

Contact Allergens in Top-Selling Textile-care Products

Heidi Bai, BS,* Idy Tam, MS,† and JiaDe Yu, MD‡§

Background: Chemicals in textile manufacturing and laundering products are important sources of allergens triggering allergic contact dermatitis. Allergens corresponding to the textile production process have been well recognized. However, there is limited information regarding potential allergens in laundering products.

Objective: The aim is to investigate the presence and prevalence of potential allergens in commonly used laundering products.

Methods: An Internet-based search was performed to identify the current best-selling laundering products in the United States. Subsequent inquiry of common allergens for each product was collected through a review of ingredients listed by manufacturers.

Results: Sixty-five laundering products were examined: 30 laundry detergents, 10 fabric softeners, 8 dryer sheets, and 17 stain removers. Ten common allergens were identified: benzisothiazolinone, benzyl benzoate, cocamidopropyl betaine, decyl glucoside, “fragrances,” lauryl glucoside, methylisothiazolinone, methylchlorisothiazolinone, phenoxyethanol, and propylene glycol. Fragrances and essential oils are the top allergens in laundry detergents (66.7%), fabric softeners (90%), dryer sheets (75%), and stain removers (58.8%). Laundry detergents labeled as “baby safe” and “free and gentle” contained common allergens, with methylisothiazolinone being the most prevalent, in 80% and 57.1%, respectively.

Conclusions: Textile dermatitis can negatively impact quality of life and function. Aside from textile dyes and finishing resins, laundering products should also be considered.

Allergic contact dermatitis (ACD) is a type IV cell-mediated delayed-type hypersensitivity reaction induced by haptens contacting the skin. Allergic contact dermatitis affects approximately 20% of both the general adult and pediatric populations,^{1,2} leading to impairment of one's quality of life and ability to work due to symptoms, functioning, and appearance.³ Epicutaneous patch testing is the criterion standard for detecting allergens responsible for ACD.⁴

Clothing can induce ACD through the use of disperse dyes for dyeing synthetic fabrics and formaldehyde resins for strength enhancement and shrinking and wrinkle prevention.⁵ The prevalence of textile dermatitis is increasing, likely related to the increasing use of such manufacturing techniques.⁶ An Italian study of 277 patients with textile dermatitis in 2014 revealed that disperse blue 124/106 and disperse yellow were positive in 79.8% of the cases, and formaldehyde resins were positive in 50%.⁶ However, over the last several years, in the United States, there has been a decreasing prevalence of ACD to formaldehyde-based textile finishes.⁷ Examples of the formaldehyde textile resins linked to ACD include dimethylol urea

and melamine formaldehyde urea.⁸ In 2015 to 2016, the North American Contact Dermatitis Group (NACDG) showed that of the 5594 patients tested, a positive reaction to disperse blue mix 124/106 was seen in 0.7% of the patients.⁹

Allergens corresponding to the textile production process itself have been well recognized, whereas washing and care products associated with textiles have been widely understudied and are potentially relevant sources for triggering ACD to textiles. A 2002 study of 738 patients with ACD demonstrated that 0.7% of the patients had positive reactions to laundry detergent.¹⁰ The haptens in the laundry detergents responsible for instigating ACD were unknown. Recently, few cases have attributed methylisothiazolinone (MI) in laundry detergent as a source of ACD, one of which was reported in a 7-year-old girl.¹¹ Another case in 2018 described a worker in the detergent production industry developing occupational ACD to MI.¹² However, the prevalence of allergens, including MI, in best-selling laundering supplies is not yet known.

Herein, we conducted a comprehensive examination to identify the presence and prevalence of common allergens in commonly used laundering products, including laundry detergents, fabric softeners, dryer sheets, and stain removers.

METHODS

In June 2019, we compiled a list of best-selling laundering products in the United States through an Internet-based search of a major online retailer, Amazon (Seattle, WA). We examined a total of 65

From the *University of Rochester School of Medicine and Dentistry, NY; †Tufts University School of Medicine; ‡Department of Dermatology, Massachusetts General Hospital; and §Harvard Medical School, Boston, MA.

Address reprint requests to JiaDe Yu, MD, Department of Dermatology, Massachusetts General Hospital, 50 Staniford St., Suite 200, Boston, MA 02114.

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best-selling laundering products, which include detergents, fabric softeners, dryer sheets, and stain removers (Table 1). The laundry detergents were subdivided into 10 scented liquid detergents, 7 free and gentle liquid detergents, 5 baby liquid detergents, 4 powder detergents, and 4 laundry pods. The fabric softeners were classified into 9 scented liquid fabric softeners and 1 free and gentle fabric softener. The dryer sheets were further organized into 6 scented dryer sheets and 2 free and clear dryer sheets. The stain removers were grouped into 11 stain remover sprays, sheets, sticks, and powders; 3 free and clear liquid stain removers; and 3 bleaches. Products without full ingredient information on either Amazon or the manufacturer's Web site were excluded from the analyses. Duplicates were also removed from the analyses. Sponsored products and bundled items that included various laundering products were also excluded. The ingredients list and price per ounce were recorded in an Excel spreadsheet (Microsoft Corporation, Redmond, WA). The ingredients of the selected products on Amazon were cross referenced to the ingredients listed on the manufacturer's Web sites. Common allergens were identified. Any components of fragrance mixes I and II and any products containing the essential oils linalool, limonene, ylang-ylang oil, citronellol, citral, lavender oil, bergamot oil, lemon peel oil, myrrh oil, palmarosa oil, patchaoui oil, cedar oil, geranium oil, or orange peel oil were included under "fragrance."

RESULTS

Sixty-five laundering products were investigated, including 30 laundry detergents, 10 fabric softeners, 8 dryer sheets, and 17 stain removers. Ten common allergens were identified: benzisothiazolinone (BIT), benzyl benzoate, cocamidopropyl betaine (CAPB), decyl glucoside, "fragrances," lauryl glucoside, MI, methylchloroisothiazolinone (MCI)/MI, phenoxyethanol, and propylene glycol (PG). "Fragrances"

was the top allergen among all laundering products: laundry detergents (66.7%), fabric softeners (90%), dryer sheets (75%), and stain removers (58.8%). Methylisothiazolinone was the second most prevalent allergen in laundry detergents (40%) and third most prevalent in fabric softeners (30%) and stain removers (29.4%).

Common Allergens in Laundry Detergents

The top common allergens in top-selling laundry detergents across all categories are listed in Table 2. The top 3 were fragrances (66.7%), MI (40%), and BIT (36.7%). The 5 top-selling laundry detergents for "babies" contained the highest average number of common allergens at 2.6 allergens per product. Fragrance and MI were the top allergens found in detergents for babies each in 4 of 5 products.

The 10 scented liquid laundry detergents carried the second highest average number of common allergens of 2.4 allergens per product. The top common allergen for scented liquid detergent was fragrance, present in all of the products. The 7 laundry detergents labeled as free and gentle contained 1.71 common allergens per product. The top common allergen of the free and gentle laundry detergents was MI, present in 57.1% of the products. The 4 detergent pods had 2.25 common allergens per product. The common allergens of PG, BIT, and fragrance were all present in 75% of the pods. Powder laundry detergents had the lowest average number of common allergens per product (0.75). They were free of common preservative allergens. The only common allergen was fragrance, seen in 3 of the 4 powder detergents.

Common Allergens in Fabric Softeners

The common allergens for 10 of the best-selling fabric softeners are listed in Table 2. The top 3 common allergens for fabric softeners were fragrances (90%), BIT (60%), and MI (30%) as well as PG (30%) (tied). The 9 scented liquid softeners contained the highest average number of common allergens per product at 2.5. The most prevalent common allergen in scented liquid fabric softeners was fragrance (100%).

Common Allergens in Dryer Sheets

The common allergens for 8 of the best-selling dryer sheets are listed in Table 2. The top common allergen for dryer sheets was fragrances (75%). There were no common allergens noted in the 2 dryer sheets labeled "free and gentle."

Common Allergens in Stain Removers

The common allergens for 17 of the most common stain removers are listed in Table 2. The top 3 allergens for stain removers were fragrances (58.8%), BIT (41.2%), and MI (29.4%). The 11 sprays, sheets, sticks, and powders had the highest average number of common allergens per product of 1.82, with fragrance present highest in 81.8% of the products. Of the 3 bleach products analyzed, fragrance was the only common allergen.

TABLE 1. Laundering Products Analyzed (N = 65)

Laundering Product Categories	No. Products
Laundry detergents	30
Free and gentle	7
Scented liquid	10
Baby	5
Powder	4
Pods	4
Fabric softeners	10
Free and gentle	1
Scented liquid	9
Dryer sheets	8
Free and gentle	2
Scented	6
Stain removers	17
Spray, sheet, stick, powder	11
Free and gentle	3
Bleach	3

TABLE 2. Potential Allergens in Laundry Detergents, Fabric Softeners, Dryer Sheets, and Stain Removers

Product Category	Potential Allergens,* n (%)									
	BIT	Benzyl Benzoate	CAPB	Decyl Glycoside	Fragrances†	Lauryl Glucoside	MI	MCI/MI	Phenoxyethanol	PG
Laundry Detergents, n = 30										
Scented liquid, n = 10	3 (30.0)	1 (10.0)	—	—	10 (100.0)	1 (10.0)	4 (40.0)	—	—	5 (50.0)
Free and gentle, n = 7	3 (42.9)	—	—	2 (28.6)	—	2 (28.6)	4 (57.1)	—	—	1 (14.3)
Baby, n = 5	2 (40.0)	—	—	—	4 (80.0)	2 (40.0)	4 (80.0)	—	—	1 (20.0)
Powder, n = 4	—	—	—	—	3 (75.0)	—	—	—	—	—
Pods, n = 4	3 (75.0)	—	—	—	3 (75.0)	—	—	—	—	—
Potential allergens in all laundry detergents, n = 30	11 (36.7)	1 (3.3)	—	2 (6.7)	20 (66.7)	5 (16.7)	12 (40.0)	—	—	10 (33.3)
Fabric softeners, n = 10										
Scented liquid, n = 9	5 (55.6)	—	—	—	9 (100.0)	—	3 (33.3)	2 (22.2)	1 (11.1)	3 (33.3)
Free and gentle, n = 1	1 (100.0)	—	—	—	—	—	—	—	—	—
Potential allergens in all fabric softeners, n = 10	6 (60.0)	—	—	—	9 (90.0)	—	3 (30.0)	2 (20.0)	1 (10.0)	3 (30.0)
Dryer sheets, n = 8										
Scented, n = 6	—	—	—	—	6 (100.0)	—	—	—	—	—
Free and gentle, n = 2	—	—	—	—	—	—	—	—	—	—
Potential allergens in all dryer sheets, n = 8	—	—	—	—	6 (75.0)	—	—	—	—	—
Stain removers, n = 17										
Scented spray/sheet/stick/powder, n = 11	5 (45.5)	—	1 (9.1)	—	9 (81.8)	—	4 (36.4)	—	—	1 (9.1)
Free and gentle, n = 3	2 (66.7)	—	—	1 (33.3)	—	—	1 (33.3)	—	—	—
Bleach, n = 3	—	—	—	—	1 (33.3)	—	—	—	—	—
Potential allergens in all stain removers, n = 17	7 (41.3)	—	1 (5.9)	1 (5.9)	10 (58.8)	—	5 (29.4)	—	—	1 (5.9)

n = total number products within the category.

*n (%) total number of potential allergens identified and percent prevalence.

†Fragrances include any components of fragrance mixes 1 and 2 and any products containing the essential oils linalool, limonene, ylang-ylang oil, citronellol, citral, elemi gum resin, lavender oil, bergamot oil, lemon peel oil, myrrh oil, palmarosa oil, patchaoui oil, cedar oil, geranium oil, sweet almond oil, or orange peel oil.

DISCUSSION

Clothing and laundering products are important causes of ACD. Dyes, formaldehyde resins, and finishes as causative agents of ACD and the rare involvement of natural cellulose and protein-based fibers have previously been discussed.¹³ The common allergens in laundering products used to clean and maintain textiles have not been extensively explored. Products such as laundry detergents, fabric softeners, and stain removers may linger on the fabric even if properly washed. Agarwal et al¹⁴ found that 139 to 2820 parts per million of detergent residue remain after one wash and required 20 to 22 washes to become undetectable. Although detergent residues remained after multiple washes, there are currently no published studies that have investigated on specific allergens that remain after multiple washes and the value of multiple fabric rinsing for sensitized patients. There have also been anecdotal reports of vinegar rinses in facilitating the removal of detergent residues; however, further studies are required to support these findings. Dallas et al¹⁵ conducted a survey indicating that 324 of 3841 people experiencing skin issues believed laundry detergents, fabric softeners, bleach, and prewash products were the problematic agents. Therefore, investigating common allergens in textile care products can be crucial for revealing additional responsible factors to textile dermatitis and enhancing diagnostic accuracy beyond dyes, resins, and finishes. Furthermore, manufacturers of laundering products often do not list ingredients on the actual product. Thus, ingredients listed on the retailers' or manufacturers' Web sites may not match with the ingredients in the actual product due to formulation updates and changes, especially for generic laundering products.

Fragrances

Fragrances and essential oils are used in laundering products to add scent and to mask odor. The most common fragrances in laundry detergent are limonene, linalool, and hexyl cinnamal.¹⁶ In our study, fragrances and essential oils are the major common allergen in laundry detergents (66.7%), fabric softeners (90%), dryer sheets (75%), and stain removers (58.8%).

Fragrances are major causes of ACD and were named allergen of the year by the ACDS in 2007.¹⁷ According to the NACDG, 11.3% patients had a positive reaction to fragrance mix I and 5.3% to fragrance mix II.⁹ Ten percent of patients with atopic dermatitis tested positive to fragrance.¹⁷ In addition to its pervasiveness, fragrance and essential oils are often difficult to avoid. Products labeled as "fragrance-free" have shown to incorporate fragrance ingredients as preservatives or as botanicals.¹⁷ One review of 1447 laundry detergents in Europe showed that the 26 fragrance allergens recognized by the European Detergents Regulations appeared almost 2000 times.¹⁷

Preservatives

Preservatives are used in laundering products to prevent microbial growth and control suds to avoid excess foaming. Methylisothiazolinone and MCI are preservatives belonging to the group of isothiazolinones, which inhibits microorganism growth. The NACDG reported a

13.4% positive patch test to MI and a 7.5% positive patch test to MCI/MI.⁹ Recently, case reports have attributed ACD to MI in laundry detergent and occupational laundry detergent handling.^{11,12} Methylisothiazolinone was named the allergen of the year in 2013 by the ACDS.¹⁸ An evaluation of 1392 patients in Italy demonstrated the rise in MI sensitization from 2.3% to 6.76% between 2012 and 2013.¹⁹ In our study, MI was the second most prevalent allergen in detergents overall and third most common allergen in fabric softeners and stain removers. It was the most common allergen for "baby detergents."

Benzisothiazolinone is an isothiazolinone with less sensitization common than MI or MCI/MI.²⁰ In this study, BIT was the second highest common allergen in fabric softeners (60%) and stain removers (41.2%) and the third highest common allergen for laundry detergents (36.7%). A toxicology study estimated that the minimal concentration of BIT in laundry detergent was unlikely to induce skin sensitization.²¹ However, Schwensen et al²² demonstrated cross-reactivity between BIT and MI in mice, which implies that individuals already sensitized to MI might react to BIT.

Phenoxyethanol is a non-formaldehyde-releasing preservative. In this study, phenoxyethanol was an uncommon allergen in laundering products. Phenoxyethanol was the most common preservative found in 5000 common products on the ACDS Contact Allergen Management Program database.²³ Phenoxyethanol has traditionally been used in combination with methylidibromoglutaronitrile, but has more recently been patch tested separately because the European Union banned methylidibromoglutaronitrile in leave-on and rinse-off products.²³ Phenoxyethanol has been shown to have low sensitization rates.²³

Formaldehyde is a preservative that may be emitted by laundry products during the washing and drying process but not listed by manufacturers. Steinemann et al²⁴ found that, using gas chromatography/mass spectrometry, laundry products emitted various volatile organic compounds such as formaldehyde, acetaldehyde, or methylene chloride. However, when authors analyzed the packaging of these products, these ingredients were not listed.

Emulsifiers and Emollients

Emulsifiers are lipids and oils that aid in combining active ingredients in different phases. Propylene glycol is an emulsifier and a known causative agent of ACD and irritant contact dermatitis.²⁵ Propylene glycol acts as a solvent with fragrances and essential oils.²⁵ In our study, PG was the third most common allergen in fabric softeners (30%). The ACDS named PG the allergen of the year in 2018.²⁶ Propylene glycol was seen in 37.8% of the 4674 products on the ACDS Contact Allergen Management Program database.²⁶ In addition, in 2015 to 2016, NACDG reports a 4% sensitization rate, a significant increase from 2.8% in 2013 to 2014.⁹ There are currently no published case reports of ACD to PG in laundering products.

Surfactants

Surfactants are cleaning agents commonly utilized in laundering products. Alkyl glucosides are nonionic surfactants with a low irritation

common in the general population, with the exception of patients with atopic dermatitis.²⁷ Decyl glucoside and lauryl glucoside are frequently reported causes of ACD.²⁷ In this study, decyl glucoside was found in 28.6% of free and gentle laundry detergent and in 33.3% of free and gentle stain removers. The ACDS named alkyl glucosides as allergen of the year in 2017.²⁸ The NACDG reported a 2.1% positivity rate to decyl glucoside in 2015 to 2016.⁹

Cocamidopropyl betaine is a surfactant used to increase foam and viscosity.²⁹ In this study, CAPB was only present in 9.1% of stain removers. In 2005, the FDA Voluntary Cosmetic Registration Program reported the presence of CAPB in 1242 of the 22,016 cosmetic products registered.²⁹ Sensitization rates increased to approximately 3% to 7.2% due to its replacement of more irritating ingredients, such as sodium lauryl sulfate.²⁹ Cocamidopropyl betaine took the title for allergen of the year in 2004.²⁹ In 2015 to 2016, the NACDG reported a 1.6% positivity rate.⁹

“Free and Gentle” and “Baby Safe”

Consumer products are often marketed as “hypoallergenic,” “free and gentle,” and “baby safe” but include many common allergens. These products claim to cause fewer allergic skin reactions, but no regulations or mandates have addressed the validity of that claim.³⁰

Our study showed that sensitizing preservatives were still among the top common allergens in “free and gentle” and “baby” products. Of the free and gentle detergents, 57.1% contained MI. Methylisothiazolinone was the top common allergen in baby detergents. Methylisothiazolinone was also observed in free and gentle stain removers as well. Surfactants, such as lauryl glucoside, were present in free and gentle and baby detergents. Decyl glucoside was found in free and gentle detergents and stain removers. In addition, fragrances were among the second most common allergen found in “baby safe” detergents. Four (80%) of 5 baby detergents contained fragrances. Of all the “free and gentle” laundering products examined, none of these products contained fragrances.

In a study on pediatric skin care products, MI appeared in 30 of the 152, including many of the ones labeled “gentle,” “sensitive,” or “hypoallergenic.”³⁰ Therefore, even “free and gentle” and products labeled for babies may still contain common allergens capable of triggering ACD.

LIMITATIONS

There were several limitations to this study. Because the purpose of this study involved the assessment of only the most commonly purchased laundering items in the United States, some products on the market that are less common, but still in use, were not included in this study. In addition, there may be other allergens in the products we examined which are potential allergens that we did not consider as “common allergens.” Furthermore, evaluation of laundry products was performed in June of 2019; however, consumer preferences change, and product formulations may change over time.

CONCLUSIONS

Textile dermatitis can negatively impact daily function and quality of life leading to loss of productivity. Aside from textile dyes and finishing resins, laundering products should also be considered. We assessed a total of 65 best-selling laundering products, including laundry detergents, fabric softeners, dryer sheets, and stain removers. Fragrances followed by preservatives, such as MI, were the most commonly found in laundry detergents, fabric softeners, and stain removers. Other common allergens identified were emulsifiers, such as PG, and surfactants, such as alkyl glucosides and CAPB. Many of these common allergens were named allergen of the year by the ACDS. These findings are particularly concerning because residues have been shown to linger after one wash. We recommend practitioners to recognize and consider the common allergens in textile care products when evaluating patients with diffuse, truncal dermatitis.

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