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# Researches of Yield and Quality Characteristics of Lavandin (*Lavandula X Intermedia* Emeric Ex Loisel) under Continental Type of Climate

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**Abstract:** This study was carried out in Lavandin (*Lavandula x intermedia* Emeric ex Loisel) planted in the farmers' land in Kayseri, Turkey in 2015-2017. Kayseri is a region with a continental climate in Turkey's Central Anatolia Region. In this study, dry flower weight, essential oil content, essential oil yield, and essential oil components were investigated in demonstrations established in 14 locations in Kayseri. Accordingly, in Lavandin, with dry flower weight of 30-127 kg ha<sup>-1</sup>, the essential oil content was 2.72-9.00% and the essential oil yield was found between 17-77 lt ha<sup>-1</sup>. A total of 37 components were identified in the essential oil analysis including linalool (37.59-50.48%), linalyl acetate (1.10-40.23%), 1,8 cineole (2.09-17.72%), and camphor (4.13-9.21%). In Lavandin (*Lavandula x intermedia* Emeric ex Loisel) cultivation studies in the Kayseri, altitude below 1350-1400 m positive results were obtained in the region.

**Keywords:** Adaptation, Lavandin, yield, essential oil content, essential oil components.

## 1. Introduction

Lavender (*Lavandula spp.*) is a perennial shrub form of the Lamiaceae family, an essential oil plant for the cosmetic and pharmaceutical industries. Two subtypes of non-endemic species of *Lavandula stoechas* L., whose general distribution area is the Mediterranean, naturally is present in Turkey. The subspecies which are *L. stoechas* subsp. *cariensis* (karan) shows spread in Catalca, Kocaeli and South Marmara, while *L. stoechas* subsp. *stoechas* (karabaş) shows spread in South Marmara and between at 0-700 m altitude in the original Aegean Section [1,2]. Lavender is found most in Mediterranean and Balkan countries all over the world [3].

There are about 39 species of lavender in the world which most of them are of Mediterranean origin. The commercial values of lavender (*Lavandula angustifolia* Mill. = *L. officinalis* L. = *L. vera* DC), lavandin (*Lavandula intermedia* Emeric ex Loisel. = *L. hybrida* L.) and spike lavender (*Lavandula spica* = *L. latifolia* Medik.) all over the world are high. The yield values of lavandin (*L. latifolia x L. angustifolia* hybrid), (essential oil content and essential oil

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yield), are higher than that called as British lavender, but the essential oil quality is lower than lavender [4,5,6,7]. Lavender production in Turkey is mostly carried out in Isparta Keçiborlu County. Lavandin (*Lavandula x intermedia* Emeric ex Loisel Super A) cultivar, commonly called hybrid lavender is also cultivated. In 2018, Turkey possessed 868 hectares of lavender cultivation area for production of 1040 tons / year with average yield of 1200 kg ha<sup>-1</sup> [1].

According to various researches, dry flower weight of lavandin species is at 1000-1500 kg ha<sup>-1</sup> levels [9,10,11], and 1620-3410 kg ha<sup>-1</sup> [12]. In the dry flower, the essential oil content is between 5.0-9.62% [9,10,11], and the essential oil yield is between 80-310 lt ha<sup>-1</sup> [13]. The linalool content of lavandin essential oil was 20-50% [4,9,10,11,14,15,16]. Linalyl acetate content is between 1.5-54% [10,11,12,14, 15,17,18]. The content of camphor is between 1.2-16% [4,10,11,15,17,18,19].

The most common monoterpenes in lavender are linalool, linalyl acetate, borneol, camphor and 1,8 cineol. Among these, linalool, linalyl acetate and camphor determine the quality of lavender essential oil [20]. Although lavandin has a higher essential oil content than lavender, it has a lower essential oil quality due to its high camphor component [21]. The content of linalool and linalyl acetate, which determines the quality of lavender essential oil, should be equal with total of 70-80%, while camphor less than 1.9%, borneol less than 3.5%, and cineole less than 0.3% [6].

Linalool is a sedative while linalyl acetate drug and has an antiseptic effect as natural camphor on lung and airways [22,23]. Lavender essential oil are effective against eczema, acne, skin diseases, burns, ulcers, and superficial inflammatory wounds [24]. It strengthens the lung with massages on the chest. Mouthwash with lavender tea which cleanses small wounds in the mouth, relaxes nerves and contracted muscles, is used in the treatment of tongue paralysis and stuttering [25,26].

Kayseri, where the project is implemented, is one of the coldest provinces in Central Anatolia. Winter is freezing, while summer is hot and dry and has a short season. The temperature difference between winter and summer is great as well as the temperature difference between day and night. The temperature can go up to 39.8 °C in summer and -32.5 °C in winter. In Kayseri which has a continental climate character, precipitation coincides with winter, spring and autumn months. In the last twenty years, the average annual rainfall of 416 mm is seen in 22% in autumn, 36% in spring, 32% in winter and 10% in summer. Winter is long and rainfall is usually in the form of snow [27]. In recent years, there has been some softening in the climate due to the construction of dams and global warming.

This study was carried out to determine the cultivation, yield potential and quality of Lavandin (*Lavandula x intermedia* Emeric ex Loisel) in different districts of Kayseri. The aim was to find an alternative product which would bring high income from unit area to the Kayseri farmers.

## 2. Experimental

### 2.1 Materials

Materials used in this study were obtained from the Directorate of Fruit Research Institute / Egridir / ISPARTA in 2015 and from the Directorate of Central Horticultural Research Institute of Ataturk Horticulture / YALOVA in 2016. The type of plant used is Lavandin (*Lavandula x intermedia* Emeric ex Loisel).

### 2.2 Methods

Field research was established in May 2015 and 2016 in 14 different locations under farmer conditions. Fertilizer was applied prior to planting at a rate of 50-50 kg ha<sup>-1</sup> N-P. Additionally, burned animal manure supplements was applied in some locations at a rate of 10-20 ton ha<sup>-1</sup>. The plants were planted to be 50 cm above the row and 120 and 150 cm between the rows. A trial pattern was not applied to the lavandin planted under farmer conditions. The plants were harvested from flower stalks in full flowering periods in 2016 and 2017 in late July and early August. The measured plant parameters were dry flowers weight, flowers essential oil content, oil yield, and oil composition. After harvest, flowers of the plant were immediately separated and were dried under shadow. Flower essential oil were distilled with Neo-Clevenger apparatus. Twenty grams of dry flowers and leaves were separated in 500 ml flask containing 250 ml water, and boiled for 2 h. The condensate was collected in the receptive flask, and the oil was removed with the help of a pipette. The extracted oils were stored in tightly closed glass vials at a temperature of 4 °C. The oil was analyzed by HP (Hewlett Packard) 6890 series GC/MS, equipped with a fused silica capillary column supelco (50 m, 0.25 mm internal diameter, film thickness 0.2 µm). The injector temperature was 250 °C. The column temperature was initially 120 °C (5 min), and then was gradually increased at a rate of 5 °C/min up to 200 °C. Having stayed for 5 min at 200 °C, the temperature was gradually increased at a rate of 10 °C/min up to 240 °C. The carrier gas was helium at a working rate of 1.5 ml/min with 2-µl injection volume.

## 3. Results and Discussion

In the research, field works were carried out in 14 different locations; 7 in 2015 and 7 in 2016. Since the plants did not reach sufficient size in the first year, harvests were not carried out in 2015, but in the plants flowering as one branch in autumn (September-October), they were cut from flower stalks to increase tillering. Due to this matter, it was not

possible to obtain results from some locations in all plants studied, while results from others in the first year or in subsequent years were not possible due to reasons arising from producers.

As can be seen in Table 1, field studies were carried out in Lavandin plant in 7 locations in 2015 and 3.35 decares in 6 districts, in 7 locations in 2016 and 5.2 decares in 7 districts which made a total of 8.55 decares. Since the surveys were carried out on the farms' land, they were deactivated in the first year due to the insufficient maintenance, irrigation and weed control of the producers in the locations in Bunyan Center and Pinarbaşı Kiliçmehmet village. In the first year, the harvest was not harvested because the plant growth was slow, but it was cut from the flower stalks to increase the tillering of the flowering plants.

**Table 1 - Lavandin (*Lavandula x intermedia* Emeric ex Loisel) Locations Established in 2015 and 2016.**

Year	Locations Name	Area(da)
2015	Yesilhisar/Merkez	0.40
2015	Yesilhisar/Kayadibi	0.70
2015	Bunyan/Merkez	0.40
2015	Melikgazi/Merkez	0.20
2015	Yahyali/Mustafabeyli	0.70
2015	Kocasinan/Yazir	0.50
2015	Pinarbaşı/Kiliçmehmet	0.45
2016	Talas/Alaybeyli	0.70
2016	Tomarza/Isiklar	0.50
2016	Develi/Sindelhocuk	1.00
2016	Yahyali/Karakoy	1.00
2016	Kocasinan/Akcatepe	1.00
2016	Felahiye/Merkez	0.50
2016	Incesu/Garipce	0.50
Total		8.55

In the 2015-2016 winter season, cold and frost-induced plant losses were observed in the plants planted in 2015. It was reported that the cold sensitivity of lavender decreased with aging [21]. Hence, our studies in the later years of studies with the development and strengthening of cold and frost damage, less damage and losses were observed. Plant losses were higher in Yesilhisar Kayadibi and Kocasinan Yazir locations. Plants that dried up after winter were able to compensate for the damage caused by the warm weather in spring. At higher altitude locations, there is no such frost damage and the fact that it occurs at lower altitudes indicates that this damage is not only dependent on altitude but also other factors. Other factors include differences such as location and direction, slope, wavy or flat terrain, open environment, presence of a number of frost protection elements (tree, fence, wall), as well as duration and effectiveness of frost. While in Yesilhisar center and Yahyali Mustafabeyli surrounded by fruit trees, frost damage is not seen. Yesilhisar Kayadibi and Kocasinan Yazir location which is open to the wind and towards the dominant cold wind has seen frost damage in some plants and most of the plants have recovered themselves by the warming of the weather. Although the plants reached a certain size in the 2016-2017 winter season, Yesilhisar Kayadibi, Kocasinan Yazir and Develi Sindelhocuk demonstrations showed that some plants had local dryness due to cold and frost damage, but in the spring, with the warming weather, the plants recovered by giving new shoots.

Table 2 below shows the results of dry flower weight, essential oil content and essential oil yield obtained in 3 locations in 2016 which are Yahya Mustafabeyli, Yesilhisar Center and Yesilhisar Kayadibi. Dry flower weight was highest in Yahyali Mustafabeyli location with 1270 kg ha<sup>-1</sup> and lowest in Yesilhisar Central location with 300 kg ha<sup>-1</sup>. Dry flower weight is considered low, but the values are close to the previous reports of 1000-1500 kg ha<sup>-1</sup> [9,10,11], and lower than other researches of 1340-4430 kg ha<sup>-1</sup> [12] and 1620-3410 kg ha<sup>-1</sup> [13]. This is due to the fact that the producers are new in lavandin cultivation, has insufficient harvesting mechanization, not knowing the harvest method, and separating the dry flowers from the stems method, and not having sufficient infrastructure in this regard. Therefore, the yield of essential oil per decare is low.

**Table 2 - Dry Flower Weight, Essential Oil Content and Essential Oil Yield Values in Some Locations by Lavandin 2<sup>nd</sup> Year (2016) Harvest.**

Features reviewed	Yahyali Mustafabeyli	Yesilhisar Merkez	Yesilhisar Kayadibi
Dry flower weight (kg ha <sup>-1</sup> )	1270	300	680
Essential Oil Content (%)	6.1	5.7	6.0
Yield of Essential Oil (lt ha <sup>-1</sup> )	77	17	48

Essential oil content of dry flower was very close to each other which is between 5.7-6.1%. Essential oil yields were 77 lt ha<sup>-1</sup> in Yahyali Mustafabeyli location due to high dry flower weight and 17 lt ha<sup>-1</sup> in Yesilhisar Central location due to low flower weight. Lavandin essential oil yield are lower compared to the results of 80-310 lt ha<sup>-1</sup> reported previously [13]. In our studies, the reason why dry flower weights were so low especially in Yesilhisar location was due to the fact that the producer delayed the harvest because of the apiculture and the shade of the fruit trees around the location. Flower weights increased more in the following years, but these values could not be measured.

The essential oil content of dry leaf in lavandin obtained from locations in 2017 is given in Table 3. As seen in the table, in 2017, the essential oil content of the locations in dry flower ranged between 2.82-9.00%. The highest was obtained from Felahiye Center and the lowest from Kocasinan Yazir location. The average essential oil content of the locations in dry flower was 5.72%. The emergence of an essential oil content of 9.00% is a significant indicator for this location with an altitude of 1330 m. The reason why the essential oil content in Kocasinan Yazir and Tomarza Isiklar locations were so low compared to other locations is that the sample sent to the analysis is not prepared very well and that some lavender flower stalks are mixed into the dry flower sample. These essential oil content in dry flowers are a good indicator for us. In the scope of the support given to the young farmers in our province, the producers can extract the essential oils of the products obtained from the essential oil distillation system made by the producer and marketed them by placing them in small glass bottles. The proportion of essential oil in lavandin dry flower coincides with the results of the researchers (5.0-9.62%) [9,10,11].

**Table 3 - Essential Oil Content in 2017 Harvest at Lavandin Locations (%).**

Locations Name	Essential Oil Content (%)
Felahiye Merkez	9.00
Develi Sindelhoyuk	5.67
Incesu Garipce	5.20
Kocasinan Akcatepe	5.80
Kocasinan Yazir	2.82
Tomarza Isiklar	4.50
Yahyali Karakoy	6.00
Yahyali Mustafabeyli	6.80
Yesilhisar Merkez	5.70
Average Value	5.72

Essential oil components in lavandin according to locations lavandin is as summarized in Table 4. Linalool content was highest in Develi Sindelhoyuk location with 50.48% and lowest in Tomarza Isiklar location with 37.59%. Linalool content is similar to the findings of previous researches which is between 20-50% [4,9,10,11,14,15,16,17]. Linalyl acetate content was highest in Yahyali Karakoy location with 40.23% and lowest in Incesu Garipce location with 1.10%. These results are consistent with the reports of 1.5-54% [4, 10,11, 12,14,17,18]. Camphor content was found between 4.13-9.21%, where the highest was recorded in Incesu Garipce location, and the lowest was recorded in Yahyali Mustafabeyli location. Camphor content of the locations are between the values 1.2-16% reported by [4,10,11, 14,15,18,19,28,]. Considering the camphor content, the locations of Yahyali Mustafabeyli, Yesilhisar Merkez and Felahiye were the lowest. Linalool and Linalyl acetate totals were obtained at the highest from Yahyali Karakoy location with 78.51%. This was followed by Yesilhisar Center with 78.46% and Felahiye Center with 69.32%.

**Table 4 - Essential Oil Components by Locations.**

Components	Develi Sindelhoyuk	Felahiye Merkez	Incesu Garipce	Kocasinan Akcatepe	Kocasinan Yazir	Tomarza Isiklar	Yahyali Karakoy	Yahyali Mustafabeyli	Yesilhisar Merkez
Linalool	50.48	43.83	43.72	46.65	41.23	37.59	38.28	43.77	41.35
Linalyl acetate	14.31	25.49	1.10	19.66	26.51	21.02	40.23	22.85	37.11
1,8 Cineole	5.27	2.09	17.72	3.67	4.53	6.16	3.46	2.98	3.61
Camphor	6.74	5.04	9.21	5.81	5.72	7.17	6.79	4.13	4.69
Lavandulyl acetate	1.52	1.66	0.55	1.79	2.06	2.10	-	1.66	1.34
Borneol	2.34	1.33	6.82	2.43	2.23	1.44	1.89	1.62	1.69
$\beta$ -Caryophyllene	0.57	1.52	-	1.36	0.62	1.09	0.41	1.12	1.40
Cis- $\beta$ -Ocimene	1.17	1.25	2.07	1.02	1.57	2.28	-	1.74	1.14
trans- $\beta$ -Ocimene	1.36	1.98	0.94	1.59	1.39	2.52	-	1.90	1.29
Camphene	0.25	-	0.42	-	-	-	0.27	-	0.27

$\alpha$ -Pinen	0.24	-	0.87	-	-	-	-	-	0.25
$\beta$ -Pinene	0.24	-	1.30	-	-	-	-	-	-
Myrcene	1.04	0.90	0.85	1.10	1.21	1.53	0.36	1.34	0.56
Limonene	0.77	0.51	1.35	0.70	0.75	0.79	0.68	0.59	0.55
3-Octanone	0.74	0.45	-	0.58	0.66	0.29	0.85	0.45	0.79
Hexyl acetata	0.64	0.45	0.32	0.39	0.56	0.47	0.64	0.58	0.70
1-Octenyl acetata	0.23	-	-	-	-	-	0.31	-	0.23
Terpinelone	0.32	-	0.36	0.32	-	0.39	-	0.34	-
Terpineol-4-ol	0.38	-	4.30	-	-	-	-	-	-
trans- $\beta$ -Farnesene	0.39	0.88	0.75	0.62	-	0.61	0.30	0.59	0.76
Lavandulol	0.54	0.42	1.26	0.54	-	-	-	-	-
Cryptone	0.30	-	0.27	0.31	-	0.38	0.30	-	-
Geranyl acetate	1.51	2.02	0.32	1.89	1.96	2.42	0.42	2.40	0.31
Neryl acetate	0.75	0.93	-	0.87	1.17	1.21	-	1.14	-
Nerol	0.85	0.78	-	0.82	0.87	1.12	-	0.94	-
$\alpha$ -Bisabolol	0.80	1.76	1.02	1.86	0.85	1.26	0.36	1.77	0.30
Cis-lynalool oxide	-	-	-	-	-	-	0.57	-	-
Hexyl butyrate	0.61	0.73	0.71	0.47	0.44	0.51	0.57	0.69	0.82
Hexyl tiglate	-	-	-	-	-	-	0.20	0.33	0.22
Caryophyllene oxide	-	-	-	-	-	-	0.73	-	-
$\alpha$ -Terpineol	3.70	3.50	2.03	3.35	3.71	4.46	0.38	4.30	0.29
$\gamma$ -Terpinene	-	-	-	-	-	0.32	-	-	-
Germacrene D	-	0.46	-	0.34	-	0.31	-	0.32	0.33
Sabinen	-	-	0.42	-	-	-	-	-	-
Hexanol	-	-	0.39	-	-	-	-	-	-
1-Octen-3-ol	-	-	0.60	-	-	-	-	-	-
Geraniol	1.94	2.02	0.33	1.86	1.96	2.56	-	2.45	-

#### 4. Conclusion

In Lavandin species (*Lavandula x intermedia* Emeric ex Loisel) from this study between the years of 2015-2017 in Kayseri for 3 years in 11 districts in 14 locations on 8.55 decares, these conclusion follows.

As the studies were carried out on the fields of the producers under field conditions, the desired results could not be obtained from each location depending on the producers. Some locations were disabled in the first phase. Nevertheless, the desired results were achieved because the number of locations was kept high.

We have got an idea about whether lavandin (*Lavandula x intermedia* Emeric ex Loisel) can be economically cultivated under the conditions of Kayseri or not based on their adaptation to Kayseri ecology, the yield and the quality of essential oil produced. According to these results, it is seen that lavandin can be cultivated in irrigated areas in altitudes not exceeding 1350-1400 meters in Kocasinan, Incesu, Yesilhisar, Yahyali, Develi, Melikgazi and Felahiye districts of Kayseri. However, when we take into consideration the quality criteria, the essential oil content and essential oil components of Yesilhisar, Yahyali and Felahiye districts come to the fore.

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