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.

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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 (autoxidation 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 β-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 linalyl 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 alphafarnesene, 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
| 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 teats                                                                                                                                                                      | Kaddu et al., 2001                                                                                                                                                                             |
| Black pepper oil      | Piperaceae   | Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; linalool, 10% pet; oil of bergamot, 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                                                                                                                                                                | Mlobacken and Frevert, 1975                                                                                                                                                                    |
| Cassia bark oil       | Lauraceae   | Cinnamic aldehyde, 1% pet; benzaldehyde, 5% pet                                                                            | Fragrance, immune support, massage, digestive and metabolism support                                                                                                                                          | Ackermann et al., 2009; García-Abujeta et al., 2005                                                                                      |
| 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                              | Insect repellent, cleansing agent, fragrance, shampoo/conditioner additive                                                                                                                                 | De Groot and Schmidt, 2016d; Larsen et al., 2001                                                                                      |
| Citronella oil        | Poaceae     | 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 repellent, cleansing agent, throat analgesic, cleansing agent, mouth rinse, massage, insect repellent, flavoring                                                                                       | 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                                                                                                                       | De Groot and Schmidt, 2016d; Larsen et al., 2001                                                                                      |
| 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; Larsen et al., 2001                                                                                      |
| 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; linalool, 10% 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; linalool, 10% pet                                                 | Blemish-reducing, metabolic support, increasing motivation kidney and urinary tract support, skin toner, calming, air freshener                                                                             | De Groot and Schmidt, 2017; Larsen et al., 2001                                                                                       |
| Juniper berry oil     | Cupressaceae| Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; linalool, 10% pet                                                 | Kidney and urinary tract support, skin toner, calming, air freshener                                                                                                                                            | De Groot and Schmidt, 2017; Larsen et al., 2001                                                                                       |
| Jasminum grandiflorum absolute | Oleaceae | Benzylbenzoate, 1% pet; jasmine officinal 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                                                                                                                                                                    | Anderson et al., 2000                                                                                                                  |
| Olibanum (frankincense) oil | Burseraceae | Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; linalool, 10% pet; orange oil, 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                                                                                           |
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 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 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 testing 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, 2016d, 2016f; Storan et al., 2016; Larsen et al., 2001; Gunatheesan et al., 2012; Clayton and Orton, 2004; De Groot and Schmidt, 2016d, 2016f; Storan et al., 2016; Varma et al., 2000; Anderson et al., 2000; Vilaplana, 2002; De Groot and Schmidt, 2016d; Ochando-Ibernón et al., 2018; Gonzalez-Mahave et al., 2006; Inui and Katayama, 2005; Vilaplana and Romaguera, 2002; Orton et al., 2004; Larsen et al., 2001; Graf et al., 1998; Vilaplana, 2000; De Groot and Schmidt, 2016d, 2016f; Storan et al., 2016; Vilaplana et al., 2002; Vilaplana and Romaguera, 2002; Vilaplana, 2000; Vilaplana, 2000)

Table 1

| 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 | Bourgeois and Goossens, 2016; De Groot and Schmidt, 2016d; Kalavala et al., 2007; Tran et al., 2010 |
| Peppermint oil | Lamiaceae | Menthol, 1% pet; mentha piperita oil (peppermint oil) 2% pet | Digestive support, reduction in nausea, respiratory support, mouth rinse, insect repellant | De Groot and Schmidt, 2016d |
| 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 | Ochando-Ibernón et al., 2018 |
| 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 | Gonzalez-Mahave et al., 2006; Inui and Katayama, 2005 |
| 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 | An et al., 2005; De Groot and Schmidt, 2016d, 2017 |
| Sandalwood oil | Santalaceae | Fragrance mix II, 14% pet (contains farnesol 2.5%); sandalwood oil, 10% pet | Skin/hair moisturizer, promotes positivity, fragrance | Silver fir oil | Pinaceae | Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet | Promotes uplifting mood, skin cleansing agent, surface cleansing agent, additive to shampoos/conditioners | Clayton and Orton, 2004; Gunatheesan et al., 2012; Larsen et al., 2001; Vilaplana and Romaguera, 2002 |
| Silver fir oil | Pinaceae | Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet; oil of rosemary, 0.5% pet | Digestive support, reduction of nausea, flavoring, dental cleansing agent, promotes positivity | De Groot and Schmidt, 2016d, 2016f; Storan et al., 2016; Vilaplana et al., 2002; Vilaplana and Romaguera, 2002; Vilaplana, 2000 |
| Tangerine oil | Rutaceae | Alpha pinene, 15% pet; dl-limonene (dipentene), 2% pet | Digestive and metabolic support, flavoring, cleansing agent, promotes uplifting mood | Clayton and Orton, 2004; Gunatheesan et al., 2012; Larsen et al., 2001; Vilaplana and Romaguera, 2002 |
| Thyme oil | Lamiaceae | Fragrance mix I, 8% pet (contains geraniol 1%); linalool, 10% pet | Antioxidant, immune support, insect repellent, 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.

1 Components available for patch testing in the NACGD baseline screening series and ACDS core series.

2 Components available for patch testing in the NACDG baseline screening series.
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 own products owing to the auto-oxidation process and change in chemical composition. It is also helpful to have knowledge of the essential oils included 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.

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**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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