

Plant-food and seafood allergens – an overview

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Many plant-food allergens belong to one of the 11 classes of pathogenesis-related (PR) proteins such as chitinases of avocado and banana, the antifungal thaumatin-like and osmotin-like proteins of cherries and bell peppers, and Bet v 1 homologues of vegetables and fruits (1). Seed storage proteins and amylase- and protease-inhibitors are the predominant allergens of mustard seeds and seeds of cereal grasses. Less biochemical variety is found among the allergens of animal foods, where muscle proteins such as tropomyosins and parvalbumins constitute the most important allergens for adult atopics. This overview focuses on allergens from plants listed according to their established taxonomic order and seafood allergens that have been cloned or N-terminally sequenced.

Allergens in foods derived from plant sources

Magnoliatae (Dicotyledoneae)

Magnoliidae – Magnoliales – Lauraceae

Avocado (*Persea americana*): *Prs a 1*. The major avocado allergen *Prs a 1* is a class-I basic endochitinase which contains a cysteine-rich N-terminal domain with chitin-binding properties (2). *Prs a 1* belongs to the PR-3 proteins that are associated with deterrence and antimicrobial activity.

Magnoliidae – Piperales – Piperaceae

Pepper (*Piper nigrum*). Birch-pollen and mugwort-

mediated hypersensitivity to celery and spices. The N-terminal 23 amino-acid residues of a 28-kDa major pepper allergen are 58% identical to the N-terminus of a mature wheat germin. This protein belongs to the germin (oxalate-oxidase) family and may play a role in altering the properties of cell walls during germinative growth (3).

Hamamelididae – Fagales – Betulaceae

Hazelnut (*Corylus avellana*): *Cor a 1*. Individuals allergic to pollen of early flowering trees are frequently allergic to hazelnuts. The N-terminus of the major hazelnut allergen is 72% identical to that of the major hazel-pollen allergen *Cor a 1* and belongs to the conserved PR-10 class of Bet v 1 homologous proteins (4). Bet v 1 homologues are present throughout the plant kingdom and have been cloned from more than 60 different plant species (5).

Dilleniidae – Cucurbitales – Caricaceae

Papaya (*Carica papaya*). Papain is a commercially processed enzyme from the papaya fruit which is widely used due to its catalytic capacity as a cysteine protease. The presence of papain in meat tenderizers justifies its characterization as a food allergen. IgE directed against papain cross-reacts with other proteinases such as actinidin, bromelain, and ficin (6).

Dilleniidae – Capparales – Brassicaceae

Yellow mustard (*Sinapis alba*): *Sin a 1*. *Sin a 1*.

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storage protein that belongs to the 2S albumin family. It is composed of two disulfide-bonded polypeptide chains. Sin a 1 possesses a high resistance to trypsin digestion (7).

Oriental mustard (*Brassica juncea*): *Bra j 1*. *Bra j 1*, the major allergen from oriental-mustard seeds, consists of two chains linked by disulfide bonds. Its amino-acid sequence is related to that of Sin a 1 (8).

Rosidae – Rosales – Rosaceae

Apple (*Malus domestica*): *Mal d 1*. Patients suffering from type I allergy caused by birch pollen frequently demonstrate an intolerance of apples. *Mal d 1*, the major allergen of apple, is 64.5% identical to Bet v 1a (5). The N-terminal sequence of a 31-kDa protein, another major allergen of apple, shares 46% identity with sequences of proteins of the PR-5 family from wheat (triamin), oat (avematin), and barley (thaumatin-like protein) (9). Thaumatin-like proteins may function as trypsin/ α -amylase inhibitors against herbivorous insects or may exhibit antifungal properties.

Cherry (*Prunus avium*): *Pru a 1*, *Pru a 2*. Some patients with tree pollinosis report allergic reactions after the ingestion of cherries. The major cross-reactive allergen *Pru a 1* is a Bet v 1 homologue (10). *Pru a 2*, another major allergen from the sweet cherry, is a 23.3-kDa thaumatin-like protein and a member of the PR-5 family of proteins (11). It may play a role in protecting the fruit against microbial pathogen attacks.

Rosidae – Fabales – Fabaceae

Peanut (*Arachis hypogaea*): *Ara h 1*, *Ara h 2*. Peanut allergy is a significant health problem because of the prevalence and potential severity of the allergic reaction. *Ara h 1*, a major peanut allergen, shows significant similarities to the vicilin seed storage protein family (12). *Ara h 2*, another major peanut allergen, has a molecular weight of 17.5 kDa and is homologous to the conglutinin family of seed storage proteins (12).

Soybean (*Glycine max*): *Gly m Bd 30 K*. The allergen *Gly m Bd 30K* is a seed oil-body-associated protein and shows homology to papain-like thiol proteinases (13).

Rosidae – Araliales – Apiaceae

Mugwort- and birch-pollen-allergic patients repre-

to plant foods derived from members of the Apiaceae.

Celery (*Apium graveolens*): *Api g 1*. *Api g 1*, a Bet v 1 homologue and the major allergen from celery tuber, was cloned, expressed, and compared to Bet v 1 (5). Incubation of serum pools with recombinant *Api g 1* did not block IgE-binding to natural Bet v 1. In contrast, recombinant Bet v 1 was able to inhibit IgE-binding to the natural celery allergen.

Parsley (*Petroselinum crispum*). The administration of a cell-wall preparation from the fungus *Phytophthora megasperma* f. sp. *glycinea* to cell suspension cultures of parsley resulted in rapid and dramatic increase of mRNAs coding for pcPR1 and PcPR2 (5). These PR-10 family members represent the conserved Bet v 1 homologues in parsley and were able to bind IgE from a serum pool of birch-pollen-allergic patients (14).

Carrot (*Daucus carota*): *Dau c 1*. CR16, the Bet v 1 homologous protein in carrot, is a major root protein and a member of the PR-5 family of proteins (15). Several of these Bet v 1 homologues of carrot were expressed in *E. coli*. Their ability to bind IgE from birch-pollen-allergic individuals justifies their designation as *Dau c 1* allergens (Hoffmann-Sommergruber K, unpublished).

Asteridae – Tubiflorae – Solanaceae

Potato (*Solanum tuberosum*). Potato pSTH-related transcripts were found to be rapidly induced by slicing tubers as well as by the treatment of leaves with *Phytophthora infestans* mycelial homogenate (5). The proteins encoded by the pSTH genes are the potato homologues of Bet v 1 and are recognized by IgE from sera of birch-pollen-allergic patients (14).

Bell pepper (*Capsicum annuum*). The N-terminus of a 23-kDa allergen from bell peppers is identical to the corresponding region of the tomato P23 PR-protein, an osmotin-like antifungal protein (3). Bet v 1 and Bet v 2 homologues are also expressed in bell pepper fruits. Bell pepper profilins represent predominant allergens in different horticultural strains (3).

Liliatae (Monocotyledoneae)

Liliidae – Zingiberales – Musaceae

Banana (*Musa paradisiaca*). Bananas are known to



Food allergens

and are included in the latex-fruit syndrome. The N-terminal amino-acid sequence of a 33-kDa banana protein which bound IgE from latex-allergic patients' sera shows high similarities to class-I plant endochitinases (16).

Commelinidae – Poales – Poaceae

Rice (*Oryza sativa*): *Ory s 1*. A cDNA clone of rice major allergenic protein was isolated from a cDNA library of maturing rice seeds. The mature protein of 14.8 kDa shows considerable similarities to the barley trypsin inhibitor and the wheat α -amylase inhibitor (12).

Wheat (*Triticum aestivum*). Wheat is one of the few major foods that account for allergic reactions in children. James et al. identified a 15-kDa wheat protein that bound IgE from sera of children with wheat allergy (17). The N-terminal 20 amino-acid sequence was identical to that of the wheat α -amylase inhibitor, which is a member of the cereal α -amylase/trypsin inhibitor family found in wheat endosperm.

Barley (*Hordeum vulgare*): *Hor v 1*. A 14.5-kDa barley endosperm protein that is a major allergen has been identified as a member of the multigene family of inhibitors of α -amylase/trypsin from cereals. A cDNA encoding this allergen has been isolated and characterized (18).

Allergens in seafood

Shrimp (*Penaeus* and *Metapenaeus* spp.): *Pen a 1*, *Pen i 1*, *Met e 1*

The *P. aztecus* allergen Pen a 1 from shrimp meat has significant sequence similarities to the muscle protein tropomyosin from various animal species (12). Pen i 1, the major allergen of *P. indicus* shrimps, was shown to be a 34-kDa heat-stable protein with 86% similarity to tropomyosin from *D. melanogaster* (12). Met e 1, the major heat-stable allergen of the *M. ensis* shrimps, codes for a protein of 34 kDa highly homologous to tropomyosins (12).

Codfish (*Gadus callarias*): *Gad c 1*. The allergen Gad c 1 of cod is a 12.3-kDa muscle protein belonging to the family of calcium-binding parvalbumins. A molecular arrangement of three domains was described, analogous to carp parvalbumin (12).

its allergenicity confirmed. Sal s 1 was shown to be the major allergen of Atlantic salmon with sera from patients with cod and salmon allergy. Sal s 1 has been cloned (19).

Squid (*Todarodes pacificus*): *Tod p 1*. The major allergen from the Pacific flying squid, Tod p 1, is a 38-kDa, heat-stable protein and is believed to be the squid muscle protein tropomyosin. Cross-reactivity between major squid and shrimp allergens was demonstrated (20).

Abalone (*Haliotis midae*): *Hal m 1*. Two major allergens of the gastropod *H. midae* with molecular weights of 38 and 49 kDa were identified. The 49-kDa IgE-binding muscle protein was named Hal m 1 (21). Abalone allergens are heat-stable proteins.

Conclusion

Sorting allergens into groups such as PR proteins, chitinases, seed storage proteins, or tropomyosins will help us to understand cross-reactivities between different foods, will simplify diagnosis of food allergies, and may stimulate original research on their development.

References

1. van Loon LC, Pierpoint WS, Boller T, Conejero V. Recommendations for naming plant pathogenesis-related proteins. *Plant Mol Rep* 1994;12:245-64.
2. Sowka S, Hsieh L-S, Krebitz M, et al. Identification and cloning of Prs a 1, a 32 kDa major allergen of avocado, and its expression in *Pichia pastoris*. *J Biol Chem* 1998 (in press).
3. Jensen-Jarolim E, Santner B, Leitner A, et al. Bell peppers (*Capsicum annuum*) express allergens (profilin, pathogenesis-related protein P23 and Bet v 1) depending on the horticultural strain. *Int Arch Allergy Immunol* 1998;116:103-9.
4. Hoffmann-Sommergruber K, Vanek-Krebitz M, Ferris R, et al. Isolation and cloning of Bet v 1-homologous food allergens from celeriac (*Apig 1*) and apple (*Mal d 1*). In: Schon A, HayGlass KT, Kraft D, editors. *Advances in experimental medicine and biology*. New York: Plenum Press, 1996:219-24.
5. Wen J, Vanek-Krebitz M, Hoffmann-Sommergruber K, Scheiner O, Breiteneder H. The potential of betv1 homologues, a nuclear multigene family, as phylogenetic markers in flowering plants. *Mol Phylogenet Evol* 1997;8:317-33.
6. Zentner A, Jeep S, Wahl R, Kunkel G, Kleine-Tebbe J. Multiple IgE-mediated sensitizations to enzymes after occupational exposure: evaluation by skin prick test, RAST, and immunoblot. *Allergy* 1997;52:928-34.
7. Gonzalez de la Pena, MA, Monsalve R, Batanero E, Villalba M, Rodriguez R. Expression in *Escherichia coli* of Sin a 1, the major allergen from mustard. *Eur J Biochem* 1996;237:827-32.

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- of a new oriental-mustard (*Brassica juncea*) allergen, Bra j IE: detection of an allergenic epitope. *Biochem J* 1993; 293:625-32.
9. Hsieh LS, Moos M, Lin Y. Characterization of apple 18 and 31 kd allergens by microsequencing and evaluation of their content during storage and ripening. *J Allergy Clin Immunol* 1995;96:960-70.
10. Scheurer S, Metzner K, Hausteiner D, Vieths S. Molecular cloning, expression and characterization of Pru a 1, the major cherry allergen. *Mol Immunol* 1997;34:619-29.
11. Inschlag C, Hoffmann-Sommergruber K, O'Riordan G, et al. Biochemical characterization of Pru a 2, a 23-kD thaumatin-like protein representing a potential major allergen in cherry (*Prunus avium*). *Int Arch Allergy Immunol* 1998; 171:22-8.
12. Bousquet J, Metcalfe DD, Warner JO. Food allergy position paper of the Codex alimentarius. *Allergy Clin Immunol Int* 1997;9:10-21.
13. Ogawa T, Tsuji H, Bando N, et al. Identification of the soybean allergenic protein, Gly m Bd 30 K, with the soybean seed 34-kDa oil-body-associated protein. *Biosci Biotechnol Biochem* 1993;57:1030-3.
14. Hoffmann-Sommergruber K, Vanek-Krebitz M, Radauer C, et al. Genomic characterization of members of the Bet v 1 family: genes coding for allergens and pathogenesis-related proteins share intron positions. *Gene* 1997;197: 91-100.
15. Yamamoto M, Satomi T, Oeda K. A major root protein of carrots with homology to intracellular pathogenesis-related (PR) proteins and pollen allergens. *Plant Cell Physiol* 1997;38:1080-6.
16. Mikkola J, Alenius H, Turjanmaa K, Palosuo T, Reunala T. Molecular identification of cross-reacting allergens in natural rubber latex and banana [Abstract]. *J Allergy Clin Immunol* 1997;99:S342.
17. James JM, Sixbey JP, Helm RM, Bannon GA, Burks AW. Wheat alpha-amylase inhibitor: a second route of allergic sensitization. *J Allergy Clin Immunol* 1997;99:239-44.
18. Mena M, Sanchez-Monge R, Gomez L, Salcedo G, Carbonero P. A major barley allergen associated with baker's asthma disease is a glycosylated monomeric inhibitor of insect alpha-amylase: cDNA cloning and chromosomal location of the gene. *Plant Mol Biol* 1992;20:451-8.
19. Lindstrom CD, van Do T, Hordvik I, Endresen C, Elsayed S. Cloning of two distinct cDNAs encoding parvalbumin, the major allergen of Atlantic salmon (*Salmo salar*). *Scand J Immunol* 1996;44:335-44.
20. Miyazawa H, Fukamachi H, Inagaki Y, et al. Identification of the first major allergen of a squid (*Todarodes pacificus*). *J Allergy Clin Immunol* 1996;98:948-53.
21. Lopata AL, Zinn C, Potter PC. Characteristics of hypersensitivity reactions and identification of a unique 49 kd IgE-binding protein (Hal m 1) in abalone (*Haliotis midiae*). *J Allergy Clin Immunol* 1997;100:642-8.