



The Role of Essential oil bioactives in antibacterial skincare

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The “natural” trend

Increasingly, people prefer food, cosmetics and medicines that have natural ingredients. Natural products are considered a healthier option, with fewer adverse reactions and better for the environment.

Over the last 20 years, essential oils have become a key ingredient in many cosmetics and toiletries, medicines, food and beverages and cleaning products.

Given these trends, essential oils have become a major global industry, expected to double in value from USD 8 billion in 2017 to USD16 billion in 2025 [1].

What are essential oils?

Essential oils are extracted from plant-based material by steam or water distillation or extraction using carbon dioxide. Sources of essential oils include:

- leaves and small branches e.g. mānuka, oregano, palmarosa, patchouli, spearmint, tea tree and thyme
- flowers e.g. German chamomile
- wood e.g. sandalwood
- seeds e.g. cardamom, kakadu plum and star anise.

Figure 1:
Sources of Essential Oils



From left: mānuka leaves, German chamomile flowers, palmarosa leaves, sandalwood bark and cardamom seeds.

Bioactives in Essential Oils

Essential oils are complex, chemical entities which are made up of hundreds of organic (carbon containing) chemical compounds. These include terpenes, terpinoids, acids, alcohols, aldehydes, esters, furans, ketones, lactones, oxides, peroxides and phenols [2]. These compounds are responsible for the essential oil's antimicrobial, anti-inflammatory and healing properties, as well as less desired attributes such as photosensitivity and toxicity.

A “chemotype” is a chemically distinct entity of a plant. Chemotypes have the same *genus* and *species*, but the chemical constituents of the plant are different. With essential oils, therapeutic properties and safety issues may be influenced by the chemotype. For example, thyme essential oil, *Thymus vulgaris* (chemotype thymol) is used to kill bacteria and viruses, but it can be a skin irritant. *Thymus vulgaris* (chemotype linalool), is also anti-infectious, but is less irritating to the skin [3].

Use of essential oil ingredients in dermatology

Skin infections are one of the five most common reasons for people to seek medical treatment [4].

Skin damage from injuries such as burns, wounds or scratches, skin thinning and eczema can compromise the skin's microbiome, increasing its susceptibility to skin infections such as acne, boils, impetigo (school sores), carbuncles, cellulitis, folliculitis, ringworm, athlete's foot, thrush and herpes.

Skin infections are often treated with antibiotic cream. Overuse and incorrect use of these pharmaceuticals has resulted in antimicrobial-resistant, virulent pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA). The problem is becoming so severe that infectious disease experts believe that topical antibiotics should not be used to treat common skin infections [5]. In this context, the value of ancient, evidence-based natural remedies such as essential oils becomes obvious.

At present, dermatological application of essential oils can be divided into three groups [4]:

- Bacterial, fungal and viral infections: 62%
- Inflammatory skin conditions such as dermatitis, eczema, and lupus: 20%
- general skin maintenance such as wrinkles, scars and scabs: 18%

Figures 2: Common Bacterial, Fungal and Viral Infections



From top left: Ringworm, impetigo (school sores) and cold sores

Given below are some essential oil ingredients used to treat common infections, wounds and other skin problems.

Table 1:
Selected Essential Oil Ingredients Used in Dermatology

#	Essential Oil <i>Botanical Name</i>	Sources, Possible Uses & Active Ingredients
1	Cardamon seed essential oil <i>Elettaria cardamomum</i> L.	<ul style="list-style-type: none"> • Sources: India, Indonesia, Malaysia, Guatemala, Tanzania. • Possible uses: bacterial infections such as impetigo and boils, yeast infections, food ingredient, fragrances. ¹ • Contains: 1,8-Cineole, α-Terpinyl acetate, Limonene, Sabinene.
2	German Chamomile <i>Matricaria recutita</i>	<ul style="list-style-type: none"> • Sources: Egypt, Germany, Holland, Brazil, Bulgaria, Finland, France, Hungary. • Possible uses: bacterial infections, ulcers, wounds, haemorrhoids, cold sores, genital herpes, eczema, cosmetics, fragrances, food ingredient. ¹ • German chamomile oil is produced in many parts of the world with great variations in composition. • Chemotypes high in α-bisabolol are preferred in the development of therapeutic applications. • Contains: α-Bisabolol oxide A& B, (<i>E</i>)-β-Farnesene, α-Bisabolol, Chamazulene.
3	Kakadu Plum seed oil (a.k.a. Billy Goat Plum)	<ul style="list-style-type: none"> • Source: Australia. • Traditional Aboriginal remedy for thousands of years.

	<i>Terminalia ferdinandiana</i>	<ul style="list-style-type: none"> • Possible uses: anti-aging, brightening, skin repair, acne, bacterial and fungal skin infections and wound healing, cosmetics, food ingredient.¹ • Contains: vitamin C, gallic acid, ellagic acid, vitamin E. • Considered to be the richest source of plant vitamin C in the world.
4	Mānuka oil <i>Leptospermum scoparium</i> (high triketone chemotype)	<ul style="list-style-type: none"> • Sources: East Cape, New Zealand. • Possible uses: Acne, cuts, burns, fungal infections (e.g. athlete's foot, ringworm), ulcers, wounds, impetigo, eczema, herpes, psoriasis, dermatological therapeutics, skincare, cosmetics, food ingredient.¹ • Contains: Leptospermone, Calamenene, α-Pinene, Flavone.
5	Oregano oil from aerial parts <i>Origanum vulgare</i>	<ul style="list-style-type: none"> • Sources: Greece, Turkey. • Possible uses: acne, bacterial infections, warts, fungal and yeast infections, cuts, wounds, eczema, psoriasis, food ingredient.¹ • Contains: Carvacrol, <i>p</i>-Cymene, δ-Terpinene, Thymol.
6	Palmarosa <i>Cymbopogon martinii</i>	<ul style="list-style-type: none"> • Sources: India (including Nepal), Indochina. • Possible uses: bacterial infections such as boils and abscesses, yeast and fungal infections, acne, eczema, psoriasis, dry and damaged skin, wrinkles, cosmetics and fragrances, aids digestion.¹ • Contains: Geraniol, Geranyl acetate, Farnesol, Linalool.
7	Patchouli <i>Pogostemon cablin</i>	<ul style="list-style-type: none"> • Sources: Indonesia, China, Brazil and Malaysia. • Possible uses: abscesses, wounds, impetigo, dermatitis, cold sores, acne, eczema, yeast and fungal infections, scalp disorders, itching, chapped, damaged, cracked or scarred skin, cosmetics and fragrances, food ingredient.¹ • Contains: Patchoulol, Bulnesene, Guaiene, Patchoulene.
8	Sandalwood (East Indian) <i>Santalum album</i>	<ul style="list-style-type: none"> • Sources: India, Australia, Africa. • Possible uses: boils, wounds, acne, eczema, fungal and yeast infections, cold sores, genital herpes, burns, itching, sunburn, oily skin, cosmetics and fragrances. • Contains: α- and β- Santalol, Nuciferol, α-<i>trans</i>-Bergamotol, α- and β- Santalal.

9	Spearmint <i>Mentha spicata</i>	<ul style="list-style-type: none"> • Source: USA. • Possible uses: Acne, fungal and yeast infections, dermatitis, itching, scabs, sores, cosmetics and fragrances. Contains: (-)-Carvone, (+)-Limonene, 3-Octanol, (Z)-Dihydrocarvone.
10	Star anise <i>Illicium verum</i>	<ul style="list-style-type: none"> • Sources: China, Vietnam. • Used as a Chinese medicine and in Ayurveda for thousands of years. • Possible uses: food and beverages, cold sores, genital herpes, shingles, cosmetics and skincare.¹ • A key active ingredient in Tamiflu. • Contains: Anethole, Foeniculin, Estragole, Limonene.
11	Tea tree leaf oil <i>Melaleuca alternifolia</i>	<ul style="list-style-type: none"> • Sources: Australia, China, South Africa, Kenya, Indonesia and Thailand. • Possible uses: Acne, abrasions, abscesses, blisters, boils, carbuncles, sores, dandruff, fungal infections, herpes, ulcers, wounds, cuts, burns, insect bites, rashes, sunburn.¹ • Contains: Terpinen-4-ol, α- and δ Terpinene, 1,8-Cineole, α-terpineol.
12	Thyme <i>Thymus vulgaris</i>	<ul style="list-style-type: none"> • Source: France, Italy. • Possible uses: acne, cuts, burns, abscesses, sores, wounds, blisters, carbuncles, cellulitis, eczema, fungal and yeast infections, herpes, oily skin, deodorant.¹ • Contains: Thymol, <i>p</i>-Cymene, Carvacrol, δ-Terpinene.

¹ Also has anti-oxidant, anti-inflammatory properties.



Synergistic action

Mixing essential oil ingredients can lead to a synergistic therapeutic effect where the effect of combining essential oils is greater than the sum of the effects of the individual oils [6].

Synergies can be achieved if the compounds in the oil are able to affect different target sites on the pathogen cells, or they may interact with one another to increase solubility and bioavailability. The large number of chemical constituents in essential oils (compared with one/few constituents in antibiotics and other antimicrobials) can work together to inhibit the mutation of microbes that leads to antimicrobial resistance (AMR). The combined essential oil formulation also has the potential to decrease toxicity and adverse side effects by lowering the required treatment dosage.

For example, in the treatment of abscesses, bergamot orange (*Citrus bergamia*) and English Lavender (*Lavendula angustifolia*) may be used in combination. *C. bergamia* is used for its antiseptic properties and *L. angustifolia* for antiseptic and anti-inflammatory effects.

This is a complex area of microbiology since synergy in one area, e.g. anti-inflammatory properties, may not necessarily translate into synergy in another e.g. antimicrobial properties.

Quality and safety

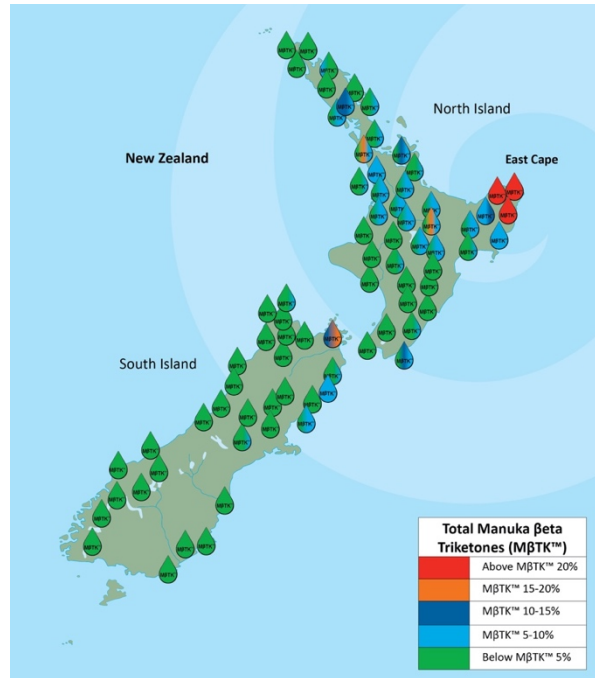
There is very little reliable information on the internet on the quality and safety of essential oils [7]. High quality essential oils from reputable suppliers are fresh, stored correctly, pure, and have a known origin and composition.

Clinical studies show that old or incorrectly stored oils can give rise to skin allergies, especially in people who are prone to dermatitis. For example, tea tree oil that is old or is exposed to air, light, humidity or high temperatures changes its chemical composition giving rise to allergic reactions in some people [8].

Purity of essential oils is extremely important since purity determines the therapeutic value of essential oils, as well as physical properties such as smell and colour. Unscrupulous suppliers adulterate high value essential oils with vegetable oils and other cheaper compounds to increase their profits. Typically, adulterants are added at 5-8% level to avoid detection through common scientific methods [9]. For example, high value Indian sandalwood oils may be adulterated with cheaper Australian and African sandalwood oil, amyris oil, castor oil, coconut oil bleached copaiba balsam, polyethylene glycol, glycol and other chemicals. Similarly, other popular essential oils such as lavender oil, peppermint oil, orange and lemon oil, eucalyptus oil, chamomile oil, rosemary oil, patchouli oil, clary sage oil, and cinnamon oil amongst others are adulterated by various means [7,9].

Chemical composition of essential oils can vary, depending on host of genetic and environmental factors (e.g. isolated position, temperature, humidity, rainfall, luminosity, UV radiation, altitude, soil conditions, seasonality, processing methods etc.) For example, the composition of mānuka oil from New Zealand is extremely variable. Mānuka oil comprises 11 chemotypes with intriguing patterns in their geographic distribution [10]. The commercially important triketone chemotype of mānuka (greater than 20% triketones), which has outstanding antibacterial, antiviral and antifungal properties, is found only in the East Cape region. Much of the mānuka found in other parts of New Zealand have triketone levels less than 5%. Furthermore, mānuka chemotypes that grow in Australia has very low triketone levels [11].

Figure 3:
New Zealand Geographic Variations in Total Triketone Content [8]



Toxicity and allergenicity

It is important to note that almost all essential oils with antimicrobial potential may cause skin irritations and/or allergic reactions in a small subset of the population, particularly those who are prone to dermatitis. These adverse reactions may be avoided by using relatively low concentrations of these potent ingredients in dermatological formulations and undertaking extensive in vivo (pre-clinical) and human (in vivo) clinical studies to ensure safety and efficacy.

Many popular essential oils with can cause skin irritation or allergic reactions if used without being properly diluted. For example, Tisserand Institute (UK) has suggested a topical maximum level of less than 1% for the following popular essential oils [7]:

- cinnamon bark and leaf oil
- cassia oil
- clove bud oil
- lemon grass oil
- bay oil
- hyssop oil
- mugwort oil
- Melissa oil
- Jasmine oil
- Ylang ylang oil

It is noteworthy that some essential oils come with the contraindication, “do not apply to or near the face of infants or young children”. Examples of this include eucalyptus oil and cardamom oil that can cause central nervous system (CNS) and breathing problems in young children.

Essential oils that are not recommended for use on any part of the bodies of very young children include oregano oil and star anise oil.

It is recommended that all essential oils are kept well out of reach of young children.

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