REVIEW ARTICLE

THE ROLE OF TEA TREE OIL AS A SKIN ANTIMICROBIAL : A LITERATURE STUDY

Kathleen Aldora[1,2], Dian Ardiana*[1,2], Eka Narayana[1]
[1,2] Faculty of Medicine, Hang Tuah University, Surabaya, Indonesia
[1] Dermatology and Venereology Department, Dr. Ramelan Naval Hospital, Surabaya, Indonesia
*Correspondence: dian.ardiana@hangtuah.ac.id

ARTICLE INFO

Article history:
Received
February 06, 2021
Accepted
February 25, 2021

Keywords:
Tea tree oil, *Melaleuca alternifolia*, skin infection, microorganism.

ABSTRACT

Backgroud: Skin disease due to microorganism infection are still widely found in community. The infections can be caused by bacteria, viruses, fungi, and parasite. Tea tree oil often used as a herbal medicine in the treatment of skin diseases due to microorganisms. This literature study is conducted to review the role of tea tree oil as an antimicrobial in skin infections.

Methods: Fifteen indexed journals published from 2015 to 2020 about tea tree oil and skin infections, were included. From 15 journals, 9 journals discuss antibacterial activity of tea tree oil, 2 journals discuss antiviral activity, 9 journals discuss antifungal activity, and 1 journal discusses antiparasitic activity. All journals state that tea tree oil has an antimicrobial effect on microorganisms that cause skin infections.

Results: From 9 journals, it was found that *A. baumanni*, *P. aeruginosa*, and *C. acnes* were the most sensitive bacteria to tea tree oil in terms of MIC and *S. epidermidis* was the most sensitive bacteria, seen from their inhibition zone. Eight journals state variations with significant differences in the activity of tea tree oil as an anti-fungal. Tea tree oil has stronger antibacterial activity than antifungal activity. It also has antiviral activity against HSV and antiparasitic on *S. scabiei*.

Conclusion: The conclusion of this study is that tea tree oil has antimicrobial activity against microorganisms that cause skin disease, including bacteria, viruses, fungi, and parasite.

Medical and Health Science Journal

INTRODUCTION

Skin is the largest organ in the human body with a surface area of 2 m^2. Skin has 2 main functional layers, epidermis and dermis, and underneath there is hypodermis or subcutis layer. As the outermost layer of the human body, the most important function of the skin is as a mechanical barrier for first defense. The skin is home to commensal microorganisms that will play a role in preventing invasion from foreign pathogens. When the barrier is damaged by trauma or when the balance between commensal microorganisms and pathogens is disturbed, skin disease or even systemic disease may occur. The entry of pathogens that penetrate the skin will trigger an immunological reaction from the body.

Microorganisms that enter through the skin are associated with the pathophysiology of dermatological infectious diseases. Wound infections are generally caused by the microorganisms *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Escherichia coli*. *Staphylococcus aureus* itself is commonly found in atopic dermatitis. Another example is the fungus *Malassezia* which causes many skin conditions pityriasis versicolor, seborrheic dermatitis, atopic dermatitis, and psoriasis (McLoone, Warnock & Fyfe, 2016). Apart from bacteria and fungi, viruses can also cause skin infections such as molluscum contagiosum which is caused by the *Molluscum contagiosum virus* (MCV) from the family *Poxviridae*.[1]

Globally, skin problems and diseases are common, and because of their visibility, often result in severe distress and stigma for sufferers. Therefore, many dermatological therapies have been developed, both herbal, conventional (chemical) and technological therapies. One of the many herbal therapies used for skin infections is tea tree oil *(Melaleuca* oil*)*. The content of tea tree oil is a mixture of components such as monoterpenes, sesquiterpenes and alcohol that contribute to various activities (analgesic, antiviral, antibacterial, antifungal, antiparasitic, anti-inflammatory, antioxidant, and anticancer). Tea tree oil has a tendency to be very minimal resistant and can overcome the development of resistance to conventional drugs in skin infections caused by microorganisms.[2]

Tea tree oil is an essential oil obtained by steam distillation of the native Australian plant *Melaleuca alternifolia*. Tea tree oil has been used for centuries by Australians as medicine, especially for wound care in 1920.[3] Long-term use of herbal therapy tea tree oil has a lower incidence of side effects, irritation or allergic reactions when compared to conventional therapy. Tea tree oil in topical use will have the added advantage of being cost effective and easy to use.[4] Seeing the potential and advantages of tea tree oil therapy, the development of this therapy needs to be improved in both the cultivation and pharmacology sectors. Therefore, the authors intend to review the role of tea tree oil as an antimicrobial in skin infections.

METHODS

The research design used is descriptive research. The method used is literature study to review the role of tea tree oil as skin antimicrobial. Database searched was Google Scholar. Search terms used were ‘tea tree oil as antibacteria, tea tree oil as antivirus, tea tree oil as antifungi, tea tree oil as antiparasit, role of tea tree oil as antimicroba, tea tree oil as antimicroba in vitro’. Limitations included ‘published between 2015-2020’ and ‘indexed by Scimago or SINTA (Science and Technology Index)’. This research was conducted in Surabaya from May to September 2020. This research get approval from the Ethics Commission for Health Research, Faculty of Medicine, Hang Tuah University.

RESULT

The results of the study are taken from 15 international journals indexed by Scimago about the role of tea tree oil as a skin antimicrobial. Nine journals discuss the activity of tea tree oil against bacteria, two journals discuss the activity of tea tree oil against virus, eight journals discuss the activity of tea tree oil against fungi, and one journal discuss the activity of tea tree oil against parasite.

Antibacterial activity

Research in the journal states the antimicrobial effect seen from the minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), imaging through electron microscopy, and the zone of inhibition. The bacteria studied in the journal include *Staphylococcus aureus, Staphylococcus epidermidis, Cutibacterium acnes, Pseudomonas aeruginosa, Bacillus subtilis, Acinetobacter baumannii, Streptococcus pyogenes, Klebsiella pneumoniae,* and various other gram-positive and negative bacteria. The bacteria were cultured on Mueller-Hinton agar and given tea tree oil with different concentrations. The method used is the liquid microdilution method. After that, the bacteria will be observed for MIC, microscopic image, and zone of inhibition to determine the antimicrobial effect of tea tree oil.

Table 1 MIC of *S. aureus* and *P. aeruginosa* by 10 types of tea tree oil products [5]

Product	*S. aureus*	*P. aeruginosa*
Tea tree oil 1	2.5	2
Tea tree oil 2	0.5	0.25
Tea tree oil 3	1	2
Tea tree oil 4	0.5	0.5
Tea tree oil 5	0.75	1.5
Tea tree oil 6	0.5	0.5
Tea tree oil 7	2.5	2
Tea tree oil 8	2	2
Tea tree oil 9	0.5	0.25
Tea tree oil 10	0.75	1

Table 2 The number of *P. aeruginosa* that are inhibited by tea tree oil [6]

Tea tree oil	0.03%	0.06%	0.125%	0.25%	0.5%	1%	2%
Inhibited bacteria	0	0	0	4	2	7	7

Table 3 MIC and MBC of tea tree oil and rosemary oil against acne-causing bacteria [7]

Bacteria	Tea tree oil		Rosemary oil	
	MIC	MBC	MIC	MBC
S. aureus	0.78	0.78	1.56	1.56
S. epidermidis	0.78	0.78	1.56	1.56
C. acnes	0.39	0.39	0.39	0.39

Table 4 MIC of essential oil against bacteria [8]

Bacteria	**Basil**	**Oregano**	**Tea tree**	**Thyme**	**Chamomile**
A. baumanni	0.5-1.25	0.25-0.37	0.12-0.25	0.25-.0.5	>4
K. pneumoniae	1.5-3	1	0.5-0.75	0.5-1.5	>4
P. aeruginosa	>4	2-4	1-1.5	4	>4

Table 5 MIC of essential oil against *S. epidermidis* and *P. acnes* [9]

Essential Oil	***S. epidermidis***	***P. acnes***
Oregano	0.67	0.34
Thyme	1.3	0.65
Lemongrass	1.22	1.22
Tea tree	1.27	1.28
Lavender	2.52	2.52
Mentha	5.28	2.6
Chamomile	6.22	3.18

Ziółkowska-Klinkosz et al. conducted a study on 193 anaerobic bacteria which were given tea tree oil and the result was that anaerobic bacteria were more sensitive than gram negative. [10]

Li et al conducted a study that showed normal cell growth in control media and bacterial growth treated with tea tree oil were viewed using a microscope. The results for normal cell growth showed normal characteristics of cocci bacteria such as cell walls and cell

membranes that were attached to the peptidoglycan layer and normal cytoplasmic membrane. In addition, the cytoplasm appears to have a homogeneous electron density. Meanwhile, the bacteria that were given tea tree oil showed a clear morphological change in which the density of the cytoplasm became heterogeneous and some of them were seen leaving the cell. The separate distance between the cytoplasmic membrane and the cell wall is also seen. [11]

Table 6 Zone of inhibition of tea tree oil against bacteria (in mm)

	S. aureus	***S. epidermidis***	***C. acnes***	***P. acnes***	***S. pyogenes***
Esmael et al [7]	15.5	21.02	20.85		
Taleb et al [9]		9 – 15		9 – 18	
Ramadan et al [12]	19.2 ± 0.44	21.7 ± 0.58			19.2 ± 0.19

Antiviral activity

The viruses tested in this study were herpes simplex viruses (HSV) 1 and 2. The method used was to use vero cells that were infected with HSV and given tea tree oil. Tea tree oil's antiviral activity can be seen from its PFU (plaque-forming unit) and viral titer. Brun showed the results of his research where after being exposed to tea tree oil, the PFU of the HSV 1 was reduced compared to before.[5]

Table 7 HSV titers before and after being given tea tree oil [12]

	Pre-test	*Post-test*	Reduction
HSV 1	7.5	6.32	15.6%
HSV 2	7.66	6.11	20.23%

Antifungal activity

Eight journals discussed the activity of tea tree oil as an antifungal. All of them stated that tea tree oil acts as an antifungal in terms of MIC, MFC (minimum fungicidal inhibition), confocal features, and also the zone of inhibition. The fungi studied from 8 journals were *Candida sp., Aspergillus niger, and Trichophyton mentagrophytes*. Before being exposed to tea tree oil, the fungus is cultured in dextrose agar. The method used is the same as for bacteria, namely with liquid micro-dilution.

Table 8 MIC *C. glabrata* on 10 types of tea tree oil products [5]

Product	MIC of *C. glabrata*
Tea tree oil 1	2.5
Tea tree oil 2	1.5
Tea tree oil 3	2.5
Tea tree oil 4	1
Tea tree oil 5	2
Tea tree oil 6	0.75
Tea tree oil 7	2.5
Tea tree oil 8	2.5
Tea tree oil 9	1
Tea tree oil 10	1.5

Table 9 MIC and MFC *C. krusei* against tea tree oil and MPP [13]

	10^3 cfu/mL	10^6 cfu/mL
Tea tree oil		
MIC	0.5	1
MFC	0.5	1
MPP		
MIC	0.25	1
MFC	0.5	1

The research conducted by Francisconi showed a confocal picture of *Candida albicans* before and after being given tea tree oil. The results showed that many of the fungi that had been given tea tree oil died.[14]

Table 10 Zone of inhibition of tea tree oil against *Candida albicans* and *Trichophyton mentagrophytes*

	Candida albicans	*Trichophyton mentagrophytes*
Narang et al (1g) [15]	±38 mm	
Ramadan et al (25µg dissolved in 0.1% dimethyl sulfoxide) [12]	20.3 ± 0.44 mm	21.1 ± 0.44 mm
Patturaja and Geetha et al [16]		
250 µg/mL	14 mm	
500 µg/mL	20 mm	
1000 µg/mL	37 mm	

Antiparasitic activity

Fang et al. conducted research on S. scabiei which was given 10 types of essential oils (lavender, bitter orange, geranium¸ tea tree, clove, eucalyptus, manuka, cade, Japanese cedar, and palmarosa). This research was conducted using 2 methods, namely contact bioassays and fumigation bioassays. With the contact bioassays method, essential oils were diluted with paraffin to obtain a concentration of 1.5, 10%, then *S.scabiei* was viewed by stereomicroscope in 10, 20, 30, 40, 50, 60, 90, 120, 150, 180 minutes after exposure. tea tree oil. The result is that clove oil is the most effective essential oil where with 1% clove oil all *S.scabiei* dies in 20 minutes. Meanwhile, with tea tree oil, all *S.scabiei* died after 90 minutes of exposure to 5% tea tree oil and 30 minutes with 10% tea tree oil. The bioassays fumigation method was carried out with 100 µL of pure essential oil dripped on filter paper and then *S.scabiei* was inspected by stereomicroscope for the first 5 minutes, then every 5 minutes for 1 hour. The result is that tea tree oil is the most effective essential oil as an antiprotozoa followed by clove oil and eucalyptus oil. [17]

DISCUSSION

Based on 15 journals, it can be concluded that tea tree oil has antimicrobial activity in skin infections, both antibacterial, anti-fungal, antiviral, and also antiparasitic activities. The level of effectiveness of tea tree oil is different for

each type of microbe seen from MIC, MBC, MFC, virus titer number, zone of inhibition, and survival time. Each type of bacteria has a different sensitivity to tea tree oil. Seven of the nine journals comparing the MICs of bacteria exposed to tea tree oil revealed a variation of the MIC of 0.12% to 2.5%. The most sensitive bacteria are *A. baumanni* with an MIC of 0.12%[8], followed by *P. aeruginosa* with an MIC of 0.25% [5,6], *C acnes* with an MIC of 0.39% [7], *S. aureus* with an MIC of 0.5% [5], and *S. epidermidis* with an MIC of 0.78% (Esmael et al. , 2020). Of the 193 anaerobic bacteria that were exposed to tea tree oil, gram-positive anaerobic bacteria are more sensitive than gram-negative ones [10]. Judging from the microscopic image, the bacteria exposed to tea tree oil showed clear morphological changes such as cytoplasmic density changing to heterogeneous and some visible out of the cell, as well as visible distances between the cytoplasmic membrane and the cell wall.[11] Three journals that looked at the zone of inhibition as a parameter of tea tree oil activity stated that *S. epidermidis* has the most extensive inhibition zone, namely 15 - 21.7 mm compared to other bacteria with the same tea tree oil concentration. [7,9,12]

Two journals discussing the antiviral activity of tea tree oil against HSV stated that tea tree oil can inhibit and kill the growth of the virus which is seen from the PFU and its titer virus. [5,12] HSV 2 was found to be more sensitive to HSV 1 seen from the decrease in viral titer before and after exposure to tea tree oil with a decrease of 15.6% for HSV 1 and 20.23% for HSV 2. [12]

Five of the eight journals compared the fungal MIC to look at the antifungal activity of tea tree oil. The five journals states that the variation in MIC was quite significant, namely from 0.06% to 8.96% for *Candida sp*. When compared with bacterial MIC, tea tree oil activity is more effective as an antibacterial than antifungal.[5] In addition, other essential oils that are more effective for *Candida* were also found, namely MPP (mentha of pancalieri) oil. [13] The confocal image also shows the presence of antifungal activity of tea tree oil where a red color is seen which indicates microbial death.[14] Three of the eight journals that observed their zone of inhibition stated that there was anti-fungal activity of tea tree oil with different areas depending on the concentration of tea tree oil given. [12,15,16]

The journal that discusses the antiparasitic activity of tea tree oil against *S.scabiei* states that its effectiveness is seen from the survival time of *S.scabiei*. With different methods, the results found are different, namely that clove oil was more sensitive than tea tree oil with the contact bioassays method, while with the fumigation bioassays method, it was found that tea tree oil was the most sensitive followed by clove oil. [17]

CONCLUSION

Tea tree oil is an essential oil that can be used as a treatment for skin infections caused by microorganisms. The antimicrobial activity of tea tree oil is supported by its composition, namely terpinen-4-ol, γ-terpinen, 1,8-cineol, α-terpinen, α-terpineol, p-cymen, and α-pinen which are lipophilic. Tea tree oil that enters the cells of microorganisms will result in inhibition of metabolism and cell death of microorganisms. The death of microorganisms can help the healing process of wound infections caused by microorganisms. Based on the results of the discussion of 15 journals that examined the effects of tea tree oil on microorganisms in vitro, it was concluded that tea tree oil has antimicrobial activity against microorganisms that cause skin infections. Nine journals stated antibacterial activity in terms of MIC (minimum inhibitory concentration), MBC (minimum bactericidal concentration), microscopic image, and zone of inhibition. From the nine journals, it was found that the most sensitive bacteria were A. baumanii and P. aeruginosa. Two journals stated antiviral activity against HSV 1 and HSV 2 in terms of PFU (plaque-forming unit) and viral titer where it was found that HSV 2 was more sensitive to tea tree oil. Eight journals stated antifungal activity in terms of MIC, MFC (minimum fungicidal inhibition), confocal features, and zone of inhibition. The eight journals stated significant variations and differences in the anti-fungal activity of tea tree oil against candida sp. One

journal stated antiparasitic activity against S. scaibei in terms of survival time.

REFERENCES

1. Meza-Romero R, Navarrete-Dechent C, Downey C. Molluscum contagiosum: An update and review of new perspectives in etiology, diagnosis, and treatment. Clin Cosmet Investig Dermatol. 2019;12:373–81.
2. Yadav E, Kumar S, Mahant S, Khatkar S, Rao R. Tea tree oil: a promising essential oil. J Essent Oil Res [Internet]. 2017;29(3):201–13. Available from: http://dx.doi.org/10.1080/10412905.2016.1232665
3. Mertas A, Garbusińska A, Szliszka E, Jureczko A, Kowalska M, Król W. The influence of tea tree oil (Melaleuca alternifolia) on fluconazole activity against fluconazole-resistant candida albicans strains. Biomed Res Int. 2015;2015.
4. Thomas J, Carson CF, Peterson GM, Walton SF, Hammer KA, Naunton M, et al. Therapeutic potential of tea tree oil for scabies. Am J Trop Med Hyg. 2016;94(2):258–66.
5. Brun P, Bernabè G, Filippini R, Piovan A. In Vitro Antimicrobial Activities of Commercially Available Tea Tree (Melaleuca alternifolia) Essential Oils. Curr Microbiol. 2019;76(1):108–16.
6. Rajeshnidhi KR, Mahesh R. Antibacterial activity of tea tree oil against clinical isolates of Pseudomonas aeruginosa. Front Microbiol. 2019;10(JULY):1422–4.
7. Esmael A, Hassan MG, Amer MM, Abdelrahman S, Hamed AM, Abd-raboh HA, et al. Antimicrobial activity of certain natural-based plant oils against the antibiotic-resistant acne bacteria. Saudi J Biol Sci [Internet]. 2020;27(1):448–55. Available from: https://doi.org/10.1016/j.sjbs.2019.11.006
8. Sakkas H, Gousia P, Economou V, Sakkas V, Petsios S, Papadopoulou C. In vitro antimicrobial activity of five essential oils on multidrug resistant Gram-negative clinical isolates. J Intercult Ethnopharmacol. 2016;5(3):212–8.
9. Taleb MH, Abdeltawab NF, Shamma RN, Abdelgayed SS, Mohamed SS, Farag MA, et al. Origanum vulgare L. Essential oil as a potential anti-acne topical nanoemulsion—in vitro and in vivo study. Molecules. 2018;23(9).
10. Ziółkowska-Klinkosz M, Kedzia A, Meissner HO, Kedzia AW. Evaluation of the tea tree oil activity to anaerobic bacteria - In vitro study. Acta Pol Pharm - Drug Res. 2016;73(2):389–94.
11. Li WR, Li HL, Shi QS, Sun TL, Xie XB, Song B, et al. The dynamics and mechanism of the antimicrobial activity of tea tree oil against bacteria and fungi. Appl Microbiol Biotechnol. 2016;100(20):8865–75.
12. Ramadan MA, Shawkey AE, Rabeh MA, Abdellatif AO. Promising antimicrobial activities of oil and silver nanoparticles obtained from Melaleuca alternifolia leaves against selected skin-infecting pathogens. J Herb Med [Internet]. 2020;20(June):100289. Available from: https://doi.org/10.1016/j.hermed.2019.100289
13. Tullio V, Roana J, Scalas D, Mandras N. Enhanced killing of candida krusei by polymorphonuclear leucocytes in the presence of subinhibitory concentrations of melaleuca alternifolia and “mentha of Pancalieri” essential oils. Molecules. 2019;24(21).
14. Francisconi RS, Huacho PMM, Tonon CC, Bordini EAF, Correia MF, Sardi J de CO, et al. Antibiofilm efficacy of tea tree oil and of its main component terpinen-4-ol against Candida albicans. Braz Oral Res. 2020;34:e050.
15. Narang J, Narang R, Singh B, Kahlon S, George J, Dogra A. Comparative efficacy of tea tree oil nanoemulgel and clove oil nanoemulgel against Candida albicans. Int J Pharm Investig. 2018;8(1):50.

16. Patturaja K, Geetha R V. Evaluation of antimycotic activity of three essential oils on candida albicans -an invitro study. J Pharm Sci Res. 2017;9(4):480–2.

17. Fang F, Candy K, Melloul E, Bernigaud C, Chai L, Darmon C, et al. In vitro activity of ten essential oils against Sarcoptes scabiei. Parasites and Vectors [Internet]. 2016;9(1):1–7. Available from: http://dx.doi.org/10.1186/s13071-016-1889-3