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Review Article

# The Role of Food Additives and Chemicals in Food Allergy

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**Abstract**

Undeclared allergens continue to be the leading cause of food recalls in the United States [1]. It results from the failure to declare allergens in food labels, or accidental introduction of allergens in non-allergen foods or processing lines. Cross-contamination, which occurs when adjacent food processing lines are used in the processing of allergenic and non-allergenic foods, can also result in the introduction of allergens into non-allergen food processing lines. This paper reviews the role of chemicals and pollutants in the development of food allergies and provides recommendations on some of the strategies that can be explored further in controlling food allergens.

## INTRODUCTION

Undeclared allergens was the leading cause of food recalls in 2014 [1]. Undeclared allergens can cause serious health consequences or even death if consumers with allergies are exposed to the contaminated food. An allergy can be defined as an adverse reaction of the body's immune system that occur immediately following exposure to a chemical, food, or drug. Allergies result from a series of chemical reactions in the body following exposure to substances in the environment (air or water) or diet. An immunoglobulin (Ig), also known as an antibody, is a substance synthesized by the immune system in response to the presence or encounter with foreign substances, called antigens. Immunoglobulins (Igs) are specific in nature, and function by targeting specific biological or chemical molecules for which they are developed, such as bacteria, viruses, fungus, animal dander, pollen, cancer cells, etc. There are five known types of antibodies which are specific to foreign bodies; these include immunoglobulin A, D, M, E, and G, also referred to as IgA, IgD, IgM, IgE, and IgG. IgE is the protein primarily associated with the body's defenses against foreign bodies; it is the defense protein, and is also involved in allergic reactions which occur during the body's encounter with foreign substances. There are certain allergic reactions that occur through mechanisms other than the activities of IgE; such allergic reactions are often referred to as non-IgE mediated allergic reactions. Examples include celiac disease, atopic dermatitis (eczema), and food intolerance.

### Allergy development: The initial stages

The development of an allergic reaction occurs in two stages. The first stage, also referred to as the *primary phase,* occurs when the body's plasma membrane begins synthesizing the defense protein – IgE [2]. This stage occurs when the body is first exposed to a chemical, food, drug, or any substance with allergenic properties. Once developed, the IgE proteins are stored in the body for future use against allergen substances that are similar to those that triggered their development. IgEs are often attached to the surface of mast cells, which are immune cells that are widely spread in tissues around the body [3]. The second stage (*secondary phase*) in the development of allergies occurs when the body encounters allergenic substances for the second time. During this stage, the IgEs developed in the primary phase are activated and begin protecting the body against the foreign molecules by binding to them [4]. During the binding reaction, the mast cells release histamine and other defense chemical substances in response to the antigens. When released in large quantities, these chemical substances can elicit extreme immediate reaction in the body's immune system. This is what is known as an *allergic reaction* [4]. The extent of individual reactions to substances varies; some individuals can have a more extreme reaction than others when exposed to similar amounts of allergens. In some cases, exposure of a person to allergens canresult in serious anaphylactic reaction or even death.

### The role of food additives

Additives are used in food for various reasons; for example, as antioxidants, colorings, flavorings, emulsifiers, stabilizers, taste enhancers, and preservatives. Food additives also function as pseudoallergens and can cause non-IgE-mediated allergic reactions. Allergic reactions can occur in sensitive groups of consumers who are exposed to foods, or food additives, that have been previously treated with certain pesticides or herbicides [5]. Research has shown that exposure to certain food additives in processed foods can result in a variety of allergic reactions or immunological hypersensitivities such as atopic dermatitis (AD), allergy asthma, and eosinophilic esophagitis [6]. In a 2011 study undertaken by Lee et al., it was found that *eosinophil cationic protein* (ECP), an eosinophil granule protein, is released and may signal an inflammatory process in these patients [6]. The effect of restricting intake of Monosodium glutamate (MSG), a flavor-

enhancer that is widely used as a food additive and found in many processed foods, in the diet of allergic patients was researched in this study. It was determined that a dietary restriction of processed foods resulted in a decreased intake in MSG, which in turn resulted in a decrease in serum ECP levels in subjects [6].

Atopic dermatitis (AD), often called eczema, is a chronic skin disease in which diet has been identified as one of the main factors in patients presenting symptoms of food allergies [6]. Mounting evidence demonstrates that consumption of processed foods can cause adverse reactions, such as immunological hypersensitivity [7]. In industrialized countries, where environmental pollution is an issue and consumption of Westernized (processed) foods is common, the prevalence of eczema among children has increased. In addition, the prevalence of adverse reactions to food additives has increased to 2% in children from these industrialized countries, while increasing to 7% in children with eczema. The children also had an improved score, which indicated the extent and severity of disease [6]. Other research studies recommend that people with allergies eat significantly higher amounts of processed foods, high frequency consumption of snack foods. These snack foods are known to contain a variety of food additives, which provoke atopic symptoms [6]. J.M. Lee, et al., also found that eczema is associated with food allergy, and the prevalence of food allergy is 50% in patients with eczema [6].

Sulfites are sulfur-based compounds that contain the sulfite ion ($SO_3^{2-}$), and have historically been used as preservatives to prevent the growth of microorganisms in food. They are also known to cause allergies in certain sensitive individuals [8]. Some beverages and foods contain naturally occurring sulfites as a result of fermentation. Sulfites can also be manufactured, and are used commercially in the pharmaceutical, cosmetic, and food industries to control microbial growth. Besides their use as preservatives, sulphites are used as bleaching agents, antioxidant, and reducing agents in the food industry [9]. The most commonly used sulfites are sodium salts, specifically sodium sulfite, sodium bisulfite, and sodium metabisulfite (SMS). Population exposure to sulphites can occur through dietary route or through the environment. For example, physical contact to sulphites in certain sensitive groups can elicit allergic reactions resulting in dermatitis [8]. Contact dermatitis, a condition triggered by physical contact to has been observed in people who work in the food industry and are in frequent contact with sulphites [9]. Garcia-Gavin et al recommend that individuals should maintain awareness of possible sources of exposure relevant to their occupational setting. This is especially true for individuals working in certain environments such as hairdressing, the food industry, and the cosmetic and pharmaceutical products industry [8]. In this study, it was determined that sodium metabisulfite (SMS) appears to be the best indicator of sulfite contact allergy when used in a patch test. Additionally, SMS patch testing may be useful in individuals who experience immediate reactions to sulfite-containing products.

## The role of vitamins and nutrients

Dietary deficiencies, introductory exposures, or exposures to high levels of certain substances can result in the development of allergic reactions. Previous research into dietary exposures has pointed to the increase in dietary exposure to high levels of vitamin D to the development of food allergies in children. Decrease in dietary exposure to vitamin D has also been suspected to result in the development of allergies in infants [10]. Dietary deficiency or exposures to vitamin D during pregnancy have been suspected to result in the development of food allergies in infants. Many other dietary-related theories have been put forth to explain the development of food allergies in infants; for example, the replacement of animal fats with vegetable fats in the diet is suspected to cause allergies in infants [10]. Decrease in dietary exposure to vitamin C, E, β-Carotene, and other elements, such as zinc and selenium; have also been suspected to cause food allergies in infants [6].

## The role of biotechnology

Current genetic modification methods allow scientists to develop plant varieties with specific desired traits. The advancement in recombinant techniques have increased precision in targeting genes that code for desired traits in plants, and has made it easier for scientists to create new plant varieties by targeting of desired genes. With increased precision, scientists can now transfer genes, introduce desired genes, suppress undesired genes, or even magnify genetic traits in plants from the same or different specie or genera, and with the same or varying physical or chemical characteristics [11]. Plant genetic modifications are sometimes applied to improve the ability of the plants to withstand pesticides, herbicides, unfavorable growth conditions such as extreme drought conditions, high or low temperatures, or rainfall conditions. Many of the current gene modifications are done for commercial purposes, such as improving crop yields, nutritional value, processing characteristics of the plants, etc. With increased use of biotechnology, there are concerns that certain applications such as the transfer of genes undertaken when developing genetically engineered plants and animals may result in creation of new food products with allergic properties. New allergens can be created through accidental transfer of genes that code for allergens from allergenic foods to non-allergenic foods [12]. Genetic modifications can also result in the accidental introduction of undesired traits in foods; they have the potential to result in the development of plant varieties with increased levels of natural toxins, increased resistance to digestive enzymes, decreased nutritional value, altered metabolic pathways, new proteins or allergens, or increased potency in known allergens [11]

Certain characteristics have also emerged as common in proteins that are capable of eliciting IgE reactions in persons with food allergies. One characteristic is the ability of a protein to withstand degradation/denaturation by protein enzymes, as well as heat. The ability of plant proteins to withstand degradation by proteases, which are enzymes that catabolize proteins, is believed to be the result of the presence of enzyme inhibitors in allergens. The ability of proteins to withstand digestive enzymes is also suspected to result in the development of allergies in consumers. Plant foods resulting from advanced plant breeding techniques often exhibit unique qualities not just in the environment, but also when consumed by humans or animals [12]. Some of the plant foods exhibit increased resistance to digestive enzymes, which can result in food intolerance or allergic reactions in certain sensitive groups of consumers [13]. For example,

modification of grain products can result in the development of grains whose gluten contents are resistant to human digestive enzymes. This can result in food intolerance or even serious allergic reaction in consumers who are allergic to gluten. Plant gene modifications can also result in the intentional creation of new allergenic proteins capable of triggering adverse allergic reactions in consumers as witnessed in Starlink corn, developed by Aventis Crop Science [14]. The Star link corn was approved by the EPA in 1998 for use in animal feed, but was inadvertently introduced in the human food supply and was suspected to have resulted in allergic reaction in some consumers. Subsequent CDC investigation established that the a new protein Cry9c, which was created from *Bacillus thuringiensis* bacteria, had pesticidal properties and was responsible for an allergic reaction in many consumers exposed to the new corn variety [15,16]. Care should be taken to ensure that genes transferred or created when developing new varieties of plants or animal foods do not result in the creation of new allergens or introduce allergenic characteristics into non-allergens.

## CONCLUSION

Genetic modification techniques undertaken when developing genetically engineered plants and animals may result in creation of new food products with allergic properties. This can occur through accidental transfer of genes that code for allergens from allergenic foods to non-allergenic foods. Extreme care should be taken to ensure that the modification of genes undertaken during genetic engineering does not result in an increase in the potency of existing allergenic proteins. Caution should be taken to ensure that the genes that code for allergens are not transferred into non-allergen foods. There is need for more research into methods that can help in identifying and in screening for cross-reacting genes, and on gene patterns that code for allergenic protein foods. Additionally, the use of animal models to screen for potency of proteins developed through genetic modifications should be explored further. More studies are needed at molecular levels to characterize the various elements that determine allergenicity of food substances.

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