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Research Article/Araştırma Makalesi

Determination of morphogenetic variability in essential oil ratio and components of Origanum syriacum L. var. bevanii (Holmes) Ietswaart

Origanum syriacum L. var. bevanii (Holmes) Ietswaart. uçucu yağ oranı ve bileşenlerinde morfogenetik değişkenliğin belirlenmesi

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ABSTRACT

The aim of this study was to determine changes in the essential oil ratio and the essential oil components of the position of leaves on the stem and the aerial parts (stem, leaf, and flower) at *O. syriacum* L. var. *bevanii* (Holmes) Ietswaart. which naturally grows in Anatolia. It was conducted in 2016 growing session, under the Diyarbakır conditions (South-eastern Anatolia, Turkey). Plants were harvested at the full flowering time and then the plant samples were separated into the leaves (according to node numbers on the stem (from top to base)), stems and flowers and dried under room conditions in the shade. The essential oils were isolated from the dry samples and were analyzed by means of GC-MS. The highest rate of essential oil was found in flowers (4.26%). The ratio of essential oil in leaves (2.76-3.10%) was determined to the higher in the upper leaves than in the middle and lower leaves. There was little change in leaf sizes on the 7th node and the next. The essential oil components varied according to the node numbers of the leaves. The highest ratio of carvacrol was determined in the stem (66.99%) and the carvacrol ratio of the leaves (58.39-64.53%) increased up to the 4th node leaves.

Key Words: Essential oil components, Stem, Leaf, Flower, Position of leaves

ÖZ

Bu çalışma, Anadolu’da doğal olarak yayılış gösteren, *O. syriacum* L. var. *bevanii* (Holmes) Ietswaart bitkisinin toprak üstü aksamlarına (gövde, yaprak ve çiçek) ve yapraklarının gövde üzerindeki konumuna göre uçucu yağ oranı ve uçucu yağ bileşenlerinin dağılımı belirlemek amacıyla, 2016 yılında, Diyarbakır koşullarında (Güneydoğu Anadolu Bölgesi, Türkiye) yürütülmüştür. Çalışmada, bitkiler tam çiçeklenme zamanında hasat edilmiş ve daha sonra bitki örneklerinde, yapraklar (sap üzerindeki boğum sıralarına göre, yukarıdan aşağıya doğru) saplar ve çiçekler ayrılarak oda koşullarında, gölgede kurutulmuştur. Kuru örneklerden uçucu yağlar elde edilmiş ve GC-MS’de uçucu yağ bileşenleri belirlenmiştir. En yüksek uçucu yağ oranı çiçeklerde (% 4.26) saptanırken, yapraklarda uçucu yağ oranı (% 2.76-3.10) üst yapraklarda orta ve alt yapraklara göre daha yüksek bulunmuştur. Yaprak boyutları 7. boğumdan sonar değişmemiştir. Uçucu yağ bileşenleri yapraklarda boğum sıralarına göre değişiklik göstermiştir. En yüksek karvakrol oranı sapta (% 66.99) tespit edilmiş ve yaprakların karvakrol oranı (% 58.39-64.53) 4. boğum yapraklarına kadar artmıştır.

Anahtar Kelimeler: Uçucu yağ bileşenleri, Sap, Yaprak, Çiçek, Yaprakların konumu

Introduction

It is known that *Origanum* genus, which includes 43 species and 18 hybrids in the Labiatae family, have been used as thyme in Anatolia since the 7th century BC. It is reported that taxa of *Origanum*, of about 60 percent is in Turkey and this region is the gene center of the genus (Lukas, 2010; Tas, 2010). The *Origanum syriacum*, one of these species, is widely distributed in the Eastern Mediterranean. It is naturally found from the south of Turkey to the Sinai Peninsula (Lukas et al., 2009). The *O. syriacum* var. *bevanii* is a perennial plant that can grow up to 90 cm, densely hairy, bushy, with prominent streaked on the lower face of the leaf, up to 10 pairs leaves per stem, and can naturally grow between 200 and 2700 m altitude (Tas, 2010). The *O. syriacum* is most used as a spice and medicinal tea. Also, the essential oil is used in the cosmetics, liquor, soap and food industry (Al-Hijazeen, 2019). It is used in folk medicine in the treatment of many diseases, including gastrointestinal problems and the treatment of respiratory diseases (Baytop, 1984; Alma, et al. 2003; Berrehala et al., 2010; Chishti et al., 2013; Qneibi et al., 2019). Essential oil of *O. syriacum* has been reported to have been important effect as antifungal (Daouk et al. 1995; Duran and kaya, 2018), antibacterial (Shafaghat, 2011), insecticidal (Karpouhtsis et al., 1998; Tunc et al, 2000), antioxidant and antimicrobial (Alma, et al. 2003). This is due to the essential oils, rich in monoterpenes, primarily carvacrol and thymol (Lukas et al., 2009; Jaafar, et al., 2015).

In *Origanum* species, the essential oil is found in the glandular hairs on the outer surfaces of the plant and the leaf surfaces. The glandular hairs consist of a single protoderm cell, occur the head, stem and foot parts. It is known that essential oil formation is carried out by the cells that make up the head of the glandular hair, accumulates in the space between the cells in the head and the cuticle tissue. These structures play a role not only in the accumulation of essential oils but also in the biosynthesis of these substances (Oflaz, 2001; Tas, 2010). In addition, Werker et al. (1985) reported that glandular hairs have a significant effect on the essential oil ratio and the distribution of essential oil components. For these reasons, it is known that the region where the plant is grown (Fleisher and Fleisher, 1991; Dudai et al., 1992; Lukas et al., 2009; Novak et al., 2010; Ali-Shtayeh et al., 2018; El-Alam et al., 2019), plant genotype (Putievsky et al., 1996; Chalchat and Pasquier, 1998; Lukas et al., 2009), harvest time (Soliman et al., 2007; Toncer et al., 2010; Sonmez, 2019) and drying conditions (Wakim et al., 2013) have an important effect on the essential oil ratio and the distribution of essential oil components. The essential oil composition of *O. syriacum* var. *bevanii* varies depending on the conditions mentioned above. According to the results of the research, three different opinions stand out about what the main ingredient of *O. syriacum* essential oil is? Some researchers (Werker et al., 1985; Berrehala et al., 2010; Toncer et al., 2010; Duran and Kaya, 2018; Qneibi et al., 2019) reported that the main ingredient in the essential oil is thymol, while the others (Baser et al., 1993; Tulmen and Baser, 1993; Baser et al., 2003; Novak, et al., 2010; Farhat et al., 2012; Wakim et al., 2013) is carvacrol as the main component, and those in the third group (Dudai et al., 1992; Putievsky et al., 1996; Chalchat and Pasquier, 1998; Soliman et al., 2007; Lukas et al., 2009; Ali-Shtayeh et al., 2018; El-Alam et al., 2019) is thymol or carvacrol as the main components depending on various factors. Among them, Soliman et al. (2007) stated that the essential oil components of *O. syriacum* changed depending on the seasons. The carvacrol was found the main component in the essential oil of spring-summer months (pre-flowering and flowering period), while the trans-sabinene hydrate was found the main component in the essential oil of autumn-winter months (seeded plant period). The carvacrol in the essential oil of autumn-winter months and thymol in the essential oil of spring-summer months was not found. On the other hand, Walker et al. (1985) reported that in *O. syriacum* the thymol ratio increased towards the bottom leaves, and the thymol ratio varied between 45.0% and 76.2% according to the leaf position on the stem, and the highest thymol ratio was detected in leaves of the sixth node.

Based on the studies for *O. syriacum* can be said that the chemical composition distribution and the ratio of essential oils are affected by many factors. Studies mainly focused on genotype, environmental conditions and essential oil compositions of the plants collected from natural flora. It is seen that the information about the changes in essential oil ratio and essential oil composition according to the aerial parts of the plant (stem, leaf, flower) and the positions of the leaves in the stem is limited. Therefore, this study was aimed to determine the essential oil ratio and the essential oil components of *O. syriacum* var. *bevanii* using the part of above soil (stem, leaf and flower) and the position of leaves on the stem.

Material and Methods

Origanum syriacum var. *bevanii*, 3 years old plants, grown in Diyarbakır International Agricultural Research and Education Center in the 2016 season, were used as the material in the experiment. They were planted in three different plots, in November 2012, at 70x20 cm distances, with 5 rows per plot.

The study area is on the base area near the Tigris River and is around 609 meters above sea level and at 37°56'29.36"N (north latitude) and 40°15'16.07"E (east longitude). General characteristics of the regional climate, summers are hot and dry, winters are cold and rainy. The trial area soils are alluvial soils, transported by river water and stored. The soils of the trial area were determined to be salt-free (0.03%), basic character (pH = 8.12), clayey (54.10%) and weak in organic matter (0.93%).

During the growing period, the necessary maintenance operations (weed control, irrigation) were carried out in appropriate periods on *O. syriacum* var. *bevanii* plant. In October 60 kg ha^{-1} of pure N_2 and P_2O_5 as the base fertilizers and in March and after the harvest 30 kg ha^{-1} of pure N_2 as the top fertilizer were applied to the trial area (Toncer et al., 2010). Plants were harvested at the full flowering, in the first week of August (August 3, 2016), at a height of 5 cm from the ground by pruning shears. The samples were taken and separated into leaves according to the nodal rows (from top to base) on the stem, stem and flower, and dried in the shade in room conditions.

The following observations were monitored the samples, harvested herb. Leaves were sorted from top to bottom (one to ten) according to the nodal numbers on the stem, and each leaf was grouped within itself. The length and width of 20 fresh leaves (mm), randomly taken from each group were measured and averaged. In each group 20 g of dried leaves, flowers and 50 g stems were ground, and the essential oil ratios (ml/g) in the samples were isolated by 3 hours of water-steam distillation. Stem, leaf and flower essential oil samples were made in 3 replications. The essential oils obtained from the samples mixed according to the node number and stored in the deep freezer until the component analysis.

Essential oil component analysis

The essential oils of *O. syriacum* var. *bevanii* were analyzed by means of GC-MS "Shimadzu Nexis GC-2030" brand Gas Chromatography, Mass Spectroscopy (MS) detector and "Teknokroma capillary column TR-CN100" (60m X 0.25mm X 0.20um), in the Harran University Science and Technology Application and Research Center (HUBTAM). It had 70 eV electron ionization energy, 35-450 amu scanning range, and 1 scan $second^{-1}$ scan rate. Helium was used as carrier gas at 1 ml min^{-1} flow rate. The inlet temperature was set as 225°C. The temperature program of the GC oven was used as follows; initial temperature 60°C and hold for 1 min, at 4°C min^{-1} raised to 140°C, at 3°C min^{-1} raised to 235°C and finally held on 15 min at 235°C. The sample was diluted one percent (v/v) with n-Hexane and injected with 1 µl. The 40:1 split ratio was used (Satıcı and Ozel, 2021).

Identification of compounds was based on Kovats retention indexes. Identity of the compounds was made by comparison of the mass spectra with data from the US National Institute of Standards and Technology (NIST-11, USA), and the WILEY-9 mass spectrum library, Standard Reference Data Program (Anonymous, 2020).

Essential oil ratios were subjected to analysis of variance according to the Randomized Plot Trial Design. Statistically significant applications were grouped according to Lsd (5%).

Results and Discussion

In *O. syriacum* var. *bevanii*, the highest ratio of essential oil was found in flowers (4.26%). This was followed by leaves (2.91%), while the lowest value was observed in stems (0.26%) (Figure 1B, Table 1). It was determined that the essential oil ratios of leaf according to the node number of the stem varied between 2.76% and 3.10% and higher in the upper leaves than the middle and bottom leaves (Figure 1A, Table 3). This may be due to the smaller structure of the upper leaves (Figure 1A) and thus per unit weight included more leaf and glandular hair. Similarly, Werker et al. (1985) were reported that glandular hairs are intense on the upper leaves. Leaf sizes were differed according to their position in the stem, and leaf length were changed between 4.9 mm and 37.8 mm and leaf width between 2.9 mm and 18.0 mm. The smallest leaf was determined at the uppermost node leaves, while the largest leaves were seen at the 9th node (Figure 1A). Generally, there was seen little change at the 7th node and subsequent node leaves.

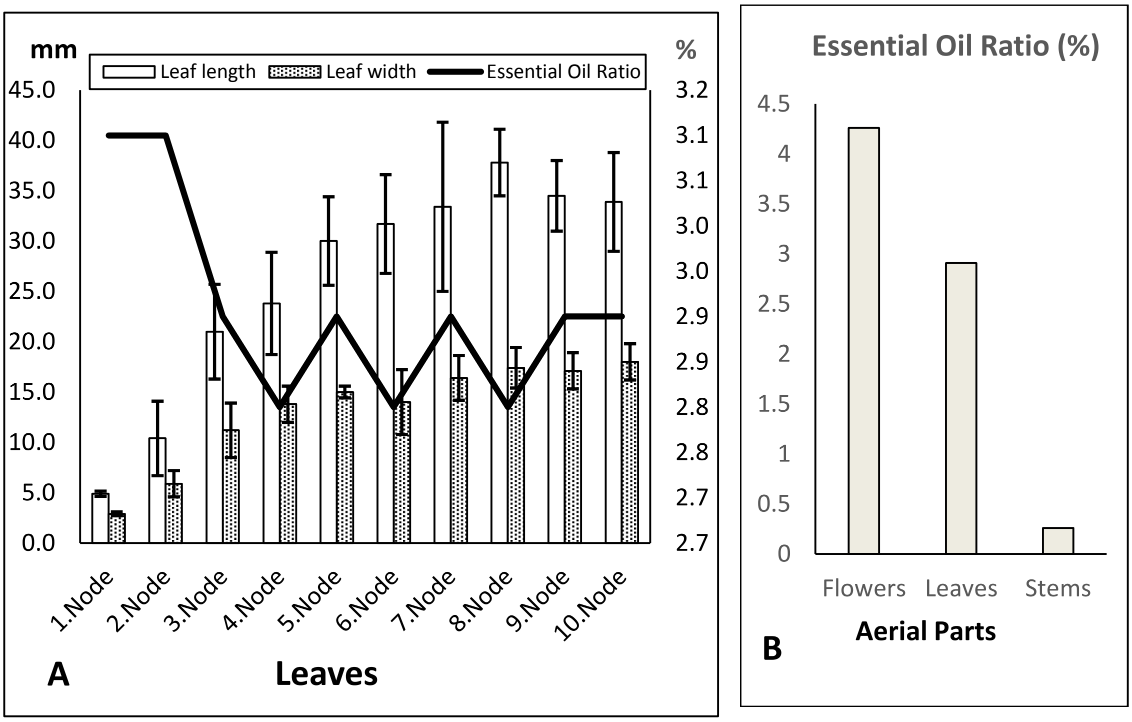

Figure 1. Average values of *Origanum syriacum* var. *bevanii* plant (A) leaf length, leaf width, essential oil ratio according to node number (from top) and (B) essential oil ratio according to aerial parts.

The proportional distribution of the essential oil components using to the aerial parts of the *O. syriacum* var. *bevanii* was given in Table 1.

The essential oil components numbers of *O. syriacum* var. *bevanii* were changed according to the aerial parts, and 37 components in the stem, 60 components in the flower and 72 components in the leaf were determined. The total identified component ratio was found to vary between 97.56% and 99.36% using to the aerial parts of the plant (Table 1). In all essential oils of aerial plant parts, the Carvacrol, an oxygenated monoterpene was seen as the main ingredient. The highest Carvacrol ratio was determined in the essential oil of stem with 66.99%, followed by the essential oil of leaves (61.62%). Among the organs, the least amount of Carvacrol was found in the essential oil of flowers (59.53%). The second major component was found to be β-Caryophyllene in stem essential oil and para-Cymene in flower and leaf essential oil. In addition, Hydroperoxide 1-methylpentyl, Linalool, Hydroperoxide 1-ethylbutyl and Linalyl Acetate in the essential oil of stem, gamma-Terpinene, Linalool, β-Caryophyllene and β-Myrcene in the essential oil of flower, Linalool, β-Caryophyllene, Linalyl Acetate and 1-Octen-3-yl-acetate in the essential oil of leaf were determined to be other prominent components, respectively (Table 1).

Table 1. The essential oil ratio and essential oil components ratio (%) using to the aerial parts of *Origanum syriacum* var. *bevanii*

Compounds Name*	Retention time	Stem	Flower	Leaf
α-Thujene	11.208	-	1.36	0.77
α-Pinene	11.493	-	0.55	0.23
Hydroperoxide. 1-ethylbutyl	12.359	1.89	0.02	0.07
Hydroperoxide. 1-methylpentyl	12.828	2.15	0.02	0.08
1-Octen-3-ol	13.804	0.40	0.66	1.06
β-Myrcene	14.371	0.43	2.79	1.19
3-Octanol	14.605	0.48	0.35	0.51
α-Phellandrene	15.005	-	0.51	0.21
(-)-3-Carene	15.242	0.22	0.16	0.09
α-Terpinene	15.585	-	2.09	0.97
para-Cymene	16.001	1.55	5.37	5.24
β-Phellandrene	16.198	-	0.74	0.53
β-Ocimene	17.252	-	0.20	-
γ-Terpinene	17.766	1.24	4.19	1.98
trans Sabinene hydrate	18.170	0.92	0.91	1.33
Terpinolene	19.245	-	0.42	0.16
Linalool	19.902	1.95	3.28	4.39
1-Octen-3-yl-acetate	20.525	1.31	1.82	2.05
3-Octyl Acetate	21.133	0.69	0.65	0.69
Borneol	23.201	0.71	0.23	0.44
Terpinen-4-ol	23.770	0.55	0.98	0.56
cis-Dihydrocarvone	24.662	-	0.34	-
α-Terpineol	25.925	0.36	0.50	0.33
(E)-dihydrocarvone	26.536	-	0.10	-
(-)-Carvone	27.281	0.21	0.14	0.24
Thymoquinone	27.434	-	0.04	0.15
Linalyl Acetate	27.724	1.57	1.39	3.05
Nerol	27.874	-	0.29	-
Thymol	29.561	0.28	0.69	0.28
Carvacrol	30.310	66.99	59.53	61.62
Neryl acetate	32.757	0.48	0.55	0.21
Geranyl acetate	33.602	0.59	0.71	0.37
β-Caryophyllene	35.311	6.37	2.49	3.32
Aromadendrene	36.150	0.91	0.62	0.40
α-Caryophyllene	36.788	0.37	0.18	0.20
Germacrene-D	37.980	0.22	0.11	0.30
Viridiflorene	38.584	-	0.42	0.34
delta-Cadinene	39.749	0.26	0.13	0.15
(E)-α-Bisabolene	40.505	0.73	0.20	1.01
4-ethyl-2-methoxy-6-methylphenol	41.109	-	-	0.23
Spathulenol	42.102	0.26	0.05	0.17
Caryophyllene oxide	42.318	1.37	0.48	0.56
Cis-3-Hexenyl Phenylacetate	44.181	0.14	0.07	0.17
Geranyl-α-terpinene	45.206	0.27	0.11	0.29
α-Bisabolol	45.805	0.46	-	0.14
3-Benzylsulfonyl-2.6.6-trimethylbicyclo (3.1.1) heptane	55.053	-	0.24	0.10
Trachylobane	57.912	-	0.33	0.32
β-Bisabolene	61.829	0.58	0.50	0.92
Total		97.56	98.84	99.36
Total Compounds Number		37	60	72
Essential Oil Ratio (%)		4.26 a	2.91 b	0.26 c

*Upper than the 0.10%, Lsd (%5):0.28 (Essential Oil Ratio)

The results were similar or higher to the findings of some researchers who reported that carvacrol is the main component, and the carvacrol ratio is 42.5% (Baser et al., 1993), 42.46% (Tulmen and Baser, 1993) and 49.70-69.89% (Wakim et al., 2013). Besides, it was found to be lower than the findings of some researchers (82.8-84.6% Novak, et al. (2010) and 78.4% Farhat et al. (2012)). This may be due to differences in growing conditions (Fleisher and

Fleisher, 1991; Dudai et al., 1992; Lukas et al., 2009; Ali-Shtayeh et al., 2018; El-Alam et al., 2019), genotype differences (Putievsky et al., 1996; Chalchat and Pasquier, 1998) and harvest time differences (Soliman et al., 2007; Toncer et al., 2010). On the other hand, it was observed that it contradicts the findings of Werker et al. (1985), Berrehala et al. (2010) and Qneibi et al. (2019), which reported that the main component of *O. syriacum* essential oil is thymol and the ratio of it is varied between 42.18% and 76.2%. In this case, it could be said that the *O. syriacum* var. *bevanii* used as a plant material on the trail was the thymol chemotype (Putievsky et al., 1996). The proportional distribution of total chemical groups of essential oil constituents identified in the aerial parts of the *O. syriacum* var. *bevanii* was given in Table 2.

Table 2. Chemical groups ratio (%) on the essential oil according to the aerial parts of *Origanum syriacum* L. var. *bevanii*

Chemical groups	Stem	Flower	Leaf	Average
Monoterpenes	**77.41**	**88.30**	**83.99**	**83.24**
Monoterpene Hydrocarbons	3.44	18.66	11.52	11.21
Oxygenated Monoterpenes	73.97	69.64	72.47	72.03
Sesquiterpenes	**12.14**	**5.53**	**8.53**	**8.73**
Sesquiterpene Hydrocarbons	10.05	4.75	7.38	7.39
Oxygenated Sesquiterpenes	2.09	0.78	1.15	1.34
Diterpenes	**0**	**0.57**	**0.75**	**0.44**
Diterpene Hydrocarbons	0	0.57	0.72	0.43
Oxygenated Diterpenes	0	0	0.03	0.01
Others	**8.01**	**4.44**	**6.09**	**6.18**
Hydrocarbons	0.14	0.04	0.06	0.08
Oxygenated	7.87	4.40	6.03	6.10
Total	**97.56**	**98.84**	**99.36**	**98.59**

When the proportional distribution of the chemical groups of essential oil total components identified in the aerial parts of *O. syriacum* var. *bevanii* was examined, it was seen that monoterpenes (77.41-88.30%) stand out and reach the highest value in the essential oil of flowers (Table 2). The highest oxygenated monoterpenes value was detected in the essential oil of stem (73.97%) and the lowest value was found in the essential oil of flower (69.64%). In monoterpene hydrocarbons, it was reached the highest value in the essential oil of flower (18.66%).

It was stand out in component the essential oil of Osyriacum that the para-Cymene (%1.55-5.24), gamma-Terpinene (1.24-4.19%) and β-Myrcene (0.43-2.79%) in monoterpene hydrocarbons, Carvacrol (59.53-66.99%), Linalool (1.95-4.39%), Linalyl acetate (1.39-30.5%) and 1-octen-3-yl-acetate (1.31-2.05%) in oxygenated monoterpenes, β-Caryophyllene (2.49-6.37%) and Aromadendrene (0.40-0.91%) in sesquiterpene hydrocarbons, and Caryophyllene oxide (0.48-1.37%) and (E)-α-bisabolene (0.20-1.01%) in oxygenated Sesquiterpene.

The proportional distribution of the essential oil components in the leaves according to the node sequence on the stem of the *O. syriacum* var. *bevanii* was given in Table 3.

The proportional distribution of essential oil total identified components in the leaves according to their location in the stems of the *O. syriacum* var. *bevanii* were showed a difference between 99.13% and 99.80% (Table 3). The Carvacrol (58.39-64.53%), an oxygenated monoterpene, was found as the main component in all leaf essential oils. According to the leaf locations on the stem, the highest Carvacrol ratio was determined with 64.53% in the 6th node leaves and the lowest value in the 1st node leaves (Table 3). The ratio of Carvacrol was increased up to the 4th node leaves, and it was seen changed between 60.42% and 64.53% in the later nodes leaf (6.-10. node). The Carvacrol component was followed by para-Cymene (4.43-6.18%), Linalool (2.12-6.21%), β-Caryophyllene (2.96-3.71%), Linalyl acetate (2.21-4.11%), 1-Octen-3-yl-acetate (1.87-2.45%), gamma-Terpinene (0.78-5.36%), trans-Sabinene hydrate (1.20-1.44%), β-Myrcene (0.72-2.00%) and 1-Octen-3-ol (0.82-1.31%), respectively. In general, it was been observed that gamma-Terpinene, 1-Octen-3-yl-acetate and (Z)-α-Bisabolene, which were high in young leaves, decrease towards the bottom leaves. In addition, the ratios of Linalool, Linalyl acetate and 1-Octen-3-ol were increased significantly towards old leaves (from top to deep) (Table 3). In general, it can be said that the essential oil components were changed according to the nodal order of the leaves on the stem, and the ratio of Carvacrol in young leaves was low.

Conflict of Interest: The article authors declare that there is no conflict of interest between them.

Author Contribution: AÖ and FT were designed the study and were set up the trials, FT was conducted the study, and AÖ was analyzed the data and wrote the article. All authors have read, revised, and approved the manuscript.

Conclusions

The result of this study showed that in *O. syriacum* var. *bevanii*, the highest ratio of essential oil was observed in flowers and the lowest in stems. In addition, it was determined that the upper leaves have higher essential oil than the middle and lower leaves. While the smallest leaf was determined in the uppermost node leaves, little change was seen in the 7th node and subsequent node leaves. Carvacrol has been identified as the main ingredient in essential oils of all aerial plant parts. The smallest proportion of Cavracrol was determined at the top node leaves and increased up to the 4th node leaves.

Table 3. The essential oil ratio and essential oil components ratio (%) in leaves according to the node sequence on the stem of *Origanum syriacum* var. *bevanii*

Compounds Name*	RT	Leaves (from top to base)										Average
		1. Node	2. Node	3. Node	4. Node	5. Node	6. Node	7. Node	8. Node	9. Node	10. Node	
α-Thujene	11.208	1.48	1.39	1.09	0.99	1.03	0.87	1.04	0.85	0.95	0.97	0.77
α-Pinene	11.493	0.34	0.33	0.29	0.26	0.27	0.24	0.27	0.23	0.26	0.26	0.23
Hydroperoxide. 1-ethylbutyl	12.359	0.05	0.05	0.06	0.14	0.06	0.12	0.06	0.06	0.06	0.06	0.07
Hydroperoxide. 1-methylpentyl	12.828	0.07	0.05	0.07	0.17	0.06	0.14	0.06	0.06	0.06	0.06	0.08
1-Octen-3-ol	13.830	0.82	0.87	1.00	0.88	1.00	1.10	1.21	1.15	1.22	1.31	1.06
β-Myrcene	14.388	2.00	1.75	1.36	1.27	1.17	0.96	1.05	0.83	0.77	0.72	1.19
3-Octanol	14.640	0.39	0.39	0.40	0.43	0.48	0.52	0.58	0.57	0.61	0.68	0.51
α-Phellandrene	14.988	0.33	0.29	0.24	0.22	0.20	0.16	0.19	0.14	0.14	0.14	0.21
(-)-3-Carene	15.241	0.10	0.10	0.08	0.08	0.09	0.07	0.09	0.08	0.09	0.08	0.09
α-Terpinene	15.585	1.84	1.35	0.99	0.86	0.92	0.72	0.87	0.70	0.73	0.75	0.97
para-Cymene	16.006	5.26	4.92	4.43	4.86	5.28	5.04	5.56	5.21	5.70	6.18	5.24
β-Phellandrene	16.196	0.64	0.59	0.53	0.50	0.53	0.49	0.54	0.48	0.50	0.51	0.53
γ-Terpinene	17.772	5.36	3.19	2.27	1.74	1.74	1.32	1.50	1.04	0.84	0.78	1.98
trans Sabinene hydrate	18.188	1.27	1.20	1.40	1.31	1.27	1.44	1.38	1.28	1.30	1.41	1.33
Terpinolene	19.245	0.18	0.17	0.16	0.17	0.15	0.15	0.17	0.15	0.16	0.15	0.16
Linalool	19.899	2.12	2.13	3.15	6.21	4.93	4.52	4.81	5.08	5.27	5.69	4.39
1-Octen-3-yl-acetate	20.537	2.45	2.20	2.25	1.97	2.00	1.94	2.00	1.87	1.87	1.96	2.05
3-Octyl Acetate	21.149	0.74	0.66	0.72	0.60	0.66	0.65	0.72	0.69	0.71	0.77	0.69
Borneol	23.175	0.52	0.34	0.32	1.02	0.60	0.31	0.32	0.29	0.31	0.35	0.44
Terpinen-4-ol	23.779	0.52	0.53	0.64	0.48	0.52	0.54	0.59	0.56	0.57	0.60	0.56
α-Terpineol	25.925	0.23	0.15	0.20	0.80	0.42	0.33	0.27	0.30	0.27	0.36	0.33
(-)-Carvone	27.281	0.18	0.19	0.32	0.24	0.22	0.26	0.23	0.22	0.25	0.21	0.24
Thymoquinone	27.435	0.07	0.03	0.05	0.13	0.10	0.15	0.13	0.15	0.26	0.38	0.15
Linalyl Acetate	27.731	2.48	2.21	2.61	4.11	3.78	2.99	2.94	3.01	3.19	3.18	3.05

Table 3. Continued…

Compounds Name*	RT	Leaves (from top to base)										Average
		1. Node	2. Node	3. Node	4. Node	5. Node	6. Node	7. Node	8. Node	9. Node	10. Node	
Thymol	29.531	0.32	0.29	0.33	0.23	0.37	0.22	0.28	0.25	0.26	0.26	0.28
Carvacrol	30.310	58.39	61.87	62.67	60.60	60.42	64.53	61.43	63.66	62.08	60.56	61.62
Neryl acetate	32.733	0.12	0.12	0.19	0.27	0.27	0.20	0.22	0.25	0.25	0.25	0.21
Geranyl acetate	33.608	0.21	0.21	0.32	0.46	0.48	0.35	0.39	0.44	0.43	0.44	0.37
β-Caryophyllene	35.313	3.71	3.66	3.23	2.96	3.20	3.32	3.38	3.21	3.27	3.28	3.32
Aromadendrene	36.166	0.68	0.61	0.45	0.31	0.35	0.33	0.37	0.30	0.32	0.32	0.40
α-Caryophyllene	36.784	0.24	0.21	0.19	0.25	0.23	0.17	0.18	0.18	0.18	0.18	0.20
Germacrene-D	38.008	0.28	0.35	0.38	0.35	0.33	0.28	0.30	0.27	0.25	0.25	0.30
Viridiflorene	38.584	0.64	0.54	0.38	0.21	0.28	0.26	0.30	0.25	0.27	0.26	0.34
delta-Cadinene	39.799	0.21	0.19	0.18	0.11	0.12	0.13	0.17	0.12	0.16	0.12	0.15
(Z)-α-Bisabolene	40.505	1.01	1.27	1.28	1.03	0.96	1.07	1.03	0.93	0.78	0.78	1.01
4-ethyl-2-methoxy-6-methylphenol	41.109	0.17	0.08	0.08	-	0.28	0.10	0.29	0.28	0.54	0.47	0.23
Spathulenol	42.066	0.16	0.17	0.13	0.10	0.14	0.14	0.19	0.20	0.21	0.24	0.17
Caryophyllene oxide	42.279	0.35	0.37	0.43	0.43	0.54	0.57	0.64	0.69	0.76	0.86	0.56
Cis-3-Hexenyl Phenylacetate	44.155	0.12	0.19	0.23	0.15	0.17	0.17	0.19	0.19	0.14	0.16	0.17
Geranyl-α-terpinene	45.206	0.28	0.35	0.41	0.21	0.29	0.26	0.31	0.28	0.28	0.27	0.29
α-Bisabolol	46.260	0.17	0.09	0.16	0.37	0.39	-	0.05	0.04	0.04	0.04	0.14
Shyobunol	46.527	0.14	0.14	0.13	-	0.10	0.08	0.11	0.10	0.10	0.10	0.10
Trachylobane	57.912	0.60	0.83	0.63	0.26	0.19	0.15	0.11	0.06	-	0.03	0.32
β-Bisabolene	61.829	0.46	0.67	0.52	0.97	0.77	1.48	0.92	1.06	1.13	1.19	0.92
Total		99.34	99.31	99.10	99.76	99.37	99.80	99.22	99.37	99.08	99.13	
Essential Oil Ratio (%)		3.10 a	3.13 a	2.93 b	2.80 bc	2.90 bc	2.76 c	2.86 bc	2.83 bc	2.90 bc	2.90 bc	

*Upper than the 0.10%, RT: Retention time , Lsd (%5):0.15 (Essential Oil Ratio)

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