Chemical Composition of the Essential Oils of Lavanda Cultivated in Herzegovina

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Abstract
In this study, we analyzed the chemical composition of essential oils of two types of lavender cultivated in Herzegovina. Lavender essential oil was isolated by hydro distillation. Chemical characterization of individual components of essential oil was performed by gas chromatography GC-MS. The most ingredients of essential oil of Lavanda angustifolia are linalool (28.01%), linalyl acetate (27.59%), cis-β-octimene (5.05), trans-β-ocimene (4.09), terpinene-4-ol (4.86), lavandulyl acetate (5.90) i β-caryophyllene (3.93). The most ingredients of essential oil of Lavanda sp are: linalool (34.76%), linalyl acetate (27.59%), 1.8-cineole (3.21), camphor (6.93), bornool (4.86), α-terpineol (2.49), terpinene-4-ol (3.21), lavandulyl acetate (2.83) i β-caryophyllene (2.28).

Keywords: Lavender; Essential oil; Chemical composition

Introduction
Lavender is a perennial, aromatic plant from family Lamiaceae. It is used in medicine, food and cosmetics industry. Lavender is a plant of the Mediterranean region. It is produced in all areas with favorable conditions. Due to high temperatures, stony soil and a large number of sunny days, the area of Eastern Herzegovina provides ideal conditions for growing lavender. However, due to some ecological modification and adaptation of this species, lavender plantations can be found in continental areas, as well as at higher altitudes [1].

To date, 48 different species of lavender have been described. However, only the essential oil of Lavandula angustifolia, Lavandula latifolia and Lavender hybrid is used in the cosmetic industry [2]. Lavender essential oil contains about 100 active ingredients. The main ingredients of lavender essential oil are linalyl acetate and linalool. True lavender essential oil contains about 35-60% esters marked in linalyl acetate, while hybrid lavender essential oil contains only 7-16% esters [3].

Lavender essential oil is an excellent sedative, it has an effect on reducing bloating. It is often used as a corrector of the smell and taste of pharmaceutical preparations [1]. A large number of previous studies have confirmed that lavender essential oil has antioxidant, antimicrobial, anti-inflammatory properties [4-6]. Lavender essential oil is a mixed of chemical compounds with different antimicrobial properties. The antimicrobial effect of lavender essential oil depends on several active ingredients. Pharmacological and clinical evidence shows that the rational use of lavender essential oil works in chronic emotional disturbance [7]. Numerous authors have confirmed that lavender essential oil has a high inhibitor of cholinesterase activity [8,9].

Demand for lavender essential oil is on the rise, so lavender cultivation has been expanding over the past few years. The aim of this research is the chemical characterization of lavender essential oils from the area of eastern Herzegovina.
Material and Methods

Plant material

Plant material was collected in the phenophase of flowering in June 2020 in the area of Ljubinje in eastern Herzegovina. The plant material was dried in the shade on a draft. The dried plant material is packed in paper bags and stored in a dry and cool place.

Oil extraction

The essential oil was extracted by hydro distillation of dried plant material in a Clevenger apparatus according to the procedure prescribed by Ph. South. V [10]. During hydro distillation, the proportional ratio of plant material and water was 1:10 (m / v). The hydro distillation lasted for two hours. Extracted essential oil is a light yellow or colorless easily volatile liquid, with a pleasant smell, spicy and bitter taste. The results of determining the content of essential oil in the herb *L. angustifolia* represent the mean value of three comparative determinations.

Gas chromatography

We used a gas chromatograph HP 5890 with flame ionizing detector (FID), a column with HP-5MS stationary phase (25m x 0.32mm x 0.52mm) and an HP-GCD system with a column of the same polarity. Helium (chromatographic quality) was a carrier gas with rate of working of 1ml / min. Samples were analyzed in a splitless injector (1:50).

The temperature of the injector was 250 °C, the detector 280 °C, and the column temperature was linearly programmed from 40 °C to 280 °C; 4 °C /min. Component identification was performed by comparing peak retention times with standard samples and their mass spectra, and by comparing the mass spectra of components with Wiley275 library data. The retention times of the determined components are correlated with the values of the Kováčević index for the DB-5 column, according to the data from the R. Adams spectrum library. The content of the components is given as the value of the percentage of areas (area%) obtained by integrating the peaks using FID detectors.

Climatic characteristics of the studied area

The study area is characterized by a sub-Mediterranean climate with mild winters and warm summers. The maximum temperature in summer is around 40 °C, while the minimum temperature in winter is around -5 °C. During the year, on average, about 1950mm of rain falls. In the geomorphological sense, the Ljubinje field is a typical karst field with a flat terrace. The experimental plot is a soil of neutral reaction, rich in nitrogen content, very rich in easily accessible phosphorus and very rich in potassium (Table 1).

| pH in 1M KCL | (N) % | mg K₂O/100g soil | mg P₂O₅/100g |
|-------------|-------|-----------------|--------------|
| 6.91        | 0.28  | 74.6            | 50.6         |

Research Results with Discussion

Analysis of lavender essential oils indicated a variety of chemical components. The most common components of Lavender angustifolia essential oil were oxidized terpenes: linalool (28.01%) and linalyl acetate (27.59%). Other less common components are: cis-β-ocimene (5.05%), trans β-ocimene (4.09%), terpinene-4-ol (4.86%), lavandulyl acetate (5.90%) and β-caryophyllene (3.93%). The results of our research are in accordance with the results of the research [11,12]. In the research of Bialon et al. [13], in Poland, a significantly higher percentage (41.8%) of linalool and linalyl acetate (32.7%) was identified. Different percentages of linalool, linalyl acetate and other constituents are probably due to different climatic conditions, which is in accordance with the research Stepić [11]. The author states that variations in the quantitative content of components is influenced by external factors. Kišgeci et al. [3] in their paper they conclude that variations in the quantitative content of components is influenced by external factors (Table 2).

Table 2: Chemical composition of essential oil in *Lavandula angustifolia*.
The most common components of essential oil in Lavandula sp. were linalool (34.76%) and linalyl acetate (27.59%), and the less represented components were 1.8-cineole (3.21), camphor (6.93), borneol (4.05), α-terpineol (2.49), terpinene-4-ol (3.21), lavandulyl acetate (2.83) and β-caryophyllene (2.28). The same components with a similar percentage were found in both types of lavender (Lavandula angustifolia, Lavandula sp.). Similar results are published by other authors [11,14-16]. Different results are published by Maskovic et al. [17]. They found a significantly higher percentage of linalool (54.24%) and a very low percentage of linalyl acetate (0.77%) in lavender essential oil (Table 3).

Table 3: Chemical composition of essential oil in Lavandula sp.

| No. | RT   | Compound          | % of Compound |
|-----|------|-------------------|---------------|
| 1   | 7.139| α-thujene         | 0.04039       |
| 2   | 7.326| α-pinene          | 0.32852       |
| 3   | 7.719| Camphene          | 0.1784        |
| 4   | 8.346| β-pinene          | 0.05371       |
| 5   | 8.454| octen-3-ol        | 0.43099       |
| 6   | 8.769| Myrcene           | 1.53083       |
|    |    |    | 7  | 8  | 9  | 10  | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|    |    |    | 9.366 | 9.546 | 9.792 | 9.903 | 10.01 | 10.119 | 10.439 | 10.801 | 11.261 | 11.721 | 12.241 | 12.309 | 12.409 | 12.979 | 13.61 | 14.32 | 14.653 | 14.97 | 15.094 | 16.555 | 17.115 | 17.115 | 18.139 | 19.388 | 20.42 | 21.014 | 21.232 | 21.698 | 22.201 | 22.608 | 22.826 | 22.19 | 23.417 | 23.661 | 24.018 | 24.537 | 24.727 | 24.958 | 25.19 | 26.948 | 28.515 | 29.625 |
|    |    |    | α - phellandrene | α - terpinene | β-cimene | limonene | 1.8-cineole | cis-β-ocimene | trans-β-ocimene | γ-terpinene | linalool oxide trans | linalool oxide cis | linalool | n.d. | octenylacetate | n.d. | camphor | borneol | terpinene-4-ol | lavandulol | α - terpineol | n.d. | n.d. | linalyl acetate | lavandulyl acetate | n.d. | n.d. | geranyl acetate | n.d. | β-caryophyllene | α-bergamotene | n.d. | n.d. | trans-β-farnesene | n.d. | n.d. | n.d. | trans-β-bergamotena | n.d. | caryophyllene oxide | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
|    |    |    | 0.13017 | 0.05819 | 0.455 | 0.78147 | 3.20934 | 0.93665 | 0.88457 | 0.13978 | 0.0852 | 0.41507 | 34.75992 | 0.14046 | 0.27597 | 0.2245 | 6.92804 | 4.04786 | 3.20865 | 0.25599 | 2.4968 | 0.44502 | 0.09913 | 23.09242 | 2.82501 | 0.10266 | 0.84971 | 1.64449 | 0.07557 | 0.09527 | 2.28564 | 0.19789 | 0.05165 | 1.50971 | 0.14769 | 0.11806 | 0.93373 | 0.10174 | 0.40331 | 0.42248 | 0.14409 | 0.64455 | 1.29699 |

The quantitative composition of essential oils depends on the method of cultivation of lavender, altitude and microclimatic conditions [18,19].

**Conclusion**

The analysis of lavender essential oils from the area of eastern Herzegovina indicated the diversity of chemical constituents in them. The percentage of components was similar in both types of lavender. The most common components of the tested lavender essential oils are oxidized terpenes: linalool, linalyl acetate, cis-β-ocimene, trans β-ocimene, terpinene-4-ol, lavandulyl acetate, β-caryophyllene, 1.8-cineole, camphor, borneol and α-terne.
Although there are data on the composition of lavender essential oils in the literature, the obtained results are significant in terms of evaluating the quality of essential oils of the tested species from the territory of Herzegovina.

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