Technological evolution and food allergies: issues of threats or contributions to the consumer?

Evolução tecnológica e alergias alimentares: matérias de ameaças ou contribuições para o consumidor?

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ABSTRACT
Objective: To verify through a review of scientific literature, whether industrial and technological developments are directly related to the increase and prevalence of food allergies or whether it has contributed to the quality of life of allergic consumers. Methods: Searches were carried out in the Scielo (Scientific Electronic Library Online), Google Scholar, Lilacs (Latín American and Caribbean Health Sciences Literature) and PubMed (National Library of Medicine) databases. Results: The results obtained in the scientific literature identified that the
significant increase in food allergies has accompanied the technological process, due to the greater consumption of food additives in ultra-processed products, but environmental influences such as dietary factors and lifestyle are also involved in the higher incidence of allergies. On the other hand, technological advances have collaborated with alternative food products for this specific population group by offering foods with reduction or exemption of allergenic compounds produced by different processing techniques or supported by biotechnology and other sciences. Final considerations: As claims for products free from allergenic compounds become mandatory, the food industry must make investments aimed at studies and production of safe alternative foods for allergic consumers.

**Keywords:** technology, hypersensitivity, quality of life.

**RESUMO**

Objetivo: Verificar, por meio de revisão de literatura científica, se a evolução industrial e tecnológica se relacionam, diretamente, com o aumento e a prevalência das alergias alimentares ou se elas têm contribuído com a qualidade de vida dos consumidores alérgicos. Métodos: Foram realizadas pesquisas nas bases de dados Scielo (*Scientific Electronic Library Online*), Google Acadêmico, Lilacs (Literatura Latino-Americana e do Caribe em Ciências da Saúde) e PubMed (National Library of Medicine). Resultados: Os resultados obtidos na literatura científica identificaram que o aumento expressivo das alergias alimentares tem acompanhado o processo tecnológico, no que tange o maior consumo de aditivos alimentares em produtos ultra processados, mas influências ambientais como fatores dietéticos e estilo de vida também estão envolvidos na maior incidência. Por outro lado, o avanço tecnológico tem colaborado com produtos alimentícios alternativos para este grupo populacional específico através da oferta de alimentos com redução ou isenção de compostos alergênicos produzidos por diferentes técnicas de processamento ou apoiados na biotecnologia e demais ciências. Considerações finais: À medida que reivindicações de produtos isentos de compostos alergênicos se tornem obrigatórias, a indústria de alimentos deverá viabilizar investimentos destinados a estudos e produção de alimentos alternativos seguros para os consumidores alérgicos.

**Palavras-chave:** tecnologia, hipersensibilidade, qualidade de vida.

**1 INTRODUCTION**

Food allergy is a pathological, potentially deadly, immune reaction triggered by food protein antigens that are normally harmless to the majority of the population. Mediated by antibodies (IgE) or cells or even both, they can cause functional changes in different target organs (BERZUINO et al., 2017) with great variability of symptoms, which include dermatological, gastrointestinal, and respiratory manifestations, with anaphylaxis being the most worrying reaction because it can cause the death of the individual if not treated immediately (BURKS and EIGENMANN, 2011).

Although more than 170 foods have already been recognized as potentially allergenic, a small portion of them has been blamed for most reactions (SOLÉ et al., 2018). In children,
the foods that most often trigger allergic reactions include eggs, cow's milk, peanuts, soy, and wheat. For adults, this list also includes fish and shellfish in addition to nuts (FERREIRA and SEIDMAN, 2007).

Despite cases of food intolerance can be confused with allergy, overestimating its diagnosis by health professionals and patients, the incidence of diagnoses of allergic reactions is increasing worldwide, being even more expressive in the last fifteen years (SOLÉ et al., 2018). Until recently, allergies, especially those caused by food, were considered only a pediatric problem, as some of them start in early childhood and can spontaneously disappear in adulthood (DE MARTINS et al., 2019). Recent data suggest that about 8% to 10% of children have this condition, 2.4% suffer from multiple food allergies, and approximately 3% of children report anaphylactic reactions (COSME-BLANCO et al., 2020).

However, about 3% to 4% of adults currently have also been affected by these immunological reactions that significantly alter their quality of life. Starting to be considered a public health problem, there are increasing investigations into its relationship with changes in lifestyle and current eating habits, such as, for example, greater exposure to allergic substances present in processed, ultra-processed and transgenic foods available, accessible, and consumed (SOLÉ et al., 2018).

Considering the advancement of knowledge about the relationship between food and health, several scientific groups, supported by food technology, have also been striving to research and develop processed foods for consumers allergic to different components (BRANDÃO et al., 2021; MACEDO, 2021; LAMOTHE et al., 2021; DUARTE et al., 2019).

Therefore, making use of an extensive review of scientific literature, the objective of this study was to discuss the increase and prevalence of food allergies and their relationship with greater exposure and consumption of food resulting from technological evolution, or whether this, in fact, has contributed to the quality of life of allergic consumers as they make available a greater number of alternative foods.

2 METHODS

This study was structured in bibliographic research based on scientific articles, dissertations and theses available in the online databases/research portals: Scielo (Scientific Electronic Library Online), Google Scholar, Lilacs (Latin American and Caribbean Health Sciences Literature) and PubMed (National Library of Medicine), with an emphasis on publications from the last five years, in addition to expanded searches on the websites of governmental and non-governmental institutions and organizations.
3 RESULTS AND DISCUSSION

3.1 HISTORY OF FOOD ALLERGIES

In antiquity, due to the lack of knowledge about physiology and pathologies among individuals, nutrition and feeding were some of the very few forms of protection against diseases because food served both for feeding, survival, and maintenance of health, as well as for reaction to external aggressions, involving many psychosocial aspects (VAUCHER and DURMAN, 2005).

The adverse effects that certain foods can cause when consumed by some individuals have been known and reported since antiquity. Although there is no scientific consensus in the literature, Hippocrates, father of Medicine, is cited as the first descriptor of “idiosyncratic” reactions to foods, when detailing the first case of allergy to cheese ingestion (possibly confused with enzymatic alteration, later described by scientific data) in classical antiquity, 5th century (WÜTHRICH and BALLMER-WEBWE, 2014).

The first scientific report of food allergy occurred in 1912, in the 20th century, when an American pediatrician, Oscar Menderson Schloss, became a pioneer in diagnosing a case of allergy to the consumption of chicken eggs through the scarification test (scraping), idealized by the scientist Blackley in 1873, in addition to making it possible to isolate chicken egg white fractions, identifying ovomucoid, ovoglobulin and ovomucin as the proteins with the greatest cutaneous hypersensitivity (PINESS and MILLER, 1926 apud SCHLOSS, 1912).

In fact, since then, epidemiological studies have identified that the egg belongs to the group of foods called The Big Eight, which include peanuts, nuts, soy, wheat, fish and crustaceans, as well as related ingredients found on industrialized food labels (Table 1) (BERZUINO et al., 2017).

<table>
<thead>
<tr>
<th>Allergenic Food</th>
<th>Ingredients/components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>Whey, whey protein, casein, lactate, cream, potassium caseinate, among others.</td>
</tr>
<tr>
<td>Eggs</td>
<td>Albumin, egg white, conalbumin, ovoglobulin, lecithin, livetin, among others.</td>
</tr>
<tr>
<td>Peanuts</td>
<td>Peanuts, hydrolyzed peanut protein, peanut flour, etc.</td>
</tr>
<tr>
<td>Nut</td>
<td>Almonds, hazelnuts, cashews, walnuts, macadamia nuts, among others.</td>
</tr>
<tr>
<td>Soy</td>
<td>Glycine, globulin, edamame, soy flour, soy sauce.</td>
</tr>
<tr>
<td>Wheat</td>
<td>Wheat flour, wheat bran and wheat flakes.</td>
</tr>
<tr>
<td>Fish</td>
<td>Fish in general</td>
</tr>
<tr>
<td>Crustaceans</td>
<td>Shrimp, shellfish, lobster, squid, tropomyosin, among others.</td>
</tr>
</tbody>
</table>

Table 1. Allergenic foods and ingredients (The Big Eight)

Source: BERZUINO et al., 2017.

Although vegetables are not included in The Big Eight, peas are involved in the first documented report of a fatal food reaction, described in 1926, when a one-and-a-half-year-old
A boy with atopic eczema had three episodes of allergic reactions at home after ingesting a few spoons of a pea puree. In hospital treatment, he was submitted to an oral provocation test (at the time, called ‘challenge’) with the ingestion of a carrot and pea puree, under the supervision of the nursing service, which immediately triggered attacks of angioedema, cyanosis, collapse, and subsequent death (WÜTHRICH and BALLMER-WEBWE, 2014).

According to the literature, the first death from allergic reaction after spontaneous food consumption occurred in the 1990s with a 24-year-old Canadian consumer with severe peanut allergy, after eating a slice of hazelnut cake, covered with marzipan and almond paste. Further investigation revealed that the almond paste contained peanut-based ingredients, but this was unknown to the confectioner at the time (BRUIJNZEEL-KOOMEN et al., 1995). In fact, according to Platts-Mills TAE (2015), an epidemic of food allergy, with the manifestation of several symptoms, only became evident from 1990 onwards.

A study carried out by the Centers for Disease Control and Prevention in 2013 in the USA revealed that food allergies increased by about 50% in children in the period between 1997 and 2011 (JACKSON et al., 2013). In Brazil, there has been a significant increase in the incidence of food allergies among children in recent years, although, according to the 2018 Brazilian Consensus on Food Allergy (SOLÉ, 2018), data about the prevalence are conflicting and may vary according to age and characteristics of the population evaluated, in addition to the immunological mechanism involved, diagnostic method, types of food, among others.

### 3.2 Causes for the Higher Incidence of Food Allergies

The etiology of these adverse reactions is not fully known, although historically associated risk factors have been pointed out, such as gender, race/ethnicity, genetics, antigenic potency of some foods, family history and intestinal alterations, especially the immaturity of the intestinal mucosa in children and early weaning (RAMOS et al., 2013).

Recent studies, however, have shown an increase in the prevalence of food allergies in industrialized regions and in countries with significant economic development (LOH and TANG, 2018), attributing the higher incidence of these reactions to other factors such as obesity, low consumption of antioxidants and other incorrect eating habits, in addition to changes in the intestinal microbiota (EISMANN et al., 2020).

Investigations into the relationship between vitamin D and food allergies have increased over the past decade, as studies have shown that vitamin D deficiency has been associated with a high risk of several allergic diseases, including atopic dermatitis triggered by reactions to eggs and peanuts (MATSUI et al., 2019).
New studies have also suggested that environmental factors may produce epigenetic changes in gene expression, increasing potentially hereditary risks over generations (CAÑAS et al., 2021). According to Reis (2015), epigenetic mechanisms can alter gene transcription, both by silencing certain genes and by increasing gene transcription of cytokines involved in the inflammatory response.

Jorge (2020) identifies in his study an important pattern of sensitization to food related to geographic areas and even more pertinent to the cultural aspects and eating habits of the population, in addition to specific genetic polymorphisms. That said, it is observed that peanut is the main cause of allergies and anaphylactic shock in the USA, United Kingdom and Scandinavian countries; egg and fish are important allergens in France; seafood in Australia; and fresh fruits, associated with the Mediterranean diet, in Portugal and southern Europe (GUPTA 2011; LYONS, 2019).

In Brazil, there are few data about the pattern of sensitization to foods, although, historically, milk, egg and soy proteins have always been among the main studies involving food allergies in children and adults (BERZUINO et al. 2017).

Considering the intestinal alterations mentioned above, Toche (2004) emphasizes that technological development and, consequently, changes in eating habits and consumption of processed foods, have increased the population's exposure to a wide variety of additives and contaminants, present in those, contributing to the modification of a microenvironment in the gut that favors the development of adverse reactions. Although the allergenic potential of all substances considered as food additives is not known, some of them have already been related to allergic reactions such as rhinitis, bronchospasm, urticaria and/or angioedema. They are: parabens, lanolin, sodium metabisulfite and sulfites (LEMOINE et al., 2020), and, to a lesser extent, the dyes tartrazine yellow, twilight yellow, erythrosine, ponceau red and monosodium glutamate (VELÁZQUEZ-SÁMANO et al., 2019).

In fact, consumer exposure to the food additives mentioned above has increased exponentially with economic development and the industrialization process of foods consumed nowadays, given their wide presence in ultra-processed food products. Therefore, foods such as artificial juices, jellies, confectionery, candies, chewing gum, caramels, syrups, desserts, cookie fillings, yogurts, flavored and fermented milks, ice cream, soft drinks, seasonings, sausages, ready-made soups, cereals and many others present dyes, preservatives, and other additives in their formulations (SOUZA et al., 2020; CABRINI and MAGALHÃES, 2019; SILVA et al., 2019).
3.3 POSITIVE ASPECTS AND CONTRIBUTIONS OF FOOD TECHNOLOGY

The concern with the production of food to satisfy the population's hunger is very old. 200 years ago, at the time of the Industrial Revolution, economist Thomas Robert Malthus already demonstrated that the agricultural sector was incapable of generating food in abundance, given that, according to him, “the world population grew in a similar way to a geometric progression, while food production grew similarly to an arithmetic progression”, therefore, there was no adequate food supply (MALTHUS, 1983). This concept boosted food technology supported by biological, physical and chemical sciences, in the application of techniques and methods for processing, storing, distributing and using safe food for consumption.

Since then, food technology has overcome obstacles to guarantee the supply of nutritious and healthy food, guarantee its safety, increase its shelf life, seek new sources of raw materials, achieve sustainable use of the planet's natural resources, and, more recently, preparing food for individuals with special nutritional needs, considering the population's needs and consumption trends (BIASI et al., 2018).

According to LI et al. (2018), food processing can reduce allergenicity, either by modifying the allergenic structure or by irreversible removal of allergens. In this way, there are countless products on the market today that offer ingredients in their formulations that replace the most known allergenic components.

According to Silva (2010) it is already possible to find gluten-free products with pleasant characteristics, from a sensory point of view, using mainly corn, cornmeal, rice, potato, cassava, cassava flour, soy, and others. Although this market has potential for growth, the problem, according to experts, is linked to the entry of companies without experience in this market, such as small bakeries without a separate kitchen for making gluten-free breads.

Technological advances have been observed in the production of infant formulas for babies and children allergic to cow's milk and soy proteins, and more recently, rice. In them, the proteins are partially or extensively hydrolyzed in their composition, since they consider aspects such as consumption safety, efficiency, age of the child, nutritional status impairment, clinical manifestations, and severity of the allergic condition (OSBORN et al., 2018).

According to Oliveira (2015), despite having a residual flavor and high cost, the numerous infant formulas based on hydrolyzed and purified soy proteins, or also on free amino acids, are considered viable alternatives for children under three years old, since they correspond to the age group with the highest prevalence of allergy to milk proteins. Numerous studies have investigated the tolerability and safety of extensively hydrolyzed whey-based
formulas, enriched with various components such as oligosaccharides and probiotics, along with vitamins and minerals, demonstrating nutritional adequacy, healthy weight gain and recovery from allergic manifestations in babies and children under two years old (NASCIMENTO et al., 2021; CORDEIRO, 2019).

According to Sugano et al (2020), biotechnology can significantly contribute to the quality of life of allergenic individuals, since some allergenic proteins can be reduced or removed from certain foods. Song et al. (2015) studied ways to eliminate the allergenicity of β-globulin in ruminant milk, by targeting genes and interfering RNA, without compromising the other nutritional components of the food.

Studies conducted by researchers in Australia and New Zealand between 2000 and 2003 showed that crosses and genetic improvement of A2A2 homozygous cattle produce milk with the A2 β-casein variant, proteins with lower allergenic potential, given that they are resistant to intestinal hydrolysis and not release bioactive peptides called β-casomorphin-7 (BCM-7), directly involved in allergic reactions, resulting from the cleavage of the A1 β-casein variants found in A1 milk (BARBOSA et al., 2019).

Sugano et al. (2020) induced gene mutations in Japanese soybean varieties, Enrei and Kariyutaka, removing two of the main allergenic proteins from mature soybean seeds. Other researchers have already dedicated themselves to suppressing the allergenic components present in wheat, milk and peanuts in order to reduce allergic reactions (AVERY, 2000).

Studies have also demonstrated the effectiveness in genetic modification of recombinant allergens that interrupt or reduce the binding of food peptides with Immunoglobulin E (IgE), attenuating allergic reactions and promoting, at least, a lower allergenicity (EBISAWA et al., 2017).

Also, according to Ahuja et al. (2010), several animal models, including rats, mice, rabbits, and swine, have been studied and, over the years, it has been proposed to establish a standard model that evaluates the allergenic potential of new food proteins developed through biotechnology.

Considering that the intestinal microbiota is directly related to the immune system and that the malfunction of one is surely followed by the imbalance of the other (PRINCE et al. 2015), dysregulation of the microbiota, characterized as dysbiosis, can generate an elevation of IgE antibodies that will cause an increase in allergic manifestations (MCCOY and KÖLLER, 2015). According to Souza et al. (2021), probiotics may be convenient for the prevention and treatment of food allergies, primarily involved with gastrointestinal disorders, either through
the potential to reduce local and systemic inflammation or through the restoration of altered microbiota balance following the pattern of colonization and symbiosis repair.

Studies indicate that specific probiotic strains can be effective in the treatment of a subgroup of allergic children, especially those with allergies to a single food. In a study conducted by Canani et al. (2012), the use of Lactobacillus GG strains added to an extensively hydrolyzed infant formula promoted earlier acquisition of oral tolerance in children allergic to cow’s milk proteins. Similarly, Crovesy et al. (2017) evaluated the effects of probiotics (Animalis subsp. Lactis and Streptococcus thermophilus) on the gastrointestinal symptoms of children aged 3 to 12 months allergic to cow’s milk, showing improvements and reducing the gastrointestinal clinical manifestations resulting from the allergic process. Other studies have investigated the protective effects of different strains of probiotics on greater tolerance and attenuation of gastrointestinal symptoms, as well as the relief of atopic dermatitis, especially in children under 3 years old who are allergic to cow's milk proteins (TAN-LIM and ESTEBAN-IPAC, 2018; CANANI et al., 2017).

A smaller number of scientific studies about prebiotics have also discussed their beneficial effects in the prevention and treatment of food allergy. Considering that they are non-digestible compounds, and they release short-chain fatty acids that act on the epithelial and immune cells of allergic children, the consumption of prebiotics may provide better immune tolerance for these individuals (BROSSEAUX et. al., 2019).

Gourbeyre et al. (2011) administered a hypoallergenic formula added with GOS (galactooligosaccharides) and inulin to infants and observed an increase in Bifidobacteria in the feces with a decrease in the levels of total IgG1, IgG2, IgG3 and specific IgE of cow's milk protein in infants younger than six months, as well as reduction of the allergic condition in babies from six months to two years old.

4 FINAL CONSIDERATIONS

Food allergies are disorders that are difficult to diagnose and clinically manage, which involve complex issues that deserve further investigation and studies. Certainly, in view of the advancement of chemical, physical and biological sciences, society has placed expectations on food technology, by the constant search for more accurate information about the production and availability of safe food for consumption by a minority group that, although growing, lives with limiting diets and is surrounded by vulnerability related to their food and social restrictions. As claims for products free from allergenic compounds become mandatory, the food industry,
relying more and more on science and technology, should enable investments aimed at studies and production of safe alternative foods for allergic consumers.
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