Gavrić, T., Gadžo, D., Hafner-Vuk, K., Erhatić, R.. (2023): Antioxidant capacity and composition of essential oil of lavender and lavandin growing in Bosnia and Herzegovina. Agriculture and Forestry, 69 (2): 71-81. doi:10.17707/AgricultForest.69.2.06

DOI: 10.17707/AgricultForest.69.2.06

Teofil GAVRIĆ*[1], Drena GADŽO [1], Katarina HAFNER-VUK [2], Renata ERHATIĆ[3]

ANTIOXIDANT CAPACITY AND COMPOSITION OF ESSENTIAL OIL OF LAVENDER AND LAVANDIN GROWING IN BOSNIA AND HERZEGOVINA

SUMMARY

The Lavandula genus is one of the world's most popular medicinal and aromatic plants and is rich in essential oil. Lavender (*Lavandula angustifolia* Mill.) and lavandin (*Lavandula intermedia* Emeric ex Loisel.) have high commercial values worldwide. However, their quality depends on genetic properties, environmental conditions, and cultural practices. Therefore, this research aimed to determine the antioxidant capacity and content of constituents in the essential oil of lavender and lavandin grown in the environmental conditions of central Bosnia and Herzegovina (B&H). Samples of lavender and lavandin (cv. grosso) were collected at Butmir, B&H. The tested properties were total phenolic, total flavonoids, antioxidant activity, essential oil content and content of constituents in essential oil. The quality of tested plants was statistically significantly dependent on the cultivar. The highest values of total phenolic, flavonoids, and antioxidant capacity were recorded in the lavender (54.26 mg GAE g^{-1}, 41.49 mg CAE g^{-1} and 17.49 μM Fe^{2+} g^{-1}, respectively), while the lowest was in the lavandin (39.30 mg GAE g^{-1}, 24.07 mg CAE g^{-1} and 10.84 μM Fe^{2+} g^{-1}, respectively). Essential oil content ranged from 4.44 (Lavender) to 8.25 mL 100 g^{-1} (lavandin). Essential oil of lavender and lavandin were rich in linalool.

Keywords: lavender, lavandin, antioxidant capacity, essential oil, GC-MS

[1]Teofil Gavrić (corresponding author: t.gavric@ppf.unsa.ba), Drena Gadžo, University of Sarajevo, Faculty of Agriculture and Food Sciences, Sarajevo, BOSNIA AND HERZEGOVINA
[2]Katarina Hafner-Vuk, Institute of Metrology of Bosnia and Herzegovina, Sarajevo, BOSNIA AND HERZEGOVINA
[3]Renata Erhatić, College of Agriculture, Križevci, CROATIA
Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.
Recieved:02/02/2023 *Accepted:18/05/2023*

INTRODUCTION

Since ancient times, people have been fascinated with medicinal and herbal plants because of their beneficial effects on human health. Lavender is one of the world's most popular medicinal and aromatic plants. Although there are 39 different species in this genus Lavandula, only three species have high commercial values, including Lavender (*Lavandula angustifolia* Mill.), lavandin (*Lavandula intermedia* Emeric ex Loisel.) and spike lavender (*Lavandula latifolia* Medik.) (Sönmez *et al*., 2018). Therefore, the cultivation of these species as therapeutic and aromatic herbs has increased significantly over the past few years (Kıvrak, 2018). Currently, the most famous countries for cultivating Lavender are Bulgaria, France, Italy, Spain, Turkey, Croatia, Greece, Kashmir, South Africa, and regions in Northern Africa (Vijulie *et al*., 2022).

Lavender is primarily cultivated for its essential oil, which has multiple uses. Lavender essential oil is highly valued in cosmetics, food preservation, agroindustry, traditional medicine, etc (Białoń *et al*., 2019; Mambrí *et al*., 2018; Wells *et al*., 2018; Komnenić *et al*., 2020). Lavender is used in traditional medicine for the treatment of various diseases (Behmanesh *et al*., 2015; Cardia *et al*., 2018; Firoozeei *et al*., 2021; Koulivand *et al*., 2013; Lis-Balchin *et al*., 1999; Pandur *et al*., 2021; Puškárová *et al*., 2017). The medicinal properties of all medicinal plants, including lavender, depending on the content of phenolic compounds and their antioxidant capacity (Gavrić *et al*., 2023). Although genetic processes control the amount of these components in the plant, environmental factors and cultivation method also significantly impact their contents (Gavrić *et al*., 2018a; Albergaria *et al*., 2020; Mohammadi *et al*., 2021; Lebedev *et al*., 2022). However, it is known that all cultivars accumulate phenolic compounds, which are characterized by high antioxidant activity (Wells *et al*., 2018).

The quality of lavender strongly depends on the content of the essential oil and its composition of constituents. Lavender oil can have more than 100 components, most of which are terpene compounds (Sałata *et al*., 2020). Previous research (Białoń *et al*., 2019; Mambrí *et al*., 2018; Minji Hong, 2022; Sałata *et al*., 2020) has shown that lavender and lavandin essential oil contains: linalyl acetate, linalool, and γ-cadinene, p-cymen-8-ol, borneol, lavandulol, o-cymene, bornyl acetate, (E)-caryophyllene, eucalyptol, camphor. However, according to many researchers (Białoń *et al*., 2019; Erhatić *et al*., 2020; Kvaternjak *et al*., 2020; Wells *et al*., 2018), the concentration of these components in essential oils varies greatly depending on cultivars and environmental factors. For example, lavender essential oil contains 17.8-50.0% linalool, 10.1-54.0% linalyl acetate, and traces of camphor, while lavandin essential oil contains 22.5-35.5% linalool, 23.6-35.4% linalyl acetate and in 6.3-12.2% camphor (Lesage-Meessen *et al*., 2015). On the other hand, it was found that the essential oil composition depends on the growing area's weather conditions. For example, the content of linalool, the main compound of lavender oil, increases with the increase in average daily temperature, while its content is reduced during the rainy season (Hassiotis *et al*., 2014).

Many studies in the literature study the composition of essential oils and the antioxidant capacity of lavender, but there are no studies in Bosnia and Herzegovina (B&H). Therefore, this research aimed to determine the antioxidant capacity and content of essential oil constituents of lavender and lavandin grown in the environmental conditions of central Bosnia and Herzegovina (B&H).

MATERIAL AND METHODS

Plant material and sampling

Lavender (*Lavandula angustifolia*) and lavandin (*Lavandula intermedia cv*. grosso) were used in this study. Samples were collected at Butmir, B&H (Experimental field of Sarajevo Faculty of Agriculture and Food Sciences, 43°49'34.42" N, 18°19'18.48" E; 505 m a.s.l.).

Materials for analysis

The total phenol content, total flavonoid content, antioxidant activity, and essential oil contents is determined in inflorescence samples. Samples were collected at the full flowering stage (July 19, 2021). The samples were dried in a dim environment for 30 days at room temperature. After that, collecting samples were dried and then ground to a size of 1 mm.

Extract preparation

Briefly, 1 g of each ground sample was added to a 100 mL volumetric flask, and the flask volume was filled with 60% ethanol and mixed. Then the extracts were filtered and stored in the refrigerator before the measurements.

Determination of total phenols content

The total phenolic contents of ethanolic extracts of lavender and lavandin were estimated using the Folin Ciocalteau reagent as described by Bystrická *et al*. (2011). Results were expressed as mg gallic acid equivalents per gram (mg GAE g^{-1}).

Determination of total flavonoid content

The flavonoid content of lavender and lavandin ethanolic extracts was determined using spectrophotometric methods based on forming aluminum-flavonoid complexes (Gavrić *et al*., 2018b). Results were expressed as mg catechin per gram (mg CAE g^{-1}).

Determination of antioxidant activity

The total antioxidant capacity of the extract was measured using the FRAP (ferric reducing antioxidant power) method described by Benzie and Strain (1996). Results was expressed as $\mu M\ Fe^{2+}\ g^{-1}$ of the dry sample.

Extraction and determination content of essential oils

Extracting essential oils from flower samples was carried out according to the protocol previously described by Clevenger (1928). Briefly, the dried flower samples were weighed (50 g) and then transferred to a 1000 mL volumetric flask with 500 mL of distilled water. The samples were distilled for two hours. The volume of essential oil was measured after distillation. After that, the essential oils were dried with sodium sulfate anhydrous, packed in dark vials, and stored in the refrigerator until analysis.

Gas Chromatography/Mass Spectrometry Analysis

The compositions of extracts were quantified by means of gas chromatograph with autosampler (Agilent Technologies, 7820A) equipped with capillary column (Agilent HP5-ms ultra-inert, 30 m×320 µm ×0.25 µm) coupled to an Agilent Technologies Mass Selective Detector (MSD-5977E). Temperature program used: 60 °C (1 min hold) to 246 °C (0 min hold) at a rate of 3 °C/min, and then to 280 °C at a rate of 10 °C/min. Injection volume of 1 µL was used in splitless injection mode at 220 °C and pressure of 8.4599 psi with carrier gas He of 99.9995 % purity.

Statistical methods

All experiments were performed in triplicate. One-way ANOVA was used to examine the data at a significance level of 0.05. The research findings were statistically analyzed using the SPSS 22 software.

RESULTS AND DISCUSSION

In this research, the amounts of total phenolic, flavonoids, and antioxidant capacity of the extracts from the inflorescence are shown in table 1.

Table 1**.** Effect of cultivars on total phenolic contents, total flavonoid contents, antioxidant capacity, and essential oil content

Cultivar	Total phenolics	Total flavonoids	Antioxidant capacity	Essential oil contents
	mg GAE g^{-1}	mg CAE g^{-1}	µM Fe^{2+} g^{-1}	mL 100 g^{-1}
Lavander	54.26a	41.49a	17.49	4.44c
Lavandin cv. grosso	39.30b	24.07b	10.84	8.25a
Average	**46.78**	**32.78**	**14.16**	**6.34**

Different letters indicate significant differences at the 0.05 level; ns: nonsignificant differences. GAE - gallic acid equivalent, CAE - cathetin acid equivalent.

The findings show that the level of these bioactive components and the antioxidant capacity depended on the cultivar. The highest values of total phenolic, flavonoids, and antioxidant capacity were recorded in the lavender (54.26 mg GAE g^{-1},41.49 mg CAE g^{-1} and 17.49 µM $Fe^{2+}g^{-1}$, respectively), while the lowest was in the lavandin (39.30 mg GAE g^{-1}, 24.06 mg CAE g^{-1} and 10.84 µM $Fe^{2+}g^{-1}$, respectively). The observed differences between lavender and lavandin in the level of total phenolics can probably be attributed to genetic variations of the plant (Gavrić *et al*., 2023). Our results align with Bajalan *et al.* (2016), which also researched flavonoid content in 30 different lavender cultivars. Their research showed that the content of flavonoids ranged from 28.19 to 71.62 mg GAE CAE g^{-1} dry matter. Furthermore, the authors emphasize that it is crucial to identify lavender cultivars with a high content of flavonoids due to their positive pharmacological effects on human health. Furthermore, our results indicate that the highest antioxidant capacity was found in lavender than lavandin. Therefore, this suggests that the antioxidant capacity significantly depends on the cultivars. In the meantime, Dobroš *et al*. (2022) studied three cultivars of lavender and two cultivars of lavandin.

They found that the cultivar greatly influences the antioxidative capacity activity. In addition to cultivars, environmental conditions such as temperature, humidity, altitude, location, and agronomic practices can significantly impact antioxidant capacity (Gavrić *et al*., 2018a).

The quality of lavender and lavandin mainly depends on the essential oil yield and its content of constituents (Sałata *et al*., 2020). Our research showed that the studied cultivars have a relatively high essential oil content. Also, analysis of essential oil content in our research showed a significant difference between the tested cultivars. The highest essential oil content was recorded in the lavandin (8.25 mL 100 g^{-1}), followed by the *Lavanda cultivars* (4.44 mL 100 g^{-1}). According to Mkaddem Mounira *et al.* (2022) variations in essential oil content can result from genetic factors, developmental stages, environmental conditions, harvesting methods, methods of drying, extraction, and analysis. Given that in our research, all factors that can influence the oil content were uniform, except for the cultivar, the resulting differences can be attributed to researched cultivars. This opinion can be supported by the finding of Renaud *et al.* (2001), who found that the essential oil content varies between 2.8-5.0% in lavender and 7.1-9.9% in lavandin.

Another important property that determines the quality and market price of essential oil of lavender and lavandin is the content of constituents. A data from the chromatogram (Figure 1 and 2) show that 23 different ingredients were isolated in essential oil of lavender and lavandin, and their percentage content is presented in Table 2.

The total of 23 ingredients were identified in the isolated essential oil, which makes up 98.06-98.30%. Furthermore, it is important to note that lavender and lavandin essential oils were different. In essential oil of lavender main isolated constituents were linalool (64.47%), β-cis-ocimene (6.50%), terpinen-4-ol (4.77%), linalyl acetate (4.22%), β-myrcene (3.38%), and other compounds in a smaller proportion. The main constituents in the essential oil of *Lavandin cv.* grosso were linalool (35.40%), eucalyptol (13.16%), camphor (9.54%), linalyl acetate (6.58%), β-myrcene (6.05%), lavandulol acetate (4.63%), β-cis-ocimene (4.56%), and other compounds.

Overall, our research determined that linalool is the main constituent of the essential oils of both cultivars. Therefore, by comparing this constituent between cultivars (Table 2), it can be said that lavender's highest proportion was recorded (64.47%). In contrast, lower linalool content was recorded in lavandin (35.40%). Our results are consistent with Lesage-Meessen *et al*. (2015), who also found higher linalool content in lavander than in lavandin cultivars.

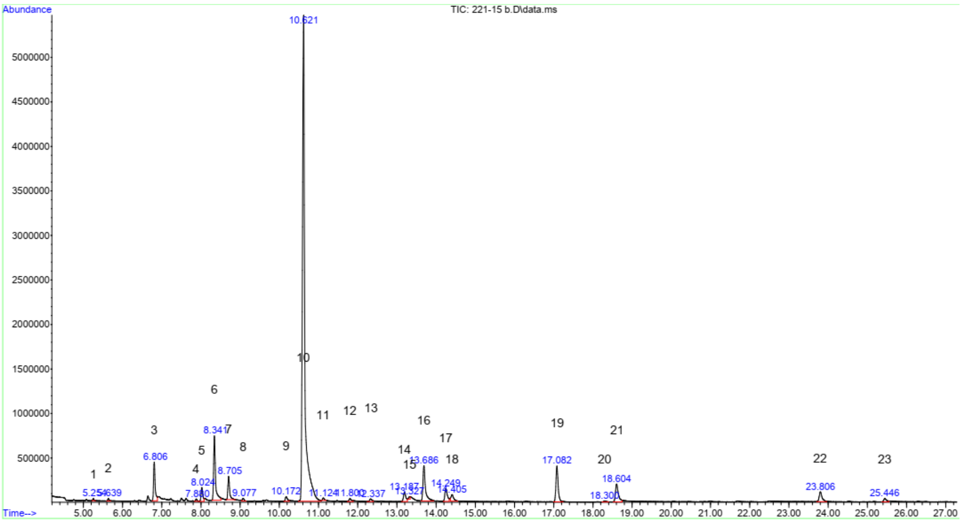

Figure 1. Chromatogram of lavender essential oil. Numbers of constituents: 1- α-pinene, 2- camphene, 3-sabinene, 4.β-pinene, 5-β-myrcene, 6-2-carene, 7- m-cymene, 8-D-limonene, 9- eucalyptol, 10-β-cis-ocimene, 11- trans- β-ocimene, 12- γ-terpinen, 13- terpinolen, 14- linalool, 15-camphor, 16-endo-borneol, 17-terpinen-4-ol, 18-α-terpineol, 19- linalyl acetate, 20-lavandulol acetate, 21-α-terpinyl aceate, 22-caryophyllene, and 23-cis-β-farnesene.

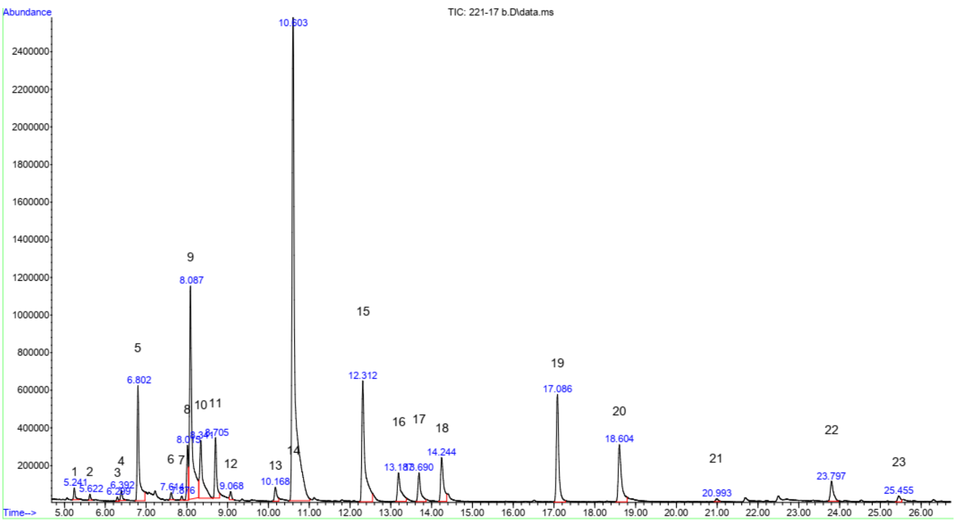

Figure 2. Chromatogram of lavandin essential oil. Numbers of constituents: 1-α-pinene, 2-camphene, 3-β-myrcene, 4-m-cymene, 5-D-limonene, 6-β-cis-ocimene, 7-trans- β-ocimene, 8-γ-terpinen, 9-terpinolen, 10-linalool, 11-1-octen-3-yl-acetate, 12-cosmene, 13-camphor, 14-endo-borneol, 15-lavandulol, 16-terpinen-4-ol, 17-α-terpineol, 18-n-hexyl butanoate, 19-linalyl acetate, 20-bornyl acetate, 21-lavandulol acetate, 22-caryophyllene, and 23-cis-β-farnesene.

Table 2. Chemical composition of essnetial oil lavender and lavandin cv grosso

№	Constituent name	Lavander essential oil, %	Lavandin cv. Grosso essential oil, %
1.	α- pinene	0.14	0.51
2.	camphene	0.18	0.21
3.	sabinene		0.16
4.	β-pinene		0.48
5.	β-myrcene	3.38	6.05
6.	2-carene		0.30
7.	m-cymene	0.17	0.16
8.	D-limonene	1.35	2.18
9.	eucalyptol		13.16
10.	β-cis-ocimene	6.50	4.56
11.	trans- β-ocimene	2.31	3.00
12.	γ-terpinen	0.25	0.37
13.	terpinolen	0.54	0.84
14.	linalool	64.47	35.40
15.	1-octen-3-yl-acetate	0.20	
16.	cosmene	0.38	
17.	camphor	0.35	9.54
18.	endo-borneol	1.18	2.48
19.	lavandulol	0.18	
20.	terpinen-4-ol	4.77	2.07
21.	α-terpineol	1.73	3.18
22.	n-hexyl butanoate	0.93	
23.	linalyl acetate	4.22	6.58
24.	bornyl acetate	0.17	
25.	lavandulol acetate	2.85	4.63
26.	α-terpinyl aceate		0.19
27.	caryophyllene	1.53	1.56
28.	cis-β-farnesene	0.51	0.46
	Σ (%)	**98.29**	**98.06**

However, in our research, the content of linalool in lavender essential oil was slightly higher than the mentioned authors' results. According to Alizadeh and Aghaee (2016) these differences may arise due to cultivars, environmental conditions, harvest time, essential oil extraction processes, and determination methodology. In addition to the linalool content, linalyl acetate is a crucial constituent determining the quality of lavender essential oil (Pokajewicz *et al*., 2021). In our research, its content ranged from 6.58% (*Lavanin cv*. grosso) to 4.22% (lavender). However, compared to previous studies (Pokajewicz *et al*., 2021), this study found a relatively small amount of linalyl acetate. This difference can be attributed to partial decomposition during hydrodistillation (Danh *et al*., 2013). Furthermore, the analyzed essential oils also differed in their camphor content. Lavender had a concentration of 0.35% camphor, while lavender had a concentration of 9.54%. It should also be noted that a significant difference between the analyzed essential oils existed in the eucalyptol content. This constituent was found in significant concentrations in lavender essential oil (13.16%), while eucalyptol was not identified in lavender essential oil (0%). According to Kara and Baydar (2013) lavender essential oil is of higher quality in the perfume industry than Lavender essential oil because of its low camphor and eucalyptol level. The same authors believe that the camphor content in quality lavender oil must be between 0.5 and 1% in lavender and between 5.0 and 10.0% in lavender.

CONCLUSIONS

This is the first research on lavender and lavandin grown in the environmental conditions of central Bosnia and Herzegovina. Research has shown that lavender has a high content of phenolic compounds, which is especially interesting if it is a source of antioxidants in the human diet. Furthermore, the research cultivars had a high yield of essential oil. Linalool dominated in the essential oil of both cultivars, especially lavender. The essential oil of lavender was rich in linalool and β-cis-ocimene but poor in camphor. On the hand, lavendin essential oil was rich in linalool, eucalyptol and camphor.

REFERENCES

Albergaria, E. T., Oliveira, A. F. M., & Albuquerque, U. P. (2020). The effect of water deficit stress on the composition of phenolic compounds in medicinal plants. South African Journal of Botany, 131, 12–17. doi: https://doi.org/10.1016/j.sajb.2020.02.002

Alizadeh, A., & Aghaee, Z. (2016). Essential oil constituents, phenolic content and antioxidant activity of Lavandula stricta Delile growing wild in southern Iran. Natural Product Research, 30(19), 2253–2257. doi: https://doi.org/10.1080/14786419.2016.1155578

Bajalan, I., Mohammadi, M., Alaei, M., & Pirbalouti, A. G. (2016). Total phenolic and flavonoid contents and antioxidant activity of extracts from different populations of lavandin. Industrial Crops and Products, 87, 255–260. doi: https://doi.org/10.1016/j.indcrop.2016.04.059

Behmanesh, F., Pasha, H., Sefidgar, A. A., Taghizadeh, M., Moghadamnia, A. A., Adib Rad, H., & Shirkhani, L. (2015). Antifungal Effect of Lavender Essential Oil (*Lavandula angustifolia*) and Clotrimazole on Candida albicans: An In Vitro Study. Scientifica, 2015, 261397. doi: 10.1155/2015/261397

Benzie, I., & Strain, J. (1996). The ferric reducing ability of plasma (FRAP)as a measure of “Antioxidan power”:the FRAP assay analytical biochemistry. Analytical Biochemistry.

Białoń, M., Krzyśko-Łupicka, T., Nowakowska-Bogdan, E., & Wieczorek, P. P. (2019). Chemical Composition of Two Different Lavender Essential Oils and Their Effect on Facial Skin Microbiota. Molecules (Vol. 24, Issue 18). doi: 10.3390/molecules24183270

Bystrická, J., Vollmannová, A., Kupecsek, A., Musilová, J., Poláková, Z., Čičová, I., & Bojňanská, T. (2011). Bioactive Compounds in Different Plant Parts of Various Buckwheat (*Fagopyrum esculentum* Moench.) Cultivars. Cereal Research Communications, 39(3), 436–444. doi: 10.1556/CRC.39.2011.3.13

Cardia, G. F. E., Silva-Filho, S. E., Silva, E. L., Uchida, N. S., Cavalcante, H. A. O., Cassarotti, L. L., Salvadego, V. E. C., Spironello, R. A., Bersani-Amado, C. A., & Cuman, R. K. N. (2018). Effect of Lavender (*Lavandula angustifolia*) Essential Oil on Acute Inflammatory Response. Evidence-Based Complementary and Alternative Medicine : ECAM, 2018, 1413940. doi: 10.1155/2018/1413940

Clevenger, J. F. (1928). Apparatus for the Determination of Volatile Oil. The Journal of the American Pharmaceutical Association (1912). doi: 10.1002/jps.3080170407

Danh, L. T., Han, L. N., Triet, N. D. A., Zhao, J., Mammucari, R., & Foster, N. (2013). Comparison of Chemical Composition, Antioxidant and Antimicrobial Activity of Lavender (*Lavandula angustifolia* L.) Essential Oils Extracted by Supercritical CO2, Hexane and Hydrodistillation. Food and Bioprocess Technology, 6(12), 3481–3489. doi: 10.1007/s11947-012-1026-z

Dobros, N., Zawada, K., & Paradowska, K. (2022). Phytochemical Profile and Antioxidant Activity of Lavandula angustifolia and Lavandula x intermedia Cultivars Extracted with Different Methods. Antioxidants (Vol. 11, Issue 4). doi: 10.3390/antiox11040711

Erhatić, R., Kvaternjak, I., & Jambrišak, Branimir Mužić, M. (2020). Sadržaj mikroelemenata u listu i cvijetu prave lavande (*Lavandula angustifolia* Mill.) i lavandina (*Lavandula × intermedia* Emeric ex Loisel.). 55th Croatian & 15th International Symposium on Agriculture.

Firoozeei, T. S., Feizi, A., Rezaeizadeh, H., Zargaran, A., Roohafza, H. R., & Karimi, M. (2021). The antidepressant effects of lavender (*Lavandula angustifolia* Mill.): A systematic review and meta-analysis of randomized controlled clinical trials. Complementary Therapies in Medicine, 59, 102679. doi: https://doi.org/10.1016/j.ctim.2021.102679

Gavrić, T., Čadro, S., Gadžo, D., Đikić, M., Bezdrob, M., Jovović, Z., Jurković, J., Hamidović, S. (2018a). Influence of meteorological parameters on the yield and chemical composition of common buckwheat (*Fagopyrum esculentum* Moench). The Journal Agriculture and Forestry, 64(4). doi: 10.17707/agricultforest.64.4.13

Gavrić, T., Jurković, J., Hamidović, S., Haseljić, S., Lalević, B., Čorbo, A., & Bezdrob, M. (2018b). Yield and contents of some bioactive components of basil (*Ocimum basilicum* L.) depending on time of cutting. In Studia Universitatis Vasile Goldis Arad, Seria Stiintele Vietii. 28(4).

Gavrić, T., Marković Stefan, & Čengić, L. (2023). Factibility of growing basil as an alternative crop for adaptation to climate change in Bosnia and Herzegovina. Chilean Journal of Agricultural Research, 83(1), 43–51. doi: 10.4067/S0718-58392023000100043

Hassiotis, C. N., Ntana, F., Lazari, D. M., Poulios, S., & Vlachonasios, K. E. (2014). Environmental and developmental factors affect essential oil production and quality of *Lavandula angustifolia* during flowering period. Industrial Crops and Products, 62, 359–366. doi: https://doi.org/10.1016/j.indcrop.2014.08.048

Kara, N., & Baydar, H. (2013). Determination of lavender and lavandin cultivars (*Lavandula* sp.) containing high quality essential oil in Isparta, Turkey. Turkish Journal of Field Crops, 18(1), 58–65.

Kıvrak, Ş. (2018). Essential oil composition and antioxidant activities of eight cultivars of Lavender and Lavandin from western Anatolia. Industrial Crops and Products, 117, 88–96. doi: https://doi.org/10.1016/j.indcrop.2018.02.089

Komnenić, A., Jovović, Z., Velimirović, A. (2020). Impact of different organic fertilizers on lavender productivity (*Lavandula officinalis* Chaix). Agriculture and Forestry, 66 (2): 51-56

Koulivand, P. H., Khaleghi Ghadiri, M., & Gorji, A. (2013). Lavender and the nervous system. Evidence-Based Complementary and Alternative Medicine: ECAM, 2013, 681304. doi: 10.1155/2013/681304

Kvaternjak, I., Erhatić, R., Stojnović, M., Louis, A., & Jouve, A. (2020). Macroelement content of true lavender (*Lavandula angustifolia* Mill.) and lavender (*Lavandula* × *intermedia* Emeric ex Loisel.) in organic fertilization. 55th Croatian & 15th International Symposium on Agriculture.

Lebedev, V. G., Lebedeva, T. N., Vidyagina, E. O., Sorokopudov, V. N., Popova, A. A., & Shestibratov, K. A. (2022). Relationship between Phenolic Compounds and Antioxidant Activity in Berries and Leaves of Raspberry Genotypes and Their Genotyping by SSR Markers. Antioxidants.11(10). doi: 10.3390/antiox11101961

Lesage-Meessen, L., Bou, M., Sigoillot, J.-C., Faulds, C. B., & Lomascolo, A. (2015). Essential oils and distilled straws of lavender and lavandin: a review of current use and potential application in white biotechnology. Applied Microbiology and Biotechnology, 99(8), 3375–3385. doi: 10.1007/s00253-015-6511-7

Lis-Balchin, M., & Hart, S. (1999). Studies on the mode of action of the essential oil of lavender (*Lavandula angustifolia* P. Miller). Phytotherapy Research: PTR, 13(6), 540–542.

Mambrí, A. P. S., Andriolo, J. L., Manfron, M. P., Pinheiro, S. M. G., Cardoso, F. L., & Neves, M. G. (2018). Yield and composition of lavender essential oil grown in substrate. Horticultura Brasileira, 36(2), 259–264. doi: 10.1590/S0102-053620180219

Minji Hong, H. J. M. K. P. D. S. H. A. S. K. (2022). Comparative Chemical Analysis of Essential Oils of *Lavandula angustifolia* Cultivated in Seorak and Jiri Mountains of Korea. Journal of Agricultural, Life and Environmental Sciences 2022 34:2, 34(2), 172–179. doi: 10.22698/JALES.20220018

Mkaddem Mounira, G., Ahlem, Z., Abdallah Mariem, B., Romdhane, M., K. Okla, M., Al-Hashimi, A., Alwase, Y. A., Madnay, M. M., AbdElgayed, G., Asard, H., Beemster, G. T. S., & AbdElgawad, H. (2022). Essential Oil Composition and Antioxidant and Antifungal Activities of Two Varieties of *Ocimum basilicum* L. (Lamiaceae) at Two Phenological Stages. Agronomy. 12(4). doi: 10.3390/agronomy12040825

Mohammadi, H., Akhondzadeh, M., Hatami, M. (2021). Exogenously applied 24-epibrassinolide modulates physiological and biochemical constituents in lavender (*Lavandula angustifolia*) plants under drought stress conditions. Agriculture and Forestry, 67 (2): 103-120. doi:10.17707/AgricultForest.67.2.08

Pandur, E., Balatinácz, A., Micalizzi, G., Mondello, L., Horváth, A., Sipos, K., & Horváth, G. (2021). Anti-inflammatory effect of lavender (*Lavandula angustifolia* Mill.) essential oil prepared during different plant phenophases on THP-1 macrophages. BMC Complementary Medicine and Therapies, 21(1), 287. doi: 10.1186/s12906-021-03461-5

Pokajewicz, K., Białoń, M., Svydenko, L., Fedin, R., & Hudz, N. (2021). Chemical Composition of the Essential Oil of the New Cultivars of *Lavandula angustifolia* Mill. Bred in Ukraine. Molecules (Basel, Switzerland), 26(18). doi: 10.3390/molecules26185681

Puškárová, A., Bučková, M., Kraková, L., Pangallo, D., & Kozics, K. (2017). The antibacterial and antifungal activity of six essential oils and their cyto/genotoxicity to human HEL 12469 cells. Scientific Reports, 7(1), 8211. doi: 10.1038/s41598-017-08673-9

Renaud, E. N. C., Charles, D. J., & Simon, J. E. (2001). Essential Oil Quantity and Composition from 10 Cultivars of Organically Grown Lavender and Lavandin. Journal of Essential Oil Research, 13(4), 269–273. doi: 10.1080/10412905.2001.9699691

Sałata, A., Buczkowska, H., & Nurzyńska-Wierdak, R. (2020). Yield, Essential Oil Content, and Quality Performance of Lavandula angustifolia Leaves, as Affected by Supplementary Irrigation and Drying Methods. In Agriculture 10(12). doi: 10.3390/agriculture10120590

Sönmez, Ç., Soysal, A. Ö. Ş., Okkaoğlu, H., Karık, Ü., Taghiloofar, A. H., & Bayram, E. (2018). Determination of some yield and quality characteristics among individual plants of lavender (*Lavandula angustifolia* Mill.) populations grown under mediterranean conditions in Turkey. Pakistan Journal of Botany 50(6).

Vijulie, I., Lequeux-Dincă, A.-I., Preda, M., Mareci, A., & Matei, E. (2022). Could Lavender Farming Go from a Niche Crop to a Suitable Solution for Romanian Small Farms? In Land. 11(5). doi: 10.3390/land11050662

Wells, R., Truong, F., Adal, A. M., Sarker, L. S., & Mahmoud, S. S. (2018). Lavandula Essential Oils: A Current Review of Applications in Medicinal, Food, and Cosmetic Industries of Lavender. Natural Product Communications, 13(10), doi: 10.1177/1934578X1801301038