TUBITTUM
ISSN: 2822-5295

Volume 3 Issue 4, 2024
690-699

INVESTIGATION OF THE ACTIVE INGREDIENT OF THE PLANT LAVANDULA ANGUSTIFOLIA AND ITS PHYSICAL AND CHEMICAL PROPERTIES (REVIEW)

Behzad Jaybashi[1], Seyed Sajad Mousavi[2], Faezeh Dorisefat [3], Ardeshir Rezaei[4], Mahmoud Zabet[5], Mohammad Reza Shadmand Heidartehrani[6], Ali Zehtab Salehi [7], Mojtaba Valizadegan Arjomand[8], Somayyeh Rezaei[9], Massoumeh Eini[10], Maryam Madani Asl[11], Mohadeseh Zare[12], Esmail Ahmadi[13]

[1] *PhD. in Naturopathic Medicine, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium*
[2,3,4,5,6] *Doctorate. in Naturopathic Medicine, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium*
[7,8,9,10,11,12] *Doctorate student. in Naturopathic Medicine, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium*
[13] *Phd student. In Cognitive Neuroscience, Technofest Institute of Technology University (TITU), Erquelinnes, Belgium*

Received 12/11/2024 **Accepted** 25/12/2024

Abstract

The use of medicinal plants has been increasing in recent years, especially in traditional and complementary medicine worldwide. Many of these medicinal plants are consumed without sufficient scientific backing, which can have consequences for people's health and impose significant healthcare costs on the system. Among these, Lavandula angustifolia is one of the most common herbal medicines due to its widespread use in traditional medicine. The use of Lavandula angustifolia has been well demonstrated in various studies for some conditions such as anxiety disorders and sleep disorders. However, evidence for its effectiveness in treating other diseases is contradictory or limited. This study examines the importance of the active ingredient of Lavandula angustifolia and the processing and post-harvest methods in the food and pharmaceutical industries based on existing research.

***Keywords**: Lavandula angustifolia, psychological disorders, active ingredient.*

Introduction

Medicinal plants have long been used in the treatment of various diseases and for food and cosmetic purposes (1-6). Due to the desire of more people to consume organic products and avoid the side effects of conventional medicine the use of medicinal plants has increased especially in recent years (7). The impacts of these medicinal plants on various diseases have been attributed to their effective ingredients (8, 9). These effective ingredients may vary in the same plant based on the processing and post-harvest methods (10-12). Also, a few clinical trials to investigate the impact of medicinal plants on various diseases have not clarified the effectiveness of these treatments. It can waste treatment time with other efficient methods or impose several

side effects on patients (13, 14). In this regard, Lavandula angustifolia has been investigated more as a medicinal plant.

Description, Taxonomy

Lavandula angustifolia is a flowering and evergreen plant (15) belonging to the family Lamiaceae and Genus Lavandula (16, 17). It is native to the Mediterranean region and Southwest Asia. It is nowadays cultivated in most parts of the world (18, 19). Growth conditions and different treatments can affect its height during maturity (20, 21). A study revealed that the mean height of this plant was between 2.7 and 33 cm in the first year and between 6.42 and 57 cm in the second year. Also, flower height was 0.7 to 7 cm in the first year and 1.4 to 20.9 cm in the second year (22). Its flowers are pale purple and grow in clusters at the top of the stem. Its leaves are linear or spear-shaped with wavy edges covered by tomentum (23, 24).).

Active ingredients

Lavandula angustifolia has more than 100 active ingredients. The most important of them in various studies in the essential oils include Linalyl acetate, Linalool, ρ-cymene, α-Campholenal, caryophyllene, (E)-3,7-Dimethylocta-1,3,6 -triene, 4-Terpineol, Acetic acid Lavandula ester, 1,8-Cineole, a-Fenchone, Coumarin, and Borneol (24-26). A study revealed that the highest antioxidant activity of essential oil was obtained in fresh aerial parts and the lowest was obtained in dried flowers (27). It is believed that the uses of Lavandula angustifolia in the food industry and its therapeutic impacts depend on these chemical compounds (28, 29).

Mechanism of action

The results of a study conducted on type 2 diabetic patients indicated that Lavandula angustifolia ethanolic extract has a great inhibitory activity against carbohydrate hydrolyzing enzymes (α-glycosidase and α-amylase), and pancreatic lipase (30). Another study indicated that the use of Lavandula angustifolia essential oil (contains 1,8-cineole, borneol, and camphor at 39, 22, and 22%, respectively) reduces edema formation, myeloperoxidase (MPO) activity, and nitric oxide (NO) production in acute inflammation due to the participation of prostanoids, NO, proinflammatory cytokines, and histamine (31). In a study on animal models of Alzheimer's disease, Soheili et al. (2015) showed that Lavandula angustifolia effectively restores long-term potentiation (LTP) and enhanced field extracellular postsynaptic potentials (fEPSPs) in the CA1 region of the hippocampus and improved the impaired spatial memory in Alzheimer's male Wistar rats (32).

The results of a study revealed that Lavandula angustifolia at doses of 200 and 400 mg/kg can lead to structural and functional improvement of spinal cord injury in rats by improving hindlimbs, reducing cavity areas, and increasing the number of ventral motor neurons (33). Aboutaleb et al. (2019) indicated that Lavandula angustifolia can restore the activity of antioxidant enzymes and reduce lipid peroxidation in rats. Lavandula angustifolia also reduced the damage to peritubular capillaries and helped maintain

the normal morphology of kidney cells in rats (34). Regarding Acute Myocardial Infarction rats, the results of a study revealed that Lavandula angustifolia essential oil modified the ECG by suppressing the ST segment elevation led to an increase in the R amplitude and a reduction in the levels of the inflammatory marker Myeloperoxidase (MPO). In this study, the protective effect of essential oil on heart attack is attributed to its antioxidant activities. Its most significant components are linalool, linalyl acetate and some other mono and sesquiterpenes, camphor, 1,8-cineol, flavonoids like luteolin, triterpenoids like ursolic, and coumarin (35). López et al. (2017) showed that the anti-anxiety and antidepressant impacts of Lavandula angustifolia are due to the inhibition of the serotonin transporter (SERT) and its modulatory impacts on NMDA receptors (linalool as a secondary process plays a significant role in this process). Lavandula angustifolia also protects SH-SY5Y cells against hydrogen peroxide-induced neurotoxicity (36). Lavandula angustifolia was used for tea in ancient times (37). Nowadays, the results of studies in the area of the food industry also indicated that Lavandula angustifolia essential oil can reduce the growth of bacteria in food products, preserves the quality of foods containing lipids, and is safe if used properly or consumed at low levels (38).

Cultivation

The use of seeds, cuttings, plant division, and layering or tissue culture is one of the most important Lavandula angustifolia propagation methods. Mature Lavandula angustifolia is relatively resistant to different weather conditions. However, it prefers hot summer and cool winter and needs a temperature of about 10-15 °C for germination. Lavandula angustifolia prefers relatively fertile crumbly soil with neutral to slightly alkaline pH. However, it can also grow in less fertile soils, eroded soils, and sloped lands (37, 39-46). Pot cultivation is another type of Lavandula angustifolia cultivation. A study investigated the effect of substrate on Lavandula angustifolia in Italy. The mentioned study used substrates containing mixes of peat (P), green compost (C), and/or demolition aggregates (A). Its results showed that the P: C mixture performed better than other mixtures in terms of survival rate, plant compactness, and flower production. However, the P:C: A mixture had a higher quality of essential oil with higher amounts of linalool (47). To control weeds, various methods can be used such as hand shoveling, coarse sand (increasing the temperature around the plant on sunny days), cultivator (high probability of damaging Lavandula angustifolia), herbicides (increasing the toxicity of the plant), and bio-herbicides (37, 39, 48-51).

Harvesting and post-harvest processes

The Lavandula angustifolia harvesting mostly starts after the second year at the time of flowering and continues for 12 to 15 years. The duration of flowering varies depending on the geographical region (37, 41, 52). The age of Lavandula angustifolia at harvest is crucial, so younger aromatic plants mostly synthesize more essential oil, but older plants have a richer composition (42). The active ingredients of plants are also affected by the Lavandula angustifolia age (53). The yield of Lavandula angustifolia oil increases over time and varies from 7.8 kg per hectare to 55.5 kg per hectare (54). The

best time to harvest seems to be mid-day and during the afternoon when linalyl acetate is at the maximum level (55). The Lavandula angustifolia drying method significantly affects the essential oil content. A study indicated that drying in the shade has the highest level of Linalool, drying under the sun has the highest level of Terpinen-4-ol, drying in the oven has the highest level of Linalyl acetate, and drying in the microwave has the highest level of Lavandulyl acetate in the essential oil (56). A study compared Lavandula angustifolia drying methods at different temperatures and showed that convective drying (CD) at a temperature of 60 °C is the optimal method for recovering the total essential oil and vacuum-microwave drying (VMD) with power 360 W combined vacuum microwave finish-drying (CPD-VMFD) with power 480 W and CD at 50 °C was the optimal method for the smell quality (57). The results of a study that investigated the drying of Lavandula angustifolia in western Himalayan conditions showed that the essential oil content and moisture loss at 72 hours were significantly higher than at zero hours. The results also showed that as we get closer to 72 hours, linalool decreased and linalyl acetate increased (58). Storage and pre-processing methods can also affect the essential oil content, so a part of the essential oil content will be lost during long-term storage of the dried content (12). The Lavandula angustifolia flower has higher-quality essential oil compounds than its stem and leaves (37). Genotype, fertilization, temperature, rainfall distribution, altitude, weather conditions, and irrigation are other factors that affect the quality of Lavandula angustifolia for drying include (59-64). A study that investigated Lavandula angustifolia leaves revealed that the optimal moisture level during the growth period causes a higher yield of Lavandula angustifolia in the harvest year and increases the total phenolic acid (TPA), which ultimately increases the antioxidant activity of Lavandula angustifolia in the post-harvest stages (65). In addition to preparing essential oil from the Lavandula angustifolia plant, it can be also processed with other methods. Extraction is one of these methods. The highest level of volatile oil is found in Lavandula angustifolia calyx (66). A study investigated three methods hydrodistillation, supercritical CO2 extraction (SCE), and hexane extraction. Its results showed that SCE had aromas closer to the raw material, lower thermal degradation, and more antioxidant activity than other methods. SCE oils and water distillation also showed higher antimicrobial activity than hexane extraction (67). Another study indicated that distillation with water compared to distillation with steam decomposes the content of linalyl acetate to an extent that can lead to an increase in the linalool content (66). The results of another study also revealed that essential oil extract by classic hydrodistillation and microwave-generated hydrodistillation is associated with increased coumarin and preparation of essential oil extract by microwave hydrodiffusion and gravity method will be richer in borneol (68). Lavandula angustifolia absolute (LA) and concrete are other methods through which Lavandula angustifolia can be processed (69). A study indicated that samples of Bulgarian lavender absolute (L. angustifolia Mill.) contain terpene, sesquiterpenes, triterpenoids, coumarins, and aliphatic compounds. Additionally, acyclic monoterpene linalool and ester linalyl acetate are two primary components of LA (70). Another study revealed that when concrete is steam-distilled; it will be richer in sesquiterpenes than steam-distilled oil (71). Lavandula angustifolia can be also processed as an ointment. Studies have shown that it has a high level of antioxidant activity in this state and can

play a role in healing wounds (72). Lavandula angustifolia ointment contains high amounts of the terpenoid rate of linalool, which has shown good wound contraction and re-epithelialization rates. It also improves antioxidant enzymes and protein synthesis (73).

Discussion

Lavandula angustifolia is one of the plants used extensively in the food, pharmaceutical, and health industries. The effectiveness of Lavandula angustifolia is due to active ingredients such as linalool and linalyl acetate, which are affected by post-harvest and processing processes. Each of these methods has advantages and disadvantages that can reduce some of these active and effective ingredients and increase some others (74, 75). Thus, it is recommended to use a method based on the purpose of consumption to have the highest amount of active ingredients for the intended purposes. In addition to post-harvest and processing methods, pre-harvest processes also affect the final product. This issue should be addressed to provide the most active and effective ingredients for the intended purposes.

Conflict of interest statement

There is no conflict between the authors of this article.

References

1. Dabas A, Yadav P, Geetanjali, Singh R. Role of Herbal Medicine in Boosting Immune System. Role of Herbal Medicines: Management of Lifestyle Diseases: Springer; 2024. p. 389-401.
2. Otimenyin SO. Herbal Medicine for the Management of Anxiety, Depression, and Insomnia. Role of Herbal Medicines: Management of Lifestyle Diseases: Springer; 2024. p. 251-69.
3. Pan S-Y, Litscher G, Gao S-H, Zhou S-F, Yu Z-L, Chen H-Q, et al. Historical perspective of traditional indigenous medical practices: the current renaissance and conservation of herbal resources. Evidence-based complementary and alternative medicine. 2014;2014.
4. Sharma A, Sabharwal P, Dada R. Herbal medicine—An introduction to its history. Herbal Medicine in Andrology: Elsevier; 2021. p. 1-8.
5. Sumit K, Vivek S, Sujata S, Ashish B. Herbal cosmetics: used for skin and hair. Inven J. 2012;2012:1-7.
6. Zhang Y, Zhang J, Yan J, Qi X, Wang Y, Zheng Z, et al. Application of fermented Chinese herbal medicines in food and medicine field: from an antioxidant perspective. Trends in Food Science & Technology. 2024:104410.
7. Sendker J, Sheridan H. History and current status of herbal medicines. Toxicology of herbal products. 2017:11-27.

8. Tayeb BA, Kusuma IY, Osman AA, Minorics R. Herbal compounds as promising therapeutic agents in precision medicine strategies for cancer: A systematic review. Journal of Integrative Medicine. 2024.
9. Koulivand PH, Khaleghi Ghadiri M, Gorji A. Lavender and the nervous system. Evidence-based complementary and alternative medicine. 2013;2013.
10. Bai C, Yang J, Cao B, Xue Y, Gao P, Liang H, Li G. Growth years and post-harvest processing methods have critical roles on the contents of medicinal active ingredients of Scutellaria baicalensis. Industrial crops and products. 2020;158:112985.
11. Zhu S, Shirakawa A, Shi Y, Yu X, Tamura T, Shibahara N, et al. Impact of different post-harvest processing methods on the chemical compositions of peony root. Journal of natural medicines. 2018;72:757-67.
12. Dušková E, Dušek K, Indrák P, Smékalová K. Postharvest changes in essential oil content and quality of lavender flowers. Industrial Crops and Products. 2016;79:225-31.
13. Tassew WC, Assefa GW, Zeleke AM, Ferede YA. Prevalence and associated factors of herbal medicine use among patients living with chronic disease in Ethiopia: A systematic review and meta-analysis. Metabolism Open. 2024:100280.
14. Mosihuzzaman M. Herbal medicine in healthcare-an overview. Natural product communications. 2012;7(6):1934578X1200700628.
15. Najafian S, Afshar M, Radi M. Annual Phytochemical variations and antioxidant activity within the aerial parts of Lavandula angustifolia, an evergreen medicinal plant. Chemistry & Biodiversity. 2022;19(10):e202200536.
16. Upson T. The taxonomy of the genus Lavandula L. Lavender: CRC Press; 2002. p. 16-48.
17. Héral B, Stierlin É, Fernandez X, Michel T. Phytochemicals from the genus Lavandula: A review. Phytochemistry Reviews. 2021;20:751-71.
18. Kiprovski B, Zeremski T, Varga A, Čabarkapa I, Filipović J, Lončar B, Aćimović M. Essential oil quality of lavender grown outside its native distribution range: a study from Serbia. Horticulturae. 2023;9(7):816.
19. Hassiotis C, Tarantilis P, Daferera D, Polissiou M. Etherio, a new variety of Lavandula angustifolia with improved essential oil production and composition from natural selected genotypes growing in Greece. Industrial Crops and Products. 2010;32(2):77-82.
20. Brailko V, Mitrofanova O, Lesnikova-Sedoshenko N, Chelombit S, Mitrofanova I, editors. Anatomy studies of Lavandula angustifolia Mill. and Lavandula hybrida Rev. plants in vitro. AgroSym-2016; 2016.
21. El-Sharnouby ME. Tolerance limits of lavender plant (LAVANDULA ANGUSTIFOLIA MILL) tissue cultures in response to abiotic stress. Pak J Bot. 2022;54(6):2063-8.
22. Sönmez Ç, Şimşek Soysal A, Okkaoğlu H, Karık Ü, Taghiloofar AH, Bayram E. 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. 2018;50(6):2285-90.
23. Góra J, Lis A, Gibka J, Wołoszyn A. Najcenniejsze olejki eteryczne: Wydawnictwo Uniwersytetu Mikołaja Kopernika; 2005.

24. Batiha GE-S, Teibo JO, Wasef L, Shaheen HM, Akomolafe AP, Teibo TKA, et al. A review of the bioactive components and pharmacological properties of Lavandula species. Naunyn-schmiedeberg's Archives of Pharmacology. 2023;396(5):877-900.
25. Chen X, Zhang L, Qian C, Du Z, Xu P, Xiang Z. Chemical compositions of essential oil extracted from Lavandula angustifolia and its prevention of TPA-induced inflammation. Microchemical Journal. 2020;153:104458.
26. Pokajewicz K, Białoń M, Svydenko L, Fedin R, Hudz N. Chemical composition of the essential oil of the new cultivars of Lavandula angustifolia Mill. Bred in Ukraine. Molecules. 2021;26(18):5681.
27. Smigielski K, Prusinowska R, Stobiecka A, Kunicka-Styczyñska A, Gruska R. Biological properties and chemical composition of essential oils from flowers and aerial parts of lavender (Lavandula angustifolia). Journal of Essential Oil Bearing Plants. 2018;21(5):1303-14.
28. Woronuk G, Demissie Z, Rheault M, Mahmoud S. Biosynthesis and therapeutic properties of Lavandula essential oil constituents. Planta medica. 2011;77(01):7-15.
29. Da Porto C, Decorti D, Kikic I. Flavour compounds of Lavandula angustifolia L. to use in food manufacturing: Comparison of three different extraction methods. Food Chemistry. 2009;112(4):1072-8.
30. Tundis R, Grande F, Occhiuzzi MA, Sicari V, Loizzo MR, Cappello AR. Lavandula angustifolia mill.(Lamiaceae) ethanol extract and its main constituents as promising agents for the treatment of metabolic disorders: chemical profile, in vitro biological studies, and molecular docking. Journal of Enzyme Inhibition and Medicinal Chemistry. 2023;38(1):2269481.
31. Cardia GFE, Silva-Filho SE, Silva EL, Uchida NS, Cavalcante HAO, Cassarotti LL, et al. Effect of lavender (Lavandula angustifolia) essential oil on acute inflammatory response. Evidence-Based Complementary and Alternative Medicine. 2018;2018.
32. Soheili M, Tavirani MR, Salami M. Lavandula angustifolia extract improves deteriorated synaptic plasticity in an animal model of Alzheimer’s disease. Iranian journal of basic medical sciences. 2015;18(11):1147.
33. Kaka G, Yaghoobi K, Davoodi S, Hosseini SR, Sadraie SH, Mansouri K. Assessment of the neuroprotective effects of lavandula angustifolia extract on the contusive model of spinal cord injury in wistar rats. Frontiers in Neuroscience. 2016;10:25.
34. Aboutaleb N, Jamali H, Abolhasani M, Toroudi HP. Lavender oil (Lavandula angustifolia) attenuates renal ischemia/reperfusion injury in rats through suppression of inflammation, oxidative stress and apoptosis. Biomedicine & pharmacotherapy. 2019;110:9-19.
35. Ziaee M, Khorrami A, Ebrahimi M, Nourafcan H, Amiraslanzadeh M, Rameshrad M, et al. Cardioprotective effects of essential oil of Lavandula angustifolia on isoproterenol-induced acute myocardial infarction in rat. Iranian journal of pharmaceutical research: IJPR. 2015;14(1):279.

36. López V, Nielsen B, Solas M, Ramírez MJ, Jäger AK. Exploring pharmacological mechanisms of lavender (Lavandula angustifolia) essential oil on central nervous system targets. Frontiers in pharmacology. 2017;8:280.
37. Crișan I, Ona A, Vârban D, Muntean L, Vârban R, Stoie A, et al. Current trends for lavender (Lavandula angustifolia Mill.) crops and products with emphasis on essential oil quality. Plants. 2023;12(2):357.
38. Erland LA, Mahmoud SS. Lavender (Lavandula angustifolia) oils. Essential oils in food preservation, flavor and safety. 2016:501-8.
39. Mason J. Growing and knowing lavender: ACS Distance Education; 2014.
40. Platt ES. Lavender: How to grow and use the fragrant herb: Stackpole Books; 2009.
41. Muntean L, Tamas M, Muntean S, Muntean L, Duda M, Varban D, Florian S. A Treatise of Cultivated and Spontaneous Medicinal Plants; Risoprint: Cluj-Napoca. Romania. 2007:372.
42. Barbieri C, Borsotto P. Essential oils: market and legislation. Potential of essential oils. 2018:107-27.
43. Giray FH. An analysis of world lavender oil markets and lessons for Turkey. Journal of essential oil bearing plants. 2018;21(6):1612-23.
44. Wells R, Truong F, Adal AM, Sarker LS, Mahmoud SS. Lavandula essential oils: A current review of applications in medicinal, food, and cosmetic industries of lavender. Natural Product Communications. 2018;13(10):1934578X1801301038.
45. Peter KV. Handbook of herbs and spices: volume 3: Woodhead publishing; 2006.
46. Gorgini Shabankareh H, Khorasaninejad S, Soltanloo H, Shariati V. Investigation of the effects of drought stress and abscisic acid foliar application on yield, physiological and biochemical properties of lavender (Lavandula angustifolia cv. Organic Munstead). Journal of Crop Production. 2021;14(2):65-82.
47. Najar B, Demasi S, Caser M, Gaino W, Cioni PL, Pistelli L, Scariot V. Cultivation Substrate composition influences morphology, volatilome and essential oil of Lavandula angustifolia Mill. Agronomy. 2019;9(8):411.
48. VÂRBAN R, Vârban DI, Stoie A, Bogdan I, Odagiu A, GHEȚE A. Identification of weed species present in lavender crops (Lavandula angustifolia L.) and (Mentha piperita L.) from the UASVM Cluj-Napoca campus. 2018.
49. Vouzounis N, Dararas V, Georghiou G. Chemical control of weeds in the aromatic crops lavender, oregano and sage. Tech Bull. 2003(218):3–7.
50. Radhakrishnan R, Alqarawi AA, Abd_Allah EF. Bioherbicides: Current knowledge on weed control mechanism. Ecotoxicology and environmental safety. 2018;158:131-8.
51. Hasan M, Ahmad-Hamdani MS, Rosli AM, Hamdan H. Bioherbicides: An eco-friendly tool for sustainable weed management. Plants. 2021;10(6):1212.
52. Giannoulis KD, Evangelopoulos V, Gougoulias N, Wogiatzi E. Lavender organic cultivation yield and essential oil can be improved by using bio-stimulants. Acta Agriculturae Scandinavica, Section B—Soil & Plant Science. 2020;70(8):648-56.

53. Najar B, Pistelli L, Fratini F. Exploitation of marginal hilly land in Tuscany through the Cultivation of Lavandula angustifolia mill.: Characterization of its essential oil and antibacterial activity. Molecules. 2022;27(10):3216.
54. Zheljazkov VD, Astatkie T, Hristov AN. Lavender and hyssop productivity, oil content, and bioactivity as a function of harvest time and drying. Industrial Crops and Products. 2012;36(1):222-8.
55. Hassiotis CN, Lazari DM, Vlachonasios KE. The effects of habitat type and diurnal harvest on essential oil yield and composition of Lavandula angustifolia Mill. Fresenius Environmental Bulletin. 2010;19(8):1491-8.
56. Mirjalili MH, Salehi P, Vala MM, Ghorbanpour M. The effect of drying methods on yield and chemical constituents of the essential oil in Lavandula angustifolia Mill.(Lamiaceae). Plant Physiology Reports. 2019;24:96-103.
57. Łyczko J, Jałoszyński K, Surma M, García-Garví JM, Carbonell-Barrachina ÁA, Szumny A. Determination of various drying methods' impact on odour quality of true lavender (Lavandula angustifolia Mill.) flowers. Molecules. 2019;24(16):2900.
58. Rathore S, Kumar R. Essential oil content and compositional variability of Lavandula species cultivated in the mid hill conditions of the western himalaya. Molecules. 2022;27(11):3391.
59. Tarakemeh A, Rowshan V, Najafian S. Essential oil content and composition of Lavandula angustifolia Mill. as affected by drying method and extraction time. Analytical Chemistry Letters. 2012;2(4):244-9.
60. Mavandi P, Abbaszadeh B, Emami Bistgani Z, Barker AV, Hashemi M. Biomass, nutrient concentration and the essential oil composition of lavender (Lavandula angustifolia Mill.) grown with organic fertilizers. Journal of plant nutrition. 2021;44(20):3061-71.
61. Sałata A. Supplementary irrigation and drying method affect the yield and essential oil content and composition of lavender (Lavandula angustifolia Mill.) flowers. Acta Scientiarum Polonorum Hortorum Cultus. 2020;19(6):139-51.
62. Erbas S, Baydar H. Effects of harvest time and drying temperature on essential oil content and composition in lavandin (Lavandula x intermedia Emerice x Loisel.). Turkish Journal of Field Crops. 2008;13(1):24-31.
63. Akcay S, Tunali S, GÜRBÜZ T, DAĞDELEN N. DETERMINATION OF OPTIMAL DEFICIT IRRIGATION STRATEGIES FOR YIELD AND YIELD COMPONENTS OF LAVENDER (LAVANDULA ANGUSTIFOLIA MILL.) IN SEMI-ARID CONDITIONS. Applied Ecology & Environmental Research. 2023;21(6).
64. OA A-AA. Effect of altitude and nitrogen fertilization on some vegetative and flowering parameters and essential oil percentage of lavender plant (Lavandula angustifolia). Kirkuk University Journal For Agricultural Sciences. 2019;10(2):40-7.
65. Sałata A, Buczkowska H, Nurzyńska-Wierdak R. Yield, essential oil content, and quality performance of Lavandula angustifolia leaves, as affected by supplementary irrigation and drying methods. Agriculture. 2020;10(12):590.
66. Aprotosoaie AC, Gille E, Trifan A, Luca VS, Miron A. Essential oils of Lavandula genus: a systematic review of their chemistry. Phytochemistry Reviews. 2017;16:761-99.

67. Danh LT, Han LN, Triet NDA, Zhao J, Mammucari R, Foster N. Comparison of chemical composition, antioxidant and antimicrobial activity of lavender (Lavandula angustifolia L.) essential oils extracted by supercritical CO 2, hexane and hydrodistillation. Food and bioprocess technology. 2013;6:3481-9.
68. Binello A, Orio L, Pignata G, Nicola S, Chemat F, Cravotto G. Effect of microwaves on the in situ hydrodistillation of four different Lamiaceae. Comptes Rendus Chimie. 2014;17(3):181-6.
69. Carrasco A, Martinez-Gutierrez R, Tomas V, Tudela J. Lavandula angustifolia and Lavandula latifolia essential oils from Spain: Aromatic profile and bioactivities. Planta Medica. 2016;82(01/02):163-70.
70. Nedeltcheva-Antonova D, Gechovska K, Bozhanov S, Antonov L. Exploring the chemical composition of Bulgarian lavender absolute (Lavandula angustifolia Mill.) by GC/MS and GC-FID. Plants. 2022;11(22):3150.
71. Bernard T, Perineau F, Delmas M, Gaset A. Extraction of Essential Oils. Part III. Two-Stage Production of the Oil of Lavandula angustifolia Mill. Journal of Essential Oil Research. 1989;1(6):261-7.
72. Momtaz S, Abdolghaffari A, Jasemi E, Yaghoobvand B, Esmaeilzadeh S, Abdollahi A, Abdollahi M. Evaluation of wound healing and anti-inflammatory activities of a herbal ointment consisting of Althaea officinalis, Lavandula angustifolia, and Rosa x damascena in animal excision wound model. Journal of Medicinal Plants. 2021;20(77):37-49.
73. Djemaa FGB, Bellassoued K, Zouari S, El Feki A, Ammar E. Antioxidant and wound healing activity of Lavandula aspic L. ointment. Journal of Tissue Viability. 2016;25(4):193-200.

74. Jaybashi B, Hemmatpour R, Rahimi M. Hamed Pourrahim marani, Masoumeh Gholami, Mehrdad Fojlaley, Fernando Maldonado Lopes."Lavender Scent Inhalation and Anxiety in Type II Diabetes Patients: Effects, Examination and Analysis". Journal of Pharmaceutical Negative Results. 2022 Dec:6581-8.

75. Jaybashi B, Hemmatpour R, Rahimi M. Lavender Scent Inhalation and Anxiety in Type II Diabetes Patients: Effects, Examination and Analysis. Journal of Pharmaceutical Negative Results. 2022 Dec 23:6581-8.