

Essential Oils, Part IV: Contact Allergy

Anton C. de Groot, MD, PhD and Erich Schmidt

Nearly 80 essential oils (including 2 jasmine absolutes) have caused contact allergy. Fifty-five of these have been tested in consecutive patients suspected of contact dermatitis, and nine (laurel, turpentine, orange, tea tree, citronella, ylang-ylang, sandalwood, clove, and costus root) showed greater than 2% positive patch test reactions. Relevance data are generally missing or inadequate. Most reactions are caused by application of pure oils or high-concentration products. The clinical picture depends on the responsible product. Occupational contact dermatitis may occur in professionals performing massages. The (possible) allergens in essential oils are discussed. Several test allergens are available, but patients should preferably be tested with their own products. Co-reactivity with other essential oils and the fragrance mix is frequent, which may partly be explained by common ingredients. Patch test concentrations for essential oils are suggested.

In this fourth article of a series, 1–4, contact allergy to essential oils are discussed. Full literature data on specific aspects of contact allergy to and allergic contact dermatitis from individual oils are found in reference 2.^{1–4}

Essential Oils That Have Caused Contact Allergy

Nearly 80 essential oils (including jasmine absolute) have caused contact allergy (as demonstrated by positive patch test reactions) or allergic contact dermatitis (Table 1). Of these, 45 have been tested in groups of consecutive patients suspected of contact dermatitis. In the United States, 4 essential oils (tea tree oil, lavender oil, peppermint oil, and ylang-ylang oil) and 1 absolute (jasmine absolute) are currently present in the screening series of the North American Contact Dermatitis Group (NACDG).⁶ Testing in groups of selected patients has been performed with 53 essential oils, usually in patients suspected of fragrance allergy or cosmetic dermatitis or patients who previously had a positive reaction to the fragrance mix I (FM I) or to one of the other indicators of fragrance allergy such as *Myroxylon pereirae* resin (balsam of Peru). Case reports of allergic contact dermatitis were found for 67 oils.

Contact allergy to 13 oils was mentioned in 1 publication only; more extensive literature is available for oils of cananga, clove, eucalyptus, geranium, jasmine absolute, lavender, lemon, lemongrass, peppermint, rose, sandalwood, spearmint, turpentine, tea tree, and

ylang-ylang. Most case report publications (with 1 or more patients described) were found for tea tree oil (n = 30), followed by oils of lavender (n = 19), peppermint (n = 18), geranium (n = 14), turpentine (n = 12, not fully reviewed), spearmint (n = 11), ylang-ylang (n = 10), lemon (n = 9), and cananga, clove, eucalyptus, jasmine absolute, lemongrass, and rose oils (8 publications each).

Frequency of Contact Allergy to Essentials Oils

For the frequency of contact allergy to essential oils, prevalence rates of positive patch test reactions, tested in consecutive patients suspected of contact dermatitis, can be used as an indication. Of the 54 essential oils that have been tested in consecutive patients (number of studies per oil ranging from 1 to 19), 11 have had maximum rates of positive patch test reactions between 1% and 1.5%, and in nine, rates of greater than 2% have been observed. These are, in order of descending maximum values, laurel oil (6.9%) (old data, cited in Foussereau et al⁷), turpentine oil (4.2%), orange oil (3.2%), tea tree oil (2.7%), citronella oil (2.5%), ylang-ylang oil (2.6%), sandalwood oil (2.4%), clove oil (2.1%), and costus root oil (2.1%) (historical allergen). Thus, it seems that contact allergy to essential oils as a group is not very frequent. Nevertheless, in the general German adult population, 2.5% of 1141 test subjects reacted to oil of turpentine (4.3% of the women and 0.7% of the men).⁸ Currently, the highest observed prevalences of positive patch test reactions—depending on the country and which oils are patch tested—are observed with tea tree oil, ylang-ylang oil, and sandalwood oil. The latter observation is surprising because the price of sandalwood oil is so high that it is virtually only used in fine fragrances.

Clinical Relevance of Positive Patch Test Reactions to Essential Oils

Determining the clinical relevance of positive patch test reactions to essential oils seems to be difficult. In greater than 80% of all

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TABLE 1. Essential Oils That Have Caused Contact Allergy/Allergic Contact Dermatitis and Probable Allergens Identified (Adapted From De Groot and Schmidt²)

Name of Essential Oil	Probable Allergen(s) Identified*	Name of Essential Oil	Probable Allergen(s) Identified*
Angelica oil	α -Pinene	Mandarin oil	
Aniseed oil	Anethole	Marjoram oil (sweet)	Caryophyllene, linalool, α -pinene
Basil oil, sweet	Linalool	Melissa oil (lemon balm oil)	Caryophyllene, geraniol
Bay oil	Eugenol	Myrrh oil	
Bergamot oil	Limonene, linalool, β -pinene	Neem oil	
Black cumin oil		Neroli oil	Geraniol
Black pepper oil	Caryophyllene, α -pinene	Niaouli oil	α -Pinene
Cajeput oil	Caryophyllene, α -pinene	Nutmeg oil	
Calamus oil		Olibanum (frankincense) oil	Caryophyllene, α -pinene
Cananga oil		Orange oil, bitter	
Cardamom oil		Orange oil, sweet	Limonene
Carrot seed oil		Palmarosa oil	
Cassia oil	Cinnamic aldehyde	Patchouli oil	
Cedarwood oil		Peppermint oil	Caryophyllene, limonene, menthol, α -pinene, piperitone, pulegone
Chamomile oil, German		Petitgrain bigarade oil	Geraniol, linalool
Chamomile oil, Roman		Pine needle oil	α -Pinene
Cinnamon oil	Cinnamic aldehyde, eugenol	Ravensara oil	Linalool, α -pinene
Citronella oil	Citronellal, citronellol, geraniol, geranyl acetate, limonene	Rosemary oil	Linalool, α -pinene
Clary sage oil	Geraniol, linalool	Rose oil	Citronellol, geraniol, linalool
Clove oil	Eugenol	Rosewood oil	Linalool
Coriander fruit oil	Linalool, α -pinene	Sage oil	
Costus root oil		Sandalwood oil	Santalol
Cypress oil	α -Pinene	Silver fir oil	
Dwarf pine oil		Spearmint oil	Carvone
Elemi oil		Spike lavender oil	
Eucalyptus oil	α -Pinene	Star anise oil	Anethole, methyl chavicol, limonene
Galbanum resin oil	α -Pinene	Tangerine oil	
Geranium oil	Caryophyllene, citral (neral + geranial), citronellol, geraniol, linalool	Tea tree oil	Aromadendrene, ascaridole, <i>d</i> -carvone, <i>l</i> -carvone, 1,8-cineole, <i>p</i> -cymene, <i>d</i> -limonene, myrcene, α -phellandrene, α -terpinene, terpinen-4-ol, terpinolene, 1,2,4-trihydroxymenthane, sabinene, viridiflorene
Ginger oil			
Grapefruit oil			
Guaiacwood oil			
Hinoki oil ⁵			
Hyssop oil			
Jasmine absolute	Eugenol, linalool		
Juniper berry oil	α -Pinene	Thuja oil	
Laurel leaf oil		Thyme oil	Linalool, α -pinene
Lavandin oil		Turpentine oil	Dipentene, α -phellandrene, α -pinene, β -pinene, α -terpineol
Lavender oil	Caryophyllene, linalool	Valerian oil	
Lemongrass oil	Citral (geranial + neral), geraniol	Vetiver oil	
Lemon oil	Limonene, β -pinene		
<i>Litsea cubeba</i> oil		Ylang-ylang oil	Caryophyllene, linalool
Lovage oil		Zdravetz oil	

*Patch test reactivity to 1 or more chemicals that have been demonstrated in the essential oil used by the patient by chemical analysis or known to be present in such oils in high concentrations (eg, geraniol in geranium and rose oils, citronellal and citronellol in citronella oils, cinnamaldehyde in cinnamon oils) or that have been demonstrated in commercial samples of the essential oil in question in concentrations greater than 3% (analytical data from Erich Schmidt²).

studies in which oils were tested in consecutive dermatitis patients, no information on relevance was provided. In fact, for nearly two thirds of all oils, no information on relevance is available at all. In 1 study, the observed patch test reactions to the tested essential oils were considered to be relevant in 82% to 100%. Unfortunately, this was a rather weak study, where “questionable” and “past” relevance were included.⁹ The NACDG provides relevance data for the essential oils, which are included in the NACDG screening series.¹⁰ Percentages for “definite” and “probable” relevance in various NACDG studies were as follows: lavender oil, 30% to 69%; tea tree oil, 20% to 56%; peppermint oil, 36% to 39%; jasmine absolute, 14% to 37%; and ylang-ylang oil, 0% to 27%. Rates for “definite” relevance were usually less than 10% to 15% and sometimes zero. It may thus be concluded that reliable data on the relevance of positive patch test reactions to essential oils as reported in literature are largely lacking or inadequate. Insufficient knowledge of the chemical composition of essential oils and difficulties in ascertaining whether oils or their ingredients are present in materials with which the patients have contact may partly be responsible. In addition, a previously acquired contact allergy to a fragrance chemical per se may result in a positive patch test to an essential oil containing it. Thus, previous sensitization to geraniol from any source may result in nonrelevant positive patch test reactions to rose oil and geranium oil, both of which contain high concentrations of geraniol.¹¹ Previously acquired contact allergy to limonene has resulted in nonrelevant positive patch tests to tea tree oil.¹²

Products Responsible for Allergic Contact Dermatitis From Essential Oils

The categories of products most frequently responsible for allergic contact dermatitis from essential oils are shown in Table 2.

Pure oils are usually applied to the skin for alleged therapeutic actions. This is certainly the case with tea tree oil; at least 85 patients with allergic contact dermatitis from tea tree oil have been described in case reports, mostly by the application of neat oil. A

separate category of patients who become sensitized to pure oils or diluted oils in high concentrations is that of people who have frequent contact with such products at work, for example, aromatherapists and masseurs. Many such cases of occupational contact dermatitis to essential oils have been described. Essential oils are widely used in cosmetic products, and the development of allergic cosmetic dermatitis from them has been reported in 20 publications. However, related to their widespread use, the role of cosmetics in essential oil contact allergy is modest.

Although toothpastes are diluted under normal use circumstances and the contact time with the oral mucosa, lips, and perioral skin is short, essential oils in these products have been reported to cause contact allergic reactions repeatedly.^{17,18} Essential oils in topical pharmaceutical preparations are mostly used as masking fragrance, not as an active ingredient. Sensitization is facilitated by application of these products on damaged skin.^{19,20}

Clinical Picture of Allergic Contact Dermatitis From Essential Oils

There are no descriptions of the clinical picture of allergic contact dermatitis from essential oils in larger groups of patients. Since the products in which the oils may be present vary considerably, as do the sites of application and the goals of applying the oils to the skin, the presentation of patients with allergic contact dermatitis from essential oils may take various forms.

Undiluted oils may be applied for therapeutic purposes, notably tea tree oil. Dermatitis will appear at the site of application and may stay limited to the primary site, but spreading of dermatitis is not infrequent, and even generalization occurs occasionally.²¹ The same applies to topical pharmaceutical products. In a group of 127 patients with iatrogenic allergic contact dermatitis from essential oils and other fragrances in topical pharmaceutical drugs, women were more frequently affected than men, and the legs, hands, and face were the most commonly affected body sites.¹⁹ Essential oils are frequently added to toothpastes, especially

TABLE 2. Categories of Products Most Frequently Responsible for Allergic Contact Dermatitis From Essential Oils

Product Category	Causative Essential Oils Reported/Products	References (Examples)
Pure essential oils	Black cumin, citronella, laurel, lavender, lovage, neem, patchouli	Athanasiadis et al, ¹³ Lapeere et al ¹⁴
Massage products	Mostly occupational allergic contact dermatitis to a large number of essential oils	
Cosmetic products	Angelica root, black cumin, citronella, eucalyptus, geranium, jasmine absolute, laurel, lavender, lemon, neroli, niaouli, orange, peppermint, rose, tea tree, ylang-ylang	Nardelli et al ^{15,16}
Toothpastes and other oral preparations	Aniseed, cassia, cinnamon, cloves, laurel, peppermint, spearmint	Magnusson and Wilkinson, ¹⁷ Clayton and Orton ¹⁸
Pharmaceutical products	Cinnamon, dwarf pine, eucalyptus, geranium, laurel, lavender, neroli, pine needle, Roman chamomile, rose, tea tree, peppermint	Nardelli et al, ¹⁹ Lauriola et al ²⁰
Other products	Immersion oil, mud bath, aromatherapy lamps, wax polish	

spearmint, peppermint, and cinnamon oils. Contact allergy may lead to symptoms of the oral mucosa, the lips, and the perioral skin including perioral dermatitis, cheilitis, burning/sore mouth, stomatitis, swelling of the tongue, lips and gingival mucosa, and ulceration of the mouth.¹⁷ There are some indications that oral lichen planus may be worsened by contact allergy to essential oils.²² Rare cases of pigmented contact dermatitis, airborne allergic contact dermatitis, systemic contact dermatitis,²³ and erythema multiforme-like reactions¹³ from contact allergy to essential oils have been reported.

Dermatitis From Occupational Exposure

There have been many case reports of patients who developed occupational allergic contact dermatitis from oils used for massaging clients, including aromatherapists,^{24,25} masseurs,²⁶ beauticians, and physiotherapists.²⁶ The patients are usually women and present with dermatitis of the hands and sometimes of the forearms. In a number of them, dermatitis spreads to other parts of the body and may become generalized.²⁵ The use of products such as massage oils, creams, or lotions containing essential oils has been shown to be a significant independent risk factor for hand dermatitis in this population.²⁷ Occupational allergic contact dermatitis from essential oils has also been observed in workers in the fragrance and cosmetic industries,²⁸ in the food industries, and in several other occupations including hairdressers.

The Allergens in Essential Oils

With the exception of tea tree oil and turpentine oil, large-scale patch testing with components of essential oils in allergic patients to determine the major sensitizers has not been performed. Tea tree oil, stored in open bottles or in a bottle opened several times, has an aging process resulting in photo-oxidation leading to degradation products (peroxides, epoxides, and endoperoxides), which are strong sensitizers. The most important sensitizers in tea tree oil seem to be terpinolene, ascaridole, α -terpinene, and its oxidation products 1,2,4-trihydroxymenthane, α -phellandrene, *d*-limonene, and myrcene.²⁹ In turpentine oil, the allergens are δ 3-carene hydroperoxides (in oils from Scandinavia [probably hardly used anymore] and Indonesia), α -pinene, oxidized limonene, β -pinene, α -terpineol, and rarely, α -phellandrene.³⁰

For some other oils, their major allergens can tentatively be identified on the basis of their general composition and co-reactions to important ingredients in patch testing as documented in literature. For example, 50% of 94 patients allergic to clove oil co-reacted to eugenol, which is the major ingredient (>82%) of this essential oil.³¹ Eugenol is also an important component of bay oil (40%–55%). Of 7 patients reacting to bay oil and tested with eugenol, five (71%) co-reacted to eugenol.³² In the case of lemongrass oil, of 67 patients reacting to this oil, 34 (51%) also reacted to citral. Citral consists of geranial + neral, both of which are the dominant ingredients of lemongrass oils.³¹ Similar combinations include geraniol and geranium oil,^{9,11} geraniol and rose oil,^{9,11} cinnamic

aldehyde and cinnamon oil, menthol and peppermint oil, and carvone and spearmint oil. In citrus peel oils (bergamot, grapefruit, lemon, orange, mandarin, tangerine), limonene is by far the most important constituent (70%–98%) but has thus far not been identified as a main allergen. The reason may be that patients allergic to citrus peel oils have not yet been tested with oxidized limonene, which is the allergenic form of limonene.³³ Probably for the same reason, linalool has as yet not been found as a major allergenic ingredient of lavender and ylang-ylang oils, in which high concentrations of linalool and linalyl acetate are present.

Determination of the allergenic ingredients of essential oils by analyzing oils that caused allergic contact dermatitis has been performed in a few studies only (eg, Ref. 24). Possible or probable allergens in essential oils are shown in Table 1.

Patch Testing With Essential Oils and Their Ingredients

Essential oils should be patch tested in any patient suspected of contact allergy to these oils on the basis of the patient's history and the clinical picture. Suspicion is high in cases of hand dermatitis in aromatherapists, masseurs, and so forth; in patients working in the fragrance industry and the food industry; and in individuals who have applied essential oils to their skin, for example, for therapeutic

TABLE 3. Essential Oils That are Commercially Available for Patch Testing

Essential oil	Suppliers			
	Trolab	Chemo	Brial	Allergeaze
Bergamot oil			2%	2%
Cananga oil		2%		
Cedarwood oil	10%		10%	10%
Cinnamon oil			0.5%	0.5%
Clove oil	2%		2%	2%
Eucalyptus oil	2%		2%	
Geranium oil, Bourbon		2%		
Jasmine absolute	5%	2%	2%	2%
Laurel leaf oil	2%		2%	2%
Lavender oil		2%	2%	2%
Lemongrass oil	2%		2%	2%
Lemon oil	2%		2%	2%
Neroli oil	2%		5%	2% and 5%
Orange oil	2%		2%	2%
Patchouli oil	10%			10%
Peppermint oil	2%	2%	2%	2%
Rosemary oil			0.5%	0.5%
Rose oil		2%, extract	0.5%	0.5%
Sandalwood oil	10%	2%		10%
Tea tree oil		5% ox		5% ox
Turpentine oil	10%	0.4% ox	10%	10%
Ylang-ylang oil	10%	2%		2%

All test substances are in petrolatum unless otherwise indicated. ox indicates oxidized. Trolab, www.smartpracticeurope.com.de; Chemotechnique, www.chemotechnique.se; Brial, www.brial.com; Allergeaze, www.allergeaze.com. Situation end of 2014. Brial and SmartPractice Europe have merged in September 2015.

purposes (notably tea tree oil). In addition, in any patient with symptoms of the oral mucosa, lips (cheilitis), and perioral skin, contact allergy to essential oils in toothpastes or other oral preparations should be considered. However, the range of products in which essential oils can be present is broad, and localization and aspect of essential oil-induced allergic contact dermatitis are often not specific.

Several essential oils are available as commercial patch test substances (Table 3). Four essential oils and jasmine absolute are currently present in the screening series of the NACDG and tested in all consecutive patients suspected of contact dermatitis.⁶ Many other investigators test a series of essential oils and other fragrance materials when fragrance contact allergy is suspected. Another indication for further testing is when a patient has previously shown positive patch test reactions to one or more of the fragrance indicator allergens, such as the fragrance mix(es) and *Myroxylon pereirae* resin; to an essential oil; to other fragrance materials; or to the patient's personal fragrances or fragranced cosmetics.

For screening purposes, these series of commercial allergens are very useful. However, when patients have a history of contact with 1 or more oils, it is preferable (if not imperative) to test these products themselves because of the strong variability that may occur in the composition of essential oils. In addition, in aged oils that have been exposed to light, oxygen, and temperature changes, new allergenic chemicals may have formed (which is well known in, eg, tea tree oil and lavender oil), which are not present in adequately stored (cool, dark, unexposed to air) commercial test substances.

For most essential oils, testing at 2% to 5% in petrolatum (or both, unless many oils are tested, risking false-positives due to the excited skin syndrome) will likely be adequate. Lower concentrations may be appropriate for costus root oil (0.1%, very unlikely to encounter, historical allergen), black cumin oil (0.5%), star anise oil (0.5%; it may be preferable to test the main ingredient, anethole 5%), and cassia and cinnamon (bark) oils (1%, because of the very high concentrations of cinnamic aldehyde). When obtaining positive patch tests to 1 or more essential oils, a search for the allergenic ingredients should preferably be initiated. Likely candidates are discussed previously in the section "The Allergens in Essential Oils" and in Table 1, right column. A list of all chemicals that can be present in essential oils and that have caused contact allergy (either from their presence in essential oils or from other sources, $n > 100$) is provided in Ref. 2.

Co-Reactivity to Other Test Substances in Patients Reacting to Essential Oils

In most publications, patients reacting positively to an essential oil co-reacted, if tested, to other essential oils, the FM I, the fragrance mix II (FM II), *Myroxylon pereirae* resin (balsam of Peru), individual fragrance chemicals, or a combination of these.

Essential Oils

Many patients in case reports react to a great number of essential oils, which is certainly true for aromatherapists and other

professionals using oils and essential oil-containing products for massaging their clients. Of 2 aromatherapists, for example, one reacted to 32 essential oils, and the other reacted to 21 essential oils.²⁴ Another aromatherapist was patch test positive to 17 of 20 oils used at her work.³⁴ In a group of 19 patients allergic to fragrances and tested with a series of essential oils, six reacted to 1 oil only, three reacted to 2 oils, three reacted to 3 oils, three reacted to 4 oils, two reacted to 5 oils, one reacted to 7 oils, and one even had positive patch test reactions to 9 oils.³²

Fragrance Mixes

Co-reactivity to the FM I (and, to a lesser degree, to the FM II) in patients with contact allergy to or allergic contact dermatitis from essential oils is very frequent, both in case reports and in investigations in groups of patients. Of 637 patients reacting to at least 1 essential oil seen by the IVDK (Germany, Austria, Switzerland), 55% co-reacted to FM I, 35% co-reacted to FM II, and 63% co-reacted to one of these two.³¹ Of 15 patients reacting to ylang-ylang oil in the Netherlands, 15 (83%) co-reacted to FM I.³⁵ Co-reactivity to FM for individual essential oils as observed in a European multicenter study was as follows: ylang-ylang oil, 36 (86%) of 42; lemongrass oil, 18 (72%) of 25; jasmine absolute, 11 (55%) of 20; and patchouli oil, 9 (69%) of 13.³⁶

There are (at least) 3 possible explanations for these co-reactivities. In many such cases, co-reactivity probably results from pseudo-cross-reactivity, meaning that the test substances share common components responsible for the positive patch test reactions. In a number of cases, real cross-reactivity may play a role. Third, as many patients (eg, in the case of occupational contact allergy) are exposed to a large number of essential oils and possibly individual fragrances, concomitant sensitization to various products and chemicals can be anticipated. In some studies (eg, Refs. 24 and 34), false-positive reactions may have occurred because of the excited skin syndrome.

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