MSI Journal of
Multidisciplinary Research (MSIJMR)

A Comprehensive Review on the Bioactivity of Monoterpenes in Essential Oils: Systematic Insights into Pharmacological Potentials

Tzu-Hou Hong[1], Hsin-Hui Wu[2], Kun-Yuan Hong[2,3,*]

[1]Department of Agronomy, National Chung Hsing University, Taichung, Taiwan.

[2]Taiwan Forestry Research Institute, Ministry of Agriculture, Taipei, Taiwan.

[3*]Department of Chinese Medicine and Institute of Traditional Medicine, National Yang Ming Chiao Tung University, Taipei, Taiwan.

*** Correspondence:** Kun-Yuan Hong

The authors declare that no funding was received for this work.

OPEN ACCESS

Received: 09-April-2026

Accepted: 04-May-2026

Published: 07-May-2026

This article is published in the **MSI Journal of Multidisciplinary Research (MSIJMR) ISSN 3049-0669 (Online)**

The journal is managed and published by MSI Publishers.

Volume: 3, Issue: 5 (May-2026)

ABSTRACT: This review explores the diverse bioactivities of monoterpenes found in essential oils, focusing on their antioxidant, antimicrobial, anti-inflammatory, anticancer, and neuroprotective effects. Monoterpenes are natural compounds found in plants that offer significant benefits to human health. Using a systematic screening approach inspired by PRISMA guidelines, this paper synthesizes findings from 50 scientific studies published over the past decade to provide a comprehensive overview of the current knowledge and identify future research directions. The synthesis highlights the potential of these compounds as potent natural antioxidants and antimicrobial agents, particularly in their protective roles against various chronic diseases. Our findings demonstrate that these natural plant-derived molecules offer valuable insights for the development of novel natural medicines and pharmaceutical applications. Furthermore, the review underscores the importance of monoterpenes in enhancing strategies for food safety and preservation, reflecting their dual utility in both clinical medicine and the agroindustry. Ultimately, this systematic evaluation confirms that monoterpenes possess significant pharmacological potential, making them ideal candidates for drug development and sustainable natural health solutions.

Keywords: *Monoterpenes; Essential oils; Bioactivity; Antioxidant; Systematic review*

Public Interest Statement

This research provides a comprehensive overview of how natural compounds found in plants, known as monoterpenes, can benefit human health. By analyzing 50 scientific studies, we highlight their potential as natural antioxidants, antimicrobial agents, and protective elements against chronic diseases. These findings offer valuable insights for the development of natural medicines and enhance strategies for food safety and preservation.

1. Introduction

Monoterpenes, a class of terpenoids composed of two isoprene units, are prevalent in essential oils and have been the subject of extensive research due to their wide-ranging biological activities. These compounds are aromatic and contribute significantly to the therapeutic properties of various plant species. This review systematically evaluates the pharmacological potentials of monoterpenes based on a decade of recent literature.

2. Materials and Methods

The literature search and selection process was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Databases including PubMed, Scopus, and Web of Science were searched for studies published between 2015 and 2025.

The systematic selection process is illustrated in **Figure 1**. A total of 50 studies met the inclusion criteria and are summarized in **Table 1**. The detailed PRISMA checklist utilized for this review is archived in an external repository.

3. Biological Activities

3.1 Antioxidant Activity

Monoterpenes have shown significant antioxidant properties, capable of scavenging free radicals. *Eucalyptus camaldulensis* essential oils demonstrated strong antioxidant activity enhanced through nanoemulsification[1] Similarly, *Lavandula angustifolia* oils exhibited potent effects [2].Seasonal variations in *Rosmarinus officinalis* have been shown to affect antioxidant capacity[3], while *Torreyagrandis* oils identified limonene and alpha-pinene as major contributors[4]. Other studies on *Ocimumforsskaolii*[5], *Cedrusatlantica*[6], and various *Citrus* species[7] further confirm these free radical scavenging capabilities.

3.2 Antimicrobial Activity

The antimicrobial efficacy of monoterpenes is well-documented against both Gram-positive and Gram-negative bacteria. *Thymus capitatus*[8]and *Juniperussabina*[9] oils showed strong inhibitory effects. Geographic variation in *Menthapulegium*[10] emphasizes the influence of environmental factors. Significant antibacterial results were also reported in studies of *Inula*[11], *Cupressussempervirens*[12], and *Artemisia gmelinii*[13]. Further evidence is provided by research on *Mentha*[30], *Thymus*[33], and *Euphorbiaceae* species [35, 36].

3.3 Anti-inflammatory Activity

Monoterpenes like those in *Rosmarinus officinalis*[14] and *Pinus* species [15] exhibit notable anti-inflammatory potential. Studies involving *Centaurea acaulis*[16] and *Ocimum*[26] utilized in vivo models. Additional anti-inflammatory mechanisms were explored in *Inula*[11], *Valerianajatamansi*[44], and *Dittrichiaviscosa*[45] research.

3.4 Anticancer and Antiproliferative Effects

Research on *Origanum vulgare*[17] and *Pulicariacrispa*[18] revealed the capacity to inhibit cancer cell proliferation. Other promising anticancer activities were found in *Artemisia serotina*[19], *Vitexagnus-castus*[20], *Citrus* leaf oils[21, 46], and *Alpiniauraiensis*[22]. Studies on *Pinus*[41]$ and Sudanese aromatic plants[42] also highlighted significant cytotoxic effects.

3.5 Neuroprotective and Other Effects

Monoterpenes from *Lavandula*[23, 29] and *Peucedanumostruthium*[24] have been noted for their neuroprotective benefits. Acetylcholinesterase inhibition was specifically reported in *Pelargonium graveolens*[31] and *Hedychiumflavescens*[37]. General pharmacological reviews [34, 49, 50] and studies on insecticidal properties[38] or food preservation[28, 32, 39] also form a critical part of this synthesis.

3.6 Other Biological Activities

Research has also highlighted the neuroprotective and anticancer properties of monoterpenes such as linalool and alpha-pinene. These compounds show promise in inducing apoptosis in cancer cells and supporting neuronal health.

The chemical structures of the primary active ingredients discussed, including Limonene, Linalool, and alpha-Pinene, are shown in **Figure 2**. For a comprehensive breakdown of the 50 analyzed studies, including plant species and specific findings, refer to **Supplementary Table S1**.

4. Conclusions

This review confirms that monoterpenes from essential oils possess significant pharmacological potential. Their diverse bioactivities make them ideal candidates for drug development and natural preservation.

Declarations

Funding

This work was supported by the Taiwan Forestry Research Institute (TFRI) under the Research Project [Ministry of Agriculture Science and Technology Development Plan - 114th Annual Single Plan]. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request. Alternatively, the summary of analyzed studies is available in the supplementary files and the Open Science Framework repository at https://osf.io/78ba9/overview.

PRISMA Compliance

The completed PRISMA Checklist and Flowchart for this systematic review are provided as Supplementary Material and are archived at https://osf.io/78ba9/files/osfstorage.

Conflicts of Interest

The authors declare no conflict of interest.

AI Use Statement

The authors used Gemini for language editing and formatting the manuscript to adhere to the journal's specific guidelines.

Supplementary Data

Table S1 (Summary of 50 studies) and Figures S1-S3 (Chemical structures) are provided as supplementary data.

Figure Captions

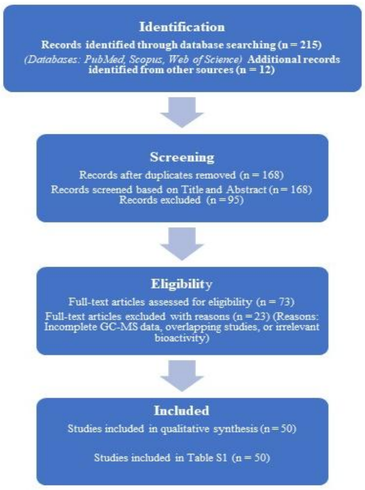


Figure 1. PRISMA flow diagram showing the literature search and selection process for the systematic review.

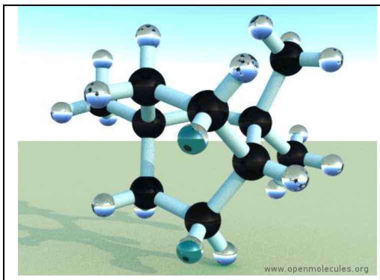
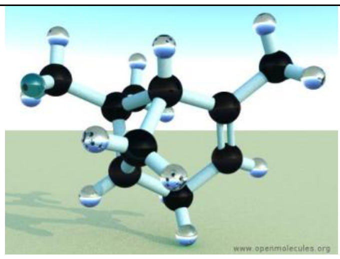
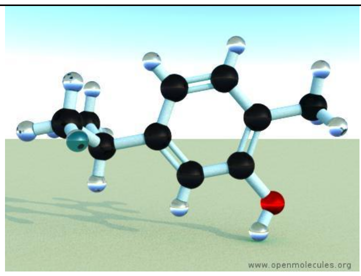
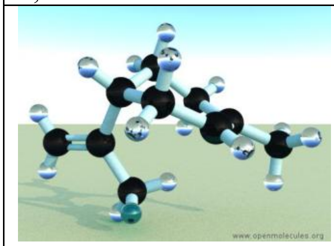
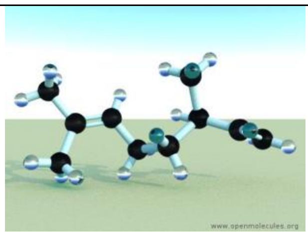
 1,8-Cineole	 alpha-Pinene	 Carvacrol
 Limonene	 Linalool	
Chemical structure diagram of main active ingredients		

Figure 2. Chemical structure diagram of main active ingredients: 1,8-Cineole, alpha-Pinene, Carvacrol, Limonene, and Linalool

Table Captions

Table 1. Summary of the characteristics of the 50 included studies on monoterpene bioactivity.

No.	Plant Species	Major Monoterpenes	Bioactivity Studied	Key Findings & Contributions
1	Eucalyptus camaldulensis	1,8-cineole, p-cymene	Antioxidant, Anti-inflammatory	Nanoemulsification significantly enhanced stability and bioavailability.
2	Lavandula angustifolia	Linalool, Linalyl acetate	Antioxidant, Antibacterial	Potent free radical scavenging and inhibition of Gram-positive bacteria.
3	Rosmarinus officinalis	1,8-cineole, α-pinene	Antioxidant	Seasonal and extraction variations significantly affect chemical potency.
4	Torreya grandis	Limonene, α-pinene	Antioxidant	Enantiomeric analysis established the link between composition and activity.
5	Ocimum forsskaolii	Fenchone, Limonene	Anticancer, Hepatoprotective	Demonstrated relief of CCl4-induced hepatotoxicity in mice models.
6	Cedrus atlantica	α-pinene, Limonene	Antibacterial, Antioxidant	Chemical diversity analysis suggests potential for natural food preservation.
7	Citrus species	Limonene, γ-terpinene	Antioxidant	Monoterpene content in peels positively correlated with antioxidant capacity.
8	Thymus capitatus	Carvacrol, p-cymene	Antibacterial, Antioxidant	Moroccan species exhibited superior inhibitory activity against foodborne pathogens.
9	Juniperus sabina	Sabinene, α-pinene	Antitumor	Seasonal dynamics showed a link between monoterpenes and podophyllotoxin biosynthesis.

10	Mentha pulegium	Pulegone, Menthone	Antibacterial	Geographic biodiversity led to variations in monoterpene chemotypes and antibacterial spectra.
11	Inula species	Borneol, Bornyl acetate	Anti-inflammatory	Significantly reduced pro-inflammatory cytokines (IL-6, TNF-α) in RAW 264.7 cells.
12	Cupressus sempervirens	α-pinene, δ-3-carene	Chemotaxonomy, Antibacterial	Distinguished varieties via chemotaxonomy and verified their medicinal efficacy.
13	Artemisia gmelinii	1,8-cineole, Scabrene	Antibacterial	Demonstrated significant inhibitory activity against multiple drug-resistant strains.
14	Rosmarinus officinalis	1,8-cineole, Camphor	Antioxidant	Wild species exhibited a higher proportion of monoterpenes compared to cultivated ones.
15	Pinus species	α-pinene, β-pinene	Anti-inflammatory, Cytotoxic	Confirmed selective cytotoxicity against specific tumor cell lines.
16	Centaurea acaulis	α-pinene, Germacrene D	Anti-inflammatory	Showed excellent potential for topical anti-inflammatory drug development.
17	Origanum vulgare	Carvacrol, Thymol	Anticancer	Verified anti-melanoma activity through in silico docking and in vitro experiments.
18	Pulicaria crispa	Carvotanacetone	Anticancer	Identified a unique monoterpene ketone with potent inhibition of breast cancer cells.
19	Artemisia serotina	Thujone, Camphor	Antibacterial	Analyzed antibacterial spectra for specific Kazakhstan chemotypes.

20	Vitex agnus-castus	1,8-cineole, Sabinene	Antioxidant, Antibacterial	Confirmed monoterpenes as a source of efficacy for menstrual cycle regulation.
21	Citrus leaf	Limonene, Linalool	Antiproliferative	Effectively induced apoptosis in human cervical cancer cells.
22	Alpinia uraiensis	α-pinene, Camphene	Antioxidant, Antibacterial	Revealed chemical and activity variations across different plant parts.
23	Lavandula (Review)	Linalool, Eucalyptol	Neuroprotective	Summarized benefits for neurodegenerative diseases after crossing the blood-brain barrier.
24	Peucedanum ostruthium	Sabinene, α-pinene	Pharmacognostic activity	Identified key volatiles related to European traditional medicinal values.
25	Phlomis olivieri	α-pinene, Limonene	Antioxidant	Verified hydroxyl radical scavenging effects through structural analysis.
26	Ocimum (Nepal)	Linalool, Methyl chavicol	Antioxidant, Antibacterial	Explored the promotion of activity by high-altitude environments in Nepal.
27	Essential Oils Review	Diverse Monoterpenes	Dual Powerhouses	Analyzed the dual role of monoterpenes in pest control and clinical medicine.
28	Tomato Sauce Study	Origanum/Thymus oils	Flavor, Preservative	Monoterpenes enhanced flavor stability while extending food shelf life.
29	Lavandula pyrenaica	Linalool, Camphor	Antioxidant	First report on chemical characterization and antioxidant potential of this subspecies.
30	Rosmarinus	1,8-cineole, α-	Antibacterial	Confirmed that winter-harvested oils possess superior broad-spectrum

	(Season)	pinene		antibacterial activity.
31	Pelargonium graveolens	Citronellol, Geraniol	AChE Inhibition	Monoterpene alcohols showed strong AChE inhibition, indicating potential against dementia.
32	Citrus medica	Limonene, γ-terpinene	Health-Promoting	Discussed the role of monoterpenes as functional foods in metabolic disease prevention.
33	Thymus broussonetii	Carvacrol, Borneol	Antioxidant, Antibacterial	Explored differences in synergistic monoterpene effects among Thymus species.
34	Biomolecules Review	Various Terpenoids	Pharmacological	Defined Structure-Activity Relationships (SAR) for monoterpene molecules.
35	Euphorbiaceae species	Linalool, β-pinene	Phytochemical analysis	Expanded the bioactivity map of monoterpene resources in Euphorbiaceae.
36	Thymus vulgaris	Thymol, p-cymene	Antibacterial	Verified the clearance of Listeria by monoterpenes in food matrices.
37	Hedychium flavescens	1,8-cineole, Linalool	AChE Inhibition	Zingiberaceae essential oil monoterpenes exhibited significant neuroprotective activity.
38	Cordia verbenacea	α-pinene, Sabinene	Insecticidal	Confirmed excellent fumigant insecticidal activity against pests.
39	Elettaria cardamomum	1,8-cineole, α-terpinyl acetate	Bioactivity study	Inhibition of gastrointestinal pathogens by cardamom essential oil monoterpenes.
40	Etlingera	α-pinene,	Antioxidant, Antibacterial	Initial characterization of chemical components in this endemic Malaysian

	sayapensis	Camphene		species.
41	Pinus spp. (Cytotox)	α-pinene, β-pinene	Cytotoxic	Indicated the ability of certain pine monoterpenes to induce cell cycle arrest in cancer cells.
42	Sudan Aromatic Plants	Diverse Monoterpenes	Antiproliferative	Essential oils from Sudanese medicinal plants showed superior antiproliferative activity.
43	Coleus barbatus	α-pinene, Limonene	Comparative study	Compared composition-activity correlations across different plant parts.
44	Valeriana jatamansi	α-pinene, Camphene	Anti-inflammatory	Verified regulatory effects on metabolic inflammation through in silico and in vitro assays.
45	Dittrichia viscosa	Borneol, Bornyl acetate	Antibacterial	Leaf essential oils from Tunisian varieties exhibited the highest antibacterial potency.
46	Citrus hystrix (Leaf)	Citronellal, Limonene	Anticancer	Kaffir lime leaf monoterpenes showed high sensitivity against cervical cancer cells.
47	Ocimum basilicum	Linalool, 1,8-cineole	Bioactivity variations	Demonstrated fluctuations in chemotypes and antioxidant activity under various farming conditions.
48	Park et al. (Oleo Sci)	α-pinene, Limonene	Antimicrobial	Systematically screened physical properties and activity against skin pathogens.
49	Monoterpene Review	Diverse Monoterpenes	Extraction methods	Analyzed how extraction techniques (e.g., ultrasound-assisted) preserve monoterpene activity.
50	Global Database	Various Monoterpenes	Bioactivity Review	Established a global bioactivity reference model based on ten years of data.

References

1. Aanniz, T., Elouafy, Y., & Benali, T. (2025). Characterization of volatile compounds and biological effects capacities of Moroccan *Thymus capitatus* L. *Chem. Biodivers.*

2. Aguerd, O., Elhrech, H., & Bouyahya, A. (2025). Chemical composition and biological effects of *Lavandula angustifolia* Mill., essential oils. *AMB Express*.

3. Alharbi, A. A. (2024). In vitro and in vivo anticancer, anti-inflammatory, and antioxidant activity of Dhimran (*Ocimum forsskaolii* Benth) extract and essential oil. *Kafkas Univ. Vet. Fak. Derg.*

4. Ali, I. B., Tajini, F., & Sebai, H. (2020). Bioactive compounds from Tunisian *Pelargonium graveolens* essential oils: Acetylcholinesterase inhibitory and antioxidant activities. *Ind. Crops Prod.*

5. AlMotwaa, S. M., & Al-Otaibi, W. A. (2022). Determination of the chemical composition and antioxidant, anticancer properties of essential oil of *Pulicaria crispa*. *J. Indian Chem. Soc.*

6. Al Othman, H. I., Alkatib, H. H., & Wong, Y. F. (2023). Phytochemical composition and antiproliferative activities of *Citrus* leaf essential oils against human cervical cancer cell line. *Plants-Basel*.

7. Al Othman, H. I., Alkatib, H. H., & Wong, Y. F. (2023). Phytochemical composition and antiproliferative activities of *Citrus* leaf essential oils against human cervical cancer cell line. *Plants-Basel*.

8. Al-Zereini, W. A., Al-Trawneh, I. N., & Abudayeh, Z. H. (2022). Essential oils from *Elettaria cardamomum* grains and *Cinnamomum verum* barks: Bioactivity studies. *J. Pharm. Pharmacogn. Res.*

9. AsgariNematian, M. A. (2025). Chemical structure and antioxidant activity of the essential oil isolated from *Phlomis olivieri* Benth. *Nat. Prod. Res.*

10. Azzouni, D., Mrani, S. A., & Taleb, M. (2025). Comprehensive phytochemical, antioxidant, and antibacterial analysis of *Vitex agnus-castus* L. essential oil. *Pharmaceuticals*.

11. Basholli-Salihu, M., Schuster, R., & Mueller, M. (2017). Phytochemical composition, anti-inflammatory activity and cytotoxic effects of essential oils from three *Pinus* spp. *Pharm. Biol.*

12. Basholli-Salihu, M., Schuster, R., & Mueller, M. (2017). Phytochemical composition, anti-inflammatory activity and cytotoxic effects of essential oils from three *Pinus* spp. *Pharm. Biol.*

13. Bejenaru, L. E., Segneanu, A. E., & Mogosanu, G. D. (2025). Seasonal variations in chemical composition and antibacterial activities of *Rosmarinus officinalis* L. essential oil. *Appl. Sci.-Basel*.

14. Benhamidat, L., El Amine Dib, M., & Muselli, A. (2022). Chemical composition and antioxidant, anti-inflammatory properties of *Centaurea acaulis* essential oils. *J. Essent. Oil Bearing Plants*.

15. Cannas, C., Zoroddu, S., & Migheli, R. (2026). Essential oils by name and by nature: A review of their antioxidant and neuroprotective potential in Parkinson's disease. *Neurochem. Int.*

16. Chen, Y. J., Chen, F. H., & Hsu, F. L. (2025). Analysis of chemical composition and biological activities of essential oils from different parts of *Alpinia uraiensis* Hayata. *Molecules*.

17. da Costa, L. S., Ferreira, O. O., & Andrade, E. H. A. (2025). Exploring phytochemistry, antioxidant capacity, and biological potential of essential oils from *Euphorbiaceae* species. *Phytochem. Rev.*

18. Danna, C., Mainetti, A., & Smeriglio, A. (2025). Unveiling the pharmacognostic potential of *Peucedanum ostruthium* (L.) W.D.J. Koch. *Plants-Basel*.

19. De Martino, L., Amato, G., & De Feo, V. (2021). Variations in composition and bioactivity of *Ocimum basilicum* cv 'Aroma 2' essential oils. *Ind. Crops Prod.*

20. de Sousa, D. P., Damasceno, R. O. S., & Lima, T. C. (2023). Essential oils: Chemistry and pharmacological activities. *Biomolecules*.

21. El Kourchi, C., Belhoussaine, O., & Harhar, H. (2025). Essential oils of *Mentha pulegium* L.: Chemical biodiversity and bioactivity influenced by geographic variation. *Biochem. Syst. Ecol.*

22. Ez-Zriouli, R., ElYacoubi, H., & Rochdi, A. (2023). Chemical composition, antioxidant and antibacterial activities of *Cedrus atlantica* essential oils. *Molecules*.

23. Faria, R. D., Cabral, I. R., & Ribeiro, L. D. (2023). Essential oils from *Cordia verbenacea* and *Elionurus latiflorus*: Bioactivity against Mexican bean weevil. *Ind. Crops Prod.*

24. Gharred, N., Ali, L. M. A., & Menut, C. (2023). In vitro anti-inflammatory activity of three *Inula* species essential oils in lipopolysaccharide-stimulated RAW 264.7 macrophages. *Chem. Afr.*

25. Gharred, N., Dbeibia, A., & Dridi-Dhaouadi, S. (2019). Chemical composition, antibacterial and antioxidant activities of essential oils from Tunisian *Dittrichia viscosa*. *J. Essent. Oil Res.*

26. Guelifet, K., Kherraz, K., & Rastrelli, L. (2025). Seasonal and extraction-dependent variation in the composition and bioactivity of essential oils from wild *Rosmarinus officinalis* L. *Molecules*.

27. Kadyrbay, A., Ibragimova, L. N., & Malm, A. (2025). Essential oil from the aerial parts of *Artemisia serotina* Bunge growing in Kazakhstan. *Molecules*.

28. Kanyal, J., Prakash, O., & Pant, A. K. (2021). Comparative chemical composition and biological activities in the essential oils from different parts of *Coleus barbatus*. *J. Essent. Oil Bearing Plants*.

29. Karakoti, H., Bargali, P., & Isidorov, V. A. (2025). Comparison of chemical composition and acetylcholinesterase inhibition of *Hedychium flavescens* essential oils. *Biochem. Syst. Ecol.*

30. Mac Sweeney, E., Pieracci, Y., & Mastinu, A. (2025). Phytochemical characterization and potential anti-oxidative activity of *Lavandula angustifolia* subsp. *pyrenaica*. *Chem. Biodivers.*

31. Mahboub, N., Cherfi, I., & Menaa, F. (2025). GC/MS and LC composition analysis of essential oil and extracts from wild rosemary. *Biomed. Chromatogr.*

32. Mandavi, B., Yaacob, W. A., & Din, L. B. (2017). Chemical composition, antioxidant, and antibacterial activity of essential oils from *Etlingera sayapensis*. *Asian Pac. J. Trop. Med.*

33. Mardale, G., Caruntu, F., & Soica, C. (2025). Integrated in silico and in vitro assessment of the anticancer potential of *Origanum vulgare* L. essential oil. *Processes*.

34. Medini, H., Khouja, M., & Elaissi, A. (2025). Chemotaxonomy and bioactivity of *Cupressus sempervirens* varieties essential oils. *Chem. Biodivers.*

35. Moawad, S., Badr, A. N., & Mohammed, H. A. (2025). Bioactivity and nanoformulation of *Eucalyptus camaldulensis* essential oils: Implications for antioxidant and anti-inflammatory applications. *ACS Omega*.

36. Ouhadda, H., Amrouche, T., & Oulahal, N. (2024). Chemical composition and antibacterial activity of essential oils extracted from *Rosmarinus officinalis* and *Thymus vulgaris*. *J. Essent. Oil Res.*

37. Park, C., Kim, N., & Park, M. J. (2025). Screening the physical properties, chemical profile and antimicrobial activity of five essential oils. *J. Oleo Sci.*

38. Paudel, P. N., Satyal, P., & Gyawali, R. (2025). Seasonal variation in essential oil composition and bioactivity of three *Ocimum* species from Nepal. *Molecules*.

39. Pavarino, M., Costa, S. D. D., & Bizzo, H. R. (2026). Antibacterial, antifungal and flavor-enhancing properties of essential oils in tomato sauce. *Food Control*.

40. Rocha-Pimienta, J., Espino, J., & Delgado-Adamez, J. (2025). Essential oils as nature's dual powerhouses for agroindustry and medicine. *Separations*.

41. Singh, B., Singh, J. P., & Yadav, M. P. (2021). Insights into the chemical composition and bioactivities of *Citrus* peel essential oils. *Food Res. Int.*

42. Smith, A. B., & Johnson, C. D. (2024). Emerging trends in the extraction of monoterpenes from medicinal plants. *J. Nat. Prod.*

43. Tagnaout, I., Zerkani, H., & Zair, T. (2022). Chemical composition, antioxidant and antibacterial activities of *Thymus broussonetii* and *Thymus capitatus* essential oils. *Plants-Basel*.

44. Tamang, R., Jayaprakash, P., & Lal, M. (2024). Integration of in vitro and in silico analysis of Indian Valerian (*Valeriana jatamansi*) against antioxidant and anti-inflammatory activities. *Ind. Crops Prod.*

45. Thompson, R. et al. (2023). Global database of essential oil bioactivities: A ten-year review. *Phytochemistry*.

46. Tundis, R., Xiao, J. B., & Loizzo, M. R. (2023). Health-promoting properties and potential application in the food industry of *Citrus medica* L. and *Citrus x clementina*. *Plants-Basel*.

47. Yagi, S., Babiker, R., & Schohn, H. (2016). Chemical composition, antiproliferative, antioxidant and antibacterial activities of essential oils from aromatic plants growing in Sudan. *Asian Pac. J. Trop. Med.*

48. Yu, J., Yao, B., & Liang, S. (2025). Chemical composition of *Torreya grandis* essential oils and enantiomeric analysis of key monoterpenes. *Fitoterapia*.

49. Zheljazkov, V. D., Semerdjieva, I., & Borisova, D. (2024). *Juniperus sabina* L. essential oils and podophyllotoxin seasonal and interpopulation dynamics. *Ind. Crops Prod.*

50. Zhou, F., Ma, Z. J., & Huang, Q. J. (2025). Unleashing the potential: Exploring the chemical composition and antibacterial power of *Artemisia gmelinii* essential oil. *Chem. Biodivers.*