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AN OVERVIEW ON TEA TREE OIL (MELALEUCA ALTERNIFOLIA) COMPOSITION, THERAPEUTIC EFFECTS, APPLICATION, TOXICITY

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ABSTRACT
The anti-inflammatory, antibacterial, antiseptic, and antioxidant effects of tea tree oil (TTO), which is extracted from Melaleuca alternifolia, are among its well-known therapeutic qualities. Over 100 components, such as terpinen-4-ol, alpha-sabine, and cineole, contribute to its medicinal advantages, including antibacterial action against Staphylococcus aureus and immunological regulation. TTO has been used to treat acne, chronic gum infections, and bacterial/inflammatory problems. Concerns surrounding its safety and possible toxicity, particularly with regard to oral consumption and cutaneous irritation, underscore the need for additional research into its long-term consequences and hazards, even in light of its demonstrated efficacy. Independent research are needed to fully evaluate the health advantages and safety profile of TTO, despite its rare and moderate adverse responses.

KEYWORDS: *Melaleuca Alternifolia, Chemical Constituent, Anti-microbial, Antiinflammatory, Uses, Safety & toxicity.*

1. INTRODUCTION

The tea tree's essential oil is known for its anti-inflammatory, antibacterial, antiseptic, and antioxidant properties, making it widely used in medicine. (1)

Here's the simplified version of the scientific classification of tea tree oil

Kingdom: Plants; Order: Myrtales; a collection of plants that bloom
Family: Myrtaceae (the myrtle family of plants)
Genus: Melaleuca (a group of trees and shrubs)
Species: Melaleuca alternifolia (the specific plant used to make tea tree oil)
Binomial Name: Melaleuca alternifolia (the scientific name for this species)
Synonyms: Previously known as Melaleuca alinariifolia var. alternifolia, named by Maiden and Betche (these are just alternate scientific names used in the past).
This is the scientific way to describe the plant that tea tree oil comes from.[2]



Figure 1 Tea Tree Oil (Melaleuca alternifolia) [3,4]

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2.CHEMICAL COMPOSITION AND ACTIVE CONSTITUENTS OF TEA TREE OIL

Here are over 100 distinct components in tea tree oil. The main one, called terpinen-4-ol, gives it antibacterial properties. Its composition is regulated by international standards (ISO4730). (5) The chemical makeup and active ingredients of tea tree oil,(6) along with their roles, are shown in Table 1.

		Quantity	Responsibilities
Chemical Compostion	1. Terpinen-4-ol 2. Y-Terpinene 3. α-Teripene 4. 1,8-Cineole 5. Terpinolene 6. α-Terpineol 7. α-Pinene 8. Limonene 9. Sabinene	30-40% 20% 10% 15% 3-5% 3-5% 1-5% 1-2% Trace	Antimicrobial Properties Antioxidant Properties Antimicrobial Properties Antiseptic Properties Anti-oxidant Properties Anti-inflammatory Properties Antiseptic Properties Anti-oxidant Properties Enhance Antimicrobial Effect
Active Compound	Terpinen-4-ol 1,8-Cineole	-	Biologically Active Compound for Antimicrobial, Antifungal, Anti-inflammatory Properties. Benifical in Small Amount Because It Can Cause Skin Irritation
Other Constituent	P-cymene Monoterpenes	**2-10%** -	Contribute Antimicrobial Activity. Antimicrobial, Antiinflammatory Properties

Table 1 Chemical composition and active constituents of tea tree oil

3. ANTI-MICROBIAL ACTIVITY

Table 1 highlights that tea tree oil exhibits a wide range of antibacterial activities. It works well against both fungi and a wide variety of gram-positive and gram-negative bacteria.[7] Common pathogens have minimum inhibitory concentrations (MICs) of 0.5%-1%. The minimum inhibitory concentration (MIC) for mutans streptococci is less than 0.0125%, whereas oral-group streptococci are also below 0.05%. (8) Many essential oils have antibacterial effects due to active monoterpene components.[9]

Tea tree oil's antibacterial activities involve disrupting bacterial cell membranes and inhibiting respiration. Most investigations have focused on its efficiency against Staphylococcus aureus, which has significant antibacterial action. For a range of bacteria, including S. aureus, S. epidermidis, B. subtilis, B. cereus, Micrococcus luteus, Streptococcus, E. coli, Pseudomonas, and Proteus, tea tree oil exhibits MIC values ranging from 0.2% to 0.5% (v/v). It has been demonstrated that M. alternifolia oil had antibacterial qualities against Actinomyces v., Lactobacillus, Staphylococcus species, and E. coli.[10]

With inhibition zones varying from 5 to 10 mm, the essential oil of M. bracteata has demonstrated antibacterial activity against S. epidermidis, B. subtilis, S. aureus, and S. typhimurium. Additionally, it has a biostatic impact on strains of Serratia marcescens, Halobacterium violaceum, and Pseudomonas aeruginosa. At a concentration of 250 µg/mL, this oil reduced the growth of B. subtilis subsp. spizizenii, with an inhibition zone as large as 44 mm. These species' methyl eugenol and terpinen-4-ol have potent antifungal, antibacterial, and anti-nematode qualities.

4.ANTI-INFLAMMATORY & ANTI-OXIDANT EFFECT

- **Anti-Inflammatory**

The essential oil's main constituent was terpinen-4-ol. It is thought that this molecule, along with others like α-terpinene, γ-terpinene, and α-terpineol, is what gives the oil its anti-inflammatory properties. In experiments on mice with histamine-induced edema, the oil demonstrated anti-inflammatory properties. The external application of the oil to vulvovaginitis, particularly in cases of yeast infections like candidiasis, is also supported by a number of research.[11]

Tea tree oil's (TTO) anti-inflammatory qualities have been validated by numerous recent investigations. Research conducted in the last ten years has demonstrated that TTO affects a variety of immunological responses in both in vitro (in a lab setting) and in vivo (in real creatures). Terpinen-4-ol, α-terpineol, and 1,8-cineole are the main ingredients contained in TTO; however, only terpinen-4-ol was shown to lower the production of TNF-α, an inflammatory marker. When administered following a histamine injection,

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TTO and terpinene 4-ol have been demonstrated in mouse tests to reduce the skin swelling brought on by histamine. TTO also lessened erythema and cutaneous flare-ups in individuals brought on by nickel-induced contact sensitivity. Additional studies have shown that terpine-4-ol aids in controlling the fluid leakage and vasodilation linked to histamine-induced inflammation in people.[12]

Anti-Oxidant

There is limited research on the antioxidant properties of tea tree oil and its bioactive components. To better comprehend the potential health advantages of tea tree oil, further research is needed into the link between its antioxidant qualities and terpenic chemicals. Understanding the antioxidant properties of tea tree oil could increase its market value. Research indicates that aromatic and medicinal plants contain natural antioxidants that can reduce chronic diseases such as DNA damage, mutagenesis, and carcinogenesis, as well as limit pathogenic bacterial growth. These effects help inhibit free radical propagation in biological systems. Antioxidant capability is widely utilized to evaluate medicinal plants and their bioactive compounds.[13]

5.TREATMENT

A. Acne Treatment

Acne is a chronic skin condition caused by excessive oil production, abnormal cell shedding in hair follicles, irritation, and Propionibacterium acnes.[15] Tea tree oil, derived from the Melaleuca alternifolia tree, found in Australia, may aid in acne treatment when applied topically. It contains over 100 natural substances, primarily plant-based terpenes and alcohols. In 1990, a study of 124 individuals compared a 5% tea tree oil gel to a 5% benzyl peroxide gel for acne treatment. Despites taking longer to than benzoyl peroxide, tea tree oil effectively reduced acne patches within three months. Tea tree oil had lower rates of adverse effects such as dryness, irritation, itching, and burning (44% vs. 79% for benzoyl peroxide). Tea tree oil may cause allergic reactions and might be hazardous if consumed. Tea tree oil's breakdown can release monoterpenes, which can cause skin sensitivity or allergies. Despite this, using tea tree oil to the skin is generally safe. [14]

The European recommendations for managing acne categorize it into four major types:
1. Comedonal acne consists primarily of blackheads and whiteheads.
2. Mild to Moderate Papulopustular Acne: Symptoms include pimples and irritation.
3. Severe Papulopustular Acne and Moderate Nodular Acne: Inflamed pimples with larger, deeper nodules.
4. Severe Nodular and Conglobate Acne: Large, painful nodules with linked lumps.

Treatment recommendations vary depending on the type.[16]



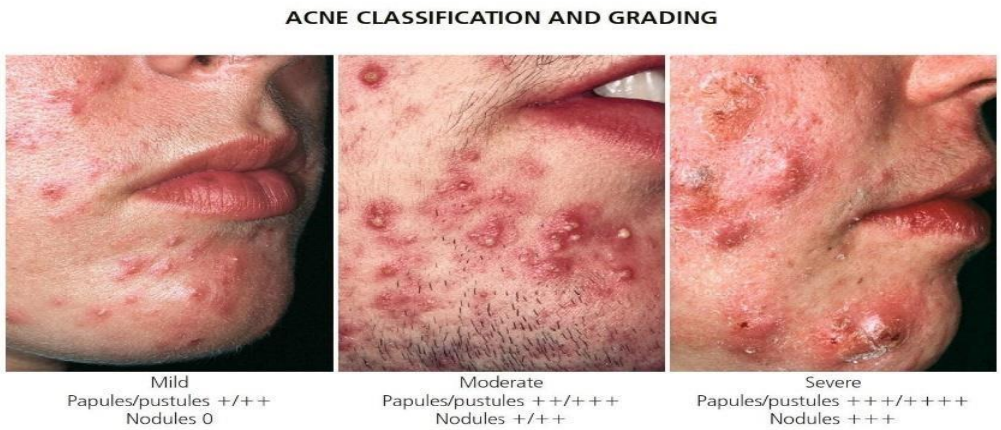


Figure 2 [17]

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B. Aromatherapy Uses

Tea tree (Melaleuca alternifolia) belongs to the Myrtaceae family and thrives in swampy environments. The leaves are needle-like, and the flowers can be yellow or purple. Tea trees are planted on plantations because of their commercial importance, particularly their essential oil. Terpinen-4-ol, the primary ingredient in this oil, has a pleasant, earthy fragrance and helps increase immunity. The oil contains alpha-sabine, which has antiviral, antibacterial, and antifungal properties, as well as cineole, which is antiseptic. [20,21,22,23]

Tea tree oil provides numerous advantages, including antibacterial, anti-inflammatory, antiviral, insect repellant, and immunological booster. Aromatherapy with oils like lemon, eucalyptus, lavender, and rosemary is commonly utilized to treat numerous health conditions. Tea tree oil is used to treat skin conditions such as herpes, acne, burns, bug bites, dandruff, and greasy skin. It can treat respiratory diseases such as coughs, bronchitis, asthma, and tuberculosis, as well as female conditions including vaginitis and cystitis. It can also treat colds, flu, fever, and chickenpox. [24,25] Tea tree oil has showed promise in treating herpes, according to studies and clinical trials.[26]

TTO is one of the most important oils often used in aromatherapy. The examples in the table are only for guidance. Use only under the supervision of a doctor or pharmacist who specializes in this area.[18]

Effect	Dose	Use
Acne	TTO 2-3 Drops	Use a cotton bud to hold it on Acne for15 sec, 2-3 time a day
Athlete's Foot	TTO 2-3 Drops	Hold on infected area for 15 sec & apply 3-4 times a day
Tooth Acne	TTO 3 Drops Mint Essential oil 3 drops	Make a mouthwash by adding 3 drops TTO & mint oil to half or full glass of water
Dandruff	TTO 80 Drops Cypress Essential oil 80 Drops	Mix With 200 ml of organic shampoo

Table 2

C. Potential Use in Oral Health

Herbal extracts and plant essential oils (EO) can effectively cure chronic gum illnesses such as gingivitis and periodontitis, which are caused by both bacteria and inflammation. These natural therapies are suitable for long-term everyday usage and do not impair a person's health. They are also less expensive and more readily available as over-the-counter products. Research is ongoing to develop herbal mouthwashes suitable for long-term use. Tea tree oil (TTO) from the Melaleuca alternifolia plant has been examined for its potential use in dentistry.[19]

6. SAFETY & TOXICOLOGY

While tea tree oil (TTO) is well-known for its antimicrobial and anti-inflammatory benefits, there has been less research on its safety and potential toxicity. The continued use of tea tree oil is mainly based on its apparent safe use over nearly 80 years, with reports suggesting that adverse effects are rare, mild, and typically go away on their own. However, more scientific evidence is needed, as much of the available information comes from company-sponsored studies rather than independent research. The risks of using tea tree oil, both when taken orally and applied to the skin, are briefly outlined below.[18]

Dermal Toxicity

Tea tree oil (TTO) can cause both irritation and allergic reactions. A study found a low level of irritation from undiluted TTO in 311 volunteers, while another study on 217 dermatology patients found no irritation with 10% TTO. This suggests that using lower concentrations of TTO can help avoid irritation, supporting the idea of using properly formulated products instead of pure oil. Some people may have allergic reactions to TTO, often caused by oxidation (when the oil is old or stored incorrectly). There's little evidence to support that a component called 1,8-cineole causes irritation. Tests on rabbits, guinea pigs, and humans, including those with previous reactions to TTO, didn't show irritation. In rare cases, applying undiluted TTO to animals, like cats, has caused serious side effects, including hypothermia and death, when a large amount was applied to their skin.[18]

Oral Toxicity

Tea tree oil (TTO) can be toxic if swallowed, as shown by studies in animals and reports of human poisoning. In rats, a dose of 1.9 to 2.6 ml per kg of body weight was lethal, and doses around 1.5 g per kg caused symptoms like tiredness and loss of coordination. There have been cases of both children and adults accidentally ingesting TTO, but in all of these cases, the people recovered with supportive careand there were no lasting effects. No human deaths from tea tree oil have been reported.[18]

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7. CONCLUSION

In conclusion, tea tree oil (TTO) demonstrates notable therapeutic potential, offering anti-inflammatory, antimicrobial, antiseptic, and antioxidant effects, especially for skin conditions and bacterial infections. Its active compounds, such as terpinen-4-ol, contribute to its effectiveness against pathogens like Staphylococcus aureus and its role in immune modulation. However, despite its benefits, concerns about dermal irritation and toxicity—particularly with ingestion— underscore the importance of further research. While adverse effects are typically mild, additional independent studies are needed to clarify TTO's long-term safety and health impact.

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