

Essential Oils, Part I: Introduction

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Essential oils are widely used in the flavor, food, fragrance, and cosmetic industries in many applications. Contact allergy to them is well known and has been described for 80 essential oils. The relevance of positive patch test reactions often remains unknown. Knowledge of the chemical composition of essential oils among dermatologists is suspected to be limited, as such data are published in journals not read by the dermatological community. Therefore, the authors have fully reviewed and published the literature on contact allergy to and chemical composition of essential oils. Selected topics from this publication will be presented in abbreviated form in *Dermatitis* starting with this issue, including I. Introduction; II. General aspects; III. Chemistry; IV. General aspects of contact allergy; V. Peppermint oil, lavender oil and lemongrass oil; VI: Sandalwood oil, ylang-ylang oil, and jasmine absolute.

Why a Series of Articles on Essential Oils?

Essential oils are complex substances, which are usually obtained by steam distillation of plant material. Citrus oils, originating from the peels of *Citrus* species such as grapefruit, lemon, mandarin, orange, or tangerine, are produced by a process called cold pressing. Essential oils are produced in many parts and countries of the world and are very important trade commodities. As a group, they have widespread applications. A rapidly growing application of essential oils is in aromatherapy.^{1,2} The oils are usually applied to the skin, but can also be given orally, by inhalation, by distribution through the air, or by other means.

Under normal conditions of established use, most oils appear to have a good safety profile. However, toxicity may sometimes occur. The majority of adverse events are mild, but serious toxic reactions from some essential oils have been observed, including abortions or abnormalities in pregnancy, neurotoxicity manifesting as seizures or retardation of infant development, bronchial hyper-reactivity, and hepatotoxicity. Accidental ingestion by young children has occasionally proved fatal.³ Allergic reactions to essential oils have long been known to occur.

Dermatologists interested in contact allergy have been confronted in increasing frequency with allergic reactions to essential oils in the recent past. This development may be explained by

increasing use of essential oils on the skin and the availability of commercial patch test preparations, which stimulates more liberal patch testing of essential oils in selected patients or in routine testing. In the United States, for example, 4 essential oils (tea tree oil, lavender oil, peppermint oil, ylang-ylang oil) and 1 absolute (jasmine absolute) are currently present in the screening series of the North American Contact Dermatitis Group.⁴ This inevitably results in more cases of contact allergy to essential oils being detected. In addition, there is increased awareness of possible allergic reactions to essential oils, resulting from, for example, the large number of publications on tea tree oil allergy.

We have found that in many studies providing results of patch testing with essential oils no relevant data were provided. In the screening studies of the North American Contact Dermatitis Group, where relevance can be assessed as “definite,” “probable,” or “possible,” relevance scores for “definite + probable” are often greater than 40%, with “definite relevance” usually being lower than 15% and sometimes even zero. This indicates that, in the majority of cases of positive patch test reactions, no source of contact with the oil can be found. Indeed, the oils or their ingredients can be present in a large array of applications and are often “hidden” in products where no details on composition are available, for example, in perfumes or in household products.

Another observation was that, in patients with established allergic contact dermatitis from essential oils, virtually no attempts have been made to identify the allergenic component(s). Few investigators have performed analyses of oils that caused allergic contact dermatitis.⁵ In fact, with the exception of tea tree oil, which has been investigated in some detail,^{6,7} the allergens in essential oils are largely unknown. We suspect that most dermatologists have limited knowledge of the composition of essential oils, as such information is not published in dermatological journals, but in journals such as *Journal of Essential Oil Research*, *Journal of Essential Oil Bearing Plants*, and many others, which never come to the attention of the dermatological community.

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ACdG and E.S. are the authors of the book *Essential Oils: Contact Allergy and Chemical Composition* (CRC Press, Taylor and Francis, 2016, ISBN 9781482246407), to which they refer in this article.

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TABLE 1. List of Essential Oils and Jasmine Absolutes With Their Botanical Sources, Plant Part(s) Used, and ISO Numbers

Common Name	Botanical Source	Part(s) of Plant Used	ISO*
Angelica fruit oil	<i>Angelica archangelica</i> L.	Fruit	
Angelica root oil	<i>Angelica archangelica</i> L.	Rhizome and root	
Aniseed oil	<i>Pimpinella anisum</i> L.	Fruit	3475
Basil oil, sweet	<i>Ocimum basilicum</i> L.	Flowering aerial top	11043
Bay oil	<i>Pimenta racemosa</i> (Mill.) J.W. Moore	Leaf	3045
Bergamot oil	<i>Citrus bergamia</i> (Risso et Poit.)	Pericarp (peel)	3520
Black cumin oil	<i>Nigella sativa</i> L.	Seed	
Black pepper oil	<i>Piper nigrum</i> L.	Fruit	3061
Cajeput oil	<i>Melaleuca cajuputi</i> Powell	Leaf, terminal branchlet	
Calamus oil	<i>Acorus calamus</i> L.	Rhizome	
Cananga oil	<i>Cananga odorata</i> (Lam.) Hook f. et Thomson, forma <i>macrophylla</i>	Flower	3523
Cardamom oil	<i>Elettaria cardamomum</i> (L.) Maton	Fruit	4733
Carrot seed oil	<i>Daucus carota</i> L.	Fruit	
Cassia bark oil	<i>Cinnamomum cassia</i> (Nees & T. Nees) J.Presl	Bark	3216
Cassia leaf oil	<i>Cinnamomum cassia</i> (Nees & T. Nees) J.Presl	Leaf	
Cedarwood oil, Atlas	<i>Cedrus atlantica</i> (Endl.) G. Manetti ex Carrière	Wood	
Cedarwood oil, China	<i>Cupressus funebris</i> (Endl.)	Wood	9843
Cedarwood oil Himalaya	<i>Cedrus deodara</i> (Roxb. ex D.Don) G.Don	Wood	
Cedarwood oil, Texas	<i>Juniperus ashei</i> J. Buchholz	Wood	4725
Cedarwood oil, Virginia	<i>Juniperus virginiana</i> L.	Wood	4724
Chamomile oil, German	<i>Chamomilla recutita</i> (L.) Rauschert	Flowering tops	19332
Chamomile oil, Roman	<i>Chamaemelum nobile</i> (L.)	Flowering tops	
Cinnamon bark oil, Sri Lanka	<i>Cinnamomum zeylanicum</i> Blume	Twig and bark of stem	
Cinnamon leaf oil, Sri Lanka	<i>Cinnamomum zeylanicum</i> Blume	Leaf	3524
Citronella oil, Java	<i>Cymbopogon winterianus</i> Jowitt.	Aerial part (leaves)	3848
Citronella oil, Sri Lanka	<i>Cymbopogon nardus</i> (L.) Rendle	Aerial part (leaves)	3849
Clary sage oil	<i>Salvia sclarea</i> L.	Flowering top (and leaf)	
Clove bud oil	<i>Syzygium aromaticum</i> (L.) Merr. & L.M. Perry	Bud	3142
Clove leaf oil	<i>Syzygium aromaticum</i> (L.) Merr. & L.M. Perry	Leaf	3141
Clove stem oil	<i>Syzygium aromaticum</i> (L.) Merr. & L.M. Perry	Stem	3143
Coriander fruit oil	<i>Coriandrum sativum</i> L.	Fruit	3516
Costus root oil	<i>Saussurea costus</i> (Falc.) Lipsch.	Root	
Cypress oil	<i>Cupressus sempervirens</i> L.	Twig with leaves	
Dwarf pine oil	<i>Pinus mugo</i> Turra	Leaf (needle), terminal branchlets	21093
Elemi oil	<i>Canarium luzonicum</i> (Blume) A. Gray	Wood exudate	10624
Eucalyptus citriodora oil	<i>Eucalyptus citriodora</i> Hook.	Leaf, terminal branch	3044
Eucalyptus globulus oil	<i>Eucalyptus globulus</i> Labill.	Leaf, terminal branch	770
Galbanum resin oil	<i>Ferula gummosa</i> Boiss.	Root exudate	40716
Geranium oil	<i>Pelargonium</i> x spp.	Herbaceous part	4731
Ginger oil	<i>Zingiber officinale</i> Roscoe.	Rhizome	16928
Grapefruit oil	<i>Citrus paradisi</i> Macfad.	Pericarp (peel)	3053
Guaiacwood oil	<i>Bulnesia sarmientoi</i> Lorentz ex Griseb.	Wood	
Hyssop oil	<i>Hyssopus officinalis</i> L. ssp. <i>officinalis</i>	Flowering top and leaf	9841
Jasminum grandiflorum absolute	<i>Jasminum grandiflorum</i> L.	Flower	
Jasminum sambac absolute	<i>Jasminum sambac</i> (L.) Aiton.	Flower	
Juniper berry oil	<i>Juniperus communis</i> L.	Fruit, terminal branchlets	8897
Laurel leaf oil	<i>Laurus nobilis</i> L.	Leaf	
Lavandin abrial oil	<i>Lavandula angustifolia</i> Mill. x <i>Lavandula latifolia</i> Medik. "Abrial"	Flowering top	3054
Lavandin grosso oil	<i>Lavandula angustifolia</i> Mill. x <i>Lavandula latifolia</i> Medik. "Grosso"	Flowering top	8902

(Continued on next page)

TABLE 1. (Continued)

Common Name	Botanical Source	Part(s) of Plant Used	ISO*
Lavandin oil	<i>Lavandula angustifolia</i> Mill. x <i>Lavandula latifolia</i> Medik.	Flowering top	
Lavender oil	<i>Lavandula angustifolia</i> Mill.	Flowering top	3515
Lemon oil	<i>Citrus limon</i> (L.) Burm. f.	Pericarp (peel)	855
Lemongrass oil, East Indian	<i>Cymbopogon flexuosus</i> (Nees ex Steudel) J.F. Watson	Aerial part (leaves)	4718
Lemongrass oil, West Indian	<i>Cymbopogon citratus</i> (DC) Stapf.	Whole aerial part (leaves)	3217
Litsea cubeba oil	<i>Litsea cubeba</i> (Lour) Pers.	Fruit	3214
Lovage oil	<i>Levisticum officinale</i> W.D.J. Koch	Root	11019
Mandarin oil	<i>Citrus reticulata</i> Blanco	Pericarp (peel)	3528
Marjoram oil (sweet)	<i>Origanum majorana</i> L.	Flowering top	
Melissa oil (lemon balm oil)	<i>Melissa officinalis</i> L.	Aerial parts	
Myrrh oil	<i>Commiphora myrrha</i> (Nees) Engl. and related <i>Commiphora</i> species	Wood exudate	
Neem oil	<i>Azadirachta indica</i> A. Juss.	Seed	
Neroli oil	<i>Citrus aurantium</i> L.	Flower	3517
Niaouli oil	<i>Melaleuca quinquenervia</i> (Cav.) S.T. Blake	Leaves, terminal branchlets	
Nutmeg oil	<i>Myristica fragrans</i> Houtt.	Seed	3215
Olibanum (frankincense) oil	<i>Boswellia sacra</i> Flueck.	Wood exudate	
Orange oil, bitter	<i>Citrus aurantium</i> L.	Pericarp (peel)	9844
Orange oil, sweet	<i>Citrus sinensis</i> (L.) Osbeck	Pericarp (peel)	3140
Palmarosa oil	<i>Cymbopogon martini</i> (Roxb.) Will. Watson	Aerial part (leaves)	4727
Patchouli oil	<i>Pogostemon cablin</i> (Blanco) Benth.	Leaf	3757
Peppermint oil	<i>Mentha x piperita</i> L.	Aerial parts, leaf	856
Petitgrain bigarade oil	<i>Citrus aurantium</i> L.	Leaf, twig, little green fruit	8901
Pine needle oil (Scots pine oil)	<i>Pinus sylvestris</i> L.	Needle, twig	
Ravensara oil	<i>Ravensara aromatica</i> Sonn.	Twig with leaves	
Rosemary oil	<i>Rosmarinus officinalis</i> L.	Flowering top, leaf	1342
Rose oil	<i>Rosa x damascena</i> Mill.	Flower	9842
Rosewood oil	<i>Aniba rosaeodora</i> Ducke, <i>Aniba parviflora</i> (Meisn.) Mez.	Wood	3761
Sage oil, Dalmatian	<i>Salvia officinalis</i> L.	Flowering top	9909
Sage oil, Spanish	<i>Salvia lavandulifolia</i> Vahl	Flowering top	3526
Sandalwood oil	<i>Santalum album</i> L.	Wood	3518
Silver fir oil	<i>Abies alba</i> Mill.	Needles	
Spearmint oil	<i>Mentha spicata</i> L.	Flowering aerial part, leaf	3033
Spike lavender oil	<i>Lavandula latifolia</i> Medik.	Flowering top	4719
Star anise oil	<i>Illicium verum</i> Hook. f.	Fruit	11016
Tangerine oil	<i>Citrus tangerina</i> Hort. ex Tan.	Peel	
Tea tree oil	<i>Melaleuca alternifolia</i> (Maiden et Betche) Cheel; <i>Melaleuca linariifolia</i> Smith; <i>Melaleuca dissitiflora</i> F. Muell.	Leaf, terminal branchlet	4730
Thuja oil	<i>Thuja occidentalis</i> L.	Twig with leaves	
Thyme oil	<i>Thymus vulgaris</i> L.	Flowering top	
Thyme oil, Spanish	<i>Thymus zygis</i> L.	Flowering top	14715
Turpentine oil, Iberian type	<i>Pinus pinaster</i> Aiton	Oleoresin	11020
Turpentine oil, Chinese type	<i>Pinus massoniana</i> Lamb.	Oleoresin	21389
Valerian oil	<i>Valeriana officinalis</i> L.	Rhizome, root	
Vetiver oil	<i>Chrysopogon zizanioides</i> (L.) Roberty	Root	4716
Ylang-ylang oil	<i>Cananga odorata</i> (Lam.) Hook f. et Thomson, forma <i>genuina</i>	Flower	3063
Zdravetz oil	<i>Geranium macrorrhizum</i> L.	Aerial part	

*Number of ISO standard (www.iso.org).

For these reasons, we decided to review the literature on contact allergy to essential oils and their chemical composition. For information on the latter, we did not only review analytical studies of essential oils presented in literature (>2500 articles were reviewed

and used for data presentation), but also had a unique set of nearly 6400 analyses of essential oils and jasmine absolutes (which were included, as there is quite extensive literature on contact allergy to them) at our disposal. These analyses were generated by GC-MS

equipment by one of us (E.S.) between 1998 and 2014 in a German company designing and producing natural compositions of essential oils and perfume oils. Our findings have been presented in *Essential Oils: Contact Allergy and Chemical Composition*.⁸

Contact Allergy to Essential Oils: A Survey of Oils and Plants

In our literature search, we have found 79 essential oils that have caused contact allergy (as demonstrated by positive patch test reactions) or allergic contact dermatitis. For some oils, only 1 or 2 such reports are available. For others, however, there is a considerable amount of literature on contact allergy and allergic contact dermatitis, for example, in the cases of tea tree oil, ylang-ylang oil, lavender oil, peppermint oil, jasmine absolute, geranium oil, rose oil, turpentine oil, and sandalwood oil. Because of the selection criterion (contact allergy reported), the group of 79 oils is very heterogeneous. Some are high-volume essential oils, such as orange oil (worldwide production 60,000 tons per year) and lemon oil (nearly 9000 tons), others are produced and commercialized in very small quantities. The estimated commercial quantity of zdravets oil, for example, which is produced in Bulgaria only, is about 20 kg. Costus root oil is apparently still used in aromatherapy,² but has been prohibited by IFRA (International Fragrance Association) for use in fragrances and cosmetics since decades because of its sensitizing properties. Others are prohibited or restricted by governmental regulations and laws, as in the case of rosewood oil, guaiac wood oil, and East Indian sandalwood oil, which are produced from endangered species.

Table 1 provides a list of 91 essential oils and 2 jasmine absolutes with their common name, botanical source, part(s) of the plant used for obtaining the oil, and—if available—numbers of ISO (International Organization for Standardization, Geneva, Switzerland, www.iso.org) standards. The number of oils/absolutes in Table 1 (n = 93) exceeds the number of essential oils for which contact allergy has been described (n = 79). This is due to the fact that some oils may be obtained from different species (eg, cedarwood oil, lemongrass oil, thyme oil, sage oil), from different

parts of the same plant (eg, cinnamon bark oil and cinnamon leaf oil, clove bud oil, clove stem oil, and clove leaf oil), or from various cultivars producing different oils (lavandin abrial oil, lavandin grosso oil). In dermatological literature, however, such data are virtually never provided (“cedarwood oil,” “clove oil,” “lavandin oil,” “thyme oil”), and therefore, we chose to present the data from all possible source species and plant parts. Full literature data on contact allergy to and allergic contact dermatitis from individual essential oils and their chemical composition are presented in the book by de Groot and Schmidt.⁸ Not included in this list is hinoki oil obtained from the wood of *Chamaecyparis obtusa* (Siebold & Zucc.) Endl.; allergic contact dermatitis from this essential oil was described recently.⁹

REFERENCES

1. Rhind JP. *Essential Oils. A Handbook for Aromatherapy Practice*. 2nd ed. London: Singing Dragon; 2012.
2. Lawless J. *The Encyclopedia of Essential Oils*. 2nd ed. London: Harper Thorsons; 2014.
3. Tisserand R, Young R. *Essential Oil Safety*. 2nd ed. Churchill Livingstone Elsevier; 2014.
4. Cheng J, Zug KA. Fragrance allergic contact dermatitis. *Dermatitis* 2014; 25:232–245.
5. Dharmagunawardena B, Takwale A, Sanders KJ, et al. Gas chromatography: an investigative tool in multiple allergies to essential oils. *Contact Dermatitis* 2002;47:288–292.
6. Hausen BM, Reichling J, Harkenthal M. Degradation products of monoterpenes are the sensitizing agents in tea tree oil. *Am J Cont Derm* 1999;10:68–77.
7. Pirker C, Hausen BM, Uter W, et al. Sensitization to tea tree oil in Germany and Austria. A multicenter study of the German Contact Dermatitis Group. *J Dtsch Dermatol Ges* 2003;1:629–634.
8. de Groot AC, Schmidt E. *Essential Oils: Contact Allergy and Chemical Composition*. Boca Raton, FL: CRC Press, Taylor & Francis Group; 2016.
9. Kim M, Hwang SW, Cho BK, et al. Allergic contact dermatitis caused by essential oil of Hinoki (*Chamaecyparis obtusa*) on the periungual area. *Contact Dermatitis* 2015;73:250–251.