

# Essential oils for the treatment of demodex

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**Abstract.** The Demodex infestation is widely spread among older people. The conventional treatment of demodex involves chemicals and antibiotics. However, these treatments have a number of side effects, such as environmental risks, acaricide resistance, toxicity to humans and animals. Benefit from abundant sources of plants and plant extractions have been a new choice for treating demodex infections. This review summarizes the anti-demodex and side effects of certain botanical essential oils. The high efficacy and low side effects of essential oils, such as TTO and its active ingredient terpinen-4-oil, camphor oil, sage oil, peppermint oil, neem oil, clove oil make them good candidates for the treatment of mites. Further studies on the biological mechanisms of the acaricide effects of these active essential oils and the structure-activity relations are necessary to clarify the functions of these drugs.

## 1 Introduction

Mites are small arthropods in the Arachnid class and the Acaris subclass. They live in a broad spectrum of habitats. At least 45,000 different species of mites have been identified. Some of the mites damage food, cause skin irritation, itching and severe bacterial infections.

Demodex is a group of elongated ectoparasites living in the face, cheeks, forehead, eyelid or nose of the surface of the human body [1, 2]. Demodex folliculorum (DF, usually present in the cilium follicle) and demodex brevis (usually present deep in the sebaceous and meibomian glands) are two main species of demodex. They cause numerous skin diseases, such as Pityriasis folliculorum, rosacea, perioral dermatitis, scab-like eruptions, facial pigmentation, bald scalp eruption and demodicosis graves [3-5]. Demodex infestation is widely spread in the elderly. Approximately 84% of the population aged 60 years was infected, whereas 100% of the population aged over 70 years was infected [6, 7].

Traditional demodex treatment includes chemicals and antibiotics. However, these treatments have many side effects, such as environmental hazards, acaricidal resistance, toxicity to humans and animals [8]. Insecticides derived from naturally occurring plants have been developed to overcome these disadvantages. Essential oils are volatile aromatic compounds that arise mainly from plants. Numerous essential oils and its ingredients, such as tea tree oil (TTO), terpinolene, and peppermint oil, have been recently tested for the treatment of demodex.

## 2 Essential oil for ocular demodex

Ocular Demodex causes blepharitis, chalazion and malfunction of the meibomian gland [9-11]. Blepharitis is an inflammatory condition that occurs in both eyelids where cilia develop. Symptoms of blepharitis include red and watery eyes, itching eyelids and other unpleasant symptoms. More than 84% of patients with eye discomfort were infected with Demodex [9, 12, 13]. The number of Demodex was significantly related to age and the Ocular Surface Discomfort Index (OSDI) [13].

Conventional treatments for Demodex include eyelid hygiene, antibiotics, topical steroids, systemic erythromycin, or doxycycline. However, the recurrence rate remains considerably high after treatment with these drugs. A number of essential oils have been studied recently.

### 2.1 TTO and its ingredients for ocular demodex

TTO is the essential oil extracted from the leaves of the tea tree, a plant growing on the swampy coast of southeast Australia. Terpinene-4-ol is the most abundant active ingredient in TTO, followed by  $\alpha$ -terpinol, 1,8-cineole and sabinene [14]. TTO has been used to mitigate skin infections, such as acne, fungal infections, lice, scabies and demodex infections. The most active component of TTO, terpinene-4-ol, kills demodex mites effectively both in vitro and in vivo [14]. It has a synergistic effect with terpinolene, but an antagonistic effect with  $\alpha$ -terpinol [14].

The TTO significantly relieved the symptoms of ocular infections, killed the demodex, and inhibited recurrence. In vitro, 50% TTO killed Demodex

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effectively, with an average survival time in 7 minutes [15]. In patients with external eye diseases, such as blepharitis and blepharconjunctivitis, TTO considerably reduced the amount of ocular demodex [9, 10, 13, 16]. The TTO causes the migration of the ocular demodex from the root of the lashes to the skin. With everyday eyelid scrub and tea tree shampoo, Demodex has been eradicated [11, 17]. In patients with chalazion, TTO inhibited the recurrence of chalazion by 96.8% [10]. Different degrees of symptomatic relief, a significant reduction in OSDI and a noticeable reduction in inflammatory signs were observed after TTO treatment [11-13]. In external eye conditions such as blepharitis, meibomian gland disease, dry eye and conjunctivitis, 91% of patients reported improvement in symptoms after using TTO [18]. The relief of symptoms may be related to the decrease of inflammatory cytokines, such as TNF- $\alpha$ , IL-6, IL-17, and IL-1 $\beta$  in the patient's tear [2, 19].

Terpinen-4-ol is the predominant ingredient in TTO. It is also the most potent ingredient in TTO in killing DF. In comparison with 50% of TTO which killed DF in 14.8 $\pm$  9.5 min, 50% of terpinen-4-ol killed them in 4.5 $\pm$ 1.0 min in vitro. Even at the 1% concentration, terpinen-4-ol had good potential for DF destruction [14]. The 8-week use of terpinen-4-ol in vivo eradicated the mites in a 61-year-old patient and resulted in marked resolution of symptoms [14].

$\alpha$ -Terpineol, 1,8-Cinéole, Sabinene, Limonene, Terpinolene and  $\alpha$ -Terpinene are other ingredients within the TTO. They killed DF efficiently, too. In the 50% concentration, they killed DF in 12.5, 18.8, 18.8, 22.8, 31.0, 21.0 min, respectively, compared with 14.8 min to 50% TTO [14].

## 2.2 Other essential oil for treatment of demodex

Peppermint oil is an essential oil obtained from peppermint, a hybrid variety of spearmint and water mint. Menthol and methane are two active ingredients in peppermint oil. The peppermint oil killed the demodex effectively, with a mean survival time of 11 min [15, 20]. Peppermint oil is more effective on killing D. Brevis than D. Folliculorum. The most suitable and effective

concentration against D. Folliculorum in vitro was 12.5%, while the concentration of D. Previous was 3.125% [21].

Camphor oil is an essential oil extracted from camphor (*Cinnamomum camphora*), a large evergreen tree originally from China and Japan. It is widely used as a stimulant, antispasmodic, antiseptic, decongestant, anesthetic, sedative and nerve suppressant. Camphor oil is an active killer of both DF and DB in vitro. Such mechanisms may be associated with direct contact and neuromuscular toxicity [22]. In vivo, camphor oil cures demodex-induced dermatological lesions effectively and safely. A daily topical application of 1/3 diluted camphor oil with glycerol, combined with an orally given 500 mg metronidazole, cured the dermatological lesion successfully in 27 patients with no clinical side effects [23]. Patients were fully cured by a concentration greater than 50% and partially cured by a concentration greater than 20% [24].

Other essential oils, such as sage oil and galangal essential oil, show good effects on demodex too. Sage oil is derived from *Salvia officinalis* from the family Labiatae. Sage oil was used as a brain tonic in many CNS diseases [25]. He also killed demodex in 7 mins in vitro [15, 20]. Galangal essential oil is extracted from the roots of the Galangal plant. The galangal oil killed DF in 14.42 minutes, and killed DB in 8.3 minutes in vitro [26].

The volatile oils of six Chinese crude medicines, clove, orange fruit, Manchurian wild ginger, cinnamon bark, Rhizome *Alpinia officinarum* and pricklyash peel, were investigated in vitro for their Demodex killing effects. All of the six volatile oils killed DF and DB within 30 min. Among them, clove was the most potential one. No significant skin irritation or other adverse events were observed in all six oils [27]. Other essential oils, such as sea buckthorn, were also investigated, but showed a very low effect on Demodex (LT50: 3 days and 9 hours, respectively)[15]. The effects of different essential oils on demodex were shown in Table 1 and Table 2.

**Table 1.** In vivo activities of essential oil on demodex.

Drug	Patient number	Disease	Mites account (Before)	Mites account (After)	Symptom improvement	Side effects	References
TTO ointment	24	Ocular demodicosis	5.5 $\pm$ 1.6	0.7 $\pm$ 0.8	Decreased the eye itching and CD significantly	No	[16]
TTO	335	Demodex blepharitis	4.0 $\pm$ 2.5	3.2 $\pm$ 2.3	OSDI reduced significantly	No	[13]
TTO	12	Pediatric blepharconjunctivitis	11 patients infected	4 patients infected	Dramatic resolution of ocular irritation and inflammation	No	[9]
TTO ointment	48	Recurrent chalazion	72.9% patients infected	N.A.	Prevented recurrence by 96.8%	No	[10]
TTO ointment	9	Cylindrical dandruff	9 patients infected	2 patients infected	Resolution of surface inflammation and irritation	No	[17]
TTO	223	Demodicosis	N.A.	N.A.	91% of patients reporting at least some improvement in	No	[18]

					symptoms		
TTO	6	Blepharitis	41	6	Conjunctival inflammation resolved	No	[12]
Basic gel containing 3%-TTO	25	Chronic blepharitis	42%	27.8%	Both OSDI and TBUT decreased; TNF- $\alpha$ decreased	No	[19]
Advanced gel containing 3%-TTO plus essential oils and vitamins	24	Chronic blepharitis	54.2%	20.6%	Both OSDI and TBUT decreased; IL-6, IL-1 $\beta$ decreased	No	[19]
TTO	11	Demodecosis	120	5	50% to 100% improvement in symptoms.	Mild to moderate irritation in 9 patients	[11]
TTO	10	Demodecosis	3.8 $\pm$ 2.2	0.2 $\pm$ 0.4	Substantial clinical improvement was observed in all patients	No	[2]
TTO	22	Demodex folliculorum	4.9 (0–21)	1.9 (0–8)	OSDI improved significantly	No	[28]
Terpinen-4-ol	1	Demodex folliculorum	22	0	Marked resolution of symptoms	No	[14]

TTO: Tea tree oil; OSDI: ocular surface discomfort index; TBUT: tear breakup time;

**Table 2.** In vitro activities of essential oil on demodex.

Drug	Number of Mites	Species	Concentration	Survival time	Reference
Terpinen-4-ol	6	Demodex folliculorum	50%	4.5 $\pm$ 1.0	[14]
clove, orange fruit, Manchurian wildginger, cinnamon bark, Rhizome Alpiniae Officinarum and pricklyash peel oil	Demodex from 20 patients	Demodex folliculorum & Demodex brevis	-	All <30min	[27]
Peppermint oil	636	Demodex	-	11 min	[15]
Peppermint oil	33	Demodex	25%	5 min	[21]
TTO	636	Demodex	50%	7 min	[15]
Camphor oil	31/33	Demodex folliculorum	50%	8min	[22]
Sage oil	636	Demodex	-	7 min	[15]
Gagangal oil	15	Demodex folliculorum	-	14.42 $\pm$ 1.14	[26]
Gagangal oil	15	Demodex brevis	-	8.3 $\pm$ 0.86	[26]

### 3 Conclusion

Mite induced diseases have led to a lot of suffering for humans. Many drugs have been used for the treatment of the skin infections and allergies diseases Ccaused by demodex. However, the problem of resistance, the environmental issues associated with chemical treatment, has led us to seek new approaches. Taking the benefits

of abundant plant sources and plant extractions have been a new option. The high efficacy and low side effects of essential oils from plants, such as TTO and its active ingredient terpinen-4-ol, camphor oil, sage oil, peppermint oil, neem oil, clove oil etc. make them good candidates for the treatment of mites. Further studies on the biological mechanisms of the acaricide effects of these active essential oils and the structure-activity relations are necessary to clarify the functions of these

drugs. For most of the previous research, the side effects of these essential oils are unclear. Further studies are therefore necessary as well.

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