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Phytochemical Screening and Biological Activities of Eucalyptus Plants Leaves

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Abstract

Eucalyptus, a genus comprising over 700 species, is widely recognized for its medicinal properties and diverse biological activities. The leaves of Eucalyptus trees have been extensively studied for their phytochemical composition and pharmacological potential. Phytochemical screening of Eucalyptus leaves reveals the presence of a wide range of bioactive compounds, including flavonoids, tannins, alkaloids, phenolics, terpenoids, saponins, and essential oils. The biological activities of Eucalyptus leaves are vast and well-documented. They exhibit significant antimicrobial activity against a broad spectrum of pathogens, including bacteria, fungi, and viruses. The essential oils and extracts from Eucalyptus leaves have demonstrated potent antioxidant properties, which are attributed to their high phenolic content. Eucalyptus leaves also possess anti-inflammatory and analgesic properties, making them valuable in the management of inflammatory diseases and pain relief. Additionally, they have shown promising immunomodulatory effects, enhancing the body's immune response. Furthermore, Eucalyptus leaves exhibit insecticidal and repellent activities, making them useful in the control of vector-borne diseases

Keywords: Deep learning, Eucalyptus leaves, Bioactive Compounds, Medicinal plants, Secondary metabolites, Extractions

Introduction

The Eucalyptus tree, belonging to the Myrtaceous family, is one of the most widely cultivated and studied plants globally, renowned for its medicinal, industrial, and ecological significance. Native to Australia but now grown worldwide, Eucalyptus species are valued for their rapid growth, adaptability, and diverse applications. The leaves of the tree have received a great deal of attention for their abundance of phytochemicals and wide range of biological effects. An analysis of Eucalyptus leaves has revealed an array of bioactive substances, including flavonoids, tannins, alkaloids, phenolics, terpenoids, saponins, and essential oils. These components contribute to the plant's healing properties, making it a

fundamental component in traditional medicine and a topic of modern pharmacological research. Eucalyptus leaves are especially rich in essential oils, with eucalyptol (1,8-cineole) being the most prominent compound. This monoterpene oxide is responsible for many medicinal properties of the plant, such as its ability to fight against microbes, reduce inflammation, and act as an expectorant. The leaves also contain significant levels of phenolic compounds like gallic acid, ellagic acid, and quercetin which contribute to their antioxidant and free radical-fighting abilities. The diverse and well-documented biological activities of Eucalyptus leaves include potent antimicrobial effects against a variety of bacteria, fungi, and viruses. This makes them valuable for treating infections and as natural preservatives. The antioxidant capacity of Eucalyptus leaves is another critical aspect, as it helps combat oxidative stress, a main factor in the pathogenesis of chronic diseases like cancer, neurodegenerative conditions and cardiovascular disorder. In addition to their antimicrobial and antioxidant properties, Eucalyptus leaves have demonstrated significant anti-inflammatory and analgesic effects. These properties are beneficial in managing inflammatory conditions such as arthritis and in providing pain relief. The immunomodulatory effect of Eucalyptus leaves further enhance their therapeutic potential, aiding in the modulation of the immune response and improving overall health. Eucalyptus leaves also show promise in the management of metabolic disorders. Studies have highlighted their antidiabetic potential, with evidence suggesting that they can help regulate blood glucose levels and improve insulin sensitivity. Furthermore, the leaves exhibit insecticidal and repellent activities, making them useful in controlling vector-borne diseases such as malaria and dengue. The wound-healing properties of Eucalyptus leaves have also been explored, with research indicating their efficacy in promoting tissue repair and regeneration. This is attributed to their antimicrobial, anti-inflammatory, and antioxidant activities, which collectively enhance the healing process. The phytochemical screening of Eucalyptus leaves reveals a complex and rich profile of bioactive compounds, underpinning their diverse biological activities. The characteristics of Eucalyptus leaves make them a valuable asset in both traditional and modern medicine. Further investigation on their pharmacological capabilities is crucial in order to comprehensively grasp their effectiveness and create new medicinal treatments for different ailments.

Research Questions And Hypothesis

The research question for the study on phytochemical screening and biological activities of eucalyptus tree leaves is to investigate the presence of bioactive compounds in the leaves and to determine their potential health benefits. The study aims to answer questions such as what are the types and quantities of phytochemicals present in eucalyptus leaves, and how do these compounds affect human health? In addition, the research also seeks to establish a correlation between the phytochemical profile and the biological activities of eucalyptus leaves, such as antioxidant, anti-inflammatory, and antimicrobial properties. The hypothesis of the study is that eucalyptus tree leaves contain a distinct array of phytochemicals that promote to their potential therapeutic effects. It is also expected that there will be apositive correlation between the phytochemical composition of eucalyptus leaves and their biological activities. This research holds significance as it can provide valuable insights into the medicinal properties of eucalyptus leaves, which have been traditionally used for treating various ailments. Overall, this aims to makes a contribution to our understanding of the potential health benefits of eucalyptus tree leaves and their potential use in modern medicine. Species: Over 700-900 species, depending on taxonomic revisions.

Botanical Description of Eucalyptus Species

The Eucalyptus genus, belonging to the Myrtaceae family, comprises over 900 species, many of which are renowned for their medicinal properties. Eucalyptus leaves, in particular, have been significantly studied for their rich phytochemical composition and diverse biological activities, including antimicrobial, anti-inflammatory, antioxidant, insecticidal, and antischistosomicidal effects 1 7. This review synthesizes current knowledge on the phytochemical screening and biological activities of Eucalyptus leaves, highlighting their potential applications in pharmaceuticals, agriculture, and traditional medicine.

Botanical classification of Eucalyptus

Kingdom: Plantae
Division: Tracheophytaa (vascular plants)
Class: Magnoliopsida (dicotyledons)
Order: Myrtales
Family: Myrtaceaee (Myrtle family)Genus: Eucalyptus (with closely related genera Corymbia and Angophora, collectively called "eucalypts")

Table 1: Notable Eucalyptus Species

Common Name	Botanical Name	Key Features
Southern Blue Gum	Eucalyptus Globulus	Dominant source of medicinal eucalyptus oil;leaves high in 1,8-cineole.
River Red Gum	E.camaldulensies	Widely planted in arid zones;used for timber and erosion control.
Rainbow Gum	E.deglupta	Striking multicoloredbark;native toSoutheast Asia.
Cider Gum	E.gunnii	Tallest flowering plant on Earth(up to 100m/330ft.
Mountain Ash	E.regnans	Tallest flowering plant on earth upto 100m.
Lemon-smelly Gum	E.citriodora	Leaves rich in citronellal, used in perfumery.
Silver Dollar Gum	E.cinerea	Round,silvery juvenile leaves used in .floristry

Biological Activities of Eucalyptus Extracts

Eucalyptus extracts, particularly essential oils (EOs) and leaf extracts, exhibit a widespread of biological activities due to their rich phytochemical composition. These activities include antimicrobial, antioxidant, anti-inflammatory, insecticidal, herbicidal, and phytotoxic effects, making them valuable in

pharmaceuticals, agriculture, and traditional medicine. Below is a detailed synthesis of key biological properties supported by recent research.

Antimicrobial Activity

Eucalyptus extracts demonstrate broad-spectrum antimicrobial effects against bacteria, fungi, and biofilms:

Antibacterial: Effective against Gram-positive (Staphylococcus aureus, Listeria monocytogenes) and Gram-negative (Escherichia coli, Pseudomonas aeruginosa) bacteria.

E. globulus EO demonstrated great activity beside S. aureus (MIC: 0.5 ug/mL) and Pectobacterium carotovorum (MIC: 2 µg/mL).

E. camaldulensis extracts inhibited Candida albicans (14 mm inhibition zone) and other fungi.

Antifungal: Active against Aspergillus spp. and phytopathogenic fungi. E. citriodora EO exhibited moderate fungitoxicity.

Antibioflim: E. gunnii EO inhibited S.aureus biofilm formation by 79.88% at 0.5 µg/mL

Mechanism: Interruption of microbial cell membranes and obstacle with metabolic pathways.

Antioxidant Properties

Eucalyptus extracts are rich in phenolics, flavonoids, and 1,8-cineole, contributing to their radical-scavenging capacity:

E. globulus EO neutralized 55.44% of ABTS+ radicals (equivalent to 3.22 TEAC).

E. citriodora showed superior antioxidant activity compared to other species in DPPH and ABTS assays.

Leaf extracts contain high levels of gallic acid, quercetin, and rutin, which mitigate oxidative stress.

Anti-inflammatory And Analgesic Effect

1,8-Cineole, the major component of E. globulus EO, reduces inflammation by inhibiting TNF-a, IL-1B, and prostaglandins.

Extracts alleviate respiratory conditions (e.g., bronchitis, sinusitis) and are used in traditional medicine for pain relief.

Insecticidal and Acaricidal Activity

E. globulus EO killed 100% of O. lavaterae insects at 100% concentration.

E. citriodora EO repels mosquitoes and agricultural pests due to citronellal.

Effective against mites and nematodes, offering eco-friendly pesticide alternatives.

Herbicidal and Phytotoxic Effects

Eucalyptus EOs inhibit weed germination and growth, serving as natural herbicides:

E. falcata and E. sideroxylon EOs suppressed Sinapis arvensis (mustard weed) germination better than glyphosate.

E. globulus EO disrupts chlorophyll synthesis and induces oxidative stress in weeds.

Phytochemical composition of Eucalyptus Leaves

Eucalyptus leaves are rich in bioactive compounds, including essential oils, phenolic mixtures, flavonoids, tannins, and terpenoids, which provide to their medicinal and industrial applications. Below

is a detailed breakdown of their phytochemical composition.

Essential Oils(volatile compounds)

Eucalyptus leaves are rich in bioactive compounds, including essential oils, phenolic mixtures, flavonoids, tannins, and terpenoids, which promote to their medicinal and industrial applications. Below is a detailed breakdown of their phytochemical composition

Table 2: Major Montoterpenes and sesquiterpenes

compounds	Percentage Range(%)	Key Properties
1,8-cineole(Eucalypto)	40-90%(E.globulus)	Antimicrobial, expectorant,anti-inflammatory.
Alpha-Pinene	1-25%	Antiseptic,bronchodilator.
Beta-Pinene	1-15%	Anti-inflammatory,insecticidal
Limonene	1-10%	Antioxidant,anticancer.
P-Cymene	1-12%	Antimicrobial,analgesic.
Gama-Terpinene	1-8%	Antioxidant,antifungal.
Terpinen-4-ol	1-5%	Antifungal,antibacterial

Materials And Methods

Materials Required

Fresh eucalyptus leaves,Solvents (ethanol,flask,funnel,water hexane, chloroform), Laboratory (beaker, Flask,funnels,test tube,pippet etc),Rotatory evaporator or water bath,Filter paper or vaccum filtration setup,Phytochemical reagents (fehlings solution,Dragedorff's reagent,wagners reagent),Microbial cultures for (antimicrobial testing) DPPH(2,2-diphenyl-1-picrylhydrozyl)or for (antioxidant testing)ABTS,Spectrophotometer,Incubator,PH meter,Weighing balance,Mortar and Pestle

Experimental Procedure

Collect fresh eucalyptus leaves from a healthy tree(morning collection recommended for higher essential oil contents).

Wash carefully with distilled water to cut off dust and contaminants.

Gloom-dry the leaves at room temperature (25-30°C) for 7-10 days.

Grind the dry leaves into a good powder using a blender or grinder or pestle or mortar).

Store the powdered leaves in an airtight container for extraction.

Solvent Extraction

Weigh about 25-50gm of dried powedered of eucalyptus leaves.

Select solvent based on the polarity of the target phytochemicals.

Polar solvent (eg water, ethanol, methanol)it extracts polar compounds like Flavonoids, Tannins and phenolic acid

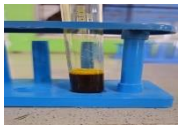
Non-polar solvent(eg hexane,chloroform)it extracts non polar compounds like terpenoids and essential oil

Use maceration or Soxhlet extraction:

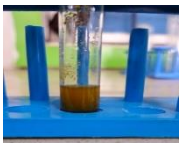
Maceration: Soak the powdered leaves in the solvent (1:10 ratio) for 24–48 hours with occasional shaki-

ng.
Soxhlet Extraction: Reflux the sample with solvent for 4–8 hours until complete extraction.
Filter the extracts using Whatman filter paper.
Concentrate the extract applying a rotary evaporator or in lowered pressure.
Store the dried obtains in a refrigerator at 4°C for further analysis.

Phytochemical Screening
Qualitative test



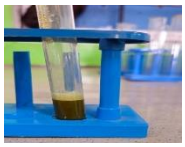
Phytochemical screening is a qualitative analysis used to detect the occurrence of bioactive mixtures in plant extracts. These tests comprise detailed chemical reactions that produce typical precipitates or color changes.
For Alkaloids test:



Alkaloids are nitrogen-containing bioactive compounds with potential pharmacological properties, including antibacterial, antifungal, and anti-inflammatory effects. The qualitative screening of alkaloids in eucalyptus leaf extracts involves specific chemical tests.After adding Dragedorff's reagent to the extract formation of an orange ppt indicates alkaloids.
For flavonoids test:

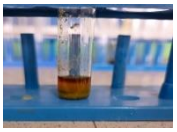
Flavonoids are polyphenolic mixtures with anti-inflammatory, antioxidant and antimicrobial properties. The qualitative screening of flavonoids in eucalyptus leaf extracts involves specific chemical tests.To verified the test add few drops of NaoH to the extract, A yellow pale color will be indicates which shows the flavonoids.
For phenol test:

Flavonoids are a category of polyphenolic secondary metabolites with distinct biological activities, including anticancer, antimicrobial, anti-inflammatory, and antioxidant properties. Diagnosis for flavonoids in eucalyptus leaves involves qualitative and quantitative methods.Add a few drops of $FeCl_3$ solution.A blue -green or black color is seen which indicates phenol.
For tannin test:



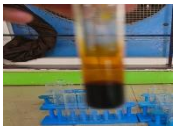
Tannins are polyphenolic compounds known for their antioxidant, astringent, antimicrobial, and anti-inflammatory properties. Screening for tannins in eucalyptus leaves has qualitative tests that indicate their presence based on color changes or precipitate formation. To 1 ml of extract solution two ml of water and 2-3 drops of ferric chloride solution was added. Blue color was studied for gallic tannins and green, black aimed at tannins.

For saponins test:



Saponins are natural glycosides known for their foaming properties, hemolytic activity, antimicrobial, and anti-inflammatory effects. Screening for saponins in eucalyptus leaves involves qualitative tests that detect their presence based on foam formation and precipitation reactions.then shake the extract with water formation of foam which indicates saponins.

For terpenoid test:



Terpenoids (or isoprenoids) are a large class of plant secondary metabolites known for its antioxidant, antimicrobial, anti-cancer, and anti-inflammatory properties. They are widely used in pharmaceuticals, cosmetics, and fragrances. Screening for terpenoids in eucalyptus leaves involves qualitative tests that detect their presence based on color changes due to chemical reactions. Then add acetic anhydride and add concentrated H2So4 a reddish brown ring will observed which indicates terpenoids.

For steroid test: Steroids are a class of lipophilic secondary metabolites with anti-inflammatory, antimicrobial, and hormonal regulatory properties. Screening for steroids in eucalyptus leaves involves qualitative tests that detect their presence based on characteristic color changes in chemical reactions. Then add chloroform and concentrated H_2So_4,a red colour indicates steroids.

Table3: summarizing the different qualitative tests

Phytochemical	Test name	Reagent used	Positive result
Alkaloids	Dragendroff's Test	Bismuth sub nitrate and (KI)	Indicates orange ppt
Flavonoids	Alkaline Reagent test	Sodium hydroxide	Indicates yellow colour
Phenols	Ferric chloride test	Ferric chloride solution	Indicates blue-green or black color
Tannins	Ferric chloride test	Lead acetate solution	Indicates blue ,greeen or black
Saponin	Foaming test	Water shaking	Formation of foam
Terpenoids	Salkowski test	Acetic anhydride and conc. Sulfuric acid	Formation of redish brown ring
Steroids	Salkowski test	Chloroform and conc. sulfuric acid	Indicates red color

Result And Discussion

Analysis of Eucalyptus Globulus Essential Oil Composition

Eucalyptus globulus essential oil is a highly fragrant and versatile oil that is extracted from the leaves of the eucalyptus tree. This essential oil is composed of a variety of chemical compounds, including 1,8-cineole, limonene, alpha-pinene, and camphene. These compounds contribute to the distinct aroma and therapeutic properties of this essential oil. 1,8-cineole, also known as eucalyptol, is the primary component of eucalyptus globulus essential oil and is responsible for its characteristic minty and fresh scent. Limonene, alpha-pinene, and camphene are also present in significant amounts and add to the overall medicinal properties of this essential oil. These chemical components have been shown to have anti-inflammatory, antimicrobial, and decongestant effects, making eucalyptus globulus essential oil a popular choice for treating respiratory issues such as coughs, colds, and congestion. Furthermore, the unique composition of this essential oil makes it an effective insect repellent and can also aid in relieving muscle pain and tension. Overall, the chemical composition of eucalyptus globulus essential oil makes it a valuable addition to any natural medicine cabinet.

Antimicrobial Activity

Eucalyptus Globulus essential oil is renowned for its powerful antimicrobial properties, creation it a popular usual remedy for treating various infections and illnesses. The oil is derived from the eucalyptus tree, native to Australia, and has been used for centuries by indigenous communities for its medicinal benefits. Studies have shown that the essential oil contains mixtures such as pinene, cineole, and limonene, which exhibit strong antibacterial, antifungal, and antiviral properties. These compounds work together to inhibit the development of destructive microorganisms and prevent the proliferation. The oil has proven to be useful in fighting a variety of bacteria, including those responsible for respiratory illnesses, skin disorders, and gastrointestinal ailments. Additionally, Eucalyptus Globulus necessary oil has been revealed to have anti-inflammatory effects, making it useful in relieving symptoms of conditions such as bronchitis and sinusitis. Its natural antimicrobial properties make it a safe and effective alternative to conventional antibiotics, with minimal risk of side effects. Overall, the antimicrobial activity of Eucalyptus Globulus essential oil makes it a valuable addition to natural medicine and a promising avenue for future research.

Insecticidal Activity

Eucalyptus globulus main oil has been widely learned for its insecticidal action, displaying promising results against a variety of insect pests. The main active compounds accountable for this activity are 1,8-cineole and pinene, which act as neurotoxins and upset the functioning of the insects' nervous system. This essential oil has shown efficacy against various insect species, including mosquitoes, flies, cockroaches, and termites, making it a potential natural alternative to chemical insecticides. Studies have also revealed that Eucalyptus globulus essential oil has a knockdown effect on insects, causing paralysis and eventually leading to their death. Additionally, the oil has shown repellent properties, making it useful in controlling insect infestations. Its low toxicity to mammals and its biodegradable nature make it an environmentally friendly option for pest management. In conclusion, Eucalyptus globulus important

oil holds great potential as natural insecticide, providing an effective and safe alternative to synthetic chemicals in controlling insect pests.

CONCLUSION

The phytochemical screening and biological activity studies of Eucalyptus tree leaves have provided significant awareness into their potential medicinal and medicinal applications. The qualitative and quantitative analyses have confirmed the manifestation of bioactive mixtures like alkaloids, tannins, flavonoid, phenols, terpenoids and saponins. which contribute to the plant's pharmacological properties. These phytochemicals have been widely recognized for their antioxidant, antimicrobial, anti-inflammatory, and analgesic effects, further validating the traditional use of Eucalyptus species in herbal medicine.

The antioxidant activity of Eucalyptus leaf extracts, as determined through various assays, highlights the plant's capacity to search free radicals and avoid oxidative pressure-related ailments. The high content of phenolic and flavonoid compounds suggests that Eucalyptus leaves could be a valuable natural source of antioxidant, which play a critical role in preventing cellular damage, aging, and chronic diseases such as cancer and cardiovascular disorders. In addition to its antioxidant potential, Eucalyptus extracts have demonstrated promising antimicrobial properties. The antibacterial and antifungal activities observed against various pathogenic strains indicate that Eucalyptus leaves contain compounds that can inhibit microbial growth, making them a potential source of novel antimicrobial agents. The effectiveness of different solvent extracts against bacterial and fungal pathogens suggests that bioactive compounds in Eucalyptus leaves exhibit selective antimicrobial potency, which could be harnessed in the growth of alternative antimicrobial therapies, especially in the wake of cumulative antibiotic resistance.

Eucalyptus extracts are widely recognized in traditional medicine for their ability to reduce pain, inflammation, and respiratory issues. This is due to the anti-inflammatory and pain-relieving properties of the essential oils present, specifically eucalyptol. These oils have been found to have a bronchodilator effect, which is why they are commonly used in products for respiratory health. Multiple studies have confirmed that Eucalyptus leaf extracts can effectively decrease inflammation and improve symptoms of respiratory conditions like asthma and bronchitis, solidifying its medicinal benefits.

Furthermore, the cytotoxic and anticancer properties observed in certain studies indicate that Eucalyptus leaf extracts may have potential relevance in cancer treatment. The presence of bioactive mixtures with cytotoxic effects on cancerous cells opens avenues for further research into their mechanisms of action and potential pharmaceutical applications.

Despite these promising findings, further studies are necessary to entirely elucidate the processes of action, bioavailability, and likely toxicity of Eucalyptus phytochemicals. Advanced research, including in vivo surveys and clinical tests, is need to prove the protection and efficacy of Eucalyptus-derived compounds for therapeutic use. Additionally, the standardization of extraction techniques and dosage formulations will be crucial in ensuring consistency and reliability in medicinal applications.

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