Tea-tree oil – a naturally occurring biocide



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Tea-tree oil (TTO) is the essential oil derived from an Australian native plant that has been used for hundreds of years, mainly for its antimicrobial and anti-inflammatory properties. With the advent of ever-increasing resistance to antibiotics and biocides amongst organisms, TTO may play an important role in the health industry in the fight against resistance.

Figure 1. Flowering *Melaleuca alternifolia.*

TTO is obtained by steam distillation of plant matter from the Australian native paperbark tree *Melaleuca alternifolia* (Figure 1). The oil comprises more than 100 components of which ranges for 15 are stipulated by an International Standard; these are predominantly monoterpenes, sesquiterpenes and their related alcohols. The antimicrobial and anti-inflammatory properties of TTO are well documented and form the basis of its many current uses[1].

There are many possible applications for products containing TTO in the health industry. These may be broadly classified as therapeutic uses, such as decolonisation of methicillin-resistant *Staphylococcus aureus* (MRSA) carriers, and non-therapeutic uses, such as disinfection and cleaning. Several studies have investigated therapeutic applications, two of which are detailed below. The first was a small pilot study involving a total of 30 hospital patients, where the combination of a 4% TTO nasal ointment and 5% TTO body wash was compared with 2% mupirocin nasal ointment and Triclosan body wash applied for a minimum of three days[2]. The TTO combination appeared to perform better than the standard regimen tested, although the difference was not statistically significant due to the small number of patients. The second more recent study was a comparison of a 10% TTO nasal and wound cream, together with 5% TTO body wash, with a standard regimen of 2% mupirocin nasal ointment, 4% chlorhexidine gluconate soap and a 1% silver sulfadiazine wound cream, both given for five days[3]. Of the 110 patients receiving the TTO combination, 46 (41%) were cleared of MRSA carriage and, of the 114 patients receiving the standard regimen, 56 (49%) were cleared. There was no significant difference between the effectiveness of the two regimens; however, the TTO treatment was more effective than the chlorhexidine and silver sulfadiazine at eradicating MRSA from superficial skin sites and skin lesions, while mupirocin was better for eliminating nasal carriage. The results from the second study are more reliable, since a much larger number of patients was involved. These data

suggest that TTO regimens perform equally well if not better than standard therapy for eradicating MRSA carriage.

Based on the results of the Dryden *et al.*[3] study, together with guidelines for the clinical management and control of community-acquired MRSA from the Wisconsin Division of Public Health, TTO was incorporated into the standard regimen used to eradicate MRSA at a 235-bed regional referral hospital with five affiliated nursing homes and an out-patient MRSA clinic in the USA. The standard regimen consisted of systemic therapy with minocycline and rifampin, and topical therapy with mupirocin nasal ointment and 5% TTO body wash[4]. After intervention and follow-up for 12 months or more, MRSA carriage decreased by 67% in nursing homes. In the hospital, nosocomial MRSA infection incidence rates, measured as infections per 1000 patient days, decreased from 0.64 prior to intervention to 0.40 after one year and to 0.32 after two years. One limitation of this study was that only patients considered at 'high risk' were screened, rather than all patients admitted; however, even better outcomes may have been achieved had all patients been screened.

It has long been known that effective hand washing is an important tool in combating nosocomial infections[5]. It is essential that healthcare workers decontaminate their hands between examining patients to prevent transmission of infectious agents such as MRSA. In a study carried out by our research group, the efficacy of a number of formulations containing TTO was assessed using standard *in vitro* suspension tests[6]. Products meeting the criteria outlined in the European standard suspension tests EN 1276 and EN 12054 were further investigated, both *in vivo* and *ex vivo*[7]. These studies showed that the most effective formulation was a solution of 5% TTO with 0.001% Tween 80. However, both the 5% TTO solution and an alcoholic hygienic skin wash containing 5% TTO and 10% alcohol were significantly more active than a non-antimicrobial soft soap against *Escherichia coli* K12. Hand washing products containing TTO have a pleasant hygienic smell and do not cause irritation or allergic reactions in most individuals. Although further investigations in this area are necessary, including testing a wider range of products, these data suggest that TTO hand washes may have a role in helping prevent transmission of nosocomial infections by encouraging increased hand-washing compliance.

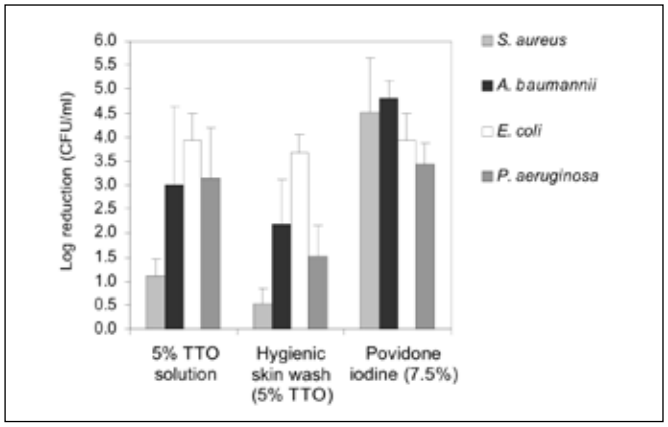

Figure 2. Activity of three antiseptic products after five minutes of contact on stainless steel surfaces (mean ± standard deviation). All products performed significantly better than the sterile distilled water control, with the exception of the hygienic skin wash against *P. earuginosa* (one way ANOVA, P <0.05) (EN 13697) (Messager *et al.*, unpublished data).

Currently, our group is continuing to assess the ability of several TTO hand-washing products to decontaminate hands. Both vegetative bacteria and bacterial spores are being used to artificially contaminate volunteers' hands. Spore-forming bacteria like *Clostridium difficile* are the causative agents of serious infectious diseases such as pseudomembranous colitis. A hand-washing agent capable of successfully removing bacterial spores from healthcare workers' hands, thus preventing transmission to other patients, would be a welcome addition to infection control measures.

In terms of non-therapeutic uses, inanimate objects found within healthcare facilities are also potential reservoirs of pathogenic organisms. These organisms may be transferred to other surfaces in the hospital environment, or to patients and healthcare workers, resulting in infection[8]. TTO and TTO products have the potential to be used as surface decontaminants, in an effort to reduce bacterial loads on inanimate surfaces. Reductions of approximately 4 $\log_{10}$ were achieved with a 5% TTO solution after five minutes of contact time with *Escherichia coli* on stainless steel (Figure 2). After five minutes of contact time on glass with *Acinetobacter baumannii* and *Pseudomonas aeruginosa*, >4 $\log_{10}$ reductions were achieved also using 5% TTO solution (Messager *et al.*, unpublished data). Further testing of a greater range of surfaces using various TTO formulations and concentrations would provide valuable additional information on the effectiveness of TTO as a surface disinfectant. Apart from harbouring pathogens, the environment may also be a source of allergens. Asthma, a chronic allergic inflammatory airway disorder, is believed to be triggered by allergens commonly found indoors, especially houses, including the house dust mites, *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*[9]. A recent study[10] comparing the bioactivity of tea tree, lavender (*Lavandula officinalis)* and lemon (*Citrus limon*) essential oils against dust mites showed that TTO was the most effective, causing 100% immobility in 30 minutes and 100% mortality in two hours.

Another mite capable of causing the parasitic skin disease scabies in humans is *Sarcoptes scabiei* var *hominis.* An *in vitro* acaricide efficacy study carried out in northern Australia indicated that

S. scabiei mites survive for extended periods of time when continuously exposed to 5% permethrin[11]. Great concern exists that *in vivo* tolerance will develop to standard treatment regimens and an effective alternative agent or combination therapy would be useful. The acaricidal activity of 5% TTO, several TTO components (terpinen-4-ol, α-terpineol, 1, 8-cineole), 5% permethrin and an ivermectin paste was assessed against a control emulsifying ointment[12]. The 5% TTO, terpinen-4-ol, 5% permethrin and ivermectin paste all performed significantly better than the control. The study concluded that TTO alone or in combination is likely to become an effective topical therapy for scabies, as it exhibited excellent *in vitro* activity. However, *in vivo* efficacy studies need to be carried out to validate TTO as an effective scabies treatment.

The incidence of infestation with head lice (*Pediculus capitis)* is increasing in the Western World, with resistance to pediculicides the most likely reason. In developing countries, most conventional chemical treatments are too expensive or unavailable. An alternative treatment, which is relatively inexpensive and effective, would be useful in both cases. An *in vitro* study was carried out comparing the efficacy of a number of essential oil components at killing adult lice, as well as their eggs[13]. Terpinen-4-ol, the major component of TTO, was the most effective at killing adult lice, but was not as effective at killing eggs, although it still exhibited ovicidal activity. Another study carried out by the same group compared the pediculicidal activity of the essential oils: tea tree, lavender and lemon[10]. Again, TTO was the most active, with 90% of lice being killed at the 210 minute time point. These data suggest TTO is an effective, natural treatment, best used in conjunction with physical removal via a nit comb.

In conclusion, TTO has a broad spectrum of activity against a variety of organisms. It is also easily obtained from natural renewable sources and is relatively inexpensive. Although TTO can be toxic if ingested, topical application of diluted TTO is relatively safe[14]. In many ways, these features make TTO an ideal antiseptic and biocide. Whilst there are many possible applications of TTO in the health industry, more *in vitro* studies and clinical trials are required to validate these. However, TTO has the potential to a play an important role as an alternative biocidal agent and, in doing so, minimise the development of resistance to conventional agents.

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Biographies

Natalie Thomsen is a research assistant who has recently begun investigating the antimicrobial properties of TTO. Prior to this she worked in the PathWest Laboratory Medicine diagnostic bacteriology laboratory for many years.

Kate Hammer is a postdoctoral scientist who has been researching the antimicrobial properties of TTO for more than 10 years. She is interested in naturally occurring antimicrobial compounds, particularly plant essential oils, other plant-derived antimicrobial compounds and honey.

Tom Riley holds a Personal Chair in Microbiology and Immunology at The University of Western Australia, and is Principal Research Scientist at PathWest. He has had a long-standing interest in alternative therapies for infectious diseases and the diagnosis and epidemiology of *Clostridium difficile* infection. He has published over 250 book chapters and refereed journal articles.