

Diversity of Food Allergy

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Summary Food allergy is defined as an immune system-mediated adverse reaction to food components. Food allergic reactions are mostly IgE mediated and also known as immediate type hypersensitivity (type I reaction). There are several characteristic clinical types of food allergy, such as Anaphylaxis, Food-dependent exercise-induced anaphylaxis (FDEIA), and Oral allergy syndrome (OAS). In addition, food allergy is also classified into two types (class 1 and class 2) based on the pathophysiological mechanism. In the class 2 food allergy, pollen allergy causes plant food allergy; therefore this type of allergy is sometimes called Pollen-food allergy syndrome (PFAS). The risk of food allergy (allergenecity) may vary with the treatment of the food allergens. The formation or status of the causative food affects its allergenicity. Class 1 food allergens are generally heat-, enzyme-, and low pH-resistant glycoproteins ranging in size from 10 to 70 kD. Class 1 food allergens induce allergic sensitization via the gastrointestinal tract and are responsible for systemic reactions. Class 2 food allergens are generally heat-labile, susceptible to digestion, and highly homologous with pollen allergens. Taken together, it may be important to consider the diversity of food allergy in order to fight against food allergy.

Key Words food allergy, food allergen, diversity of food allergy

Food allergy is an important public health problem that affects children and adults worldwide. Food allergy is defined as an immune system-mediated adverse reaction to food components. Even a tiny amount of the allergy-

causing food can trigger signs and symptoms such as digestive problems, hives or swollen airways. In some cases, a food allergy can cause severe symptoms or even a life-threatening reaction known as anaphylaxis or anaphylactic shock. It is common to confuse a food allergy with a much more common reaction known as food intolerance. Food intolerance does not involve the immune system.

Allergy is classified into five patterns (1). Food allergic reactions are mostly IgE-mediated, which is also known as immediate type hypersensitivity (type I reaction). Priming of IgE on mast cells or basophils causes signaling events followed by secondary exposure of allergens, degranulation and release of various chemical mediators like histamines and leukotriene. These released mediators induce several kinds of allergy symptoms.

In this mini-review, we will summarize food allergy, focusing on its diversity (2).

1. Major Symptoms of Food Allergy

The most common food allergy signs and symptoms are tingling or itching (mouth); swelling of the lips, face, tongue and throat; hives, itching or eczema (skin); wheezing, nasal congestion (breath); abdominal pain, diarrhea, nausea or vomiting (digestive organs); dizziness, lightheadedness or low blood pressure.

2. Clinical Type of Food Allergy

The clinical types of food allergy can be classified as described in Table 1 (3). In this section, three characteristic clinical types are described below.

(1) Anaphylaxis (immediate type allergy)

In some people, a food allergy can trigger a severe allergic reaction called anaphylaxis. This can cause life-threatening signs and symptoms, including constriction and tightening of airways, a swollen throat or the sensation of a lump in the throat that makes it difficult to breathe, rapid pulse, shock with a severe drop in blood pressure and dizziness, and loss of consciousness. Emergency treatment (for example, epinephrine autoinjection) is critical for anaphylaxis. Untreated, anaphylaxis can cause a coma or even death (2).

(2) Food-dependent exercise-induced anaphylaxis (FDEIA)

Food-dependent exercise-induced anaphylaxis (FDEIA), in which anaphylaxis develops only if physical activity occurs within a few hours after eating a specific food (4). Neither food intake nor physical activity by itself produces anaphylaxis. In serious cases, an exercise-induced food allergy can cause certain reactions such as hives or anaphylaxis. The foods most commonly implicated in food-dependent exercise-induced anaphylaxis are wheat, shellfish, tomatoes, peanuts, and corn. Wheat is the most popular food inducing this type of anaphylaxis, called WDEIA (5). However, FDEIA has been reported with a wide variety of foods, including fruits, seeds, milk, and soybeans (6).

(3) Oral allergy syndrome (OAS)

Oral allergy syndrome (OAS) is a type of food allergy classified by a cluster of allergic reactions in the mouth in response to eating certain (usually fresh) fruits, nuts,

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Table 1. The clinical types of food allergy.

Clinical types	Age	Popular causative foods	Possibility of tolerance	Risk of anaphylaxis	IgE dependency
Gastrointestinal Allergy in infant	newborn infant	cow milk	(+)	(+/-)	IgE-independent
Food allergy associated atopic dermatitis	infant	egg, cow milk, wheat, soybean, rice, etc	(+)	(+)	mainly IgE-dependent
Immediate type allergy (anaphylaxis, urticaria)	infant-Adult schoolchild-adult	egg, milk, wheat, buckwheat, fish, peanuts, etc fish, wheat, shrimp, crab, fruits, buck-wheat, peanuts, etc	(+) egg, milk, wheat, soybean (+/- or -) others	(+ +)	IgE-dependent
Food-dependent exercise-induced anaphylaxis (FEIA/FDEIA)	schoolchild-adult	wheat, shrimp, crab, etc	(+/-)	(+ + +)	IgE-dependent
Oral allergy syndrome (OAS)	infant-adult	fruits, vegetables, etc	(+/-)	(+/-)	IgE-dependent

Table 2. Class 1 food allergy and Class 2 food allergy.

	Class 1	Class 2
Sensitization to allergens	Gastrointestinal tract	Respiratory exposure
Age of peak prevalence	Early childhood	After school age
Symptoms	Rapid onset of gastrointestinal responses (nausea, abdominal pain, cramp, vomiting, diarrhea); other target organ responses (e.g., skin, respiratory tract) often involved	Mild pruritus, tingling, and/or angioedema of the lips, palate, tongue or oropharynx; occasional sensation of tightness in the throat and rarely systemic symptoms
Typical foods	Egg, milk, wheat, peanut, fish	Fruit, vegetable
Stable or labile in presence of heat, acid, and proteases	Stable	Labile
Diagnosis	Clinical history and positive SPT responses or CAP-RAST results Oral challenge-positive on double-blinded food-challenge test	Clinical history and positive SPT responses (prick-plus-prick method) Oral challenge-positive with fresh food, negative with cooked food
Treatment	Elimination diet	Elimination diet Foods may become edible by heating Immunotherapy to treat the pollen-induced rhinitis may improve PFS

(cited from Ref. 7).

and vegetables that typically develops in adult hay fever sufferers (7). The most common reaction is an itching or burning sensation in the lips, mouth, ear canal, and/or pharynx. Sometimes other reactions can be triggered in the eyes, nose, and skin. Swelling of the lips, tongue, and uvula and a sensation of tightness in the throat may be observed. It seldom results in anaphylaxis. OAS

seems to be the most common food-related allergy in adults. The body's immune system produces IgE antibodies against pollen; in OAS, these antibodies also bind to (or cross-react with) other structurally similar proteins found in plants. Therefore, OAS is typically only seen in tree and weed allergic patients, and is usually limited to ingestion of only uncooked fruits, vegetables

or beans. Another term used for this syndrome is pollen-food allergy or pollen-food allergy syndrome (PFAS). As described below, this type of food allergy is classified as a class 2 food allergy.

3. Classification of Food Allergies Based on the Pathophysiological Mechanism

Food allergies are also classified into two types (class 1 and class 2) based on the mechanism (Table 2) (7). Class 1 food allergens are represented by peanuts, egg whites, and cow's milk; they are heat- and acid-stable glycoproteins that induce allergic sensitization via the gastrointestinal tract and cause systemic reactions. On the other hand, Class 2 food allergens are homologous to proteins in birch tree pollen and class 2 food allergy develops as a consequence of respiratory sensitization to the cross-reactive pollen. Class 2 food allergens are generally heat-labile and tend to induce reactions limited to oral allergy symptoms (OAS). So, most cooked fruits and vegetables generally don't cause cross-reactive oral allergy symptoms. In class 2 food allergy, pollen allergy causes plant food allergy; therefore this type of allergy is sometimes called pollen-food allergy syndrome (PFAS).

4. Major Food Allergens

Class 1 food allergens are generally heat-, enzyme-, and low pH-resistant glycoproteins ranging in size from 10 to 70 kD. Class 1 food allergens induce allergic sensitization via the gastrointestinal tract and are responsible for systemic reactions. Class 2 food allergens, such as apples and celery, are generally heat-labile, susceptible to digestion, and highly homologous with pollen allergens. Class 2 food allergy is typically the result of sensitization to labile proteins, such as pollen allergens, encountered through the respiratory route. IgE antibodies to pollen allergens recognize homologous epitopes on food proteins of plant origin. There are several allergen families among pollens and foods. These cross-reactive popular allergens are known as plant pan-allergens.

5. Changes in Allergenicity from Food Treatment

The risk of food allergy (allergenicity) may vary with the treatment of the food allergens. The formation or status of the causative food affects its allergenicity (2).

Heating processes can reduce or increase the allergenicity of certain food proteins. Thermal denaturation of globular proteins disrupts the tertiary structure, leading to random-coiled aggregation and an insoluble form. It is reported that heating for 15 minutes at 95°C reduced IgE binding with ovalbumin and ovomucoid. On the other hand, roasting at higher temperatures apparently

increases the allergenic properties of peanut allergenic proteins. Chemical processing can also change allergenicity. The allergenicity of the major peanut allergens Ara h 1, Ara h 2, and Ara h 3 was decreased by vinegar treatment, suggesting that the extent of allergenicity varies with pH. Generally, allergenicity of class 2 allergens is known to be easily decreased by a denaturation process such as cooking, heating, or lowering pH.

Fermentation is known to decrease allergenicity in both class 1 and 2 food allergy. During fermentation, bacterial or fungal proteases digest allergens. Miso paste (miso), the fermented soybean food, is popular in Japan and other Asian countries. The allergenicity of various kinds of miso available in Japan was evaluated (8).

The influences of gamma-irradiation on the allergen levels have been also studied (9). The obtained results suggested that gamma-irradiation might decrease the allergenicity.

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