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A Review on Antibacterial Properties of Eucalyptus Oil and Different Eucalyptus Species Used in Pharmaceuticals

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Abstract

Medicinal plants with antimicrobial compounds play a crucial role in combating various pathogens. Eucalyptus, belonging to the myrtle family, is notable for its diverse antimicrobial compounds. This fast-growing plant thrives in many countries and its various parts offer significant medicinal value, including timber, pulpwood, and essential oils. The leaves, often considered forest harvesting waste, contain essential oils with potential medicinal benefits. Members of the genus Eucalyptus are highly valued for their contribution to various commercial essential oils and aroma chemicals. Extracts obtained from these plants undergo thorough analysis, including phytochemical examination, quantitative assessment, and antibacterial assays. In the phytochemical analysis of Eucalyptus oil, key components identified include 1,8-cineole, α-terpinyl acetate, ρ-cymene, and ϒ-terpinene. Eucalyptus oils have demonstrated a pronounced bacteriostatic effect against gram-positive bacteria, while the oil derived from Eucalyptus urophylla hybrid has been observed to specifically affect gram-negative bacteria. These antibacterial properties are associated with the terpenoid content present in the essential oils. Appreciating the antibacterial qualities of essential oils is essential in choosing suitable antibiotics, whether they are bacteriostatic or bactericidal, for effective treatment. The formulations derived from these oils hold promise for potential applications in both the food and pharmaceutical industries. In summary, the study highlights the antimicrobial potential of Eucalyptus essential oils, emphasizing their effectiveness against a range of bacteria. The findings suggest potential applications in various industries, including food and pharmaceuticals.

Keywords: Eucalyptus oil, antibacterial activity, plant extract, essential oils, antioxidants, bacteriostatic, natural antibiotics, phytochemicals

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INTRODUCTION

Eucalyptus is distinguished as one of the most widespread plant genera globally, renowned for its rapid growth and substantial economic significance [1]. Originating from Australia, this genus, belonging to the myrtaceae family, comprises approximately 800 species, with over 300 of them containing volatile oils in their leaves. Notably, only a limited number of species, less than 20, have been commercially utilized for the extraction of essential oils. These oils, characterized by a high concentration of 1,8-cineole (exceeding 70%), are widely employed in pharmaceuticals and cosmetics [2]. Additionally,

extracts derived from eucalyptus leaves have received approval for use as food additives.

Research has explored the potential of eucalyptus as an alternative remedy for various infections, given its antimicrobial properties. Essential oils from eucalyptus, especially those abundant in 1,8-cineole, have been employed through inhalation for pulmonary infections [3]. Certain eucalyptus species are utilized in Tunisian folk medicine as antiseptics for respiratory tracts Throughout history, the medicinal properties of eucalyptus have been utilized to address various health conditions, including arthritis, asthma, burns, fever, influenza, sore throat, malaria, wounds, and pharyngitis. Studies have unveiled a range of properties in eucalyptus leaf extracts, including antihyperglycemic, antioxidant, antibacterial, ulcer-healing, cytotoxic, anti-inflammatory, and analgesic effects [4].

When compared to chemical-based medications, pharmaceuticals derived from plants are thought to be comparatively safer. Over 80% of the world's population relies on traditional medicinal herbs to meet their basic healthcare needs, according to the World Health Organization (WHO). Plant-derived compounds present a chance to create novel antibiotic classes in the ongoing hunt for antibiotics (ATBs). When choosing the right antibiotics for therapy, understanding the difference between bacteriostatic and bactericidal effects is essential.

In the face of diminishing effectiveness of many antibiotics against pathogens, there's a pressing need to discover alternative antimicrobial agents to combat resistant microorganisms. Additionally, research has focused on understanding the influence of growth conditions on the chemical composition and antibacterial properties of eucalyptus essential oils. The correlation between the major components of these oils and their potential antibacterial activity is also subject of investigation (Figure 1).

Figure 1. Eucalyptus oil.

SCIENTIFIC CLASSIFICATION OF EUCALYPTUS

The scientific classification of Eucalyptus is provided in Table 1.

Table 1: SCIENTIFIC CLASSIFICATION OF EUCALYPTUS

Kingdom	Plantae
Subkingdom	Tracheobionta

Super division	Spermatophyta
Division	Magnoliophyta
Class	Dicotyledons
Subclass	Rosidae
Order	Myrtales
Family	Myrtaceae
Genus	Eucalyptus
Species	Eucalyptus globules labill

MAJOR SPECIES

There are over 800 species of eucalyptus, the major ones are enlisted below (Table 2).

Table 2: Species of Eucalyptus

Major species of eucalyptus	**Major species of eucalyptus**
Eucalyptus amygdalina	Eucalyptus microtheca
Eucalyptus australiana	Eucalyptus nitens
Eucalyptus botryoides	Eucalyptus ovate
Eucalyptus calophylla	Eucalyptus pauciflora
Eucalyptus camaldulnesis	Eucalyptus perriniana
Eucalyptus citriodora	Eucalyptus pilularis
Eucalyptus cladocalyx	Eucalyptus polyanthemos
Eucalyptus consideniana	Eucalyptus polybractea
Eucalyptus cypellocarpa	Eucalyptus populnea
Eucalyptus dives	Eucalyptus radiate
Eucalyptus gigantean	Eucalyptus regnans
Eucalyptus globulus	Eucalyptus risdonni
Eucalyptus gomphocephala	Eucalyptus robusta
Eucalyptus grandis	Eucalyptus rossi
Eucalyptus gunnii	Eucalyptus rostrata
Eucalyptus incrassate	Eucalyptus saligna
Eucalyptus kino	Eucalyptus sideroxylon
Eucalyptus largeflorens	Eucalyptus sieberiana
Eucalyptus lesouefii	Eucalyptus smithii
Eucalyptus macrocarpa	Eucalyptus tereticornis
Eucalyptus macrorhyneha	Eucalyptus tetrodonta
Eucalyptus maculate	Eucalyptus umbra
Eucalyptus marginata	Eucalyptus urophylla
Eucalyptus melanophloia	Eucalyptus viminalis
Eucalyptus melliodora	Eucalyptus wandoo

GEOGRAPHICAL LOCATION

Eucalyptus, a member of the Myrtaceae family, is native to Australia, and some species are also found in neighboring countries [5]. This versatile plant thrives in a broad range of soils and climates, leading to its introduction into North and South Africa, Asia, and Southern Europe [6]. Interspecific

hybrids are cultivated in various countries, including Brazil, Congo, China, Indonesia, South Africa, the Philippines, Vietnam, Thailand, Malaysia, Argentina, Chile, Paraguay, and Uruguay [7] [Table 3].

Globally, there are around 700 eucalyptus species, but only about 1% find industrial applications [8] (Figure 2). The timber of eucalyptus is utilized for fuel, shelterbelts, windbreaks, and hardwood fiber [9]. In addition to its industrial uses, eucalyptus essential oils have diverse medicinal and commercial applications [10]. Essential oils derived from eucalyptus are utilized in traditional or folk medicine and are recognized for their diverse properties, including anesthetic, anodyne, antiperiodic, antiphlogistic, antiseptic, astringent, deodorant, diaphoretic, disinfectant, expectorant, febrifuge, fumigant, hemostatic, inhalant, insect repellent, preventive, rubefacient, sedative yet stimulant, suppurative, tonic, and vermifuge properties [11].

Figure 2. Different eucalyptus species.

Table 3: Different eucalyptus species

Country	Species
Thailand	E. urophylla, E. urophylla(RFD clones)
Thailand and China	E. urophylla X E.camaldulnesis
Congo, Portugal, Taiwan, Ethiopia, Brazil, China, Australia	E. urohylla
Tunisia	E.maidenii, E.astrengens, E.cinerea, E.leucoxylon, E.lehmanii, E.sideroxylon, E.bicostata, E.angulosa, E.oxidantes , E.microcarpa
North Queensland, Papua New Guinea and Indonesia	E. pellita
East Kalimantan	E.globulus, E.camaldulnesis, E.odorata, E.deglupta
Nigeria	E. camaldulnesis
Senegal	E. alba
Central java, Indonesia	E. melaleuca leucadendra
Tunisia	E.diversifolia, E.falcata, E.gomphocephala, E.maculata, E.platypus, E.polyanthemas, E.rudis, E.dundasii, E.populifolia
Germany	E. globulus, E.radiata , E.citriodora
Iran	E. aeurginosa
Saudi Arabia	E. camaldulnesis

North Eastern Tunisia	E.globulus, E.maidenii, E.astrigens, E.camaldulnesis, E.lehmanii, E.melliodora, E.erythrocorys, E.gomphocornuta, E.oxidantes, E.microcarpa, E.angulosa, E.paniculata

Nine species of eucalyptus are specifically used for medicinal and commercial purposes, as outlined in Table 4. Additionally, E. cinerea and E. cneorifolia possess medicinal value, and E. macarthurii is utilized in perfumery. The varied uses of eucalyptus underscore its significance in both traditional medicine and various industries [Fig. 3]. The Physical and chemical properties of Eucalyptus oil are mentioned in Table 5.

Table 4: Cultivated Eucalyptus species.

Uses	Species	Country
Medicinal	Eucalyptus globulus Labill.	China, Portugal, Spain, India, Brazil, Chile, Bolivia, Uruguay, Paraguay
	E. smithii R. Baker	South Africa, Swaziland, Zimbabwe
	E. polybractea R. Baker (syn. E. fruticetorum F. Muell. ex Miq.)	Australia
	E. exserta F. Muell.	China
	E. radiata Sieber ex DC. (syn. E. australiana, E. radiata var. australiana)	South Africa, Australia
	E. dives Schauer	Australia
	E. camaldulensis Dehnh. (syn. E. rostrata Schldl.)	Nepal

Table 5: Physical and Chemical Properties of Eucalyptus Oil

State	Liquid oil
Color	Pale yellow
Taste	Cooling pungent taste
Boiling point of cineole	176˚C-177˚C
Density	0.921-0.923
Odor	Camphoraceous with sweet odor
Solubility	Insoluble in water but soluble in high concentration, alcohol, oil fats etc..

Five commonly used extraction methods are:

1. *Hydrodistillation:* This method entails placing plant material and water in a container, heating from below, and condensing the aromatic vapor into a liquid with minimal hydrosol (water). The total oil yield increases with distillation time, but the principal component percentage decreases accordingly [12, 13].
2. *Steam distillation:* In this method, plant material is introduced into a flask, and steam is applied to vaporize the volatile oils. Although akin to hydrodistillation, steam distillation often yields a higher quantity of oil [14].
3. *Vacuum distillation:* For extracting essential oils from various eucalyptus species, vacuum distillation is employed at lower temperatures to prevent changes in the chemical composition of essential oils during distillation [15].
4. Supercritical fluid extraction (SFE); This method involves using gases, commonly CO2, as non-polar solvents under specific temperature and pressure conditions. Recognized for its efficiency and speed, this approach is faster compared to hydrodistillation [16].

5. *Subcritical-water extraction (SWE):* Using hot water (100-374°C) as an extractant under high pressure, this method is faster and more efficient than hydrodistillation. It offers advantages such as shorter extraction time, high extract quality, lower costs of the extracting agent, and environmental friendliness [17, 18].

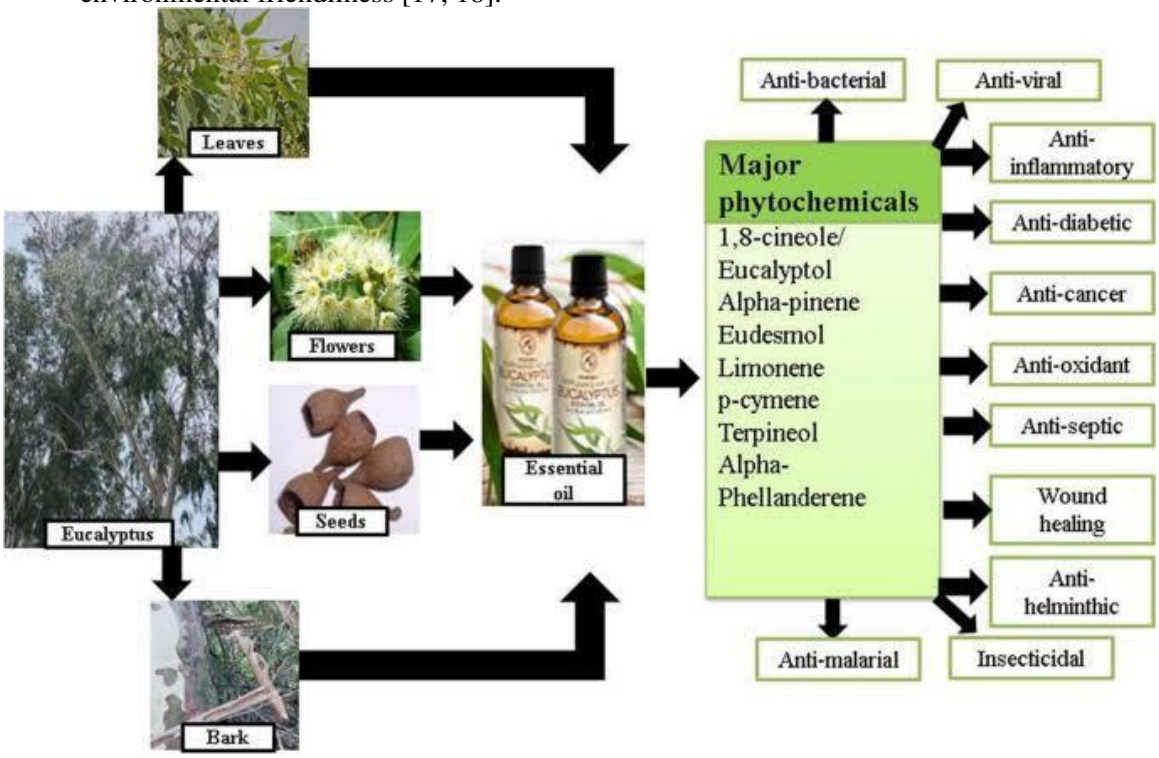

Figure 3. Eucalyptus phytochemical composition and medical applications.

It's important to note that each extraction method has its unique characteristics and advantages, allowing for flexibility in choosing the most suitable technique based on the specific requirements of the extraction process [19, 20].

DISCUSSION

The World Health Organization (WHO) has identified antibiotic resistance as one of the top ten dangers to global health in 2020 [21, 22], posing a serious threat to public health worldwide. The development of antibiotic resistance mechanisms in bacteria, which is a concerning trend, is made worse by the overuse and abuse of antibiotics in both clinical and agricultural settings [23, 24].

Using essential oils is a good substitute to fight antibiotic resistance. Particularly eucalyptus essential oil is a complex blend of volatile substances with variable degrees of antibacterial action [25, 26]. Interestingly, eucalyptus essential oil's antibacterial qualities can be strengthened even more when combined with other substances, such as other essential oils and traditional antibiotics [32, 33]. This approach opens up new possibilities for addressing bacterial infections and may contribute to mitigating the global challenge of antibiotic resistance [27].

Uses of Eucalyptus Oil

- Medicinal and antiseptic
- Repellent and biopesticide
- Flavouring
- Fragnance
- Industrial

- Safety and toxicity.

General Uses

- Timber
- Essential oil
- Phenolics

Pharmacological Actions

Various pharmacological activities reported in this plant such as diabetic, inflammation, malarial, bacterial infection, neurological disorder and other CNS disorder [36, 40].

Benefits and Uses of Eucalyptus Oil

- Relieves stuffy nose
- Best of all skin types
- Eases sore muscle and joint pain
- Pain comforter
- Improve hair health
- For Diffusion
- Promotes healing
- Stress buster.

Future Prespective

Various research and development initiatives have been launched to explore the diverse medicinal, agronomic, and commercial aspects of the eucalyptus plant [28, 29]. Genomic endeavors in this plant species offer the potential for developing enhanced, fast-growing varieties. Additionally, there is a growing focus on researching the medicinal properties of eucalyptus oil and extracts, particularly in the context of their bioactivity against zoonotic and infectious diseases [30, 35].

In the majority of studies, evidence is presented in the form of MIC values (Minimum Inhibitory Concentrations), diameters of zones of inhibition, and time kill studies [31, 36]. This analytical approach helps in assessing the efficacy of eucalyptus-derived compounds against various pathogens, providing valuable insights for further applications in medicine and agriculture.

CONCLUSION

Eucalyptus, with its natural and cloned varieties, is extensively utilized for various commercial purposes [35]. Eucalyptus globulus, in particular, has been renowned for its ethnomedicinal and therapeutic significance for many decades. Numerous eucalyptus species have been subject to extensive research, revealing their therapeutic activities, including antiviral, antibacterial, anti-diabetic, anti-inflammatory, antioxidant, antitumor, anticancer, and hepatoprotective properties [38]. The rich content of bioactive secondary metabolites, such as terpenoids, tannins, flavonoids, and their derivatives, contributes to the observed antiviral and antibacterial effects, supporting the plant's traditional use as an antiseptic [37].

In the present review, an effort has been made to compile information on eucalyptus species, encompassing descriptions, phytochemical analyses, therapeutic applications, and related details [34,39]. This comprehensive approach contributes to the existing knowledge on the multifaceted uses and potential benefits of eucalyptus [36, 41].

Abbreviations

EO – Essential Oil
GC-MS – Gas Chromatography – Mass Spectrometry
FTIR – Fourier Transform Infrared
ATR-FTIR – Attenuated Total Reflection – Fourier Transform Infrared

MIC – Minimum Inhibitory Concentration
MBC – Minimum Bactericidal Concentration
GLC-MS – Gas Liquid Chromatography – Mass spectrometry
PCA – Princial Components Analysis
HCA – Heirarchical Cluster Analysis
GC/MS – Gas Chromatography/ Mass spectrometry
EGEO – Eucalyptus Globulus Essential oil
EGEO nanoemulsion – Nanoemulsion Containing EGEO
EGEO nanogel – Nanogel Containing EGEO

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Conflict of Interest
The author declares no conflicts of interest.

Data Availability Statement
All data are contained within this article.

REFERENCES
1. Limam H, Jemaa MB, Tammar S, Ksibi N, Khammassi S, Jallouli S, Del Re G, Msaada K. Variation in chemical profile of leaves essential oils from thirteen Tunisian Eucalyptus species and evaluation of their antioxidant and antibacterial properties. Industrial Crops and Products. 2020 Dec 15; 158:112964.
2. Tine Y, Diallo A, Diop A, Costa J, Boye CS, Wélé A, Paolini J. The Essential oil of Eucalyptus alba L. Growing on the Salt Zone of Fatick (Senegal) as a Source of 1, 8 ‖ Cineole and Their Antibacterial Activity. Journal of Drug Delivery and Therapeutics. 2020 Feb 15;10(1-s):140-3.
3. Putih sa. A preliminary study on the application of eucalyptus oil for antibacterial properties on cotton/polyester fabrics (2022).
4. Alipanah H, Abdollahi A, Firooziyan S, Zarenezhad E, Jafari M, Osanloo M. Nanoemulsion and nanogel containing Eucalyptus globulus essential oil; larvicidal activity and antibacterial properties. Interdisciplinary Perspectives on Infectious Diseases. 2022 Aug 31;2022.
5. Diloksumpun S, Wongkattiya N, Buaban K, Saleepochn T, Suttiarporn P, Luangkamin S. Variation in the antibacterial and antioxidant activities of essential oils of five new Eucalyptus urophylla ST Blake clones in Thailand. Molecules. 2022 Jan 20;27(3):680.
6. Sebei K, Sakouhi F, Herchi W, Khouja ML, Boukhchina S. Chemical composition and antibacterial activities of seven Eucalyptus species essential oils leaves. Biological research. 2015 Dec;48(1):1-5.
7. Ghalem BR, Mohamed B. Antibacterial activity of leaf essential oils of Eucalyptus globulus and Eucalyptus camaldulensis. African journal of Pharmacy and pharmacology. 2008 Dec 1;2(10):211-5.
8. Sugumar S, Mukherjee A, Chandrasekaran N. Eucalyptus oil nanoemulsion-impregnated chitosan film: antibacterial effects against a clinical pathogen, Staphylococcus aureus, in vitro. International journal of nanomedicine. 2015 Oct 1;10(sup2):67-75.
9. Sugumar S, Ghosh V, Nirmala MJ, Mukherjee A, Chandrasekaran N. Ultrasonic emulsification of eucalyptus oil nanoemulsion: antibacterial activity against Staphylococcus aureus and wound healing activity in Wistar rats. Ultrasonics sonochemistry. 2014 May 1;21(3):1044-9.
10. Tine Y, Diallo A, Ndoye I, Gaye C, Ndiaye B, Diop A, Costa J, Bouh Boye CS, Wélé A, Paolini J. Chemical Variability and Antibacterial Activity of Eucalyptus camaldulensis Essential Oils from Senegal. International Journal of Organic Chemistry. 2022 Dec 2;12(04):173-80.

11. Elaissi A, Salah KH, Mabrouk S, Larbi KM, Chemli R, Harzallah-Skhiri F. Antibacterial activity and chemical composition of 20 Eucalyptus species' essential oils. Food Chemistry. 2011 Dec 15;129(4):1427-34.
12. Mulyaningsih S, Sporer F, Reichling J, Wink M. Antibacterial activity of essential oils from Eucalyptus and of selected components against multidrug-resistant bacterial pathogens. Pharmaceutical biology. 2011 Sep 1;49(9):893-9.
13. Al-Hadhrami RM, Al Muniri RM, Hossain MA. Evaluation of antimicrobial and cytotoxic activities of polar solvent extracts from leaves of Ammi majus used by the omanis. Pacific science review A: natural science and engineering. 2016 Jan 1;18(1):62-5.
14. Ghareeb MA, Habib MR, Mossalem HS, Abdel-Aziz MS. Phytochemical analysis of Eucalyptus camaldulensis leaves extracts and testing its antimicrobial and schistosomicidal activities. Bulletin of the National Research Centre. 2018 Dec; 42:1-9.
15. Kuspradini h, Putri AS, Egra S, Yanti Y. In vitro antibacterial activity of essential oils from twelve aromatic plants from East Kalimantan, Indonesia. Biodiversitas Journal of Biological Diversity. 2019 Jul 3;20(7).
16. Rajasulochana P. Research studies on evaluation of phytochemical and antibacterial activity of cold ethanoic extract of eucalyptus oil. Information technology in industry. 2021 Apr 13;9(2):1164-8.
17. OO A, Adeniyi BA. The antibacterial activity of leaf extracts of Eucalyptus camaldulensis (Myrtaceae). Journal of Applied Sciences Research. 2008;4(11):1410-3.
18. Sabo VA, Knezevic P. Antimicrobial activity of Eucalyptus camaldulensis Dehn. plant extracts and essential oils: A review. Industrial crops and products. 2019 Jun 1; 132:413-29.
19. Zhang J, An M, Wu H, Stanton R, Lemerle D. Chemistry and bioactivity of Eucalyptus essential oils. Allelopathy Journal. 2010 Apr 1;25(2).
20. Coppen JJ. Flavours and fragrances of plant origin. Fao; 1995.
21. Coppen JJ, editor. Eucalyptus: the genus Eucalyptus. CrC Press; 2002 Apr 25.
22. Ahmad NR, Hanif MA, Rashid U. Chemical compositional and intra provenance variation for content of essential oil in Eucalyptus crebra. Asian J. Plant Sci. 2005;4(5):519-23.
23. Dungey HS, Nikles DG. An international survey of interspecific hybrids in forestry. Queensland Forestry Research Institute; 2000.
24. Quoirin M, Quisen R. Advances in genetic transformation of Eucalyptus species. Molecular biology of tropical plants. 2006:41-56.
25. Aune PS, Redding CA. SEED-TREE METHOD. InGenetics/Silviculture Workshop Proceedings 1991 (p. 224).
26. Kandasamy, O.S., Mohamed Yassin, M. and Babu, R.C. (2000). Biology, ecology, silviculture and potential uses of Eucalyptus - an overview. Journal of Medicinal and Aromatic Plant Sciences 22: 330-335.
27. Duke JA. Handbook of energy crops. Handbook of Energy Crops. 1983.
28. Zhang J, An M, Wu H, Stanton R, Lemerle D. Chemistry and bioactivity of Eucalyptus essential oils. Allelopathy Journal. 2010 Apr 1;25(2).
29. Alghamdi AI, Ababutain IM. Research article phytochemical screening and antibacterial activity of Eucalyptus camaldulensis's leaves and bark extracts. Asian Journal of Scientific Research. 2019;12(2):202-10.
30. Kesharwani V, Gupta S, Kushwaha N, Kesharwani R, Patel DK. A review on therapeutics application of eucalyptus oil. Int. J. Herb. Med. 2018;6(6):110-5.
31. Eucalyptus: A Review on Agronomic and Medicinal Properties. Biological Forum – An International Journal, 13(1): 342-349.
32. Rathva, D., Pal, P., Parmar, D., Upadhyay, S., & Upadhyay, U. A Basic Review on Eucalyptus Oil (2020).
33. Elangovan, S., & Mudgil, P. (2023). Antibacterial properties of Eucalyptus globulus essential oil against MRSA: A systematic review. Antibiotics, 12(3), 474.

34. Ahmad, N.R., Hanif, M. A. and Umer, R. (2005). Chemical compositional and intra provenance variation for content of essential oil in Eucalyptus crebra. Asian Journal of Plant Sciences 4: 519-523.
35. Boland, D.J., Brophy, J.J. and House, A.P.N. (1991). Eucalyptus Leaf Oils: use, chemistry, distillation and marketing. Inkata Press, Melbourne. 252 pp.
36. Barazandeh, M.M. (2005). The effect of the method and duration of distillation on the essential oil yield and composition of Eucalyptus globules. Iranian Journal of Medicinal and Aromatic Plants Research 21: 75-93.
37. Sefidkon, F., Bahmanzadegan, A. and Assareh, M.H. (2008). Effect of distillation methods and harvesting times on the essential oil and cineole content of Eucalyptus dealbata. Chemistry of Natural Compounds 44: 250-253.
38. Bignell, C.M., Dunlop, P.J. and Brophy, J.J. (1997). Volatile leaf oils of some south-western and southern Australian species of the genus Eucalyptus (Series I). Part XVIII. Flavour and Fragrance Journal 12: 423-432.
39. Rozzi, N.L., Phippen, W., Simon, J.E. and Singh, R.K. (2002). Supercritical fluid extraction of essential oil components from lemon-scented botanicals. Lebensmittel-Wissenschaft und - Technologie 35: 319-324.
40. Herrero, M., Cifuentes, A. and Ibanez, E. (2006). Sub- and supercritical fluid extraction of functional ingredients from different natural sources: plants, food-by-products, algae and microalgae. Food Chemistry 98: 136-148.
41. Jimenez-Carmona, M.M. and Luque de Castro, M.D. (1999). Isolation of eucalyptus essential oil for GC-MS analysis by extraction with subcritical water. Chromatographia 50: 578-582

