lowest in the leaves of lavender (5.23%). Linolenic acid was detected in low levels in the stems of lavender (16.18%). The linolenic acid content was highest in the leaves of thyme (51.74%).

According to a study on the fatty acid concentrations of the above-ground part of *Thymus capitatus*, fifteen fatty acids constituting 95.0% of the lipid content were identified and the two main fatty acid components reported, were linolenic (29.6%) and linoleic (15.1%) acids [22]. It has been reported that the main fatty acid composition of basil species is stearic acid, oleic acid, palmitic acid, linoleic acid, myristic acid, linolenic acid, carpic acid, lauric acid and arachidonic acid [23]. Oleic, linoleic and linolenic acids were determined as 8.7-11.6, 18.3-21.7 and 57.4-62.5% in basil seeds [16], as 4.37, 8.83 and 13.55% in lavender leaves, 4.33, 7.36 and 9.87% in thyme leaves [14], as 8.6-14.2, 9.5-16.5 and 64.9-73.0% in some *L.* species [15], as 6.0-10.0, 12.0-32.0 and 49.0-62.0% in fourteen basil accessions [20], as 13.33, 32.18 and 48.50% in basil seeds [12], as 1.4-2.0, 9.7-9.9 and 66.6-69.0% in *O. basilicum* leaves [8], as 10.3-12.3, 23.4-26.0 and 49.3-52.4% in herb and seed of *O. basilicum* [17], as 0.9-11.0, 1.8-19.1 and 6.1-50.1% in *O. basilicum* [18], as 2.50-8.29, 10.85-19.47 and 40.68-56.53% in some Lamiaceae taxa [4], as 7.55, 20.20 and 63.80% in basil seeds [19], as 6.22-19.92,

16.73-24.93 and 42.45%-61.85% in basil seeds [21], as 0.808, 0.231 and 0.094 g/kg of essential oil in *Thymus capitatus* [7], and as 0.01, 32.18 and 43.92% in *O. basilicum* seeds [13].

Eicosenoic acid was detected only in lavender seeds (0.56%) and flowers (0.40%) of and basil seeds (0.15%), thyme seeds (0.22%) and leaves (0.10%). On the other hand, eicosapentaoic acid was only obtained from thyme leaves and seeds. While eicosatrienoic acid was found at high levels in the lavender, thyme, and basil seeds (5.70, 5.08 and 5.41%, respectively), it was detected at a low rate in thyme leaves (0.10%) and flowers (2.77%). Docosaenoic acid was detected only at a very low rate in lavender (0.06%), basil (0.02%) and thyme (0.02%) seeds. While eicosenoic, eicosapentaoic and heneicosanoic acids were 0.036, 0.037 and 0.007 g/kg of essential oil in *Thymus capitatus*, respectively [7], eicosenoic acid was 0.2-0.4% in some *L.* species [13] and as 0.27% in basil seeds [13].

4. CONCLUSION

In this study, the fatty acid composition of stems, leaves, flowers, and seeds of three different medicinal plant species was investigated. Among the saturated acids, myristic, palmitic, stearic and arachidic acids were determined as the main component fatty acids. In addition, oleic, linoleic, and linolenic acids were found as the main unsaturated fatty acids. As a result, there are qualitative and quantitative differences in the fatty acid composition of stem, leaves, flowers, and seeds of medicinal plant species depending on collection time, environmental factors, climatic factors, genetics, season, analysed plant part, analytical methods.

Conflict of interest

The authors declare they have no conflict of interest.

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