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Antimicrobial properties of tea tree oil

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ABSTRACT

Phytomedicine such as tea tree (melaleuca) oil have become increasingly popular in recent decades. This essential oil has been used for almost 100 years in Australia but is now available worldwide both as neat oil and as an active component in an array of products. The primary uses of tea tree oil have historically capitalized on the antiseptic, antifungal, antiviral and anti-inflammatory actions of the oil. Reports of activity in the field of antibacterial Tea tree oil research are widely conflicting, probably owing to inter- and intra-assay variation in susceptibility testing. However, several high-quality investigations have examined the relationship between component structure and antibacterial activity and these are in close agreement. The mechanism of action of tea tree oil and three of its components, 1,8-cineole, terpinen-4-ol, and alpha terpineol, against *Staphylococcus aureus* were investigated. In addition, numerous research groups have sought to elucidate the antibacterial mechanisms of action of selected components of tea tree oil. These compounds represent novel leads, and future studies may allow the development of a pharmacologically acceptable antimicrobial agent or class of agents. This review summarizes recent developments in our understanding of the antimicrobial activity of the oil. Specific mechanisms of antibacterial activity are reviewed, and the toxicity of the oil is briefly discussed.

Keywords: Tea tree oil, Antibacterial activity

BACKGROUND

Resistance to antimicrobial agents has become an increasingly day by day and it is a problem of global concern. Of the 2 million people who acquire bacterial infections in US hospitals each year, 70% of cases now involve strains that are resistant to at least one drug. A major cause for concern in the UK is methicillin-resistant *Staphylococcus aureus* (MRSA), which was at low-level a decade ago but now accounts for ca.50%of all *S. aureus* isolates(Adock 2002). Substantial investment and research in the field of anti-infective are day now desperately needed if a public health crisis is to be averted.

Tea tree oil, or melaleuca oil, is a pale yellow color to nearly colorless and clear essential with a fresh camphoraceous odor(Directory of essential oils for Aromatherapy). It is taken from the leaves of the *Melaleuca alternifolia*, which is native to Southeast Queensland and the Northeast coast of New, Australia. Tea tree

oil should not be confused with tea oil, the sweet seasoning and cooking oil from pressed seeds of the tea plant *Camellia sinensis* (beverage tea), or the tea oil plant *Camellia oleifera*. The indigenous Bundjalung people of eastern Australia use "tea trees" as a traditional medicine by inhaling the oils from the crushed leaves to treat coughs and cold. They also sprinkle leaves on wounds, after which a poultice is applied. In addition, tea tree leaves are soaked to make an infusion to treat sore throats or skin ailments(Shemesh and Mayo ,1991 and Low ,1990). Use of the oil itself, as opposed to the unextracted plant material, did not become common practice until researcher Arthur Penfold published the first reports of its antimicrobial activity in a series of papers in the 1920s and 1930s. In evaluating the antimicrobial activity of *M. alternifolia*, tea tree oil was rated as 11 times more active than phenol(Penfold and Grant ,195). The commercial tea tree oil industry was born after the medicinal properties of the oil were first reported by Penfold. Production ebbed after World War II, as demand for the oil declined, presumably due to the development of effective antibiotics and the waning image of natural products. Interest in the oil was rekindled in the 1970s as part of the general renaissance of interest in natural products. Commercial plantations were established in the 1970s and 1980s, which led to mechanization and large-scale production of a consistent essential oil product(Johns *et al* ,1992).

Among over 98 compounds contained in the oil, terpinen-4-ol is responsible for most of the antimicrobial activity(Hart *et al* ,2000).Tea tree oil is defined by international standard ISO 4730 (2004) ("Oil of *Melaleuca*, Terpinen-4-ol type"), which specifies levels of 15 components which are needed to define the oil as "tea tree oil." TTO has a relative density of 0.885 to 0.906 is only sparingly soluble in water, and is miscible with non polar solvents((IOS)

Medicinal properties of Tea tree oil

Increasingly, Tea tree oil is becoming the subject of medical research. They have been reported to possess many useful properties, including, antiviral (Schnitzler *et al* ,2001)antibacterial, antifungal and antiseptic qualities. It also has beneficial cosmetic properties(Aburjai and Natsheh ,2003).The active ingredients of *Melaleuca alternifolia* (or Tea Tree) oil are terpinen and cineole. Terpinen is the ingredient responsible for the healing properties. Cineole contributes the disinfectant properties. In large amounts, cineole is caustic to human tissue. In order to obtain the best results from using tea tree oil, the percentage of terpinen must be between 35 and 60 percent, and the percentage of cineole must be below ten percent to ensure skin safety during usage (Figure 1).

Tea tree oil is also effective as an additional treatment for colds, bronchitis, whooping cough and pneumonia. Adding it to a vaporizer and inhaling the fumes helps to kill germs that infect the sinuses and lungs. Similar to eucalyptus oil, tea tree oil also opens clogged respiratory passages. It has been suggested for some time that tea tree oil may be an effective agent for both the treatment and prevention of oral

infections or conditions.

In vitro studies show the effectiveness of tea tree oil in inhibiting several common skin pathogens. Terpinen-4-ol and whole tea tree oil were found equally effective for activity against *Staphylococcus aureus(*Williams *et al* ,1997*)* Raman and associates tested several major components of tea tree oil (terpinen-4-ol, alpha-terpineol, alpha-pinene, and cineole) for their effects against *S. aureus, Staphylococcus epidermidis, and Propionibacterium acnes*(Raman *et al* ,1995) Except for cineole, all of the constituents tested were inhibitory to all three organisms.

Toxicity of tea tree oil

When ingested, tea tree oil may cause abdominal pain, diarrhea, confusion, drowsiness, lethargy, uncoordinated walking, depressed immune function and coma. Tea tree oil used as a mouthwash may alleviate symptoms of gingivitis or thrush, a yeast infection of the mouth; it cautions that swallowing any amount of tea tree oil is toxic. Exercise discretion when using any mouthwash containing tea tree oil to avoid oral toxicity. The American Cancer Society cautions that tea tree oil preparations should not be used in children or if you are a woman who is pregnant or breastfeeding.

Recent evidence has demonstrated that exposure to tea tree oil can lead to allergic contact dermatitis in susceptible individuals. At the Skin and Cancer Foundation in Sydney, Australia, three of 28 normal volunteers were positive to patch testing with tea tree oil(Rubble *et al* ,1998). Further testing of tea tree oil constituents showed that all three patients were responding to the sesquiterpenoid fraction of the essential oil. In an earlier study, seven patients who had become sensitized to tea tree oil were exposed to 1% tea tree oil and 1% solutions of 11 isolated individual constituents(Knight *et al* ,1994) Of the seven patients who reacted to 1% tea tree oil, six also reacted to limonene, five to alpha-terpinene and aromadendrene; two reacted to terpinen-4-ol and one each to p-cymene and alpha-phellandrene. These reports indicate that several components of tea tree oil are capable of causing allergic skin reactions.

Antimicrobial action of tea tree oil

The mechanism of action of TTO against bacteria has now been partly elucidated. Prior to the availability of data, assumptions about its mechanism of action were made on the basis of its hydrocarbon structure and attendant lipophilicity. Since hydrocarbons partition preferentially into biological membranes and disrupt their vital functions(Sikkema *et al*,1995) TTO and its components were also presumed to behave in this manner. This premise is further supported by data showing that TTO permeabilize model liposomal systems .In previous work with hydrocarbons not found in TTO and with terpenes found at low concentrations in TTO lyses and the loss of membrane integrity and function manifested by the leakage of ions and

the inhibition of respiration were demonstrated. Treatment of *S. aureus* with TTO resulted in the leakage of potassium ions and 260-nm-light-absorbing materials and inhibited respiration. Treatment with TTO also sensitized *S. aureus* cells to sodium chloride and produced morphological changes apparent under electron microscopy.

In summary, the loss of intracellular material, inability to maintain homeostasis, and inhibition of respiration after treatment with TTO and/or components is consistent with a mechanism of action involving the loss of membrane integrity and function.

The antimicrobial activity of TTO against those bacteria which are antibiotic-resistant has attracted considerable interest, with methicillin-resistant *Staphylococcus aureus* (MRSA) receiving the most attention thus far. Since using TTO against MRSA was first hypothesized(Walsh and Longstaff,1987) several members have demonstrated the activity of TTO against MRSA, started with (Carson *et al,*1995) who examined 64 MRSA isolates from Australia and the United Kingdom, including 33 Mupirocin-resistant isolates. The MICs and minimal bactericidal concentrations (MBCs) for the Australian isolates were 0.25% and 0.5%, respectively, while those for the United Kingdom isolates were 0.312% and 0.625%, respectively. In another studies tea- tree oils, terpinen-4-01, α-terpineol and a-pinene were found to be active against *Staphylococcus aureus, Staphylococcus epidermidis and Propionibacterium* acnes whereas cineole was inactive against these organisms(Raman *et al,*1995 and Gibbons 2004) who examined 1, 8-cineole exhibits little antimicrobial activity inherently, however, it has been shown to enhance the lethal action of terpinene. It is hypothesized that 1, 8-cineole helps permeabilize bacterial membranes, allowing more active terpinen to enter and kill the bacterial cell(Mehrotra *et al*2010). demonstrated the comparative antimicrobial activities of neem, amla, aloe, Assam tea and clove extracts against *vibrio cholera, Staphylococcus aureus* and *pseudomonas aeruginosa*.

Assay of antimicrobial activity of essential oil like lemon grass, oregano, tea tree against *Enterococcus fecalis, Escherichia coli, Klebsiella pneumonia, and Staphylococcus aureus* at d" 2.0% by using an agar dilution method(Hammer *et al* ,1999). Further Chao has also been demonstrated(Chao *et al* ,2008) a significant zone of inhibition [45-57 mm] for thyme, cumin, eucalyptus, cetriodora, tsuga, oregano, *melaleuca alternifolia* and limette essential oils. Bosnic *et al*. who examined antibacterial potential of *Melaleuca alternifolia* (tea tree) oil and members of the *Myrtaceae* family, against strains of *Staphylococcus aureus* especially MRSA, exhibiting zones of inhibitions ranging from 10-45mm.

Carson *et al*. investigated the mechanism of action of *Melaleuca alternifolia* (Tea tree) oil on *Staphylococcus aureus* determined by time kill, lyses, leakage, and salt tolerance assays and electron microscope. Mann *et al* critically reviewed the techniques used for determining the comparative anti-microbial properties of tea tree oils. They note that most methods rely on Tween as a dispersant, which

underestimates the MIC of tea tree oil. Since producing reliable data in this area is required for registration of the oil as a therapeutic agent, they developed a new micro-dilution method based on the redox dye resazurin using 0.15%w/v agar to stabilize and provide adequate contact between oil and test organism. Subsequent reports on the susceptibility of MRSA to TTO have similarly not shown great differences compared to antibiotic-sensitive organism(Chan *et al*,1998,Elsom *et al*,1999,Hada *et al* 2001,May *et al*,2000 and Nelson 1997).

Tea tree oil

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Properties

↓

It carries medicinal properties.

↓

Antimicrobial

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Antibacterial
Antifungal
Antiviral

Mode of action of essential oil to target site**'**→ Disruption of cell wall**'!** Loss of membrane integrity**'**→ Inhibition of cell respiration**'!** Blockage of DNA synthesis.

Figure 1: Flow Chart for Tea tree oil

CONCLUSION

Despite some progress, there is still a lack of clinical evidence demonstrating efficacy against bacterial, fungal, or viral infections. Large randomized clinical trials are now required to cement a place for TTO as a topical medicinal agent. It is clear from the literature that Tea tree oil does have beneficial medicinal properties, relevant to the needs of modern populations. Future research should be directed to this goal.

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