Kale Allergy: A New Member in LTP Syndrome

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The so-called superfoods have become extremely popular in terms of enhancing dietary patterns. One such superfood, kale (*Brassica oleracea var acephala*), belongs to the Brassicaceae vegetable family, which also comprises broccoli, cauliflower, cabbage, kohlrabi, and Brussels sprouts as varying forms cultivated from wild mustard [1]. Despite the widespread consumption of these foods, only anecdotal cases of allergy to Brassicaceae vegetables have been reported to date [2-5]. In the specific case of kale, no reports of hypersensitivity have been published. Several allergens have been shown to be responsible for Brassicaceae allergy, including the mustard allergens 2S albumin (Sin a 1 from yellow mustard and Bra j 1 from oriental mustard), 11S globulin (Sin a 2), lipid transfer protein (LPT; Sin a 3), and profilin (Sin a 4) [6-8]. Brassicaceae LTP, Bra o 3 (9 kD), is a major allergen in broccoli, cauliflower, and cabbage [2].

We report the case of a 26-year-old woman with allergic rhinoconjunctivitis and bronchial asthma resulting from allergy to grass pollen, peach, melon, and watermelon. She presented hives and palmoplantar pruritus within 10 minutes after eating a kale salad with walnuts, cranberries, and goat cheese. Her symptoms subsided 1 hour after administration of dexchlorpheniramine. This was the first time she had eaten kale, and she has never eaten it since. However, she has consumed the other ingredients again, without symptoms. She has tolerated Brassicaceae (broccoli and cauliflower) but has not consumed cabbage, mustard, or Brussels sprouts.

Commercial extracts were used for skin prick testing to aeroallergens (pollen, animal epithelia, dust mites, fungi) and food (peach, melon, banana). The results were positive for *Alternaria alternata* (10 mm), *Cupressus arizonica* (8 mm), *Cynodon dactylon* (7 mm), cat and dog dander (5 mm and 8 mm), grass mix (7 mm), *Phleum pratense* (8 mm), *Olea europaea* (12 mm), *Platanus acerifolia* (10 mm), peach (3 mm), and melon (4 mm). Prick-by-prick testing was also positive for watermelon (4 mm), cabbage (8 mm), Brussels sprouts (10 mm), kale (12 mm), and mustard (7 mm). Histamine (5 mm) and physiologic saline solution (0 mm) served as positive and negative controls, respectively. The result of blood testing for total IgE was 227 kU/L (UniCap System, Phadia). In the case of specific IgE, the results were as follows: Phl p 12, 0.35 kU_A/L; Ole e 7 LTP, 0.40 kU_A/L; Phl p 1 + p 5b, 32 kU_A/L; Cor a 8, 0.83 kU_A/L; mustard, 0.16 kU_A/L; Ara h 9, 7.11 kU_A/L; rPru p 3, 5.76 kU_A/L; Mal d 3, 7.07 kU_A/L; and Pla a 3, 0.00 kU_A/L.

Kale, mustard, cabbage, and Brussels sprouts proteins were obtained by homogenization of 20 g in 100 mL of phosphate-buffered saline. The homogenates were centrifuged for 30 minutes at 17 700 rpm at 4ºC, and the supernatant was dialyzed against deionized water. Serum specific IgE analysis was performed using an IgE slot blot assay, which revealed IgE reactivity to peach peel, kale, cabbage, watermelon, and melon. IgE reactivity was not detected in Brussels sprouts, mustard, or *Artemisia vulgaris* extracts in or phosphate-buffered saline (negative control) (Figure, A). SDS-PAGE IgE immunoblotting assay was performed with the patient's serum (1:10 dilution) under reducing conditions, revealing IgE reactivity with a molecular weight of 9 kDa in kale, cabbage, and Pru p 3 extracts (Figure, B). IgE bands from kale and cabbage extracts were cut from polyacrylamide gel (15% acrylamide, 2.6% acrylamide-bis-acrylamide cross-linking) for gel trypsin digestion and analyzed using MALDI-TOF mass spectrometry (MS) and liquid chromatography with tandem MS. Protein identification based on MS or tandem MS spectra using the MASCOT software search algorithm revealed high homology to peach LTP (Pru p 3) in both extracts.

SDS-PAGE immunoblotting-inhibition assays were performed to demonstrate the presence of cross-reactivity between Pru p 3 and kale or cabbage extracts. IgE binding was not completely inhibited by kale or cabbage extracts, although it was completely inhibited by peach peel (Figure, B).

Mustard tolerance was confirmed by an open oral challenge. Increasing doses of mustard sauce were administered up to a total dose of 10 g without symptoms.

LTP is the most frequent cause of food allergy in adults in the Mediterranean. LTP-sensitized patients may experience symptoms after consumption of a large variety of plant foods owing to the wide distribution and high homology between LTPs from a long list of unrelated fruits and vegetables. Nevertheless, clinical expression of this sensitization may vary, ranging from patients who tolerate most foods despite being strongly sensitized or who only experience reactions in the presence of cofactors to others who, despite

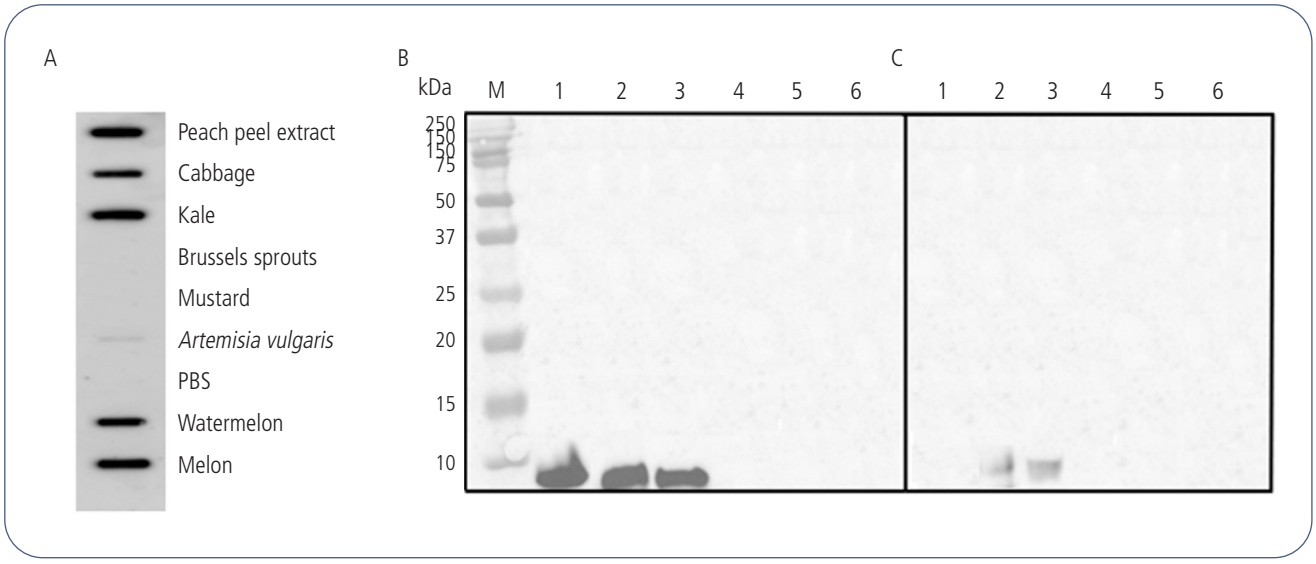

Figure. Detection of IgE reactivity protein from the patient's serum. A, Slot blot showing IgE binding to extracts of peach peel, cabbage, kale, mustard, Brussels sprouts, *Artemisia vulgaris*, watermelon, and melon, with PBS as a negative control. B, Western blot of peach peel (line 1), cabbage (line 2), kale (line 3), mustard (line 4), Brussels sprouts (line 5), *Artemisia vulgaris* (line 6). C, SDS-PAGE immunoblotting-inhibition with purified peach peel LTP in the inhibitory phase and the same extracts as in Western blot in the solid phase. PBS indicates phosphate-buffered saline.

being minimally sensitized, experience significant allergic reactions [9].

Palacín et al [2] identified Bra o 3 (cabbage LTP), which cross-reacts with other plant foods (eg, mustard and peach), and found that it shares 50% identity with Pru p 3. Sin a 3 shares 65% and around 55% identity with Bra o 3 and Pru p 3, respectively [9]. These findings confirm cross-reactivity between Rosacea and Brassicaceae LTPs.

A recent publication showed that in peach-allergic patients with or without peanut allergy, determining IgE and IgG4 recognition patterns for linear B-cell epitopes in various LTPs could differentiate between patients with different phenotypes of tolerance to LTPs [10].

The observations made above reveal the importance of identifying and characterizing the allergens involved in an allergic reaction in order to establish avoidance measures and indications.

To our knowledge, this is the first case of kale allergy in which an LTP was identified as the culprit allergen.

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

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