

Fragrance ingredient labelling in products on sale in the U.K.

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Summary

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Accepted for publication

23 March 2007

Key words

allergic contact dermatitis, consumer products, fragrance, labelling, limonene, linalool

Conflicts of interest

None declared.

Background The seventh amendment of the European Union (EU) Cosmetics Directive (March 2005) and the Detergents Regulations of the EU (October 2005) are now legal requirements in Europe. Cosmetic products and detergents must be labelled for 26 individual named fragrances, when present at concentrations of > 10 parts per million (p.p.m.) in leave-on products and > 100 p.p.m. in rinse-off products.

Objectives To make an assessment of the exposure pattern to fragrance of the U.K. consumer and to determine the frequency with which the constituent fragrances of fragrance mix I (FM I) and fragrance mix II (FM II) are included in products currently sold in the U.K.

Methods A study of perfumed cosmetic and household products available on the shelves of U.K. retailers was carried out in January 2006. Products were included if 'parfum' or 'aroma' was listed among the ingredients. Three hundred products were surveyed and any of the 26 listed fragrances named on the label were recorded.

Results The top six most frequently labelled fragrances were linalool (190; 63%), limonene (189; 63%), citronellol (145; 48%), geraniol (126; 42%), butyl phenyl methyl propional (LilialTM) (126; 42%) and hexyl cinnamal (125; 42%). One of these, geraniol, is present in FM I and two others, citronellol and hexyl cinnamal, in FM II, thus tested as part of the British Standard patch test series. The frequencies of other constituents of FM I were as follows: eugenol, 80 (27%); hydroxycitronellal, 52 (17%); isoeugenol, 27 (9%); cinnamic alcohol, 25 (8%); amyl cinnamal, 22 (7%); cinnamal, 17 (6%); *Evermia prunastri* (oak moss absolute), 13 (4%). The other constituents of FM II occurred as follows: coumarin, 90 (30%); hydroxyisohexyl-3-cyclohexene carboxaldehyde (LyrTM), 88 (29%); citral, 74 (25%); farnesol, 23 (8%). Linalool (n = 46; 66%) was the most frequently found fragrance in 70 personal care products (soap, shampoo, shower gel). Linalool (n = 47; 80%) and limonene (n = 45; 76%) were the most frequent in 59 products for men (e.g. aftershave). Limonene (n = 29; 51%) predominated in 57 household products (washing-up liquid, detergent). Limonene (n = 43; 98%) and linalool (n = 42; 95%) were the most frequent fragrances in 44 perfumes for women. Alpha-isomethyl ionone (n = 28; 72%) was the most frequent in 39 cosmetics (foundation, lipstick, etc). Citronellol predominated (n = 15; 88%) in 17 deodorants and limonene (n = 9; 64%) was the commonest in 14 dental products (toothpaste and mouthwash). Thirty-four products (11%) contained none of the listed fragrances but were labelled as containing 'parfum' or 'aroma'.

Conclusions There is ongoing consumer exposure to the most frequent sensitizers in FM I: *E. prunastri*, isoeugenol and the cinnamon fragrances cinnamal and cinnamic alcohol. Hydroxyisohexyl-3-cyclohexene carboxaldehyde (LyrTM) is present at significant concentrations in almost one-third of products. Linalool and limonene, fragrance terpenes which are significant allergens in their oxidized state, are the most frequent fragrances encountered by individuals living in the U.K. The current exposure pattern of the U.K. consumer suggests that we should add oxidized limonene and oxidized linalool to the test series for patients suspected to have fragrance allergy.

Fragrance allergy is a significant problem for many individuals, affecting 6–13% of patch tested patients in Europe^{1,2} and about 1% of the general population.³ It ranks second only to nickel as the most frequent cause of allergic contact dermatitis. Fragrances are ubiquitous in the environment, found in soaps and shampoos, detergents, air fresheners, shaving toiletries, deodorants, dental products, cosmetics, perfumes, some prescribed emollients and as flavourings in foodstuffs.

Since the late 1970s, testing for fragrance allergy has been carried out using fragrance mix I (FM I), a mixture of eight common fragrance chemicals (plus an emulsifier, sorbitan sesquioleate, added since 1984). A Danish study published in 2003 found that the fragrances in FM I are being added less frequently by the big perfume houses to their newer products⁴ and a German multicentre study found the incidence of allergy to FM I to have declined between 1999 and 2002.² A second fragrance mix, FM II, containing hydroxyisohexyl-3-cyclohexene carboxaldehyde (LyrallTM), citral, farnesol, citronellol, hexyl cinnamal and coumarin, was added to the British standard patch test series in 2005 to reflect significant levels of allergy to other fragrance chemicals as determined by European Union (EU)-funded multicentre studies. FM II is intended to improve the diagnosis of fragrance allergy by detecting patients who would have been missed by testing to FM I alone.⁵

In addition, hydroxyisohexyl-3-cyclohexene carboxaldehyde was added separately to be tested in the British standard patch test series at the higher concentration of 5% pet., because of a significant rate of positive patch test reactions in European and U.K. patients.^{6,7}

In 1998 the sixth amendment of the EU Cosmetics Directive (76/768/EEC) introduced ingredient listing for products classed as 'cosmetics'. However, as a result of intense lobbying by the cosmetic industry for a 'fragrance exception', a compromise was reached where fragrance compositions in cosmetics would be indicated simply by the word 'parfum'. There was no requirement to indicate which specific fragrance chemicals had been included. Thus, a patient who had been patch tested to the breakdown constituent fragrances of FM I and was allergic to isoeugenol had to avoid all fragranced products in case isoeugenol were present. Manufacturers were sometimes reluctant to confirm whether a product contained a particular fragrance, even when the product had induced or elicited a contact allergic dermatitis, due to concerns about commercial confidentiality.

The seventh amendment of the EU Cosmetics Directive (http://pharmacos.eudra.org/F3/cosmetic/pdf/vol_1en.pdf) legislated that products containing fragrances had to be labelled more specifically. Since 11 March 2005, cosmetic products are required to be labelled for the presence of 26 individual fragrance chemicals, if present at > 10 parts per million (p.p.m.) (0.001%) in leave-on products and > 100 p.p.m. (0.01%) in rinse-off products. Since October 2005, the Detergents Regulations of the EU (http://europa.eu.int/eur-lex/pri/en/oj/dat/2004/l_104/l_10420040408en00010035.pdf) have meant that similar labelling is required for detergent products, if any of the

26 chemicals is present at > 100 p.p.m. These levels were suggested by the European Parliament as a pragmatic solution, as the 'safe' levels for most of the fragrance substances are largely unknown. The availability of such information to the consumer facilitates avoidance of specific fragrance allergens and the provision of accurate advice by dermatologists. It also allows a picture to be formed of the current pattern of use of fragrance chemicals by manufacturers.

This survey assesses the use of fragrance chemicals by EU manufacturers of cosmetics and detergents intended for the U.K. market. It also examines the frequency with which fragrances from FM I and fragrances from FM II are found in products in current use.

Materials and methods

During January 2006, supermarkets, pharmacies and duty free shops in the South of the U.K. (London, Bath and Bristol) were visited (by D.A.B.) to examine consecutive products on the shelves which were labelled to contain 'parfum' or 'aroma'. Products were excluded where they appeared either to be old stock or a product manufactured outside the EU. The study included as wide a range of manufacturers and brands as possible. To provide a broad picture of consumer exposure to fragrance allergens, the survey included not only those products which are in day-to-day use for personal and dental care and shaving, but also cosmetic products, domestic cleaning chemicals and fragrances aimed at women and men.

The names of any or all the listed fragrances present on the label of each product were recorded. Products were characterized into seven groups: (i) personal care (soap, shampoo, shower gel, bath foam); (ii) men's products (aftershave, emollient, shaving gel or foam, men's eau de toilette, deodorant); (iii) household products (washing-up liquid, detergent, fabric conditioner, surface wipes, spray detergent); (iv) women's fragrances (eau de parfum, eau de toilette); (v) cosmetics (foundation, powder, lipstick); (vi) deodorants (women's antiperspirants and body sprays); (vii) dental products (toothpaste, mouthwash). The legal definition of a 'cosmetic' in EU legislation includes all of the above types of product except household products. However, it would seem of interest to compare whether there is a different pattern of exposure to fragrances in products used by men vs. those used by women and in products used by virtually all individuals such as dental products and soap vs. those used only by a limited number such as foundation and lipstick. In the case of some household products, the consumer was directed to a website to find the labelling information for the relevant product, and this was consulted. All information was entered into a computerized spreadsheet.

Results

Of the 300 products examined, 266 (89%) contained at least one of the listed fragrances. Thirty-four (11%) were labelled to contain parfum but none of the fragrances on the list.

Table 1 Mean number of listed fragrances in each product

Product category	n	Mean	Range
Women's perfumes	44	12	4–21
Deodorants	17	7.8	3–13
Products for men	59	6.5	0–15
Cosmetics	39	5.6	0–15
Personal care	70	4.4	0–17
Household	57	3	0–12
Dental	14	1.1	0–3
Total	300	5.9	0–21

These products were new stock from a company which was labelling others in its range with the 26 specified fragrances, therefore were unlikely to contain any of them above the threshold concentration without having been labelled accordingly.

The mean number of listed fragrances in a product was 5.9 (range 0–21) (Table 1). Women's perfumes contained the highest number of listed fragrances (mean 12, range 4–21), while deodorants contained a mean of 7.8 (range 3–13). Men's products contained a mean of 6.5 (0–15), cosmetics 5.6 (0–15), personal care products 4.4 (0–17) and household

products 3 (0–12). Dental products contained the least number of listed fragrances (mean 1.1; range 0–3).

The most frequently occurring listed fragrances were linalool, labelled in 190 products (63%) and limonene, labelled in 189 (63%) (Table 2). From FM I geraniol and eugenol were those most frequently present, in 126 (42%) and 80 (27%), respectively. From FM II citronellol (145; 48%) and hexyl cinnamal (125; 42%) occurred the most frequently. Butyl phenyl methyl propional (LilialTM), a fragrance not routinely patch tested in the U.K., also occurred frequently, in 126 products (42%). Hydroxyisohexyl-3-cyclohexene carboxaldehyde (LyrallTM) was commonly labelled, in 88 products (29%).

In 70 personal care products, linalool (n = 46; 66%) was the most frequently found listed fragrance. In 59 products aimed at men, linalool (n = 47; 80%) and limonene (n = 45; 76%) were the most frequent, but hydroxyisohexyl-3-cyclohexene carboxaldehyde was present in 24 (41%) and both geraniol and eugenol in 26 (44%). Limonene (n = 29; 51%) predominated in 57 household products. Limonene (n = 43; 98%) and linalool (n = 42; 95%) were the most frequently listed fragrances in 44 prestige perfumes aimed at women. Alpha-isomethyl ionone (n = 28; 72%) was the most frequently listed in 39 cosmetics. Citronellol predominated

Table 2 Frequency of occurrence of the 26 fragrances in consumer products

INCI name of fragrance	PCP (n = 70)	MP (n = 59)	HP (n = 57)	WP (n = 44)	Cos (n = 39)	Deo (n = 17)	Dent (n = 14)	Total (n = 300)
Linalool	46	47	17	42	26	12	0	190 (63%)
Limonene	34	45	29	43	18	11	9	189 (63%)
Citronellol	23	24	21	37	25	15	0	145 (48%)
Geraniol	19	26	15	36	18	12	0	126 (42%)
BPMP	30	27	21	27	13	8	0	126 (42%)
Hexyl cinnamal	37	20	22	22	14	10	0	125 (42%)
Benzyl salicylate	23	23	10	31	15	12	0	114 (38%)
Alpha-isomethyl ionone	15	20	7	24	28	10	0	104 (35%)
Coumarin	12	27	8	23	12	8	0	90 (30%)
Lyrall TM	17	24	3	24	15	5	0	88 (29%)
Eugenol	13	26	4	22	6	6	3	80 (27%)
Citral	2	28	6	29	7	2	0	74 (25%)
Benzyl benzoate	8	9	3	31	11	8	0	70 (23%)
Benzyl alcohol	9	8	1	30	9	3	1	61 (20%)
Hydroxycitronellal	5	6	1	30	6	4	0	52 (17%)
Isoeugenol	2	5	0	17	0	3	0	27 (9%)
Cinnamic alcohol	4	2	0	13	4	2	0	25 (8%)
Farnesol	1	3	0	17	2	0	0	23 (8%)
Amyl cinnamal	5	0	3	7	5	2	0	22 (7%)
Cinnamal	3	4	0	7	0	0	3	17 (6%)
Evernia prunastri/oak moss	0	3	0	5	5	0	0	13 (4%)
Benzyl cinnamate	2	0	0	8	0	0	0	10 (3%)
Evernia furfuracea/tree moss	1	5	0	3	0	0	0	9 (3%)
Anisyl alcohol	0	0	0	1	0	0	0	1 (0.3%)
Amyl cinnamic alcohol	0	0	0	0	0	0	0	0
Methyl heptine carbonate	0	0	0	0	0	0	0	0

INCI, International Nomenclature of Cosmetic Ingredients; PCP, personal care products; MP, men's products; HP, household products; WP, women's perfumes; Cos, cosmetics; Deo, deodorants; Dent, dental products; BPMP, butyl phenyl methyl propional; LyrallTM, hydroxyisohexyl-3-cyclohexene carboxaldehyde.

($n = 15$; 88%) in 17 deodorants and limonene ($n = 9$; 64%) was the most commonly listed in 14 dental products (Table 2).

The predominant fragrance allergens from FM I were labelled as follows: *Evernia prunastri* (oak moss absolute), 4% of all products; isoeugenol, 9%; cinnamal, 6%; cinnamic alcohol, 8%. A significant number of these products was new to the market, notably dental preparations containing cinnamal and celebrity designer perfumes containing *E. prunastri* and cinnamal (Table 3). *Evernia furfuracea* (tree moss absolute), often substituted for or mixed with *E. prunastri* as a cheaper alternative, was labelled in 3% of products.

Discussion

This survey shows that most perfumed products on sale in the U.K. are labelled to contain significant numbers of the 26 fragrance chemicals covered by the EU directive. The number is lowest in dental products and highest in prestige perfumes intended for use by women; 11% of products were not labelled to contain any. However, as labelling is only required at concentrations > 10 p.p.m. (0.001%) in leave-on and 100 p.p.m. (0.01%) in rinse-off products, it is likely that the 11% may contain some of the 26 fragrances at concentrations below the labelling threshold. Alternatively, they might contain other fragrances not covered by EU law.

Allergens of FM I are still commonly represented in products on sale to the public. *Evernia prunastri* is the most frequently sensitizing fragrance chemical in FM I for both sexes,¹ as it contains the potent allergens chloroatranol and atranol.⁸ It has a woody, earthy, seaweed-like 'masculine' odour. Five of 44 women's fragrances (11%) and 4% of all the products in this survey were labelled to contain *E. prunastri*, but it is likely that it is present in others at concentrations below the labelling threshold. An analysis of 31 popular European women's perfumes found 27 (87%) to contain chloroatranol and atranol, with the median chloroatranol concentration (0.235 p.p.m.)

above that which would elicit a positive patch test reaction in 50% of sensitized individuals (0.15 p.p.m.).⁹ *Evernia prunastri* is likely to contain approximately 1% chloroatranol, hence labelling of chloroatranol is not required below the equivalent of 0.1 p.p.m. in leave-on products and elicitation of allergy to chloroatranol may occur in some very sensitive individuals even when *E. prunastri* is not labelled.⁹ Some of the products labelled to contain *E. prunastri* were newly formulated prestige perfumes aimed at women and men. For example, Estée Lauder Intuition Eau de parfum (launched in 2000) is labelled to contain *E. prunastri* and *E. furfuracea* as well as cinnamal, cinnamic alcohol, isoeugenol, eugenol, geraniol, hydroxycitronellal, hydroxyisohexyl-3-cyclohexene carboxaldehyde and 11 other fragrances from the list of 26. *Evernia furfuracea* (labelled in 3% of products) has a woody, forest, or tar-like odour and up to recently its frequent presence in '*E. prunastri*' caused contamination with resin acids of the type found in colophony. Since April 2000 the International Fragrance Association (IFRA) has recommended that *E. prunastri* extracts used in perfumery should not contain *E. furfuracea*.

Isoeugenol (sweet, spicy, floral odour) has been restricted to a 0.02% concentration in finished cosmetic products since 1998; despite this, the incidence of allergy to isoeugenol has increased in the U.K. in the last 5 years from 3 to 3.5% of unselected patch test patients.¹⁰ One explanation may be an increase in the frequency of use of this potent allergen; in this survey it was labelled in 9% of products and 39% of women's perfumes, including new women's and men's perfumes and new deodorants. Eugenol (clove-like odour) is a less allergenic isomer of isoeugenol, with which it has a low rate of concomitant sensitivity.¹¹ Eugenol was present in a relatively high number of products, 27%, yet only had a 1.2% rate of positive reactions in an unselected patch test population.¹²

Cinnamal (cinnamon-like odour) and cinnamic alcohol (hyacinth-like odour) are related fragrances and extensively cross-sensitize.¹¹ Allergy to the cinnamon fragrances had decreased in the U.K. between 1980 and 1996;¹ however,

Table 3 Occurrence of fragrance allergens of interest in products by different manufacturers

INCI name of fragrance	PCP	MP	HP	WP	Cos	Deo	Dent	Total
<i>Evernia prunastri</i> /oak moss (Manufacturers Bj, Cach, CK, EL, G, JLo, RL, TB, WhC)	0	3	0	5	5	0	0	13
<i>Evernia furfuracea</i> /tree moss (Manufacturers Cach, CK, EL, G, HBoSS, RL, Yd)	1	5	0	3	0	0	0	9
Isoeugenol (Manufacturers BSh, Cach, C + E, Ch, CK, Cla, Cli, Cot, Cus, Di, EL, Giv, Gu, HBoSS, La, Le, NR, Pa, PR, RG, RL, Uni)	2	5	0	17	0	3	0	27
Cinnamal (Manufacturers Adi, Bad, Boots, Burb, Cach, Cla, Colg, Cot, Di, EL, Hack, JLo, La, Pears, RL, Wrights)	3	4	0	7	0	0	3	17
Cinnamic alcohol (Manufacturers AMcQ, Bj, Cach, C + E, Ch, Cla, Cli, Cot, Di, D + G, EL, GA, NR, Pa, Rob, Sh, Uni)	4	2	0	13	4	2	0	25

INCI, International Nomenclature of Cosmetic Ingredients; PCP, personal care products; MP, men's products; HP, household products; WP, women's perfumes; Cos, cosmetics; Deo, deodorants; Dent, dental products; Adi, Adidas; AMcQ, Alexander McQueen; Bad, Badedas; Bj, Bourjois; Boots, Boots Chemist; BSh, Body Shop; Burb, Burberry; Cach, Cacharel; C + E, Crabtree and Evelyn; Ch, Chanel; CK, Calvin Klein; Cla, Clarins; Cli, Clinique; Colg, Colgate; Cot, Coty; Cus, Cussons; D + G, Dolce and Gabbana; Di, Dior; EL, Estée Lauder; G, Gillette; GA, Giorgio Armani; Giv, Givenchy; Gu, Guerlain; Hack, Hacketts; HBoSS, Hugo Boss; JLo, Jennifer Lopez; La, Lacoste; Le, Letheric; NR, Narciso Rodriguez; Pa, Palmolive; Pears, Pears soap; PR, Paco Rabanne; RG, Right Guard; RL, Ralph Lauren; Rob, Robinsons; Sh, Shield; TB, Ted Baker; WhC, White Company; Wrights, Wright's traditional soap; Uni, Unilever; Yd, Yardley.

recent data from Germany show a relatively stable level of allergy between 1996 and 2002.² This may reflect their continued presence in traditional soaps, old prestige perfumes, and their recent addition to new fragrances, dental products and children's toothpastes. Data from IFRA and the Research Institute for Fragrance Materials showed that the annual use of cinnamal by the fragrance industry remained stable between 1996 and 2000.² Of the products in this survey, 6% and 8% were labelled to contain cinnamal and cinnamic alcohol, respectively.

Geraniol has a sweet, floral odour of rose and occurs in rose, geranium, citronella, lavender, jasmine and many other essential oils, so is also present in 'natural' fragranced products. It was present on 42% of product labels in this survey; previous studies have found it on analysis in 41% of household products¹³ and 76% of deodorants.¹⁴ Despite geraniol's relatively low inherent allergenicity, its frequent presence in household and cosmetic items is likely to maintain a significant level of population allergy. Geraniol in washing-up liquid has previously been associated with hand eczema,¹⁵ and positive patch tests to geraniol 5% pet. were found in 0.9% of patients with chronic hand eczema.¹⁶ In a worldwide multicentre study, 3% of patients with suspected fragrance allergy had positive patch test reactions to geraniol 5% pet.¹⁷ and in a German multicentre study 1–2% of patients with suspected fragrance allergy were allergic to geraniol 1% pet.² The use of geraniol in the manufacture of fragranced products increased between 1996 and 2000 and it holds approximately 50% of the market in terms of use volumes.²

Hydroxyisohexyl-3-cyclohexene carboxaldehyde is a significant allergen in the U.K. and Europe and is now tested in the British standard series both separately at 5% pet. and in FM II at 2.5% pet. This synthetic fragrance has a floral, lily or cyclamen-like note reminiscent of hydroxycitronellal. Previous studies showed that 2.7% of consecutive patch test patients in Europe and 2.1% of patients with chronic hand eczema had positive reactions to hydroxyisohexyl-3-cyclohexene carboxaldehyde 5% pet.^{6,16} It was found in 46% of women's prestige perfumes (mean concentration 3.2% or 32 000 p.p.m.),¹⁸ 53% of 73 deodorants (mean concentration up to 0.066% or 664 p.p.m.)¹⁴ and in 10% of 59 household products (mean concentration 74.8 p.p.m. or 0.007%, below the labelling threshold).¹³ This survey found it labelled in 29% of products and in 55% of women's perfumes, confirming significant and probably increasing population exposure.

Citronellol (light, fresh, rose-like odour) and hexyl cinnamal (floral, jasmine, waxy odour) are now routinely tested in the U.K. in FM II at 0.5% pet. and 5% pet., respectively, and in this survey were labelled in 48% and 42% of products. A recent multicentre European study of consecutively patch tested patients found positive reactions to citronellol 0.5% pet. in 0.12% and hexyl cinnamal 5% pet. in 0.06%.¹⁹ Patients with chronic hand eczema had positive reactions to citronellol 5% pet. in 0.3% and to hexyl cinnamal 10% pet. in 0.5%.¹⁶ The synthetic fragrance butyl phenyl methyl propional (LilialTM) has a powerful floral-fresh odour and was labelled

in 42% of products in this survey. Previous studies have found 1.2% of 167 patients with suspected fragrance allergy (tested at 5% pet.) and 0.5% of patients with chronic hand eczema (tested at 10% pet.) to be allergic to butyl phenyl methyl propional.^{16,17} There is no routine patch test preparation available for testing to butyl phenyl methyl propional.

The most notable finding in this survey was the predominance of limonene and linalool in the fragrance market. These are substances for which suitable patch test preparations to detect contact allergy are not readily available. Both are naturally occurring fragrances which are readily oxidized on exposure to air at room temperature. Stability of patch test preparations represents a significant challenge; however, Chemotechnique Diagnostics (Malmö, Sweden) can provide patch test preparations by special arrangement.

Linalool is a terpene fragrance which has a refreshing floral-woody odour with a faintly citrusy note. It is present in more than 200 natural oils including lavender, cinnamon, ylang-ylang, bergamot, jasmine, rosewood, coriander and in orange and lemon zest.¹⁸ Synthetic linalool, a racemic mixture of the R and S enantiomers R-linalool (licareol) and S-linalool (coriandrol), is used to make synthetic essential oils such as lavender, geranium and bergamot. Pure linalool is itself an infrequent allergen; however, its primary and secondary oxidation products are allergenic. Commercially available linalool is 97% pure and contains 0.6% linalool oxide.²⁰ After 10 weeks' exposure to air at room temperature, 20% of linalool is oxidized to relatively stable highly allergenic hydroperoxides.²¹ In a multicentre European study, 1.3% of consecutive patch test patients were allergic to oxidized linalool 2% pet.; 58% of these patients had a fragrance-related contact allergy, mainly affecting the legs and feet, hands and face.²²

Previous European studies have found linalool to be present in a very high proportion of perfumed products: in 90% of 49 prestige perfumes on the European market (mean concentration 4.7%), and 97% of 73 deodorants (concentration range 0.0009–0.19%).^{14,18} In this study 95% of perfumes and 12 of 17 (71%) deodorants were labelled to contain it, although in the remaining deodorants the concentration of linalool may have been below the labelling threshold of 0.001%. Linalool was labelled in 17 of 57 household products in this present study; a previous study analysing 59 household products found it in 61% of them at concentrations of 0.0003–0.0439%, i.e. in some cases below the labelling threshold of > 0.01%.¹³ The use of essential oils in 'natural ingredient'-based cosmetics makes linalool difficult to avoid as a consumer.

Limonene is one of the most inexpensive perfume materials and is used in large volumes for household products and at high concentration as a solvent in cleansing and degreasing agents. Limonene occurs in its racemic form as dipentene, a mixture of D- (also known as R-) limonene and L- (S-) limonene. Both isomers occur in varying proportions in essential oils such as tea tree, lavender, eucalyptus, rosemary, peppermint, caraway, lemon grass, citrus and in turpentine. D-limonene constitutes more than 95% of citrus peel oils,

e.g. orange, mandarin, bergamot and lemon, and has an odour of citrus or orange. It is a major by-product of the fruit juice industry and is widely added to fragranced products. L-limonene originating from essential oils is also present in many products. Both D- and L-limonene are irritant at high concentrations but are relatively nonallergenic in their nonoxidized state.

The sensitizing potential of limonene increases with prolonged air contact at room temperature, when it is oxidized to allergenic derivatives such as 1,2-limonene oxide and limonene-2-hydroperoxide. Sixty per cent of limonene is oxidized after 10 weeks' exposure to air at room temperature, a faster rate of oxidation than linalool. A multicentre study showed that 2.8% (0.3–6.5%) of consecutive patch test patients in Europe were allergic to oxidized D-limonene 3% pet.; 57% of these had negative reactions to both FM I and balsam of Peru (*Myroxylon pereirae*).²³ Of patients with chronic hand eczema 0.8% were allergic to oxidized D-limonene 3% pet. and 0.9% to oxidized L-limonene 3% pet.¹⁶ Nonoxidized D-limonene produced no positive reactions in 30 patients with known allergy to oxidized D-limonene.²³ In a chemical analysis of household products in Europe, limonene was present in 78%, more than the 51% (29 of 57) in this study, with a mean concentration of 826.7 p.p.m. (range 6–9400), and was therefore present in some products at concentrations below the labelling threshold.¹³

Reduction in the frequency of allergy to linalool and limonene may be achieved by restricting the exposure to air of fragranced products and reducing their recommended shelf life. The use of antioxidants such as ascorbic acid, α -tocopherol and butylated hydroxytoluene to slow oxidation of commercial products is also advised. IFRA recommends that an antioxidant be added to keep the peroxide concentration below 20 mmol L⁻¹.²³ The antioxidant is consumed as the product ages, allowing oxidation of limonene to take place. In practical terms, a shelf life of 1 year is often suggested. However, many people may use products after their expiry date and in some cases may not replace the lid between uses, allowing oxidation to occur sooner.

The results of this survey indicate that traditional fragrance allergens such as E. prunastri and isoeugenol are still being relatively widely used. Newer allergens such as hydroxyisohexyl-3-cyclohexene carboxaldehyde are present in approximately one-third of products. Less known but potentially significant allergens such as linalool and limonene predominate as the labelled fragrances in products on sale at present. In view of this, the availability of oxidized linalool and limonene in a stable form for patch testing would be helpful, to ascertain the frequency of positive patch tests to these fragrances in a British patch test population.

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