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A Research Article on Optimized Extraction of Essential Oil from Eucalyptus Camaldulensis Leaves Using Water Distillation Method

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ABSTRACT: Eucalyptus camaldulensis leaves are a rich source of essential oil, renowned for its medicinal properties, including antibacterial, anti-inflammatory, and analgesic effects. The oil's primary active compound, 1,8-cineole (eucalyptol), is responsible for its therapeutic benefits. Steam distillation is an effective method for extracting essential oils from eucalyptus plants, preserving the oil's potency and quality. This study focuses on extracting essential oil from E. camaldulensis leaves using water distillation. The extracted oil can be used in various applications, including aromatherapy, perfumery, and pharmaceuticals. With its high oil content and ease of extraction, E. camaldulensis is a valuable resource for producing high-quality essential oil. The oil's chemical composition, particularly its high 1,8-cineole content, makes it a sought-after natural remedy for various health issues.

Keywords: Eucalyptus camaldulensis, essential oil, water distillation, extraction optimization, GC-MS analysis.

I. INTRODUCTION:

The genus Eucalyptus, part of the Myrtaceae family of flowering plants, includes approximately 700 species. Members of the Myrtaceae family exhibit a range of biological effects, such as antifungal, anti-inflammatory, and antibacterial actions. While some Eucalyptus species grow as shrubs, the majority are trees, often in the form of mallees. Commonly called "gum trees" or eucalypts, these plants also include related genera like Corymbia and Angophora within the Eucalypti group.

Eucalyptus species are known for their distinctive features, including leaves with oil glands, bark that may be smooth, fibrous, hard, or stringy, and floral structures where the sepals and petals fuse into a cap-like operculum covering the stamens. Their fruit is a woody capsule called a "gumnut."

Traditionally, Eucalyptus leaves have been used to manage fungal infections and aid wound healing. These leaves possess several beneficial properties, such as antibacterial, anti-inflammatory, and antioxidant effects. Furthermore, the essential oil extracted from Eucalyptus and its compounds also demonstrate herbicidal, insecticidal, anthelmintic (anti-parasitic), and anti-tumour activities.

India shares a long-standing connection with Eucalyptus. The first known planting was carried out in 1790 by Tippu Sultan, the ruler of Mysore, who introduced the tree in his royal garden located in the Nandi Hills near Bangalore. According to one account (Shyam Sundar, 1984), he imported seeds from Australia and introduced about sixteen different species. The next significant introduction of Eucalyptus took place in 1843 in the Nilgiri Hills of Tamil Nadu. Later, in 1856, organized plantations of Eucalyptus globulus were established to meet the growing demand for firewood (Wilson, 1972). Following this, several other efforts were made across various parts of the country to cultivate eucalypts.

Essential oils possess significant medicinal and antimicrobial qualities, making them widely utilized in the food, pharmaceutical, and cosmetic industries. These natural oils cannot be effectively substituted with synthetic alternatives, as pure essential oils contain a broader and more diverse range of chemical components than their artificial counterparts. [1-6]

Table 1: The major raw material utilized in the extraction of essential oil.

Flower	Peel	Seed	Wood	Leaves
Chamomile, Clary Sage, Clove, Geranium, Hyssop, Jasmine, Lavender, Manuka, Marjoram, Orange, Rose, Ylang-Ylang	Bergamot, Grapefruit, Lemon, Lime, Orange and Tangerine	Almond, Anise, Celery, Cumin, and Nutmeg Oil	Camphor, Cedar, Rosewood, Sandalwood	Eucalyptus, lemon grass,Bes

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The pharmacological properties of essential oils: -

◎ Antiseptic**:** Essential oils exhibit strong antiseptic properties, effectively combating both common and antibiotic-resistant bacterial strains.

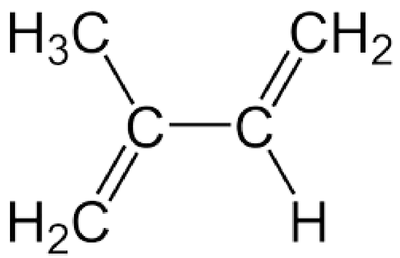
◎ Expectorant **and Diuretic:** These oils help relieve joint pain and sprains, while also acting as gentle local anesthetics.

◎ Sedative **and Antispasmodic:** Essential oils derived from plants such as Verbena, Mentha, and members of the Umbelliferae family are known to alleviate gastrointestinal spasms and promote relaxation.[5]

Chemical composition of essential oil:

The chemical composition of essential oils primarily consists of approximately 200 natural compounds, with terpenes and phenylpropanoid compounds being the most abundant. These constituents generally undergo only minor structural and chemical modifications. Essential oils are typically categorized as follows:

1. **Volatile Fraction:** This portion accounts for about 90–95% of the oil's total weight and includes compounds such as alcohols, esters, aliphatic aldehydes, monoterpenes, sesquiterpene hydrocarbons, and their oxygenated derivatives.
2. **Non-Volatile Fraction:** Making up about 1–10% of the oil, this fraction contains waxes, hydrocarbons, fatty acids, sterols, carotenoids, and flavonoids.
3. **Hydrocarbons:** These are organic molecules composed solely of hydrogen and carbon. The fundamental hydrocarbon in plants and trees is isoprene, which serves as the basic structural unit for many essential oil components.



Isoprene

- **Terpenes:** These compounds typically end with the suffix "-ene," such as limonene, pinene, peperone, and camphene. They possess notable antibacterial, antiviral, antiseptic, and anti-inflammatory properties. Terpenes are classified into monoterpenes, sesquiterpenes, and diterpenes based on the number of isoprene units they contain — two units form a monoterpene, three form a sesquiterpene, and four form a diterpene.
- **Alcohols:** These compounds exhibit antiviral, antiseptic, germicidal, and antibacterial effects. Naturally occurring alcohols can exist independently or in association with terpenes and esters. They are produced when terpenes bond with hydrogen and oxygen atoms. Due to their low toxicity, they are generally safe for topical or limited internal use. Common examples include nerol and geraniol from geranium and rose, and linalool found in Ylang-Ylang and lavender oils.
- **Aldehydes:** Aldehydes have diverse applications, including as sedatives, disinfectants, antibacterial, antiviral, antifungal, and anti-inflammatory agents. Essential oils containing aldehydes are effective in treating fungal infections such as Candida. Examples include citral in lemons and citronellal found in lemongrass, lemon balm, and citrus eucalyptus.
- **Acids:** Organic acids present in essential oils exhibit anti-inflammatory properties. Although they occur in small quantities, these acids help maintain the oil's pH balance by acting as natural buffers. For instance, benzoin contains both benzoic and citric acids, while other oils may include lactic and citric acids.
- **Esters:** Formed through the reaction between acids and alcohols, esters contribute a soothing and harmonizing quality to essential oils. They possess strong antibacterial and antifungal properties and have a calming effect on the nervous system. Examples include linalyl acetate in bergamot and lavender, and geranyl formate in geranium oil.
- **Ketones:** Ketones demonstrate properties such as being anti-catarrhal, expectorant, wound-healing, and cell-regenerative. They are particularly beneficial for respiratory conditions by promoting mucus flow and easing congestion. However, some ketones are toxic — for instance, thujone (found in sage, mugwort, and wormwood) and pulegone (found in pennyroyal). Non-toxic varieties include jasmone (jasmine), fenchone (fennel), carvone (spearmint and dill), and menthone (peppermint).
- **Lactones:** These compounds have expectorant, antipyretic (fever-reducing), anti-inflammatory, and detoxifying effects. By

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inhibiting prostaglandin synthesis, they help reduce inflammation and promote respiratory relief. Unlike ketones, lactones exhibit stronger expectorant activity.

Additionally, analysis of Eucalyptus camaldulensis essential oils revealed that leaves from saline and non-saline regions contained oil yields of 0.98% and 0.96%, respectively. Gas Chromatography-Mass Spectrometry (GC-MS) identified 24 compounds in the saline sample and 27 in the non-saline sample. The dominant component was 1,8-cineole, comprising 34.42% in saline and 40.05% in non-saline samples. Other major constituents included t-pinocarveol (8.36% and 3.32%), ledol (7.42% and 7.67%), γ-terpinene (9.42% and 7.48%), and α-pinene (14.68% and 12.43%). Statistical analysis indicated no significant difference in total oil yield between the two environments, though salinity caused notable variations ($p < 0.05$) in the concentration of several chemical components.

Objectives

◎ This study seeks to elucidate the role of eucalyptus oil as a valuable natural remedy with potential benefits for human health and wellness by integrating existing knowledge and highlighting recent developments in the field.

◎ By reviewing current research and showcasing the latest findings on eucalyptus oil, this study aims to clarify its status as a beneficial natural treatment with promising effects on human health and well-being.

Method and material

Sample: For this project, we collected eucalyptus leaves from Waknaghat (Solan). All the leaves were thoroughly cleaned to remove any dirt and debris.

Fig.1: Leaves of Eucalyptus plant

Apparatus and chemical used: - Clevenger –type apparatus, condenser, round bottle flask, heating melting point apparatus, Ethyl acetate.

Procedure: First, the eucalyptus leaves were washed thoroughly to remove any dirt or debris. They were then cut into small pieces, approximately 12 cm in length, and weighed, totalling 85.61 g. The prepared leaves were subsequently placed into a round-bottom flask.

Fig.2: Leaves in round bottle flask

Distillation Setup:

◎ First, we set up the distillation apparatus, which includes a distillation flask, a condenser, a Clevenger apparatus, and a melting point apparatus.

◎ Next, the plant material is placed into the distillation flask.

◎ The flask is then filled with 250 ml of distilled water, ensuring the plant material is fully submerged. A crushed capillary tube is also added to prevent bumping during distillation.

Fig.3: Distillation set up

◎ The melting point apparatus is then set to a temperature of 70 °C and maintained for 5–8 hours.

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◎ During this time, the vaporization of water occurs, and the essential oil is collected in the Clevenger apparatus.

◎ To separate the oil from the water, 1ml of ethyl acetate is added, and the mixture is transferred to a separating funnel.

Fig.4: Separation of oil from separating funnel

Qualitative methods

The phytochemical tests were performed by the method given by Harborne, 1973.

Foam Test:

Two milliliters of the extract were mixed with 3 ml of distilled water and shaken vigorously. The formation of a stable layer of foam on top indicated the presence of saponins in the sample.

Hansch Test (Carbohydrate Test):

Two milliliters of the extract were placed in a test tube, and 1 ml of concentrated H_2SO_4 was carefully added along the side of the tube. The appearance of a brown ring confirmed the presence of carbohydrates.

Tannin Test:

To 0.5 ml of the extract solution, 1 ml of water and 1–2 drops of ferric chloride solution were added. A blue coloration indicated gallic tannins, whereas a green-black color indicated catecholic tannins.

Flavonoid Test:

Two milliliters of the filtrate were taken, and a few magnesium filings along with 5–6 drops of concentrated HCl were added. The development of a red color indicated the presence of flavonoids.

Phenol Test:

A small amount of ferric chloride was added to 2 ml of the extract. The appearance of a green color indicated the presence of phenolic compounds.

Protein Test:

Two milliliters of the extract were treated with 1–2 drops of nitric acid. A yellow color indicated the presence of proteins.

Quinone Test:

A few drops of concentrated H_2SO_4 were added to 2 ml of the extract. The formation of a red color confirmed the presence of quinones.

Fat Test:

The extract was applied to filter paper. The appearance of oil stains on the paper indicated the presence of fats in the eucalyptus extract.

II. RESULTS:

The yield of essential oil is 5.4 ml

Table 2: Physical and Chemical properties of Eucalyptus oil

Colour	Pale Yellow liquid
State	Liquid-oil
Odor	Camphoraceous odor ,sweety,fruity
Taste	Pungent and cooling taste
Boloing point of cineol (eucalyptus)	176 -177 C
Solubility	1 Insoluble in water. 2 Miscible in oil, fats, Chloroform, ether. 3 Miscible in alcohol having high concentration.
Colour	Pale Yellow liquid
State	Liquid-oil

1. Chemical Name: 1, 3, 3-Trimethyl 1-2-Oxabicyclo [2. 2. 2.]-Octane or 1, 8-epoxy-p-methane.

Molecular Formula of Cineole (Eucalyptol): $C_{10}H_{18}O$ Molecular Weight: 154.25

Structure of Cineol:

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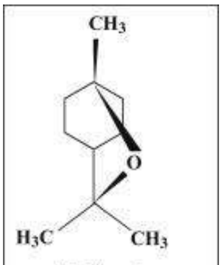
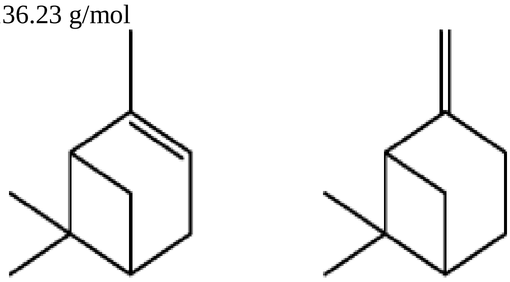


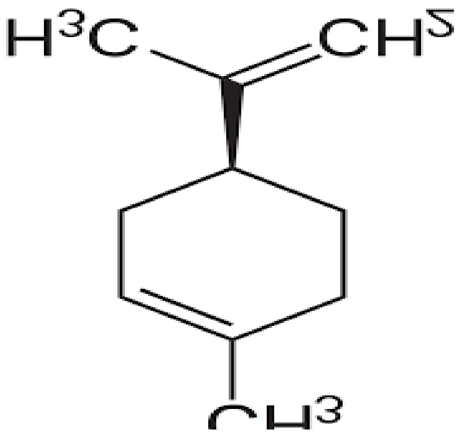
1,8-Cineole

2. Chemical Name: (±)-2-Pinene, 2, 6, 6-Trimethylbicyclo [3.1.1] hept-2-ene
Molecular Formula: C10H16 Molecular weight: 136.23 g/mol

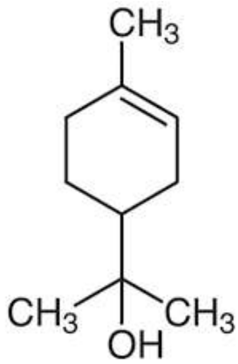


α-pinene β-pinene

3. **Chemical Name**: - Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-
Molecular Formula: C10H16 **Molecular weight:** 136.23g/mol
Structure of limonene:



4. Chemical Name: - propan-2-ol substituted by a 4-methylcyclohex-3-en-1-yl group at positio
Molecular Formula: C10H18O **Molecular weight:** 154.24g/mol
Structure of alpha- Terpineol:



Phytochemical screening of Eucalyptus extract by qualitative screening:

A qualitative phytochemical analysis of the acetone extract of eucalyptus leaves showed that saponins, carbohydrates, tannins, and phenols were present, whereas quinones, lipids, proteins, and flavonoids were absent.

III. CONCLUSION: -

The essential oil derived from Eucalyptus g exhibits a broad spectrum of medicinal properties. Renowned for its antibacterial, anti-inflammatory, and analgesic effects, eucalyptus oil is widely used in both traditional and modern medicine. Many of its therapeutic benefits are attributed to cineole (eucalyptol), the primary active compound. Eucalyptus oil serves as a natural antibacterial agent, respiratory aid, and muscle pain reliever. Its invigorating aroma also makes it popular in aromatherapy for reducing stress and enhancing mental clarity. In holistic health practices, eucalyptus essential oil remains a versatile natural remedy, provided its efficacy continues to be scientifically validated.

For temperature-sensitive substances such as oils, resins, and hydrocarbons—which are water-insoluble and may decompose at their boiling points—steam distillation is an effective separation technique. The steam must be sufficiently hot to vaporize the oil without damaging the essential oils or plant material. Eucalyptus plants are rich in essential oils, making them valuable for chemical and perfumery applications. Eucalyptus oil contains a high concentration of 1,8-cineole (over 65%), which is why only small amounts are required when used in aqueous ethanol or gasoline as a solvent.

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