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Contact sensitization to fragrance markers and surfactants/emulsifiers/ emollients among cosmetologists and cosmetology students – a pilot study

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Abstract

Background: Sensitization to cosmetics ingredients is an important problem in occupational and consumer exposures.

Aim: This pilot study evaluates the prevalence of contact sensitization to fragrance markers and surfactants/emulsifiers/emollients as cosmetic ingredients among cosmeticians and cosmetology students and identifies the most common allergens in occupational and non-occupational exposures.

Material and Methods: Skin patch testing with fragrance markers - fragrance mix-I, peru balsam, colophonium, hydroxy-isohexyl 3-cyclohexene carboxaldehyde; surfactants/emulsifiers/emollients - cetearyl glucoside, decyl glucoside, cocamidopropyl betaine, and lanolin alcohol was performed among 109 participants - 37 cosmetology students, 26 cosmeticians, and 46 individuals – controls, occupationally unexposed to cosmetics. In parallel with the standard reading,

thermographic examination was performed. The relationship between test-haptens and groups was evaluated by Fisher's exact test.

Results: Lanolin alcohol was the main contact sensitizer taken for the whole tested population, as well as for the cosmetologists, with significantly higher patch test positivity if compared to the students (p=0,028). Regarding the fragrance markers, for the whole tested population, hydroxy-isohexyl 3-cyclohexene carboxaldehyde was identified as a main sensitizer, followed by Peru balsam. Fragrance mix-I was the main allergen for cosmeticians, with significantly higher prevalence of sensitization if compared to cosmetology students and controls (p=0.005). Regarding the surfactants/emulsifiers, the positivity prevalence to decyl glucoside was significantly higher among the cosmetology students if compared to the controls (p=0,028).

Conclusions: We established high prevalence and risk of contact sensitization to the tested fragrance markers and surfactants/emulsifiers/emollients. In occupational exposure, fragrance mix-I was the main sensitizer. The provision of proper occupational risk information, workplace risk assessment and management, and complex programs for prevention of occupational skin diseases is outlined.

Keywords: contact sensitization, fragrance markers, surfactants/emulsifiers/ emollients, cosmetics, occupational exposure, educational exposure

Introduction

European legislation (REGULATION (EC) No 1223/2009) defines ‘cosmetic product’ as any substance or mixture intended to be placed in contact with the external parts of the human body (epidermis, hair system, nails, lips and external genital organs) or with the teeth and the mucous membranes of the oral cavity with a view exclusively or mainly to cleaning them, perfuming them, changing their appearance, protecting them, keeping them in good condition or correcting body odors (1).

According to the Federal Food, Drug & Cosmetic Act (FD&C Act), cosmetics are "articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body...for cleansing, beautifying, promoting attractiveness, or altering the appearance." Included in this definition are products such as skin moisturizers, perfumes, lipsticks, fingernail polishes, eye and facial makeup preparations, shampoos, permanent waves, hair colors, toothpastes, deodorants, as well as any material intended for use as a component of a cosmetic product (2).

During the last decades the use of cosmetics has considerably increased among the general population, with new products being continuously produced and presented by media in some extent aggressively to the consumers. Fashion trends also impose cosmetics use. Due to the wide variety of their applications, different cosmetic products contain a numerous ingredients, some of which being potential sensitizers. Therefore, allergic contact dermatitis as common adverse reaction caused by cosmetics is increasingly being observed, with a varying prevalence depending on the specificity of exposures, cultural habits, regional legislation, and the tested population.

Consumers are confronted with a large number of fragrance allergens from various sources, mainly cosmetics, together with scented products in households (3). Fragrances, including fragrance mix, balsam of Peru, and cinnamic aldehyde are considered as the most common causative ingredients of contact sensitization to cosmetics (4,5). According to a recent study, highest patch test positivity rate over 30 years was observed in the cosmetics series (70.2%), and among the top three most common allergens were two fragrances - fragrance mixed I and linalool hydroperoxide (6).

Surfactants and emulsifiers are abundantly presented in cosmetics and household products. Generally they are not considered to be among the main causative agents of contact sensitization, but it was suggested that cases of occupational contact dermatitis could be attributed to them (7).
Numerous studies are focused to evaluate the prevalence of contact sensitization to cosmetic ingredients among the general population or patch-tested patients with suspected allergic contact dermatitis. Cosmetologists are a high-risk group for development of occupational contact dermatitis - a condition often remaining unrecognized and diagnosed. Among this professional group, apart from the consumer exposures, the occupational one starts at the beginning of their practical education. In our knowledge, quite a few data in the available literature was found regarding the prevalence of contact sensitization among occupationally exposed cosmetologists and no studies were found concerning the risk of arising of allergy among students of cosmetology.

Aim

Therefore, the aim of the present study was to perform a comparative evaluation of the prevalence of contact sensitization to fragrance markers and selected common surfactants/emulsifiers/emollients among occupationally exposed cosmetologists and cosmetology students, and to outline the main causative allergens for each studied group.

Material And Methods

A cross-sectional study was conducted in October – December 2022 upon obtaining approval from the Medical Ethics Board at Medical University – Sofia and in accordance with the Helsinki Declaration. A total of 109 participants (8 men and 101 women) were included in the study. They were divided into 3 groups – 37 cosmetology students from the Medical College – Medical University – Sofia, 26 occupationally exposed cosmeticians, and 46 individuals without occupational exposure to cosmetics, serving as a control group. The demographic characteristics of the groups are presented in table 1.

Table 1. Demographic characteristics of the studied population.

Group	N	Age		
		[Mean±SD]	Min	Max
Cosmetology students	37	23.70±6.62	18	41
Occupationally exposed cosmeticians	26	32.77±9.60	20	51
Controls	46	31.98±14.54	17	62
Total	**109**	29.48±11.84	17	62

All the participants were informed about the purpose of the study and gave their written informed consent before its commencement.
The study was granted by the Medical University of Sofia, Contract No D-169/ 14.06.2022.

Skin patch testing

All the participants were skin patch tested with the following haptens: fragrance markers - Fragrance mix – I (8.0% pet), Peru balsam (25.0% pet), Colophonium (20.0% pet), Hydroxy-isohexyl 3-cyclohexene carboxaldehyde (HICC) (5.0% pet); surfactants/emulsifiers/emollients - Cetearyl glucoside (5.0% pet), Decyl glucoside (5.0% pet), Cocamidopropyl betaine (1.0% pet), and Lanolin alcohol (30.0% pet) – Chemotechnique Diagnostics, by placing the haptens in IQ Ultimate hypoallergenic patches of Chemotechnique Diagnostics (IQ Chambers®, Vellinge, Sweden). Lack of anti-allergic medication one week before and during the testing was a mandatory requirement. Patches were applied on the upper back of the tested individuals and left for 48 hours. Patch test reading was performed on day (D) 3 or D4 and on D7. The reactions were interpreted as negative, doubtful, weakly positive (+), strongly positive (++), extremely positive (+++), and irritant reactions, as recommended by the International Contact Dermatitis Research Group (ICDRG). For the statistical analyses, as positive reactions were counted reactions with least one plus (+) on D3/4 or D7, whereas negative, doubtful, and irritant reactions were concluded as negative.

Thermographic examination of patch test reactions

In parallel with the standard reading, as an objective method to confirm the results, thermographic examination was performed using an infrared-based FLIR T320 thermal imaging camera. Then, the recorded image was archived and processed by means of the FLIR Tools software (FLIR Systems, Wilsonville, OR). The recorded image was archived and processed by means of the FLIR Tools software. The methodology used calculates the difference between the average skin temperature in the reaction area and in a control area located usually about 1 cm to the sides of the reaction area - ΔT. For values above 0.9, it is assumed that the reaction is highly positive.

Statistical methods

Statistical analyzes were performed using statistical software SPSS for Windows version 20.0. Continuous variables were presented as mean±standard deviation (SD). The category variables were presented as a percentage. The relationship between test-haptens and groups was evaluated by Fisher's exact test. A two-tailed p value < 0.05 was considered statistically significant.

Results

Regarding the age characteristics of the tested groups, the mean age of the students was significantly lower if compared to the control group (p=0.006) and the one of the occupationally exposed cosmeticians (p=0.008). No significant differences between the controls and cosmeticians were observed (p=0.957). Data on the prevalence of contact sensitization to the selected test-haptens in the defined groups are presented in table 2.

Regarding the fragrance markers, taken for the whole tested population, HICC was identified as a main contact sensitizer, followed by Peru balsam. Moreover, the statistical analysis revealed, with high significance, an increased prevalence of contact sensitization to Fragrance mix-I among the group of cosmeticians, if compared with the one of cosmetology students and the controls. No significant between-groups differences were established for the remaining allergens.

Table 2. Prevalence of sensitization to the selected metals in the defined groups.

Positive reactions to:	Controls	Cosmetology students	Occupationally exposed cosmeticians	Total	p-value
	N (%)	N (%)	N (%)	N (%)	
Fragrance markers					
Fragrance mix – I	5_a (10,9)	1_a (2,7)	8_b (30,8)	14 (12,8)	**0,005***
Peru balsam	5 (10,9)	6 (16,2)	4 (15,4)	15 (13,8)	0,752
Colophonium	3 (6,5)	5 (13,5)	1 (3,8)	9 (8,3)	0,447
Hydroxyisohexyl 3-cyclohexene carboxaldehyde (HICC)	6 (13,0)	4 (10,8)	6 (23,1)	16 (14,7)	0,367
Surfactants/emulsifiers/ emollients					
Decyl glucoside	3_a (6,5)	10_b (27,0)	$3_{a,\ b}$ (11,5)	16 (14,7)	**0,028***
Cetearyl glucoside	6 (13,0)	6 (16,2)	1 (3,8)	13 (11,9)	0,362
Cocamidopropyl betaine	7 (15,2)	1 (2,7)	4 (15,4)	12 (11,0)	0,132
Lanolin alcohol	$8_{a,\ b}$ (17,4)	2_b (5,4)	8_a (30,8)	18 (16,5)	**0,028***

Note: *Fisher's Exact Test; Different letters show a statistically significant difference between the proportions (%) in the groups ($p<0.05$), and the identical letters indicate that there is no significant difference.

The positivity prevalence to decyl glucoside was found to be significantly higher among the cosmetology students if compared with the controls.

Lanolin was outlined as the main contact sensitizer taken for the whole tested population, as well as for the cosmetologists. The patch test positivity among the latter group was significantly higher if compared with the one of students.

In the thermographic examination, the strongly positive reactions were of a higher value than the limit – figure 1. In cases of weakly positive, doubtful or negative reactions, thermal imaging analysis showed low temperature amplitudes between the studied areas and control skin areas – figure 2.

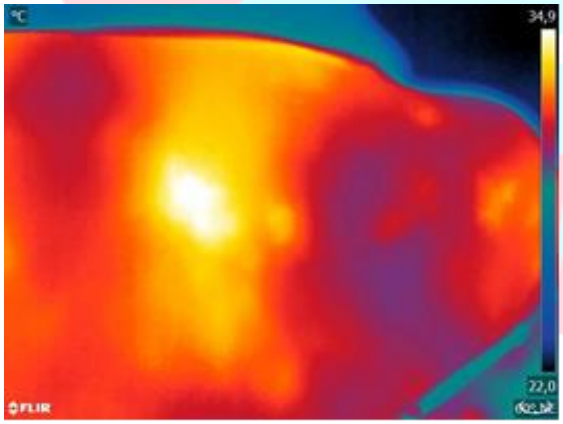

Figure 1. Strongly positive reaction

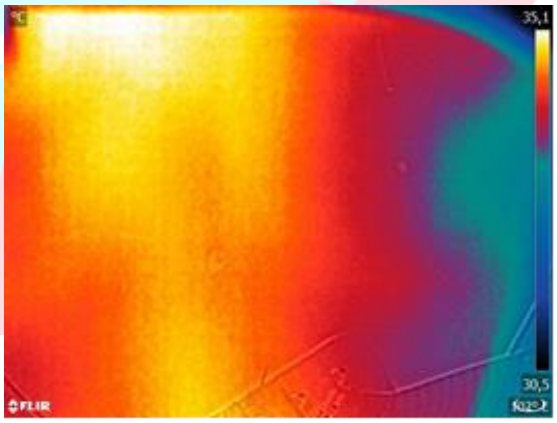

Figure 2. Weakly positive reaction

The results confirm the application of the method in patch test reactions reading.

Discussion

Fragrances are considered as the most common contact allergens after nickel. They are also one of the most frequently identified allergens in cosmetics, as they are used to add scent or flavor. Sensitization is most commonly caused by products such as aftershaves and deodorants, toothpastes, skin care products, air fresheners. Fragrances and essential oils are also top allergens in laundry detergents (66.7%), fabric softeners (90%), dryer sheets (75%), and stain removers (58.8%) (8). In 2007, fragrances have been named by the American Contact Dermatitis Society as Allergen of the year. Due to the growing importance of fragrance allergy and to ensure that consumers are sufficiently informed, since March 2005 a requirement has been introduced for 26 fragrance components to be labelled on cosmetic products in EU (Annex 3 of Directive 2003/15/EC).

Fragrance mix I (cinnamyl alcohol, cinnamal, hydroxycitronellal, amyl cinnamal, geraniol, eugenol, isoeugenol, oakmoss absolute) is included in many standard patch testing series. According to a study covering individuals from European countries, highest was the frequency of contact allergy to fragrance mix I (9). Results from a retrospective analysis of data from the Information Network of Departments of Dermatology (IVDK), mostly for the years 2016-2018, indicate the lowest prevalence of positive reactions to Fragrance mix I in 2018 - 5.4% (10). Among 3105 patch tested patients, 603 suffered from cosmetic dermatitis, and 26.33% were positive to Fragrance-mix I (11). Data obtained in 53 departments in 13 European countries during 2019 and 2020 suggest a trend of increased percentage of positive reactions to FM I (6.80%), if compared with the period 2015-2018 (12,13).

Fragrance allergy is taken as a major contributor to occupational contact dermatitis. A 47-fold higher incidence rate ratio of fragrance-related allergic occupational contact dermatitis for beauticians and related occupations than the reference category was supposed (14). Our results indicate even higher prevalence of contact sensitization to Fragrance mix I if compared with the findings cited above. Cosmeticians could be outlined as a group at particular risk of occupationally induced contact sensitization to fragrances.

Balsam of Peru is a natural resin extracted from the Myroxylon pereirae tree growing in Central and South America. It consists of more than 250 chemical substances, incl. some flavors (cinnamyl alcohol, cinnamic aldehyde, eugenol and isoeugenol) and is also considered as a fragrance-allergy screening agent. Due to its antiseptic and aromatic properties, Peru balsam has a wide range of applications, the main being: as a fragrance in perfumery and cosmetics; as a flavoring agent and aroma in the composition of foods, beverages and sweets, cleaning products and medications for local application (15). Meta-analysis of 12 studies covering 8002 patch tested established 1.8% sensitization rate (16). In the United States, the sensitization prevalence ranged from 6.6% to 13.7% (17), and in Europe –from 6.62% (12) to 11.87% (11). Our findings indicate some higher positivity rates if compared with recent European data, without significant differences between the defined groups.

Colophonium (Rosin rosin, CAS no. 8050-09-7) is a term used for the solidified, distilled form of resins from pines, cedars, spruce, firs and junipers. The name colophonium, is noted by the International Nomenclature of Cosmetic Ingredients (18). Its chemical composition varies depending on the origin and production. The major skin-sensitizing compounds are the oxidized abietic-type acids. Except of being a cosmetic ingredient (in mascaras, rouge, eye shadows), colophonium is used in varnishes, printing inks, paper, greases, adhesives, surface coatings, insulations, waterproof paper, waxes, topical medications, cleaning agents, etc. (19).

In the large European multicenter studies, the frequency of positive reactions to colophonium was 1%–6% (20). Recent results obtained in Span and Netherlands indicate positivity rate 2.18% (12), and in Slovenia - 5.1% (21). It is a considered as a common contact allergen not only in consumer, but also in occupational settings (22). Basing on our findings, we can't consider colophonium as an important sensitizer in

occupational exposure to cosmetics. Puzzling was the observed high positivity rate among cosmetology students, but to confirm these finding further investigations are needed, with more age-matched participants included.

Hydroxyisohexyl 3-cyclohexene carboxaldehyde (HICC, Lyral®) belongs to the group of fragrance allergens. From August 2021, its use in cosmetic products was banned on in the EU. Ahlström et al (2021) presented results on the trend in the incidence of contact allergy to HICC in European dermatitis patients for the period 2009 - 2019. The prevalence of contact sensitization was 1.62% - 1.98%, demonstrating a significant reduction in HICC allergy in European dermatitis patients prior to the then impending European ban (23). In a retrospective study of patch tested patients between 1996 and 2019, conducted in Turkey, the prevalence of sensitization to HICC was found to be 0.5%, and occupational exposure was assumed as the main cause of sensitization in 6.1% of the clinically significant cases (24).

The results obtained in our study confirm the role of occupational exposure for contact sensitization to HICC. Highest was the positivity rate among the cosmeticians, though without statistical significance.

Surfactants are commonly presented in numerous products, such as shampoos, conditioners, soaps, and cosmetics (7). Alkyl glucosides (decyl glucoside, lauryl glucoside) are plant-derived nonionic mild surfactants created by reacting glucose with a fatty alcohol. They are increasingly being used in a wide range of cosmetics and household products (shampoos, soaps, liquid cleaners, wet wipes, etc.) as emulsifiers and foaming agents, and were named as Allergen of the year 2017 (25). The prevalence of allergic contact dermatitis induced by alkyl glucoside is considered to be relatively high, with frequent concomitant reactions between them. Of the patients with positive reactions, 79.3% were sensitized to multiple alkyl glucosides and 72.4% were women (26). According to the British Society for Cutaneous Allergy, most patients with positive reactions to decyl glucoside were female, which may reflect their greater use of cosmetic products (27).

We patch-tested the participants with decyl and cetearyl glucoside. In some extent, surprisingly, our results outline as a group at particular risk of contact sensitization the one of cosmetology students, though statistical significance was established only regarding the prevalence of positive tests to decyl glucoside among them if compared with the controls. A possible explanation could be the wider popularity among the young people of cosmetics personal care products, in some extent due to imposed fashion trends. Nevertheless, further studies with more participants is needed so a more categorical statement to be given.

Regarding the relevance of alkyl glucosides to occupational contact sensitization, a very recently published retrospective study by the North American Contact Dermatitis Group is of interest. The analysis included 24 097 patients who underwent patch testing with decyl and/or lauryl glucoside between 2009 and 2018. Of these, 2.0% had positive reactions. Results indicated that glucoside-positive patients were more likely to have an occupational skin disease. The most common source was personal care products (63.0%), especially hair (16.5%) and skin care products (15.2%) (28). In our study, 11.5% of cosmeticians reacted to decyl glucoside, but no clinical significance was established.

Cocamidopropyl betaine, an amphoteric surfactant also used in cosmetics products, has an irritant potential and can cause skin sensitization (29). Cocamidopropyl betaine was voted 2004 Allergen of the year and belongs to top 40 North American Contact Dermatitis Group allergens (1.6% prevalence of sensitization) (17). Recent study confirmed both its irritant and sensitizing properties, with 6.7% positive and 5.2% doubtful reactions (21).

Our results don't indicate a possible role of occupational exposure to cosmetics for the onset of contact sensitization to cocamidopropyl betaine. The positivity rate is nearly equal among the cosmeticians and the controls, proposing the importance of age characteristics and/or the duration of exposure to products containing this ingredient.

Lanolin is derived from a secretion of the sebaceous glands of sheep. It is a complex mixture of sterols (wool wax alcohols), fatty alcohols and fatty acids with a varying composition. Because of its emollient properties, lanolin is used in cosmetic products and topical medicaments (30). Lanolin is an important cause of allergic contact dermatitis and has been named by the American Contact Dermatitis Society as the Allergen of the Year for 2023 (31). Lanolin-induced contact dermatitis usually develops after repeated or prolonged topical exposure, especially on damaged skin (32).

The reported prevalence of lanolin sensitization varied between different studies. Results obtained in a retrospective analysis of patch tested patients by the North American Contact Dermatitis Group between 2001 and 2018 (n=43,691) indicate 3.3% positive reactions, and 2.8% - currently relevant. Often reactions were considered as linked to personal care products and medications, and 2.24% of them were suspected to be related with occupation (33). Bizjak et al (2022) reported 3.6% positivity rate (21).

The results obtained in the present study confirm the possible role of repeated or prolonged exposure for sensitization onset. Cosmetologists could be outlined as a group at particular risk, with significantly higher positivity prevalence if compared with the group of students. Also, we suppose the role of occupational exposure as a risk factor.

Conclusion

This pilot study established comparative high prevalence and risk of contact sensitization to the tested fragrance markers and surfactants/emulsifiers/emollients of as ingredients of cosmetic products. Lanolin alcohol was identified as the main contact sensitizer, especially for the cosmetologists, with significantly higher patch test positivity if compared to the students. Regarding the fragrance markers, for the whole tested population, hydroxy-isohexyl 3-cyclohexene carboxaldehyde was identified as a main sensitizer, followed by Peru balsam. In occupational exposure, fragrance mix-I was the main sensitizer. Regarding the cosmetology students, highest was the positivity prevalence to decyl glucoside. A limitation of this study is that, being a pilot, cross-sectional one, with a relative small number of tested individuals included, further investigations are needed to validate the reliability of the presented results, focusing on the role of occupational exposure to cosmetics. We outline the need of provision of proper occupational risk information, developing and disseminating of practical tools for workplace risk assessment and management, with elaboration and communication of complex programs for prevention of occupational skin diseases.

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