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Determination of Essential Oil Yields and Composition Lavender and Lavandin Cultivars (*Lavandula sp.*) Cultivated in Tuzlukçu, Konya

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HIGHLIGHTS

- Lavender and lavandin cultivars were compared.
- As Konya and its surroundings are more ecologically arid, the impact of stress conditions on the constituents of lavender species was examined.
- The interpretation of the difference between the ratio of essential oils and the constituents of lavender.

Abstract

Lavender is an important medicinal plant, which used in many fields such as perfumery, cosmetics, medicine, aromatherapy and phytotherapy thanks to its high quality essential oils components. Hemus and Sevtapolis lavender cultivars of Lavandula angustifolia and Super A lavandin of Lavandula x intermedia were used in the study. The lavenders and lavandin were planted in 2022 in Tuzlukçu district of Konya province and harvested in 2023. Essential oils were obtained from the dried flowers of the plant. The essential oil components of the plant materials were measured by GC-MS. The essential oil yield of *Lavandula angustifolia* cv. Hemus was 2.65%, that of *Lavandula angustifolia* cv. Sevtapolis was 2.14% and that of *Lavandula x intermedia* cv. Super A was 7.95%. In the Hemus cultivar of lavender, the concentration of linalyl acetate was 19.76%, linalool was 39.09%, and camphor, an undesired component in lavender essential oil, amounted to 0.41%. Meanwhile, the Sevtapolis cultivars contained 10.64% linalyl acetate, 40.41% linalool and 0.47% camphor. In Lavandin (Super A) cultivar contained 30.39% linalyl acetate, 30.29% linalool, and 6.71% camphor.

Keywords: Lavender, lavandin, essential oil content, essential oil composition

1. Introduction

Lavender (*Lavandula* sp) is a perennial plant that produces essential oil and belongs to the Lamiaceae family. It has a semi-shrub form, grows between 20 and 60 cm in height and has lilac-blue flowers (Ceylan, 1996; Zeybek and Zeybek, 1994). The plant originates from the Mediterranean and grows naturally in the Balkans, as well as Southern Europe and North Africa, bordering the Mediterranean Sea. There are approximately 39 lavender species (*Lavandula* sp.). The lavender species with commercial value globally are Lavender (*Lavandula angustifolia* Mill. = *L. officinalis* L. = *L. vera* DC), Spike Lavender (*Lavandula spica* = *L. latifolia*

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Medik.), and Lavandin (*Lavandula intermedia* Emeric ex Loisel. = *L. hybrida* L.), known as hybrid and has high essential oil yield (Beetham and Entwistle, 1982).

The essential oil obtained from the flowers of the lavender is used in aromatherapy, perfumes, cosmetics and foods (Ceylan et al., 1996; An et al. 2001; Giray, 2018), calming nerves and reducing insomnia problems (Sönmez et al., 2018) thanks to its beautiful and relaxing scent. Besides, owing to its beautiful flowers, it is used as an ornamental plant in parks and gardens (Zeybek and Zeybek, 1994). In pharmacological studies indicate that lavender essential oil possesses antifungal, anti-inflammatory, antibacterial, antiviral (Kurt and Çankaya, 2021), and antioxidant (Hui et al, 2010) effects.

The flowers are the parts of lavender utilized to extract essential oil. The obtained essential oil from the plant's flowers has a colourless or slightly yellow. The essential oil content of lavender flowers is between 1-3%. The quality and market value of lavender oil depend on the composition of its essential oil, with high amount of linalool and linalyl acetate, and low amount of camphor being crucial for good quality lavender oil. In line with International Organization for Standardization (ISO) standards on lavender essential oil composition (ISO 3515:2002), lavender oil can only be used in the perfume industry if it contains a minimum of 25% linalool and linalyl acetate ratio and less than 0.5% camphor ratio (Anonymous, 2002). Lavender oil with a low camphor content finds its use in the food, cosmetic, and pharmaceutical industries, such as perfume, cream, and cologne. On the other hand, lavender oil with a high camphor content is utilized in the manufacturing of candles, soaps, and insecticides, among other products (Tisserand and Balacs, 1999).

It is widely acknowledged that the composition and yield of essential oil in lavender vary depending on their species and genotype of the plant (Tinmaz et al., 2012) as well as the ecological conditions of the region in which they are cultivated (Kara and Baydar, 2011), the methods used for their cultivation (Arabacı and Bayram, 2005), the parts of the plant used, harvest time, and post-harvest treatments (Arabacı and Ceylan, 1990; Balcı, 2019). The objective of this study was to assess the quality and yield of essential oil derived from lavender species cultivated in the Tuzlukçu district of Konya, in accordance with regional conditions, and to contribute the production of high-quality lavender oil to enhance the national economy.

2. Materials and Methods

2.1. Description of the research location

The study was carried out in the ecological surroundings of Tuzlukçu situated in Konya during 2022-2023. Tuzlukçu district falls in the continental climate zone characterized by warm and mild summers and cold and wet winters. The mean annual temperature equals 11.3 °C and the average annual precipitation stands at 484 mm. The location where the experiment was conducted is situated between 38°47' North latitude and 31°63' East longitude, with an average altitude of 1000 meters. The soil texture class of the test area was identified as clayey-loamy with a slightly alkaline pH of 7.6. Moreover, the soil was found to have a high calcium carbonate content of 29.6% and a moderate amount of soil organic matter at 2.14%. The content of phosphorus is low, whereas the content of potassium, iron, zinc, and copper are medium and sufficient. Additionally, the nitrogen content is also medium and adequate, although the content of manganese is high, and the content of iron is inadequate.

2.2. Plant materials

The lavenders and lavandin used in the study, were 'Hemus' and 'Sevtapolis' lavander cultivars of *Lavandula angustifolia* species and 'Super A' lavandin cultivar of *Lavandula x intermedia* species. Lavender and lavandin seedlings were sown in April 2022. However, in the first year, the lavender and lavandin bloomed less, it achieved its full development in the second year to obtain essential oil. When they reach the full flowering stage, lavender plants were manually harvested in July (4 July 2023) and subsequently transported to the laboratory. The freshly collected flower samples were weighed before being dried in the shade at room temperature for a two-week duration. Following the drying process, the weight of the resulting dry flowers was measured.

2.3. Essential Oils Distillation

The water-distillation process was employed to extract essential oils from 100 g of dry flower samples in 1L water, using a Clevenger apparatus, following the standard procedure outlined in the European Pharmacopoeia for determining oil content (v/w %) over a 3-hour period. GC-MS instrument was used to determine the essential oil components. The essential oils were stored at -20^{0}C until analyzed.

2.4. GC-MS Analysis

GC-MS analysis was performed on a Agilent 6890N Network GC system combined with Agilent 5975 C VL MSD Network Mass Selective Detector. The GC conditions were; column, DB Waxe tr; 60.0m x 0.25mm x 0.25µm; oven temperature programme: The column held initially at 60 ^{0}C for 10 min after injection, then increased to 22 ^{0}C with 4 ^{0}C min-1 heating ramp for 10 min and increased to 240 ^{0}C with 10 ^{0}C min-1 heating ramp without hold; inject or temperature 250 0C; carrier gas; He; inlet pressure, 9.60 psi; linear gas velocity, 7 cm sec-1; initial flow 0.3 ml min-1; split ratio,65.0:1; injected volume 1.0 µl. Computer matching against commercial libraries (Wiley GC–MS Library, Adams Library, MassFinder 3 Library) as well as MS literature data was used for the identification of essential oil components (European Pharmacopoeia 7.0).

3. Results

The percentage of essential oils extracted from the flowers of *Lavandula angustifolia* species 'Hemus' and 'Sevtapolis' and *Lavandula intermedia* species 'Super A', harvested at full bloom, were measured. Essential oil components and their amount obtained with GC-MS in lavenders and lavandin are shown in Table 1. The total amount of each cultivars were 100 %. Essential oil compound was assessed at levels above 0.4%.

The essential oil yields of lavender species of 'Hemus' and 'Sevtapolis' were determined as 2.65% and 2.14%, respectively. The essential oil yield of lavandin variety of the 'Super A' from the *Lavandula x intermedia* species was 7.95%. Although it is established that the yield of *Lavandula angustifolia* essential oil yield is between 1-3% (Demirezer et al. 2011). The studies conducted by Arabacı and Bayram (2005) reported 1.5 - 2.3% and Atalay (2008) reported 2.1 - 2.6%. Baydar (2009) documented that the essential oil content of the lavandin variety Super A varied between 5 - 6%, whereas Renaud et al. (2001) noted that it ranged between 7.1 - 9.9% in dry stemless flowers. The essential oil ratios of lavender and lavandin varieties obtained in this study, showed findings consistent with the literature.

Linalool, linalyl acetate were determined as the main compounds in the essential oil of lavender and lavandin cultivars. In the research, while the highest linalool content was determined in Sevtapolis (43.3 %), this order is followed by the Hemus (39.09%) and then Super A (30.29%) cultivars. The highest linalyl acetate content in the experiment was determined from Super A (30.39 %), and then Hemus (19.76%), and the lowest linalyl acetate content was obtained from Sevtapolis (10.64%). In both lavender cultivars and lavandin examined in the study, the linalool content exceeded the linalyl acetate content. The highest 4-terpineol content was determined from Sevtapolis and Hemus cultivars (6.89 and 6.53 %, respectively), it was found to be less than 0.4 % from Super A. Camphor, an undesirable component in lavender and lavandin, was obtained from Sevtapolis, Hemus and Super A. The camphor content of Sevtapolis and Hemus cultivars were measured 0.47% and 0.41%, respectively and the camphor content of Super A cultivar was measured 6.71%.

According to the quality standards outlined by the International Organization for Standardization (ISO 3515:2002) for lavender essential oil composition, the percentages of linalool, linalyl acetate, cymene, 4-terpineol, and camphor should fall within the ranges 25.0-38.0%, 25.0-45.0%, 4.0-10.0%, 2.0-6.0%, and 0-0.5%, respectively (Anonymous, 2002). And according to the European Pharmacopoeia (2011), the camphor content is restricted to a maximum of 1.2%. The linalyl acetate content of the Sevtapolis cultivar was lower than the normal values, and the camphor content of the Super A cultivar was significantly higher than the desired amount. Further, the camphor content of the cultivars, except for Super A, comply with the ISO 3515:2002 lavender oil standards and the European Pharmacopoeia (2011). In addition, the amount of 4-terpinol was measured in a very small amount in The Super A. In a study carried out in L. angustifolia Mill. essential oil, linalool was measured as 25.1 - 59.9 % and linalyl acetate was measured as 25.8 - 54.8 % (Arabacı and Bayram, 2005). Kara and Baydar (2011) stated that the ratio of linalool ranged from 34.3% to 54.6%, while the ratio of linalyl acetate ranged from 2.0% to 29.0%. Additionally, the ratio of camphor ranged from 1.6% to 6.0%, and the ratio of borneol ranged from 6.7% to 0.8%.

Secondary metabolites in medicinal and aromatic plants are affected by various factors. These include genotype (Marotti et al., 1989), cultivation techniques, ecological conditions (Atalay, 2008), harvest time, distillation method and drying method (Arabacı and Ceylan, 1990; Kara and Baydar, 2013). It can be said that the differences in the amount of essential oil composition are due to the application of water distillation in essential oil extraction, analysis environment and conditions, ecological factors, soil structure, excessive rainfall in Tuzlukçu district in the summer period of 2023, differences between cultivars, harvest and post-harvest treatments.

Table 1. Chemical composition of essential oil of lavender and lavandin species (%)

Compound	*L. angustifolia*		*L. intermedia*
	Sevtapolis	Hemus	Super A
Amylethyl ketone	0,47	0,94	0,67
Myrcene	1,81	1,08	0,72
ρ - Cymene	0,58	-	-
Limonene	0,61	0,47	-
cis-Ocimene	4,11	4,23	-
β-Ocimene	1,85	2,15	0,99
Linalool oxide	1,56	0,50	0,41
Linalool	**40,41**	**39,09**	**30,29**
Camphor	**0,47**	**0,41**	**6,71**
Lavandulol	0,69	0,75	-
Endo-borneol	1,07	1,13	4,36
4-Terpineol	6,89	6,53	-
Cryptone	-	0,51	0,66
α-Terpineol	5,68	4,83	2,94
Nerol	0,91	0,76	0,75
Linalyl acetate	**10,64**	**19,76**	**30,39**
Geraniol	2,11	-	-
Lavandulyl acetate	5,14	4,91	2,64
Neryl acetate	1,38	1,21	0,69
Geranyl acetate	2,56	2,16	1,15
β-caryophyllene	0,64	1,21	0,85
Farnesene	0,41	0,81	0,48
Germacrene D	-	-	0,47
Caryophyllene oxide	1,34	0,48	0,24
1,8 cineole	1,24	1,07	7,31
Acetic acid	-	0,66	-
α-Bisabolol	-	-	0,89

4. Conclusions

In the research, the ecological conditions of Tuzlukçu district are suitable for cultivating lavender and lavandin cultivars. Especially Hemus cultivars are identified as quality cultivars for lavender oil standard based on their high contents of linalool, 4-terpineol and low camphor levels, in accordance with ISO 3515:2002 lavender oil standards.

Based on the results of the research, Super A exhibited a higher essential oil yield than the other cultivars. The cultivars Sevtapolis and Hemus were identified as better quality due to their low camphor content. In conclusion, Super A is recommended for floriculture and landscape decoration purposes, while Sevtapolis and Hemus are recommended for essential oil compounds and essential oil quality. Lavender and Lavandin cultivars (*Lavandula* sp.) demonstrate agricultural suitability and sustainability within the ecological conditions of the Tuzlukçu district. There is a demand for the advancement of lavender and lavandin agriculture in the Tuzlukçu district of Konya province, due to its significant production potential. Furthermore, it is important to explore and examine various lavender and lavandin cultivars in this region to meet the efficiency and quality standards set by global markets.

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