Phytophotodermatitis From Celery Among Grocery Store Workers

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• **We detected 19 cases of phytophotodermatitis during a cross-sectional epidemiological investigation of two Oregon grocery stores that were part of the same supermarket chain. Outdoor sunlight exposure during the workshift and tanning salon use were identified as risk factors; the most severe cutaneous reactions tended to occur among tanning salon users. Although both stores carried the same brands and varieties of produce, all 19 cases occurred among employees of one store, which had held a celery sale coincident with the outbreak, resulting in a quadrupling of the usual volume of celery sold. We found elevated psoralen levels in two of three celery samples obtained from the affected store; cutaneous provocation tests with trimmed surfaces of these celery samples produced phototoxic reactions. Preliminary experiments with one brand of celery have demonstrated psoralen levels as high as 25 $\mu g/cm^2$ of trimmed surface. These observations suggest that clinical phytophotodermatitis among grocery store workers may be caused by healthy celery and results from a complex interaction of exposure variables, including ultraviolet radiation from tanning salon use, frequency of handling celery, celery brand, and sporadic elevations of psoralen content from environmental stresses.**

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Phytophotodermatitis is a toxic dermal reaction caused by the interaction of long-wave ultraviolet radiation (UVA) and photoactive substances deposited on the skin surface following contact with various species of plants. When the photoactive substance is psoralen or other related furanocoumarins, this interaction typically produces an erythematous, sunburnlike response, accompanied by blisters when severe, and is invariably followed within seven to ten days of hyperpigmentation localized to the site of the cutaneous reaction. In mild cases, the sunburnlike response may go unnoticed, and the hyperpigmentation that follows may be the only visible cutaneous change characterizing this toxic reaction. The onset of this toxic reaction following UVA exposure is typically delayed for 12 to 36 hours, and symptoms of pain or tenderness are usually present in moderate to severe reactions.

Since 1981, researchers from the National Institute for Occupational Safety and Health (NIOSH), Cincinnati, and the Center for Infectious Disease (Centers for Disease Control, Atlanta) have investigated three previous outbreaks of phytophotodermatitis that have occurred among grocery workers employed in the produce or checkout departments of their respective stores.[1-3] Although two investigations failed to establish a causal agent, exposure to UVA from commercial tanning booth usage was established as a risk factor.[2] The third investigation incriminated exposure to a specific brand of celery with native psoralen content higher than other brands.[3] We report a fourth investigation, which has confirmed that healthy-appearing celery on grocery store shelves is a potential cause of phytophotodermatitis.

SUBJECTS AND METHODS

Epidemiologic Survey

In March 1986, we evaluated supermarket employees at two grocery stores in Oregon for suspected phytophotoder-

matitis following the diagnosis of two cases by one of the authors (W.S.S.). A cross-sectional study of 27 (77%) of 35 current full and part-time baggers, cashiers, and produce clerks at the index store (store A) and 21 (68%) of 31 similar employees at another store in the same supermarket chain (store B, 12 miles away), was performed. The investigation was confined to produce handlers, since previous epidemiologic studies had implicated a produce item.[1-3] Cases of phytophotodermatitis were initially ascertained by a self-administered questionnaire, in which we asked participants if they had experienced any of the following three cutaneous reactions on their dorsal hands or arms: (1) red blotches, streaks, or blisters only; (2) hyperpigmentation only; and (3) red blotches, streaks, or blisters followed by hyperpigmentation. Positive responders to questions 1 and 2 were accepted as cases of phytophotodermatitis only if they were confirmed by a follow-up dermatologic examination; positive responders to question 3 were accepted as cases without a dermatologic examination, although this was performed whenever possible. We asked participants to estimate the number of hours they spent outdoors during their usual workshift (11 AM to 4 PM only), and if they were using tanning salons. We did not consider any potential confounding effects of exposure to small amounts of UVA from fluorescent fixtures in the grocery stores. The frequency of handling various types of unwrapped produce was ascertained by requesting participants to estimate both the number of times they handled the produce during their usual workshift and the percent of time it was unwrapped or only partially wrapped. We reviewed produce inventories at the two stores for the two months preceding and during the outbreak, inspected the produce storage facilities, and interviewed the produce managers concerning changes in the handling of produce. We also observed the work routine for produce clerks, baggers, and cashiers.

Photoprovocation Testing

Based on results of our initial epidemiologic assessment, we subsequently performed photoprovocation tests with celery, parsnips, and carrots as follows. Three randomly selected, healthy-appearing stalks of trimmed celery and one trimmed parsnip were selected off the consumer displays from store A. Three investigators (P.J.S., M.A.O., and C.G.T.M.) rubbed intact surfaces (from the base ends) and store-trimmed surfaces (from the leafy ends) of the celery stems from two stalks on the upper outer part of their arms and the trimmed surface only from the third stalk on the forearms. We repeated this skin application procedure with the cut surface of the trimmed parsnip root, as well as the intact surface of the parsnip root base. Two investigators (C.G.T.M. and P.J.S.) also rubbed both the trimmed and intact surfaces of a carrot and a fourth celery stem from the shelves of a local grocery store (Cincinnati) carrying the identical celery brand; other celery brands were not investigated. Approximately one hour after dermal exposure (recommended interval for optimum photoactivation based on topical psoralen phototherapy protocols),[4] the skin of the arms was irradiated with 7.5 joules per square centimeter of UVA (approximately equivalent to 30 to 45 minutes of midday sun exposure)[5] from a phototherapy light box (Psoralite, Daavlon Co, Bryan, Ohio). We evaluated the irradiated sites 72 hours following exposure and at weekly intervals thereafter for one month.

LABORATORY ANALYSIS

Separated portions of the leaves and stems of the three celery samples (used in the photoprovocation experiments) from store A, as well as three additional randomly selected celery stalk samples from store B, were removed from the stalks, ground, and frozen at −16°C. These samples were subsequently packed on dry ice and shipped overnight to a United States Department of Agriculture (USDA) laboratory in Texas. The samples were analyzed using high-performance liquid chromatography (HPLC) for psoralen, bergapten (5-methoxypsoralen [5-MOP]), and xanthotoxin (8-methoxypsoralen [8-MOP]), following a minor modification of the existing analytical method[6] for linear furanocoumarins in celery, in which the HPLC solvent system for both leaf and stalk samples was changed to 0.09% methanol in chloroform and pumped at a rate of 2.0 mL per minute. Each sample was divided into four subsamples and analyzed separately, and a mean concentration and SD were calculated for each sample. Authenticities of the peaks quantitated by HPLC were verified by collecting each quantitated peak and obtaining the correct mass spectrum for each psoralen compound by capillary gas chromatography/mass spectroscopy on a mass spectrometer (VG 70-250 EHF). No analyses of psoralen content in parsnips or carrots were performed.

Table 1.—Phytophotodermatitis Cases Among Produce Handlers and Exposure to Ultraviolet Radiation

Exposure	Cases*	Total	Case Rate, %	Relative Risk	P Value†
≥2 h outdoor sun‡	13 (7)	20	65	2.9	.004
<2 h outdoor sun	6 (3)	27	22		
Tanning salon use	6 (6)	8	75	2.3	.04
No tanning salon use	13 (4)	39	33		
≥2 h outdoor sun, tanning salon use	5 (5)	6	83	4.2	.008
<2 h outdoor sun, no tanning salon use	5 (2)	25	20		

*Number of cases with severe (blistering) reactions in parentheses.

†One-tail Fisher's exact test.

‡During workshift hours 11 AM to 4 PM only.

Table 2.—Frequency of Handling Unwrapped or Only Partially Wrapped Produce During Usual Workshift Hours, Phytophotodermatitis Cases vs Noncases

Produce Item Frequency†	Handling Frequency*		Relative Handling
	Cases	Noncases	
Potato	8.8	3.5	2.5
Parsnip	2.4	1.3	1.8
Carrot	9.1	5.3	1.8
Celery	12.9	7.6	1.7
Lemon/lime	3.2	2.3	1.4
Parsley	1.9	1.5	1.3
Spinach	2.5	2.3	1.1
Broccoli	4.3	4.4	0.98

*Number of times handled during workshift multiplied by percent of time item was either unwrapped or partially wrapped, based on employee estimates in response to the questionnaire.

†Cases compared with noncases for each of the listed produce items.

Table 3.—Values of Linear Furanocoumarins in Celery*

		Mean (±1 SD)†			
		Psoralen	5-MOP‡	8-MOP‡	Total§
Store A					
Stem sample	1	1.0 (.1)	0.6 (.1)	7.2 (.6)	8.8 (.7)
	2	1.1 (.2)	0.9 (.2)	4.1 (.4)	6.1 (.7)
	3	3.1 (.3)	0.7 (.1)	5.2 (.4)	9.0 (.8)
Leafy end sample‖	1	2.0 (1.2)	3.4 (.6)	18.5 (4.8)	23.9 (6.4)
	2	4.2 (1.7)	3.7 (1.1)	14.6 (7.9)	22.5 (10.6)
	3	0.7 (.4)	1.3 (.5)	2.6 (.8)	4.6 (1.6)
Store B					
Stem sample	1	0.03 (.02)	0.2 (.02)	0.7 (.02)	0.8 (.02)
	2	4.9 (3.3)	0.7 (.1)	5.9 (1.0)	11.4 (4.3)
	3	0.1 (.1)	0.3 (.1)	2.1 (.5)	2.6 (.6)
Leafy end sample	1	1.2 (.5)	0.6 (.1)	1.6 (.5)	3.3 (.4)
	2	1.7 (.6)	1.5 (.2)	3.3 (.8)	6.4 (1.4)
	3	1.3 (.5)	1.1 (.2)	1.0 (.2)	3.5 (.8)

*Values are given in parts per million.

†The means were derived from four subsamples.

‡5-MOP indicates 5-methoxypsoralen; 8-MOP, 8-methoxypsoralen.

§No significant difference between store A and store B celery when total means are compared. When only samples 1 and 2 from store A are compared with all samples from store B, $P < .005$.

‖Used in phytoprovocation experiments. Samples 1 and 2 produced phototoxic reactions in three of three investigators, but sample 3 produced phototoxic reactions in only one of three.

RESULTS

Epidemiologic Survey

We identified 19 cases of phytophotodermatitis among 48 produce handlers employed at stores A and B by dermatologic examination (15 cases) or questionnaire alone (four cases). One employee (a noncase from store B) did not complete the questionnaire section concerning outdoor sun exposure and was excluded from further analysis. Produce handlers who were exposed to two or more hours of outdoor sunlight (11 AM to 4 PM) during the workshift or who used tanning salons had significantly increased risks for developing phytophotodermatitis (Table 1); the risk was greater for those who had exposure to both. The number of tanning salon users was too small to permit a valid stratified analysis for possible confounding by exposure to outdoor sunlight. All six produce handlers who used tanning salons had severe (blistering) reactions, compared with only four of 13 who did not (Table 1).

Table 2 lists the frequencies of handling various unwrapped or partially wrapped produce during the produce workers' usual workshift. Celery was the produce item most frequently handled, compared with other produce items. Cases handled celery with a relative frequency of 1.7 times greater than noncases, although relative handling frequencies for potatoes, parsnips, and carrots were greater than for celery.

All 19 cases of phytophotodermatitis occurred among the 27 employees at store A, and were distributed as follows: 16 of 17 baggers, two of nine cashiers, and one of one produce clerk. No statistically significant differences between employees of stores A and B were detected for the following parameters; age, sex, race, duration of employment, usual frequency of handling various produce items, outdoor sunlight exposure, or tanning salon use. Both stores carried the same brand of celery, and sales records indicated that the volumes of celery sold at both stores were usually comparable. However, store A had held a store-wide sale, which included a substantial reduction in the price of celery, with an approximate quadrupling of celery sold coincident with the outbreak. This indirectly suggested that employees of store A were exposed to relatively more celery than employees of store B during the period of the outbreak.

The supermarket chain bought its produce from a local wholesaler. The wholesaler did not store celery for more than 48 hours. Typically, celery was purchased daily by both stores A and B, since most celery was usually sold from the grocery store shelves within 24 hours. Both stores stored their celery and other perishable produce in refrigerated units, but placed their celery onto consumer displays within 48 hours of purchase from the wholesaler. All celery sold at stores A and B appeared normal and healthy; we could not detect any changes caused by wilting, rotting, or disease.

We observed that produce clerks unpacked boxes of celery and trimmed away the leafy portions by cutting through the stems at the leafy end of the stalks before setting them out on the consumer displays. Some produce items, such as celery, were trimmed by hand. Direct contact of the cut surfaces of celery stems with the skin of the forearms and hands occurred during trimming and stocking of the consumer displays. Parsnip roots and carrots were the only other produce items known to contain psoralens that were trimmed, leaving an exposed (cut) surface.

Cashiers were responsible for coding the prices of grocery items into the cash register. This required the handling of every produce item. Although plastic bags were provided to consumers for individual bagging of produce items, celery stalks were longer than the provided bags. The trimmed ends typically protruded out of these bags, thus allowing the cut surface of the stems to strike the hand and forearms of the cashiers. Cashiers rarely went outdoors during the workshift.

The baggers placed the grocery items into brown paper bags for consumers. Celery was typically placed into these bags in an upright position, and the exposed cut surfaces frequently protruded above the tops of the bags. Bagging was performed by checkers when baggers were busy elsewhere. The work routine required the baggers to transport all groceries to the customers' cars in the parking lot. As a result, baggers spent a considerable portion of the workshift outdoors; cashiers, on the other hand, remained

at the cash registers and did not frequently go outdoors during the workshift.

Photoprovocation Testing

Photoprovocation testing of trimmed surfaces at the leafy ends of two celery samples from store A produced faint to mild erythematous responses in all three investigators by 72 hours. A freshly trimmed surface from the leafy end of a third sample produced a mild linear inflammatory reaction in only one of the three investigators. All reactive sites began to develop characteristic hyperpigmentation within two weeks following irradiation, which persisted for several months. The intact surfaces of celery stems failed to provoke any reactions; intact celery leaves were not tested. The trimmed surface of a parsnip from store A produced brisk, tender, erythematous reactions in two investigators and a moderate blistering reaction in the third. Like the celery stems, the intact surfaces of the parsnip failed to provoke any reactions. Again, a characteristic and persistent hyperpigmentation subsequently developed in the parsnip-reactive sites. The trimmed surface of the same brand of celery from a third store (Cincinnati), not involved in the investigation, produced a moderate erythematous reaction in two of two investigators, followed by typical hyperpigmentation, suggesting a widespread potential for clinical phytodermatitis to develop in grocery store workers. Neither the trimmed nor intact surfaces of a carrot produced any reactions.

Laboratory Analysis

The furanocoumarin content of celery samples (same brand) from stores A and B are presented in Table 3. Total psoralen content was not significantly different, when all samples of stems and leaves from store A were compared with those from store B. However, psoralen levels in the leafy ends from two of the three samples from store A are significantly elevated ($P < .005$) when only these two samples are compared with those from store B. These two samples produced phototoxic reactions in three of three investigators, while the third sample produced reactions in only one of the three. Greater amounts of 8-MOP in the celery from store A accounts in large part for any of these apparent differences. Thus, sporadic elevations of psoralen content in some celery stalks from store A remain a possible explanation for the clustering of cases within store A.

COMMENT

Psoralens occur naturally in a variety of plants, mainly the *Umbelliferae, Rutaceae,* and *Moraceae* families. Psoralen-containing plants that are frequently sold in grocery stores include limes, lemons, figs, parsley, parsnips, carrots, dill, and celery.[5] However, the clinical occurrence of phytophotodermatitis probably involves a complex interaction of quantitative psoralen levels within these plants, sufficient skin exposure to their essential oils through contact with cut, broken or trimmed surfaces, and duration of subsequent exposure to UVA. In this investigation, we observed parsnips, celery, and carrots on grocery store shelves to have trimmed surfaces. Published measurements of total psoralens in these healthy produce items have found approximate concentrations of 40 ppm (parsnips),[7] 1 to 2 ppm (celery),[6,8] and <0.3 ppm (carrots).[7]

In the present outbreak, we have implicated healthy-appearing celery offered to consumers on the grocery store shelves as the produce item most probably responsible for causing phytophotodermatitis. Celery was the item most frequently handled in an unwrapped or partially wrapped condition. The inability to completely wrap the trimmed ends of the celery with the plastic consumer bags provided by the store ensured the greatest potential for direct skin exposure among baggers and cashiers. We found relatively high psoralen concentrations (22 to 24 ppm) in two celery samples from store A, both of which produced phototoxic reactions in three of three investigators. The photoprovocation tests also confirmed that skin contact with cut or trimmed surfaces of celery was necessary to produce a phototoxic reaction; no phototoxic reactions were produced in volunteers from skin contact with the intact surfaces of these produce items. While trimmed parsnips also produced phototoxic reactions in volunteers and could potentially cause phytophotodermatitis, the small volume of parsnips sold and their smaller size, which allows them to be completely covered in plastic consumer bags, argue that exposure to parsnips did not contribute to this outbreak. Exposure to the trimmed surfaces of carrots, which did not provoke phototoxic reactions, is also not likely to have been important.

Healthy celery sold in grocery stores is not generally suspected as a cause of phytophotodermatitis. Celery infected with *Sclerotinia sclerotiorum* (pink rot fungus) is a common cause of phytophotodermatitis among field workers who harvest celery,[9] but this is due to increased synthesis of furanocoumarins in response to infection. Ashwood-Smith et al[8] found withering celery, sold on grocery store shelves as "soup celery" to be infected with small colonies of *S sclerotiorum,* one sample of which caused phytophotodermatitis. Berkley et al[3] suspected that healthy celery sold in grocery stores could cause phytophotodermatitis, based on an association between cases and exposure to one brand which contained higher relative levels of psoralen (10 to 20 ppm) than other brands.

In preliminary (R.C.B., unpublished findings, 1986) experiments utilizing an ethanol extraction technique and computerized calculations of surface area, one of the authors (R.C.B.) has detected psoralen levels as high as 25 $\mu g/cm^2$ on the trimmed surfaces of the same brand of celery implicated in our present investigation, while no psoralens could be detected on the intact surfaces of the stem. Surface concentrations of psoralens in this range may produce phototoxic reactions in human beings.[10] Since psoralens are phytoalexins, which may be synthesized in

response to a variety of diverse stimuli, other factors that can influence natural psoralen concentrations in celery may be important. These include: the amount of UV light, temperature, and other climatic stresses to which the growing celery is subjected[11]; treatment of field celery with the copper salts,[11] herbicides,[12] or other fungicides; and inadequate or prolonged storage of the celery.[13] Outdoor exposure to sunlight during the workshift and tanning salon use were implicated as important risk factors in this investigation. Severe blistering reactions were more frequent among tanning salon users. This risk may be added to other risks already identified from tanning salon use.[14]

Based on our above observations and findings, we recommend the following preventive measures: (1) education of grocery store employers and workers about possible phototoxic reactions from trimmed celery and parsnips (or other psoralen-containing produce where the plant surface has been cut or abraded), and the additional risk of tanning salon use; (2) provision of plastic bags at consumer displays that are large enough to enclose trimmed celery completely; and (3) reconsideration of the practice of trimming celery (or parsnips) for consumer display, since it is generally performed only to enhance the attractiveness of the produce item to consumers.

Further research by phytochemists is necessary to establish the relative importance of celery brands and the various factors that may increase their psoralen content, thus contributing to clinical outbreaks of phytophotodermatitis among grocery store workers. In two previous investigations, as well as the present one, the same variety (brand) has been associated with the outbreaks.[2,3] However, we did not observe any cases in store B, which carried this same brand, suggesting either that volume of exposure or sporadic elevations of psoralen content may be critical determinants . We encourage dermatologists who encounter new cases to report them to: Toby Mathias, MD, 4676 Columbia Pkwy, Cincinnati, OH 45226.

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