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Food Allergy and Physiology: A Review Article

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Abstract. Given the rising incidence of allergies, Proteins, either in their natural state or in forms arising from food preparation, are the source of food allergies. The field of proteomics has substantially benefited from advancements in mass spectrometry. These developments round out the range of biological assays that have been employed up to this point, including PCR and ELISA, and enable the identification and measurement of allergenic protein traces in complicated mixtures. We highlight significant advancements in mass-spectrometric techniques and examine approaches categorized based on their capacity to simultaneously quantify and detect allergenic proteins

Highlights:

1. Proteomics Advancements – Mass spectrometry improves allergen detection in food.
2. Diagnostic Methods – ELISA, PCR, and immunoassays enhance allergen identification.
3. Regulations – European laws mandate allergen labeling on food products.

Keywords: Food allergies, proteomics, mass spectrometry, ELISA, PCR

Introduction

Food allergies are becoming more common, particularly in developed nations where 2% of adults and 5-8% of children suffer from them [1-3]. In Europe and the USA, allergies to cow's milk and eggs are most common in young children (2.5–3%), while the main food allergens for adults in Europe are Rosaceae fruits (0.5%) and shellfish (2%) [4-8]. Despite the significance of food allergies, which the World Health Organization ranks as the fourth most serious public health issue, the only effective treatment available to those who suffer from them is to avoid foods that contain allergens completely [9, 10]. However, when allergies are common dietary proteins, such as those found in eggs or milk, avoidance becomes challenging. European legislation established a list of ingredients having possible negative (allergenic) effects in 2003 (Directive 2003/89/EC amending Directive 2000/13/EC). Food manufacturers are required to list these substances on food product labels. This requirement enables consumers with allergies to be informed when allergens are present in foods [11-13]. Since 2007, food products must include 14 chemicals on the label if they contain them [14, 15].

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In a recent review, Monaci and Visconti [16, 17] Discussed all of the allergenic food proteins. Our analysis goes beyond that review's purview and provides an update on the state of the art in terms of allergen quantification techniques in food products, particularly those that use proteomics and mass spectrometry. Since two studies [18, 19] Thoroughly examining all of these methods with their benefits and limitations, the current review focuses on classical methods in the first section and only briefly describes the various methods available for detecting allergens in food. The second section then discusses MS-based methods.

Classical Approaches for The Identification and Quantification of Food Allergies

An unfavorable immunological reaction to oral exposure to food allergens is known as a food allergy. The allergen-specific immunoglobulin E (IgE) is a crucial molecule that frequently mediates the allergic reaction, but there is also a mechanism that is not IgE-mediated. IgE can bind selectively to antigens, which, are produced instantly when an allergen cross-links to a receptor-bound IgE in IgE-mediated allergies. A few hours later, there occurs a late-phase response in which T cells and eosinophils release interleukins and cytokines that control the production of IgE and cause inflammation [18, 20-23].

Several indirect detection methods utilizing blood serum characteristics are used to diagnose food allergies in patients. Because of this, most diagnostic tools use immunochemical methods to identify IgE, receptors, or mediators. However, techniques for detecting allergens in food have been developed to stop allergens from contaminating the food chain. The difficulty nowadays is identifying and measuring minute levels of allergens in various food matrices that might cause an allergic reaction, the intensity of which varies according to the allergen and the individual [22].

ELISA, ELISA inductively coupled plasma MS

We start by mentioning the most widely used immunochemical technique in labs for identifying food allergens that are hidden: ELISA. The allergen–primary antibody combination is bound by this second antibody [22, 24].

With the development of a multiallergen immunoassay based on the ELISA model, it is possible to assess at least 1 µg/g protein of each peanut and tree nut allergen

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in chocolate simultaneously, even though a limit of quantification enzyme substrates has not yet been established [25, 26].

The sensitivity and accuracy of simple ELISA detection have recently been increased by combining ELISA with inductively coupled plasma mass spectrometry (ICP-MS) [27, 28]. A stable isotope, rather than an enzyme, is utilized to mark the secondary antibody in ELISA-ICP-MS, which allows for mass spectrometer measurement [27].

PCR, real-time PCR, PCR-ELISA

A nucleic acid-based technique called PCR was created for the indirect detection of dietary components that cause allergies. To make the protein detectable, it entails focusing on a specific DNA fragment that codes for the target allergenic protein and amplifies it exclusively. For peanuts, almonds, hazelnuts, soy, or milk, the LOD is less than 10 mg/kg this instrument is incredibly sensitive and selective [29, 30]. PCR is also offered as real-time PCR and PCR coupled to ELISA. PCR-ELISA enables gel-free detection since the amplified DNA fragments are hybridized to a protein probe and recognized by ELISA. Through PCR product amplification, real-time PCR is a gel-free, real-time detection technique that generates fluorescence according to the amount of the target gene present in the food sample. To account for variations in DNA extraction and amplification efficiency, quantification could be carried out using a special internal standard [31, 32].

Other immunoglobulin-based tests

The dot immunoblotting test, radioallergosorbent test (RAST), and enzymeallergosorbent test (EAST) are three more immunochemical procedures that function similarly to ELISA. The secondary antibody in the RAST is marked with a radioactive isotope and measured using a gamma counter rather than an enzyme [33-35]. For peanut allergens in various meals including hazelnut and Brazil nut allergens in chocolate ice cream, its limit of detection (LOD) is 0.1 µg/g [36, 37].

On a 2D gel, the detected allergens appear as isolated spots; on a 1D gel, they appear as protein bands. The antigen-antibody combination precipitates from the beginning of the migration because antibodies are added to the gel before rocket immunoelectrophoretic [38, 39].

Cell-based methods

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The allergenicity of soybean allergens has been tested using a variety of in vitro mediator release tests [40-42] Or to regulate how allergen extracts from various manufacturers are standardized [43, 44]. They exhibit excellent repeatability and sensitivity. The BAT sometimes referred to as the "flow-cytometric allergen stimulation test," examines for surface receptors (such as CD63 and CD203c) and mediators (such as histamine, leukotriene C4, interleukin-4, and interleukin-13). The quantification process is made possible by dye-labeled antibodies [45-48].

The observed fluorescence serves as the foundation for the quantification concept of the relevant allergen. When diagnosing food allergies, it has been shown that the BAT is more sensitive and specific than BHR testing [49-51]. The BAT has analyzed both roasted and native hazelnut extracts to demonstrate the decrease in allergenicity following hazelnut processing; To achieve 50% basophil activation [52, 53].

Conclusion

Direct or indirect methods can be used to detect allergens. Regarding diagnostics, there is a wide range of proven indirect techniques that identify the patient's response rather than the allergen. Because of the quantitative examination of the allergens themselves. According to that viewpoint, once particular reagents are available, amplification techniques like PCR and enzymatic testing can be highly beneficial. The sensitivity and specificity of the approach were significantly enhanced by advancements in MS. a peanut protein was found using an MS-based method.

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