MORPHOLOGICAL AND BIOCHEMICAL CHARACTERISTICS OF SOME TAXA OF *LAVANDULA* L.

CARACTERESTICI MORFOLOGICE ŞI BIOCHIMICE ALE UNOR TAXONI DE *LAVANDULA* L.

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Abstract. *Among the various species within the Lavandula genus, Lavandula angustifolia (true lavender) and Lavandula × intermedia (lavandin) are considered the most significant, because they are grown both for their beauty as ornamental plants and for their essential oils, which are widely used in cosmetics, perfumery, and aromatherapy. This paper presents the results of a study carried out on plants in their second year of cultivation, from two varieties of lavender (`Little Lottie` and `Munstead`) and one variety of lavandin (`Grosso`), grown under the ecological conditions of NE Romania (city of Iași). The plants' decorative aspect (by determining some morphological characters) and the chemical composition of the organic extract obtained from the flowers were analyzed. Lavandin showed the highest growth in height (88.5 cm) and diameter (141 cm), as well as the highest number of inflorescences/plant (570 infl./pl.). The lavender varieties had 38.4-56.7 cm heights and bush diameters of 61.2-70 cm, with the highest values in `Munstead` and an almost identical number of inflorescences/plant (199.4-200.1). The chemical composition, evaluated by GC-FID-MS showed the presence of higher linalool amounts (maximum in lavandin), linalyl acetate, and lavandulyl acetate (maximum in `Munstead`), eucalyptol (maximum in lavandin), and camphor (only in lavandin).*

Key words: lavender, lavandin, morphological characters, organic extract.

Rezumat. *Dintre speciile genului Lavandula L., levănțica (L. angustifolia Mill.) și lavandinul (L. x intermedia Emeric ex Loisel) sunt considerate cele mai importante deoarece sunt cultivate atât pentru valoarea decorativă, cât și pentru uleiurile esențiale utilizate pe scară largă în cosmetică, parfumerie, aromaterapie. Lucrarea prezintă rezultatele unui studiu efectuat la plante aflate în anul doi de cultură, de la două soiuri de levănțica (`Little Lottie` și `Munstead`) și un soi de lavandin (`Grosso`), cultivate în condițiile ecologice din NE României (orașul Iași). A fost analizat aspectul decorativ al plantelor (prin determinarea unor caractere morfologice) și compoziția chimică a extractului organic esențial obținut din flori. Lavandinul a înregistrat creșterile cele mai mari în înălțime (88,5 cm) și diametru (141 cm), dar și numărul cel mai mare de inflorescențe (570 infl./pl.). Soiurile de levănțică au avut înălțimi de 38,4-56,7 cm și diametrul tufei de 61,2-70 cm, cu valori maxime la soiul `Munstead`, iar numărul de inflorescențe/plantă aproape identic (199,4-200,1). Compoziția chimică, determinate cu GC-FID-MS, a evidențiat prezența în cantități mai mari a linaloolului (maxim la lavandin), acetatului de linalil și acetatului de lavandulil (maxim la `Munstead`), eucaliptolului (maxim la lavandin) și camforului (numai la lavandin).*

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Cuvinte cheie: levănțică, lavandin, caractere morfologice, extract organic.

INTRODUCTION

The *Lavandula* L. genus (*Lamiaceae* family) comprises 47 species, numerous hybrids and about 400 varieties of herbaceous or subshrub plants native to the Mediterranean climate, many of them appreciated for their decorative appearance but also for their valuable volatile oil content, with uses in different fields (perfumery, cosmetics, pharmacology, traditional medicine, aromatherapy, food, etc.) [Aprotosoaie *et al.*, 2017; Pokajewicz *et al.*, 2021; Pokajewicz *et al.*, 2023]. The specific fragrance of plants of the genus is due to the presence of monoterpenes synthesized in the aerial parts of the plants, especially in flowers [Hassanpouraghdam *et al.*, 2011; Cantor *et al.*, 2018; Bogdan *et al.*, 2020; Nedeltcheva-Antonova *et al.*, 2022]. Some *Lavandula* species contain high amounts of camphor, which has antimicrobial and antifungal effects, while others have a high content of antioxidant substances (Cavanagh and Wilkinson, 2002).

Among the species of greater economic and ornamental importance are lavender or English lavender (*L. angustifolia* Mill.) and lavandin (*L.* x *intermedia* Emeric ex Loisel.), a hybrid between *L. angustifolia* and *L. latifolia* Medik. [Asci *et al*., 2019].

Lavender has lignified stems at the base, with an average height of approx. 40-60 cm, and forms compact, regular clumps. The leaves are linear or lanceolate, with wavy margins, silver-green, and covered with tomentum. The flower stems are unbranched, with the flowers arranged in compact terminal spikes organized in whorls of 3-5 flowers. The essential oil is of low toxicity, even undiluted, and can be used to treat wounds and burn infections. It is one of the species widely cultivated globally and is officially recognized by the European Pharmacopeia as a medicinal plant [Nedeltcheva-Antonova *et al.*, 2022; Kiprovski *et al.*, 2023].

Lavandin differs from lavender in its larger bush size, broader leaves and branched flower stems with flowers in lax spikes. Its primary use as a raw material for the extraction of essential oils, which are particularly rich in terpenoids (linalyl acetate, linalool), as it has a higher yield than lavender [Asci *et al.*, 2019].

The ISO (International Organization for Standardization) standards for lavender and lavandin are reliable reference points for assessing essential oil quality and authenticity [Wilson *et al.*, 2023].

The present work analyzes a number of morphological characters of ornamental interest, as well as aspects concerning the composition of organic extracts from fresh flowers of *L. angustifolia* Mill. and *L.* x *intermedia* Emeric ex Loisel.

MATERIAL AND METHOD

Two cultivars of *L. angustifolia* (`Little Lottie` and `Munstead`) and one cultivar of *L.* x *intermedia* (`Grosso`) were studied (fig. 1).

'Little Lottie' is a cultivar with white - pink flowers and height up to 40 cm (fig. 1.a), and 'Munstead' a variety with purple flowers, silver- green foliage that grows in dense bushes up to 60 cm high (fig. 1.b).

'Grosso' reaches a height of 90-100 cm, forms a globular bush, has green leaves and inflorescences of approx. 15 cm in length and 5 cm in diameter, with purple flowers (fig. 1.c).

The experimental cultures were established in 2022, in the field of the Floriculture discipline at the Iasi University of Life Sciences, Romania. Planting was done at distances of 50 cm between rows and 50 cm between plants per row. The experiment was single-factor, the experimental factor being the cultivar, with three graduations, resulting in three experimental variants, arranged in randomized blocks with three replicates (5 plants/replication).

a) 'Little Lottie' b) 'Munstead' c) 'Grosso'

Fig. 1. Appearance of studied taxa

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Biometric determinations considered total plant height from ground level, total length of flower stems, inflorescence length and number of inflorescences per plant. The results were statistically interpreted by determining the correlations between some morphological characters to establish their relationship. Correlation coefficients were calculated and linear regression through mathematical modeling from MS EXCEL application of MS Office 2019 package was used.

To determine the composition of the organic extract, 30 flowers were collected from each cultivar using tweezers, without pressing the calyx, and placed in 20 mL vials with 4 mL of ethyl acetate (Sigma). The hermetically sealed tubes were stored at 4°C until extraction. The extract containing volatile compounds from the flowers was collected and dried by adding anhydrous sodium sulfate (Sigma) (Guitton *et al.*, 2009). Analyses were performed with an Agilent 7890A gas chromatograph (GC) coupled with an Agilent 5975C quadrupole mass spectrometer (MS). A DB-WAXetr column with a length of 30 m, internal diameter of 0.32 mm and film thickness of 0.32 µm was used. The operating conditions were as follows: the helium flow rate was 5.0 mL min-1 and the oven temperature started at 65 °C, increasing to 170 °C at a rate of 1.5 °C min-1. The injection was done in splitless mode with a purge flow rate of 3 mLmin-1. Both injector and detector temperatures were set at 250 °C. The MS source was operated in electron ionization (EI) mode at an electron energy of 70 eV, and the ion source temperature was 200°C. Mass spectra were acquired in the mass range of 40-300 a.m.u. (atomic mass units) (Zagorcheva *et al.,* 2013). The constituents present in the EO samples were identified by comparing their relative retention indices, estimated using a mixture of a homologous series of aliphatic hydrocarbons from C_8 to C_{40} and MS fragmentation patterns with those from an Adams mass spectra library and NIST'08 (National Institute of Standards and Technology). The GC analysis was performed on an Agilent GC-7890A gas chromatograph (Agilent Technologies, USA) equipped with a flame ionization detector (FID) under the same conditions as described above. The FID temperature was maintained at 280 °C for the oil analyses. The relative composition of the investigated samples was

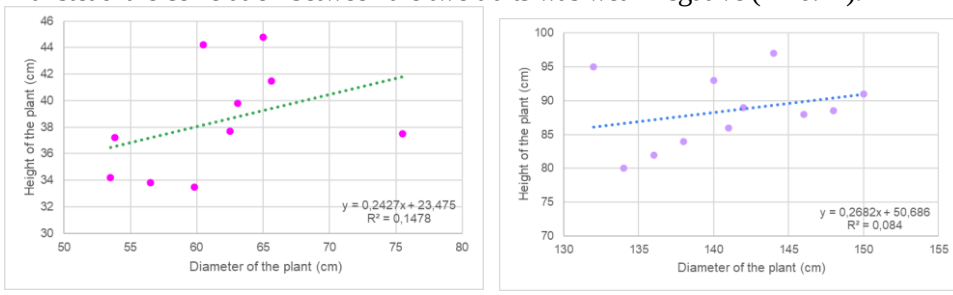
calculated based on the GC-FID peak areas (measured using the HP-5 ms column) without using a correction factor.

RESULTS AND DISCUSSIONS

Morpho-decorative characters

The study analyzed the correlations between different morpho-decorative characters of the three *Lavandula* taxa, constructed the corresponding linear regressions, wrote the regression equations and calculated the Pearson correlation coefficients. Results were interpreted according to the following significance intervals: r<0.25 weak correlation, 0.25<r<0.5 medium correlation, 0.5<r<0.75 strong correlation and r >0.75 very strong correlation.

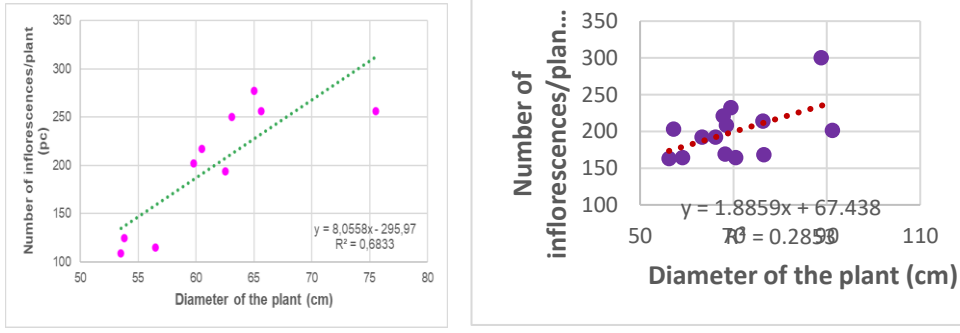
Between total plant diameter and total plant height (fig. 2), medium positive correlations were obtained for 'Little Lottie' (r = 0.38) and 'Grosso' (r = 0.29), while in 'Munstead' the correlation between the two traits was weak negative (r = 0.12).



a) 'Little Lottie' b) 'Grosso'

Fig. 2. Correlation between the diameter of the plant and the total height of the plant

In the case of plant diameter and number of inflorescences/plant (fig. 3), a strong positive correlation was identified for 'Little Lottie' (r = 0.83) and a medium to strong positive correlation for 'Munstead' (r = 0.53), while a non-significant negative correlation was identified for 'Grosso' (r = 0.02).

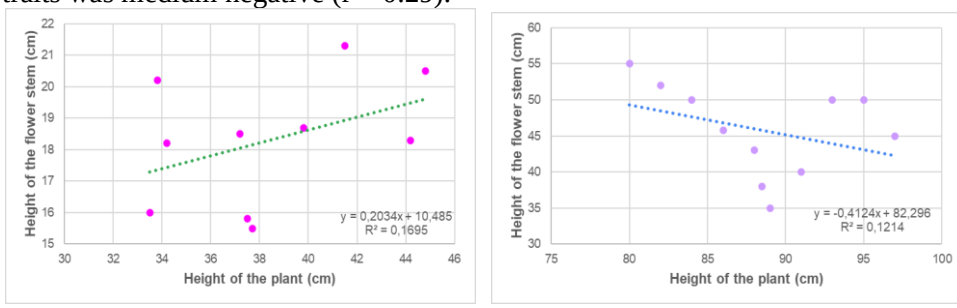


a) 'Little Lottie' b) 'Munstead'

Fig. 3. Correlation between the diameter of the plant and the number of inflorescences/plant

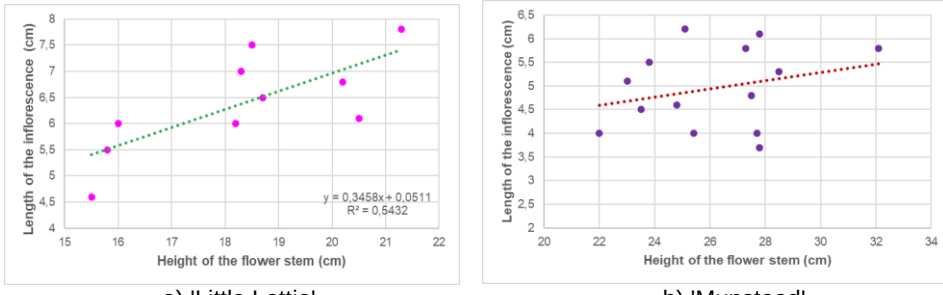
The pair of total plant height and flower stem height (fig. 4) correlated average positive for 'Little Lottie' (r = 0.41), average negative for 'Grosso' (r = 0.35) and non-significant in 'Munstead' (r = 0.09).

It was found that the correlations between flower-stem length and inflorescence length (Fig. 5) were strongly positive in 'Little Lottie' (r = 0.74), and medium in 'Munstead' (r = 0.28). In cv. 'Grosso', the correlation between the two traits was medium negative (r = 0.29).



a) 'Little Lottie' b) 'Grosso'

Fig. 4. Correlation between the total height of the plant and the height of the flower stem



a) 'Little Lottie' b) 'Munstead'

Fig. 5. Correlation between the total height of the plant and the length of the inflorescence

Composition of the organic extract

The study aimed to identify the main essential constituents—linalool, linalyl acetate, lavandulyl acetate, eucalyptol, and camphor—extracted from an organic sample, using a more accessible and cost-effective method. A comparative analysis was conducted using GC-MS to evaluate the extract obtained from fresh flowers alongside the essential oil. Essential oil extraction, performed using the Clevenger method, resulted in yields of approximately 2.9% for lavandin and 2.6% for lavender. These results are consistent with previous studies, such as Xiangyang and Pu (2020), which reported a lavender yield of 2.2%.

The extraction yield calculation was performed by relating the concentrations of volatile aromatic compounds identified in the essential oil to the corresponding values of the same analytes in flowers. Thus, by comparing the results obtained from the organic extract with ISO standards, the feasibility of oil extraction (the oil content being more concentrated) and the valorization potential of the cultivars could be detected.

Data are presented in table 1 of means, medians and standard deviations based on samples tested in triplicate.

The lavandin cultivar ('Grosso') showed the highest content of linalool (21.61±0.224%), a terpene known for its floral and slightly spicy aroma and valued for its calming and relaxing properties in aromatherapy. In the two cultivars of *L. angustifolia*, lower linalool content was observed: 15±3.168% in 'Munstead' and only 5.09±3.168% in 'Little Lottie'. Linalyl acetate recorded the highest concentration in 'Munstead' (39.93±6.548%), followed by 'Little Lottie' (11.82±0.111%) and 'Grosso' (2.42±0.049%).

Table 1

Concentrations of aromatic main constituents

Sp. / cv.	Ec.	Linalool (%)	Linalyl acetate(%)	Lavandulyl acetate(%)	Eucalyptol (%)	Camphor (%)
***L.* x *intermedia* 'Grosso'**	$\bar{x}$	21.61	2.42	0.43	12.56	2.05
	$\tilde{x}$	21.51	2.40	0.42	12.63	2.05
	σ_x	0.224	0.049	0.017	0.400	0.025
***L. angustifolia* 'Munstead'**	$\bar{x}$	5.09	39.93	2.99	0.34	-
	$\tilde{x}$	4.77	36.69	2.94	0.34	-
	σ_x	1.388	6.548	0.298	0.035	-
***L. angustifolia* 'Little Lottie'**	$\bar{x}$	15.00	11.82	1.45	0.37	-
	$\tilde{x}$	13.58	11.8	1.97	0.39	-
	σ_x	3.168	0.111	0.985	0.053	-

$\bar{x}$ - mean value, $\tilde{x}$ - median value, σ_x standard deviation

Lavandulyl acetate was the compound with much lower concentrations than linalyl acetate in all the taxa analyzed, in the same descending order: 'Munstead' with 2. 99±0.298%, followed by 'Little Lottie' (1.45±0.985%) and 'Grosso' (0.43±0.017%). Eucalyptol showed large differences between species, with the highest content being determined in the lavandin cultivar, 12.56±0.400%. The lavender cultivars had a much lower content, 0.37±0.053% in 'Little Lottie' and 0.34±0.035% in 'Munstead'. The lavandin cultivar 'Grosso' also stood out for its camphor content (2.05±0.025%), a component not identified in lavender cultivars. The average content (%) of the compounds identified in the organic extract of lavender and lavandin cultivars is shown in fig. 6.

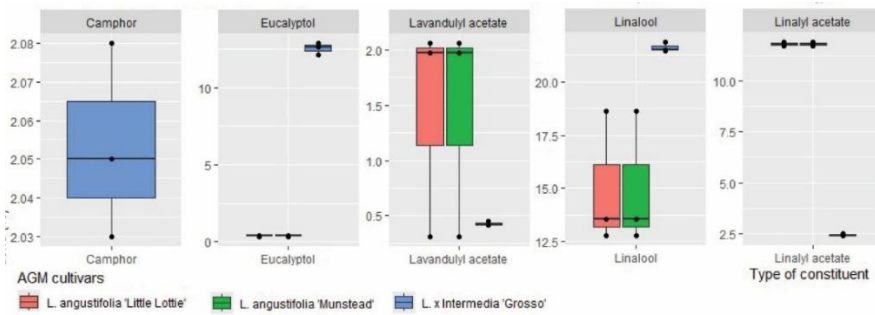


Fig. 6. Main aromatic constituents (concentrations %)

L. angustifolia premium oils (ISO 3515:2002) should contain 25–38% linalool, 25–45% linalyl acetate, 3.4–6.2% lavandulyl acetate, and 0.5–1% camphor. Both analyzed varieties had lower linalool levels; 'Munstead' met the linalyl acetate range, while 'Little Lottie' did not. Neither met the lavandulyl acetate standard.

Lavandin 'Grosso' oils (ISO 8902:2009) require 24–35% linalool, 28–38% linalyl acetate, 1.5–3% lavandulyl acetate, and 6–8% camphor. The study found all compounds below these limits, except for relatively better linalool (21.61%) and camphor (2.05%), but very low linalyl acetate (0.43%), suggesting reduced aromatic quality.

CONCLUSIONS

1. The intensity and direction of the correlation coefficient between the morphological characters analyzed were different between species and cultivars of *Lavandula*. In the two *L. angustifolia* cultivars, 'Little Lottie' showed direct correlations with medium and high intensity (r>0.38) for all pairs of characters, whereas 'Munstead' showed negative correlations with weak or insignificant values for the character pairs plant diameter/height and plant height/flowered stem length, respectively medium positive correlations for the other character pairs. In the case of lavandin ('Grosso'), the correlations were negative, insignificant or of medium intensity, except for the character pair bush diameter/plant height where the correlation was positive.

2. The variety of morpho-decorative characters such as plant size, number of inflorescences, color, as well as the intensity of the fragrance, make the studied cultivars suitable for ornamental purposes.

3. 'Grosso' had terpene levels that were partially aligned with the ISO standards for lavandin (by linalool content), and 'Munstead' had values close to the ISO specifications for *L. angustifolia*, in terms of linalyl acetate and lavandulyl acetate.

4. Use in aromatherapy recommends cv. 'Grosso' for its linalool content and cv. 'Munstead' for its linalyl acetate content.

REFERENCES

1. Aprotosoaie Ana Clara, Gille Elvira, Trifan Adriana, Luca V.S., Miron Anca, 2017 – *Essential oils of Lavandula genus: a systematic review of their chemistry*. Phytochem Rev., 16:761-799, DOI 10.1007/s11101-017-9517-1.

2. Asci Özlem Aras, Hikmet D., Erdeger A., Kübra Nur Özdemir, Demirci T., Nilgün Göktürk Baydar, 2019 - *Brassinosteroids Promote Growth and Secondary Metabolite Production in Lavandin (Lavandula x intermedia Emeric ex Loisel.)*. Journal of Essential Oil Bearing Plants, DOI: 10.1080/0972060X.2019.1585298

3. Bogdan Mihaela, Bungau Simona, Tit Delia Mirela, Copolovici L., Behl T., Otrisal P., Aleya L., Cioca Gabriela, Berescu Doina, Uivarosan Diana, Copolovici Dana Maria, 2020 – *Variations in the Chemical Composition of the Essential Oil of Lavandula angustifolia Mill., Moldoveanca 4 Romanian Variety.* Revista de chimie, 71(4): 307-315.

4. Cantor Maria, Vlas Natalia, Szekely-Varga Z., Jucan Denisa, Zaharia A., 2018 - *The influence of distillation time and the flowering phenophase on quantity and quality of the essential oil*

of Lavandula angustifolia cv. 'Codreanca', Romanian Biotechnological Letters, 23(6):14146-14152, DOI: 10.26327/RBL2018.192.

5. **Cavanagh H.M.A., Wilkinson J.M., 2002** - *Biological activities of Lavender essential oil*. Phytotherapy Research, 16(4): 301-308, DOI: 10.1002/ptr.1103.
6. **Crișan Ioana, Ona Andreea, Vârban D.; Muntean L., Vârban Rodica, Stoie A.; Mihăiescu Tania, Morea Adriana, 2023** - *Current Trends for Lavender (Lavandula angustifolia Mill.) Crops and Products with Emphasis on Essential Oil Quality*. Plants, 12(2), 357.
7. **Guitton Y., Nicole Florence, Moja S., Valot Nadine, Legrand S., Jullien F., Legendre L., 2010** - *Differential accumulation of volatile terpene and terpene synthase mRNAs during lavender (Lavandula angustifolia and L.* x *intermedia) inflorescence development*. Physiol. Plantarum, 138(2), 150-163, DOI:10.1111/j.1399-3054.2009.01315.x.
8. **Hassanpouraghdam M.B., Hassani A., Vojodi Lamia, Hajisamadi A.B., Rostami A., 2011** - *Essential oil constituents of Lavandula officinalis Chaix from Northwest Iran*. Chemija, 22(3), 167-171.
9. **Hassiotis C.N., 2010** – *Chemical compounds and essential oil release through decomposition process from Lavandula stoechas in Mediterranean region*. Biochemical Systematics and Ecology, 38, 493–501, https://doi.org/10.1016/j.bse.2010.05.002.
10. **Jianu C., Pop Georgeta, Gruia Alexandra, Horhat F.G., 2013** - *Chemical Composition and Antimicrobial Activity of Essential Oils of Lavender (Lavandula angustifolia) and Lavandin (Lavandula* x *intermedia) Grown in Western Romania.* Int. J. Agric. Biol., 15(4): 772–776.
11. **Kiprovski B., Zeremski T., Varga A., Čabarkapa I.; Filipović J., Lončar B., Aćimović M., 2023** - *Essential Oil Quality of Lavender Grown Outside Its Native Distribution Range: A Study from Serbia*. Horticulturae, 9, 816. https://doi.org/10.3390/.
12. **Nedeltcheva-Antonova Daniela, Gechovska Kamelia, Bozhanov S., Antonov L., 2022** - *Exploring the Chemical Composition of Bulgarian Lavender Absolute (Lavandula Angustifolia Mill.) by GC/MS and GC-FID*. Plants, 11(22), 3150.
13. **Pljevljakusic D., Drinic Zorica, 2020-***GC/MS chemical analysis of lavandin (Lavandula* x *intermedia) hydrolat: successive extraction fractions.* Nat. Medicinal Materials, 40, 33-39
14. **Pokajewicz Katarzyna, Bialon Marietta, Svydenko Liudmyla, Fedin R., Hudz Nataliia, 2021 -** *Chemical Composition of the Essential Oil of the New Cultivars of Lavandula angustifolia Mill. Bred in Ukraine*. Molecules, 26(18), 5681.
15. **Pokajewicz Katarzyna, Czarniecka-Wiera Marta, Krajewska Agnieszka, Maciejczyk Ewa, Wieczorek P.P., 2023** – *Lavandula* x *intermedia – A Bastard Lavander or a Plant of Many Values? Part I. Biology and Chemical Composition of Lavandin*. Molecules, 28(7), 2943.
16. **Prusinowska Renata, Smigielski K.B., 2014** - *Composition, biological properties and therapeutic effects of lavender (Lavandula angustifolia* L.*). A review*, Kerba Polonica, 60(2): 56-66, DOI: 10.2478/hepo-2014-0010.
17. **Wilson T.M., Poulson Ariel, Murphy B.J., Nebeker B., Cuchet A., Schiets F., Casabianca H., Carlson R.E., 2023** - *Authentication of Lavandula angustifolia Mill. (Lamiaceae) essential oil using physical property, gas chromatography, enantiomeric selectivity, and stable isotope analyses.* Journal of Essential Oil Research, 35(6): 529–541.
18. **Xiangyang G., Pu W., 2020** – *Aroma Characteristics of Lavander Extract and Essential Oil from Lavandula angustifolia Mill.*, Molecules 2020, 25, 5541.
19. **Zagorcheva T., Stanev S., Rusanov K., Atanassov I., 2013** - *Comparative GC/MS analysis of lavender (Lavandula angustifolia Mill.) inflorescence and essential oil volatiles*. Agricultural Science and Technology, 5(4): 459 – 462, https://www.cabidigitallibrary.org/doi/pdf/10.5555/20143008880.