International Journal of Women's Dermatology 7 (2021) 304–308

Contents lists available at ScienceDirect

International Journal of Women's Dermatology

Review

Art of Prevention: Essential Oils - Natural Products Not Necessarily Safe

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ARTICLE INFO

Article history:
Received 9 March 2020
Received in revised form 20 October 2020
Accepted 30 October 2020

Keywords:
Essential oils
Allergic contact dermatitis
Patch testing
Lavender oil
Peppermint oil
Tea tree oil
Ylang-ylang oil

ABSTRACT

Aromatherapy is defined as the use of essential oils, through inhalation or direct application to the skin, to achieve physical, psychological, and spiritual well-being. It has become an increasingly popular trend in modern-day holistic approaches to health care. Essential oils are thought to be natural and pure products, some of the most common being lavender, tea tree, peppermint, and ylang-ylang. In recent years, however, the composition of these oils has been found to be more complex than previously thought. Increased use has led to increasing reports of allergic contact dermatitis (ACD), a delayed-type hypersensitivity reaction to allergens in sensitized individuals. Inquiring about essential oil use is important when conducting clinical evaluations of suspected ACD. Herein, the authors seek to highlight the possibility that natural products may not be necessarily as safe as once thought and in particular seek to highlight ACD caused by essential oils.

Contents

Introduction

Allergic contact dermatitis (ACD) is a type IV delayed hypersensitivity reaction that requires primary sensitization and a secondary allergic response to a contact allergen. Personal care products are well known for containing preservatives and fragrances that result in ACD. In recent years, essential oils have gained popularity with a more holistic approach to health care. Aromatherapy, the practice of inhaling or directly applying essential oils to the skin to achieve physical, psychological, and spiritual well-being, has become common practice (Corazza et al., 2019). A

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https://doi.org/10.1016/j.ijwd.2020.10.013

general population survey showed that essential oils were used due to past treatment failures, a desire for alternative treatments, and the thought that essential oils were safer than other available therapies (Goodier et al., 2019). Oils such as lavender, tea tree, peppermint, and ylang-ylang have become increasingly prevalent in over-the-counter personal care products and are used by patients for diffusing, oral ingestion, incorporation into homemade products, and direct application to the skin (Goodier et al., 2019). Although essential oils are typically marketed as pure, it is important to realize that their formulation is complex, exposing the skin to numerous potential allergens.

A breakdown of essential oils

Essential oils are derived from plant material that has undergone steam distillation. Despite their natural source, the chemical composition of each individual oil is not widely known by the general public (De Groot and Schmidt, 2016a). In the manufacturing process, essential oils often undergo "post treatment," which allows removal of specific chemicals, concentration of the oil, or change in color (De groot and Schmidt, 2016b). The final composition of each oil can vary based on, for example, country of production, harvest year, and production process (De Groot and Schmidt, 2016b). Most oils are marketed as pure, but this does not always correlate to the quality of the oil. Processes by which essential oils can be made of lesser quality include adulteration (adding additional products to the essential oil), aging (autooxidation leading to byproducts, such as hydroperoxides, which are more sensitizing), and contamination (De Groot and Schmidt, 2016b). Most essential oils contain 100 to 250 components; however, as many as 500 components have been found in select oils (De Groot and Schmidt, 2016c). Some of the most commonly found components include B-caryophyllene, limonene, linalool, and terpenes (De Groot and Schmidt, 2016c).

Lavender oil

Lavender, one of the most commonly marketed and used essential oils, is employed for its calming, soothing, and antimicrobial effects (Corazza et al., 2019). It is found in drinks, chewing gum, and sweet treats as a flavoring in addition to its use in aromatherapy (Warshaw et al., 2017). Lavender oil is composed of terpenes, linalool, linalyl acetate, and caryophyllene, among >450 other chemicals (Corazza et al., 2019). The chemicals thought to be most allergenic include linalool and linayl acetate (De Groot and Schmidt, 2016e). Lavender is not often reported by patients in the evaluation of ACD because it is marketed as both natural and safe. With the increased use of lavender, it has been added to the American Contact Dermatitis Society (ACDS) core patch testing series (Bingham et al., 2019) and is included in the North American Contact Dermatitis Group (NACDG) baseline screening series.

Tea tree oil

Tea tree oil has been used for its antibacterial, anti-fungal, and antiviral properties (Warshaw et al., 2017). It is used in its pure oil form, in addition to formulations such as shampoo. It has been shown to undergo the aging process after exposure to air, leading to the production of strong sensitizers, such as peroxides, epoxides, and endoperoxides (De Groot and Schmidt, 2016d). Other sensitizers in tea tree oil include terpinolene, ascaridole, alpha-terpinene, and oxidation products such as limonene (De Groot and Schmidt, 2016d). Tea tree oil is included in both the ACDS core and NACDG screening series (Hagen et al., 2016).

Peppermint oil

Peppermint oil is primarily used for its ability to soothe an upset stomach but is also used as a flavoring in gum, oral hygiene products, beverages, and sweets (Warshaw et al., 2017). The most prevalent allergens in peppermint oil are menthol, caryophyllene, limonene, alpha-pinene, piperitone, and pulegone (De Groot and Schmidt, 2016e). Peppermint oil is also included in the NACDG screening series (Hagen et al., 2016).

Ylang-ylang oil

Ylang-ylang oil is derived from ylang-ylang tree (*Cananga odorata*) flowers (De Groot and Schmidt, 2017). Given its floral tones, this oil is primarily employed as a fragrance in personal care products. It can also be used as a flavoring in beverages, candies, sweets, and baked goods (De Groot and Schmidt, 2017). When used for aromatherapy, it is marketed as helping depression, respiratory issues, high blood pressure, and anxiety (De Groot and Schmidt, 2017). The most prevalent allergens in ylang-ylang oil are alpha-farnesene, germacrene, beta-caryophyllene, benzyl acetate, benzyl benzoate, and linalool (De Groot and Schmidt, 2017). Ylang-ylang oil is included in both the ACDS and NACDG baseline screening series.

Other essential oils

Although lavender, tea tree, peppermint, and ylang-ylang are among the most commonly used oils for aromatherapy and personal care products, numerous other essential oils are available on the market and have allergenic potential. Table 1 lists other commonly used essential oils and their marketed benefits.

Essential oils in therapeutics

Essential oils and their components are commonly found in therapeutics, many of which are recommended by physicians for their analgesic, antipruritic, and cough suppressant/decongestant properties. Menthol, a component of peppermint oil, is found in popular pain- and itch-relief products, as well as cough-suppressant topical products. Camphor, a terpene derived from camphor trees, is frequently found in combination with menthol because it provides similar benefits. Eucalyptus oil, derived from eucalyptus trees, is in formulations that aid in decongestion and suppression of cough. These products are often employed by physicians as safer alternatives to other topical and systemic pharmaceuticals or in conjunction with additional therapies to achieve an added benefit. Although these plant-derived components retain their allergenic potential, they are compounded in significantly reduced concentrations compared with direct application of the oils to the skin and are therefore safer alternatives.

Allergic contact dermatitis to essential oils

As previously discussed, ACD is a delayed type IV hypersensitivity that requires primary sensitization with a secondary allergic response. Individuals at increased risk of ACD are those with frequent contact with an allergen and those with a breakdown in their normal skin barrier (i.e., patients with atopic dermatitis, or eczema). Occupations in which essential oils are commonly encountered include massage and aromatherapy (Corazza et al., 2019). Patients with a history of atopic dermatitis have a decreased barrier function that leads to increased exposure to allergic substances and allows for heightened sensitization and an allergic response. This can occur from direct application of oils, application

Table 1
Comprehensive clinical reference for commonly used essential oils.

Essential oil	Family	Components available for patch testing	Marketed benefits	Reports of associated dermatitis in the literature
Basil oil	Lamiaceae	Fragrance mix I, 8% pet (contains eugenol 1%)†; linalool 10% pet	Focus/calming, flavoring, massage	Kiec-Swierczynska et al., 2010
Bergamot oil	Lamiaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; dl-limonene (dipentene), 2% pet; linalool, 10% pet; oil of bergamot, 2% pet	Calming/stress relief, flavoring in teas	Kaddu et al., 2001
Black pepper oil	Piperaceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet	Flavoring, antioxidant and digestive support, massage	García-Zamora et al., 2019
Cardamom oil	Zingiberaceae	dl-limonene (dipentene), 2% pet; linalool, 10% pet	Digestive support, flavoring, clear breathing	Mobacken and Fregert, 1975
Cassia bark oil	Lauraceae	Cinnamic aldehyde, 1% pet†; benzaldehyde, 5% pet	Fragrance, immune support, massage, digestive and metabolism support	
Cedarwood oil	Pinaceae	Cedar oil, 10% pet	Relaxation, insect repellant, blemish-reducing	Franz et al., 1998; Noiles and Pratt, 2010
Cinnamon bark oil	Lauraceae	Cinnamic aldehyde, 1% pet†; fragrance mix I, 8% pet (contains eugenol 1%)†; linalool, 10% pet	Immune and metabolic support, throat analgesic, cleansing agent, mouth rinse, massage, insect repellant, flavoring	Ackermann et al., 2009; García-Abujeta et al., 2005
Citronella oil	Poaeceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; fragrance mix II, 14% pet (contains citronellol 0.5%)†; dl-limonene (dipentene), 2% pet; citronellal, 2% pet	Insect repellant, cleansing agent, fragrance, shampoo/conditioner additive	De Groot and Schmidt, 2016d; Larsen et al., 2001
Clary sage oil	Lamiaceae	Linalool, 10% pet	Massage, bath additive, stress relief, shampoo/conditioner additive, sleep-promoting	
Clove bud/leaf oil	Myrtaceae	Fragrance mix I, 8% pet (contains eugenol 1%)†; oil of cloves, 2% pet	Dental cleansing agent, throat analgesic, cardiovascular support, antioxidant	De Groot and Schmidt, 2016d
Coriander fruit oil	Apiaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; linalool, 10% pet	Blemish-reducing, massage, relaxation	Kanerva and Soini, 2001
Cypress oil	Cupressaceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet	Enhancement of senses, fragrance, reduce oily appearance of skin	Samaran et al., 2020; Tammaro et al., 2012
Eucalyptus oil	Myrtaceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; oil of Eucalyptus, 2% pet	Relaxation, skin moisturization, clear breathing, cleansing agent	De Groot and Schmidt, 2015; Noiles and Pratt, 2010
Geranium oil	Geraniaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; fragrance mix II, 14% pet (contains citronellol 0.5%)†; linalool, 10% pet	Skin and hair cleanser/moisturizer, calming, insect repellant	Larsen et al., 2001
Ginger oil	Zingiberaceae	Alpha pinene, 15% pet	Digestive support, relief of indigestion and nausea, calming, flavoring, massage	Kanerva et al., 1996
Grapefruit oil	Rutaceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet	Blemish-reducing, metabolic support, increasing motivation	
Juniper berry oil	Cupressaceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet	Kidney and urinary tract support, skin toner, calming, air freshener	
Jasminum grandiflorum absolute	Oleaceae	Benzylbenzoate, 1% pet; jasminum officinale oil (jasminum grandiflorum), 2% pet; linalool, 10% pet	Blemish-reducing, fragrance, promotes uplifting environment	De Groot and Schmidt, 2017; Larsen et al., 2001
Jasminum sambac absolute	Oleaceae	Benzyl alcohol, 1% pet; benzyl alcohol, 5% pet*; linalool, 10% pet	Blemish-reducing, fragrance, promotes uplifting environment	De Groot and Schmidt, 2017; Larsen et al., 2001
Lavender oil	Lamiaceae	Lavandula angustifolia oil (lavender oil), 2% pet*; linalool, 10% pet	Soothing, anxiety relief, sleep-inducing, flavoring, fragrance	Brown and Browning, 2016; Corazza et al., 2019; De Groot and Schmidt, 2016e; Varma et al., 2000
Lemon oil	Rutaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; oil of lemon, 2% pet	Cleansing agent, air freshener, respiratory support, uplifting	Schubert, 2006
Lemongrass oil	Poaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; dl-limonene (dipentene), 2% pet; linalool, 10% pet; oil of lemongrass, 2% pet	Digestive support, massage, flavoring, insect repellant	De Groot and Schmidt, 2016e
Marjoram oil	Lamiaceae	Linalool, 10% pet	Massage, calming, cardiovascular support, stress relief, flavoring	Anderson et al., 2000
Melissa oil	Lamiaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; dl-limonene (dipentene), 2% pet; citronellal, 2% pet	Immune support, anxiety relief, relaxation	
Olibanum (frankincense) oil	Burseraceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet	Cellular support, fragrance, blemish-reducing, immune support, massage	Anderson et al., 2000
Orange oil, sweet	Rutaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; linalool, 10% pet; orange oil, 2% pet	Cleansing agent, immune support, promote uplifting environment	De Groot and Schmidt, 2016d; Schubert, 2006

Table 1 (*continued*)

Essential oil	Family	Components available for patch testing	Marketed benefits	Reports of associated dermatitis in the literature
Patchouli oil	Lamiaceae	Oil of patchouli, 10% pet	Blemish-reducing, wrinkle-reducing, promotes balance	
Peppermint oil	Lamiaceae	Menthol, 1% pet; mentha piperita oil (peppermint oil) 2% pet‡	Digestive support, reduction in nausea, respiratory support, mouth rinse, insect repellant	Bourgeois and Goossens, 2016; De Groot and Schmidt, 2016e; Kalavala et al., 2007; Tran et al., 2010
Petitgrain bigarade oil	Rutaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; dl-limonene (dipentene), 2% pet; linalool 10% pet	Cardiovascular and immune support, antioxidant, calming, sleep-support, calming	
Rose oil	Rosaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; fragrance mix II, 14% pet (contains citronellol 0.5%)†; oil of rose, 0.5% pet	Skin moisturizer, blemish-reducing, stress relief, promotes energy	Ochando-Ibernón et al., 2018
Rosemary oil	Lamiaceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; oil of rosemary, 0.5% pet	Digestive support, respiratory support, fatigue reduction, calming, flavoring	Gonzalez-Mahave et al., 2006; Inui and Katayama, 2005
Sandalwood oil	Santalaceae	Fragrance mix II, 14% pet (contains farnesol 2.5%)†; sandalwood oil, 10% pet	Skin/hair moisturizer, promotes positivity, fragrance	An et al., 2005; De Groot and Schmidt, 2016d, 2017
Silver fir oil	Pinaceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet	Massage, fragrance, refreshing	
Spearmint oil	Lamiaceae	dl-limonene (dipentene), 2% pet; carvone, 5% pet‡	Digestive support, reduction of nausea, flavoring, dental cleansing agent, promotes positivity	Clayton and Orton, 2004; Gunatheesan et al., 2012; Larsen et al., 2001
Tangerine oil	Rutaceae	Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet	Digestive and metabolic support, flavoring, cleansing agent, promotes uplifting mood	Vilaplana and Romaguera, 2002
Tea tree oil	Myrtaceae	Tea tree oil, oxidized 5% pet†	Skin cleansing agent, surface cleansing agent, air freshener, additive to shampoos/conditioners	De Groot and Schmidt, 2016d, 2016f; Storan et al., 2016; Varma et al., 2000
Thyme oil	Lamiaceae	Fragrance mix I, 8% pet (contains geraniol 1%)†; linalool, 10% pet	Antioxidant, immune support, insect repellant, flavoring	Anderson et al., 2000
Ylang-ylang oil	Annonaceae	Cananga odorata (ylang ylang I), 2% pet†; linalool, 10% pet	Antioxidant, bath additive, relaxation, fragrance, hair moisturizer	De Groot and Schmidt, 2016d, 2017; Romaguera and Vilaplana, 2000

Benefits and applications are not approved by the U.S. Food and Drug Administration.
* Components available for patch testing in the ACDS core series.
† Components available for patch testing in the NACDG baseline screening series and ACDS core series.
‡ Components available for patch testing in the NACDG baseline screening series.

of personal care products containing essential oils, or the diffusion of oils (cause of airborne contact dermatitis; Shah et al., 2019). Approximately 80 essential oils have been shown to cause contact allergy (De Groot and Schmidt, 2016d). Table 1 references the reported dermatitis in the literature for specific essential oils that are widely used. It is important to consider patch testing for essential oil contact allergy in patients with frequent contact with oils and in patients with a history of atopic dermatitis with recalcitrant disease despite typical treatment methods.

Clinical considerations

It is important to recognize that not all forms of dermatitis related to essential oils or other plant products are true ACD or delayed type IV hypersensitivity reactions. Because essential oils contain many plant products and chemicals, their application can lead to an irritant contact dermatitis, defined by a direct physical or chemical injury to the epidermis. This reaction typically occurs more quickly after application, as opposed to the delayed reaction associated with an allergy. Irritant contact dermatitis can appear clinically similar to ACD, with eczematous papules and plaques, some with overlying vesiculation if severe or fissuring if chronic. Patch testing can be helpful in elucidating irritant versus ACD. Another possible clinical presentation is dermatitis in a geometric pattern associated with vesiculation and subsequent hyperpigmentation. Should this be observed after application of essential oils, especially those from citrus fruits or bergamot, the clinician should consider phytophotodermatitis. This entity involves a reaction to furocoumarins in plant-based products with ultraviolet A, leading to a phototoxic eruption. Given its unique clinical presentation, this is often more easily distinguished from true ACD.

Patch testing

The NACDG screening series includes tea tree, peppermint, and ylang-ylang oils (De Groot and Schmidt, 2016d; Hagen et al., 2016). Because of the similarities in the chemical structure of many essential oils and fragrances, co-sensitization is common, with frequent positive patch tasting reactions to fragrance mix I, fragrance mix II, and myroxylon pereirae resin (Corazza et al., 2019). Studies have been conducted to determine the common breakdown products of the most frequently used essential oils (De Groot and Schmidt, 2016c). Many of these breakdown products, including geraniol, eugenol, citronellol, linalool, limonene, and alpha pinene (De Groot and Schmidt, 2016c), are available for patch testing (Table 1). With the complexity of essential oils, however, it is important to test to specific oils, given that fragrance mixes alone are not sufficient for elimination of essential oil contact allergy (De Groot and Schmidt, 2016d; Warshaw et al., 2017).

In a prior study, 54 essential oils were tested in patients, with positive patch test reactions ranging between 1% and 2% (De Groot and Schmidt, 2016d). Relevance data provided by the NACDG showed a "definite" and "probable" relevance of positive patch test reactions as high as 69% (30%-69%) in lavender oil, 20% to 56% in tea tree oil, and 36% to 39% in peppermint oil (De Groot and Schmidt, 2016d). It is often difficult to accurately determine the responsible allergen owing to the complexities of the chemical compositions and co-reactivity with other fragrances

(De Groot and Schmidt, 2016d). Although the screening series includes several popular essential oils, it is important to test patients against their own products because the composition may have been altered by the aging process (De Groot and Schmidt, 2016d). Testing can be achieved safely for most essential oils with a formulation of 2% to 5% oil concentrations in petrolatum (De Groot and Schmidt, 2016d). When evaluating patch testing results and distinguishing irritant versus ACD, grading the palpability of the reaction and the presence or absence of vesiculation is important. Irritant reactions are often erythematous without palpability. True allergic reactions should be palpable with increasing palpability and overlying vesiculation with an increased response.

Practical intervention

When evaluating a patient for ACD, a thorough history should be obtained, including occupational exposures, use of personal care products, and use of essential oils. Because essential oil use is not typically reported by patients, it is important to ask about specific use of topical oils, ingestion of oils, oils that have been added to homemade products, and oils that may be diffused in the home. When considering patch testing to essential oils, it is helpful to test patients against their personal products owing to the auto-oxidation process and change in chemical composition. It is also helpful to have knowledge of the essential oils and their breakdown products included in each baseline screening series (NACDG vs. ACDS) to determine whether specific oils/breakdown products of concern are included or should be added with additional patches. Although it may seem that essential oil contact allergy is not widely prevalent, it is often a relevant finding and can have a significant impact on a patient's quality of life. With the increasing use of essential oils, there is expected to be increased contact allergy necessitating need for increased knowledge of essential oils and patch testing against them.

Conflicts of interest

None.

Funding

None.

Study approval

The author(s) confirm that any aspect of the work covered in this manuscript that has involved human patients has been conducted with the ethical approval of all relevant bodies.

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