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Report of the Scientific Committee of the Spanish Agency for Food Safety and Nutrition (AESAN) on the effects of climate change on food allergy

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Working group

Araceli Díaz Perales (Coordinator), Concepción María Aguilera García, Irene Bretón Lesmes, Ángel Gil Izquierdo, Gema Nieto Martínez, Ana María Rivas Velasco and María de Cortes Sánchez Mata

Scientific Committee

Concepción María Aguilera García
Universidad de Granada

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Universidad Autónoma de Madrid

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Universidad de Santiago de Compostela

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Consejo Superior de Investigaciones Científicas

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Universitat de València

Ángel Gil Izquierdo
Consejo Superior de Investigaciones Científicas

Gema Nieto Martínez
Universidad de Murcia

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Universidad Complutense de Madrid

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Hospital Gregorio Marañón de Madrid

Ángel Gutiérrez Fernández
Universidad de La Laguna

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María del Carmen Recio Iglesias
Universitat de València

Antonio Valero Díaz
Universidad de Córdoba

Araceli Díaz Perales
Universidad Politécnica de Madrid

Baltasar Mayo Pérez
Consejo Superior de Investigaciones Científicas

Ana María Rivas Velasco
Universidad de Granada

María Roser Vila Casanovas
Universitat de Barcelona

Technical Secretary
Vicente Calderón Pascual

Technical management of the report AESAN: María Ángeles Carlos Chillerón

Abstract

Food allergies are diseases with a high prevalence in our society and bring about a reduction in the patients' quality of life, in addition to a significant healthcare burden for health systems.

The constant rise in global temperature, the result of fossil fuel combustion and the accumulation of greenhouse gases, is changing the distribution of many species, as well as the pollination kinetics of many vegetables, with a great impact on food allergies. It has also been seen that high levels of carbon dioxide (CO_2) and pollution in cities increase the production of allergens from some of these plants.

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Changes in climate and the need for more arable land are increasing the occupation of new natural spaces, causing a reduction in environmental biodiversity, in addition to food availability, which can lead to an increase in intestinal dysbiosis and, hence, a reduction in tolerance and an increase in food allergies.

Finally, the need to increase the half-life of food and its transport over long distances has made the use of chemical preservatives and the use of petroleum derivatives as packaging widespread. At present there is little evidence, but it is beginning to be confirmed that some of the compounds used have a direct effect on our immune system, resulting in a greater likelihood of allergic sensitization. Furthermore, the waste products of this human activity generate particles and nanoparticles that, although different in their mechanism of action, both influence the mucous membranes, activating them and increasing the probability of suffering from an allergic disease.

In this context, the Scientific Committee of the Spanish Agency for Food Safety and Nutrition (AESAN) has carried out a review of the existing evidence on the relationship between the direct and indirect effects of climate change and the development of food allergies, based on the scientific evidence published so far.

Key words

Climate change, food allergy, dysbiosis, biodiversity.

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1. Introduction

The skin, mucosa, respiratory and digestive tracts make up a large immunologically active surface that interacts directly with the external environment. Food allergies are adverse reactions to certain foods, arising from a specific immune response, including reactions mediated by immunoglobulins (Ig)E, by immune cells or by both (Sampson, 2003). An allergen often triggers a pathogenic immune response that can affect different organs. Food allergies can be caused by multiple allergens and can give rise to an immune response with highly diverse clinical manifestations, affecting different organs and with varying intensity, from mild clinical conditions to situations that can put the life of the person who suffers from it at risk.

Food allergies are highly prevalent. More than 17 million people in Europe suffer from a food allergy, and one in four school-age children lives with one (Spolidoro et al., 2023). The number of serious and life-threatening allergic reactions (anaphylaxis) due to food allergies that occur in children is increasing (Spolidoro et al., 2023) and is already the first cause of hospital emergency care in Europe in this age group (Higgs et al., 2021).

Under optimal health conditions, there are regulatory and tolerance pathways in the body that prevent food components from causing damage or causing adverse immunological reactions. However, under specific conditions such as exposure to certain environmental factors, some dietary patterns or exposure to certain foods, tolerance is broken and excessive and aberrant immune responses to food allergens occur. Understanding the complex mechanisms present during the establishment (sensitization phase) and evolution of food allergy (symptom phase) allows identifying potential therapeutic targets and developing more effective therapies, aimed at modifying the allergy's natural course and improving patients' quality of life.

Although the underlying causes of the upward trend of allergic diseases are not clear, they have been related to various climatic factors (for example, with the increase in temperature or carbon dioxide (CO_2) concentrations) and their impact on the production and distribution of allergens (pollen, mold and food) (Bielory et al., 2012), with the use of chemical agents as food preservatives, as well as with the use of petroleum derivatives as packaging and storage to extend of the shelf-life of food when it is transported. These new agents have a direct effect on human health in the short and long-term, which has made it difficult to study and provide evidence. However, increasing studies confirm its relationship with the development of food allergy. Irrespective of the cause, the impact of allergies, including food allergies, on people's quality of life and their economic repercussions pose a well-known health and social burden (Verhoeckx et al., 2020).

2. Main families of food allergenic proteins

Food allergens are usually proteins stable to heat, acids and proteases. There is great variability in the biochemical properties of the allergens described, and this makes it difficult to predict which foods, especially among those newly incorporated into our markets, may behave as allergens in humans (Bianco et al., 2023).

Many of the plant food allergens are pathogenesis-related proteins (PR), proteins that are induced by pathogens, by wounds or by certain environmental stresses such as drought, increased temperatures, increased CO_2 concentration or the presence of certain chemical agents. Examples of PR allergens are avocado, banana and chestnut chitinases (family PR-3), which are expressed after attack by herbivores; antifungal proteins, such as thaumatins (PR-5) from kiwi and apple; proteins homologous to the main allergen of birch pollen Bet v 1 (PR-10), from vegetables and fruits; and lipid transfer proteins (PR-14), from fruits and cereals. Allergens other than PR homologues can be assigned to other well-known protein families, such as cereal seed α-amylase and trypsin inhibitors, fruit and vegetable profilins, nut and mustard seed storage proteins, and fruit proteases (Breiteneder and Ebner, 2000).

Fruit allergy stands out among the most prevalent food allergies in adults in Spain, representing 44.7 % of the total. This is one of those that has most increased in recent decades, according to data from the *Alergológica* report of the Spanish Society of Immunology and Clinical Allergology (SEIAC, 2015). Many fruits and vegetables cause particularly serious clinical conditions, such as anaphylactic-type reactions, although they are not included in the list of foods causing allergies and/or intolerances in Annex II to Regulation (EU) No. 1169/2011 (EU, 2011). In the Mediterranean area, the fruits most related to food allergies are those of the Rosaceae family (apple, pear, peach, apricot, plum, cherry) and the Cucurbitaceae (melon, watermelon, cucumber, pumpkin, courgette), as well as banana and kiwi. This group of foods have, as main allergens, proteins of a highly diverse nature, with lipid transfer proteins being the most frequent allergens (SEIAC, 2015). They often exhibit cross-reactivity with various pollens, for example, between birch pollen and allergy to apples, hazelnuts, celery or carrots (AESAN, 2007) (EFSA, 2014) (Siekierzynska et al., 2021) (Suriyamoorthy et al., 2022) (Koidl et al., 2023).

Furthermore, in Spain, nuts (such as almonds, hazelnuts, cashews, peanuts, walnuts, Brazil nuts, pecans, pistachios, pine nuts, sunflower seeds) also stand out as vegetable allergens, as well as other seeds, such as sesame (SEIAC, 2015). Their main allergens include storage proteins, such as albumins, globulins or vicilins, as well as lipid transport proteins and profilins (Bianco et al., 2023).

Among foods of animal origin, those most related to food allergies are milk and egg, with these allergies being the most frequent in children under 2 years of age (51.2 % and 28.2 %, respectively (SEIAC, 2015)). Allergy to cow's milk is mainly caused by lactoglobulins and albumins (Martorell-Aragonés et al., 2015). Cow's milk has cross-reactivity with other types of mammalian milk such as sheep's, goat's and buffalo's milk, with derived products, such as cheese, being the most common source of allergens. On the other hand, the main allergens of donkey and mare milk seem to also be whey proteins, such as lysozyme, α-lactalbumin and β-lactoglobulins, due to the low casein/whey protein ratio in equine milk (Lajnaf et al., 2023).

In relation to chicken egg allergens, the five main ones are ovomucoid, ovalbumin, ovotransferrin, lysozyme and albumin, most of which are found in egg white. Ovomucoid is resistant to heat and the degradation of digestive enzymes, making it the most allergenic protein, while ovalbumin is the most abundant protein (Tan et al., 2014).

As in the above cases, seafood allergy has also increased in recent decades, currently accounting for around 14.8 % of food allergies in Spain (SEIAC, 2015). The foods responsible for this belong to different species of crustaceans and mollusks that can cross-react with each other, and even with some species of insects and mites. Their main allergens are usually derived from tropomyosin (as is the case with allergens from octopus, oysters or shrimp), arginine kinase (for example, in lobster or potato), myosin light chains (in some species of prawns) or also from troponin C (Bianco et al., 2023). These proteins are usually very thermostable, although some treatments at high temperatures can partially reduce their allergenicity (Koidl et al., 2023).

3. Impact of climate change on the development of food allergy

Climate change refers to long-term changes in temperatures and weather patterns. As a result of increasing concentrations of greenhouse gases, such as CO_2, the Earth is now warmer than at the end of the 19th century. Due to human activity, the global average temperature of the last 10 years reached 1.14 ºC above pre-industrial levels, in 2013-2022, triggering global climate and environmental changes that pose an unequivocal, immediate and increasing threat to the health and survival of people around the world. The last 8 years have been the warmest on record; unprecedented extreme weather events occurred on every continent in 2022; and July 2023 was the hottest month ever recorded; with detection and attribution studies showing the influence of climate change on many of these events, becoming more severe or more likely to occur. The global average temperature is currently increasing at a rate of 0.2 °C per decade (likely range: 0.1 to 0.3 ºC) due to past and present emissions (Pacheco et al., 2021) (Romanello et al., 2023).

Temperature changes in one area can affect weather changes in others and can include intense droughts, water shortages, wildfires, sea level rise, flooding, polar melt, catastrophic storms, and declining biodiversity. Air pollution and accompanying environmental stressors, such as ozone, CO_2, high salt concentration and lack of micronutrients in the soil or drought, can increase allergenicity due to direct changes in the production of allergen-proteins or to intrinsic adaptations of the same by plants, in different organs of these (D'Amato et al., 2015). In this regard, the increase in pollen production is noteworthy, with a higher content of allergens, as well as the increase of these in foods of plant origin, due to their impact on the development of food allergies (El Kelish et al., 2014).

Climate change, pollution, the decrease in biodiversity, as well as people's lifestyle, also cause changes in the body's epithelial barriers, in its microbiota and in the diversity of its nutrition, which translates into an increase in the prevalence of allergies, in general, and food allergies in particular (Pali-Schöll et al., 2017, 2019) (Venter et al., 2020) (Korath et al., 2022) (Trujillo et al., 2022).

Therefore, this report will comment on the evidence that has been found on the effect of climate change and its impact on the development of food allergies, distinguishing the following sections:

1. Secondary effects to the increase in CO_2 emissions, which favor the increase in temperature, and therefore, cause a reduction in the biodiversity of species, globally.
2. Effects due to our lifestyle, with less diversity in food consumption, from early childhood, which has led to increasing dysbiosis.
3. Effects caused by the need to feed an increasingly large population, which leads to the use of food preservatives and the use of petroleum derivatives (plastics in containers) for their protection and transport. All of this has also led to a concerning side effect: the generation of microplastics and nanoplastics that accumulate in the water, forming actual islands in the ocean.

3.1 Effects of climate change on food allergy

3.1.1 Rise in average annual temperature and increase in CO_2 emissions

Increased temperature and CO_2 levels have negatively affected the production of agricultural crops, the diversity and distribution of natural species and biological patterns, such as the flowering season and pollination, as well as productivity, particularly of basic and commercial crops (Raza et al., 2019) (Sharma, 2019). The most obvious consequence is an increase in the symptoms that allergic people present (more crises and more lasting), and quite possibly, an increase in the prevalence of allergies, in general. However, it should be borne in mind that the distribution and prevalence of allergies are subject to variations, both geographical and chronological, which makes it difficult to extract global patterns (Seth and Bielory, 2021). Most of the information that has been published in this regard focuses on the effect on pollination, and not on its direct relationship with food allergies. However, pollen is a source of sensitization to food allergies, given that there is a great cross-reactivity between pollen allergens and some food allergens (EFSA, 2014) (Koidl et al., 2023). Therefore, although the increase in temperature directly affects the pollen, this could also affect the food allergy indirectly (Loraud et al., 2021). Likewise, and as described above, many of the plant food allergens are PR proteins whose expression/production is conditioned by abiotic or environmental changes, which are expressed both in pollen and in other parts of the vegetables that are common foods.

On the other hand, the increase in temperature has caused certain forest species, such as cypress, clematis or evergreen clematis (*Clematis cirrhosa*) and the olive tree, to extend the duration of their pollination and geographical distribution, invading regions in central and northern Europe, where they were not found 50 years ago (Rasmussen et al., 2017) (Grosch et al., 2022) (Perera and Nadeau, 2022). A study in western Liguria (Northwest Italy; 1981-2007) (Ariano et al., 2010) revealed that the duration of pollen seasons had been extended for parietaria (by 85 days), for olive (by 18 days) and for cypress (by 18 days). These variations have resulted in increased sensitization (allergies) to pollen, with an increasing pollen load, compared to other non-climate dependent sensitisations (dust mites). This had also led to an increase in food allergies related to these pollens (Ariano et al., 2010). This fact has direct consequences on patients with allergy, who suffer the symptoms for a longer time, due to the prolonged presence of pollen in the environment, but also due to the appearance of new sensitisations, which lead to an increase in the prevalence of this disease. And this phenomenon is global. As another example, Anderegg et al. (2021) have shown a global increase in pollen concentration of 21 % and an average lengthening of the pollen season in the United States by more than 20 days between 1990 and 2018. It is urgent to carry out studies like this in other parts of the world, such as, for example, in Spain.

But changes in climate also favor certain species to increase their geographical distribution. This is the case of the evolution of the plant species *Ambrosia artemisiifolia* L. (common ragweed) in recent years, with a highly allergenic pollen (Schiele et al., 2019). Ragweed, native to the United States, has invaded large areas of South America and Europe in recent decades and has been identified as one of the main causes of severe allergic respiratory diseases. The species has become naturalized throughout Europe at a rapid pace. In Germany, for example, 8.2 % of adults are sensitized to *A. artemisiifolia*, a prevalence that has been increasing in recent decades (Sikoparija et al., 2017). But, in addition to its invasive capacity, it has been seen that the increase in CO_2 levels leads to a significant increase in the pollen count and the concentration of the main allergen in it, Amb a1, without changes in the total level of other proteins (Singer et al., 2005). Thus, the pollen of this species, collected along roads with heavy traffic shows a higher allergenicity than the pollen sampled in areas of vegetation. The global impact results in an alteration of the calendar and the load of the pollen season and, hence, a change in exposure (D'Amato et al., 2017).

The case of ragweed is not an isolated case. In urban environments, where there is greater environmental pollution, pollens have been shown to change their allergenic profile, increasing the concentration of certain allergens. For example, in birch pollen, the concentration not only of the main allergen (Bet v 1), but also of adjuvant substances (such as lipid mediators associated with pollen or lipopolysaccharides) increased, inducing effects on inflammatory and immune mechanisms, and exacerbating their allergenicity (Lucas et al., 2019) (Rauer et al., 2021) (Luchkova et al., 2022). Birch pollen has been described as one of the routes of entry of food allergies to fruits in central and northern Europe, such as apple and celery, for including allergens like most of the birch pollen (Biedermann et al., 2019).

In the same way, the relationship between greater environmental pollution with a lower efficiency of photosynthesis and an increase in oxidative stress in grass pollen, as in *Lolium perenne*, has been demonstrated, so that these types of stresses favour the increase of certain allergens and, therefore, give rise to a greater allergenicity thereof (Lucas et al., 2019). In Spain, allergy to grass pollen is closely related to allergy to melon and other cucurbits. It is known that the longer the grass pollen season, the greater the number of cases of anaphylaxis in the emergency services due to melon consumption (Rodríguez Del Río et al., 2017).

Finally, and although with more limited evidence, it has been observed that the increase in CO_2 concentrations causes a direct rise in the concentration of allergens in other parts of the plants that constitute food, as is the case of the main peanut allergen (Ara h 1) (Burks et al., 1995) (Ziska et al., 2016) or Bet v 1 homologous allergens present in fruits and nuts.

3.1.2 Decrease in environmental biodiversity (reduction in the number of species)

In 1992, the Convention on Biological Diversity of the United Nations (UN) defined environmental biodiversity as "the variability of living organisms from any source, including, but not limited to, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are a part; it comprises diversity within each species, between species and of ecosystems" (UN, 1992). The increase in human population that has been recorded since the end of the nineteenth century, but especially since the last half of the twentieth century, has meant that more and more natural spaces are occupied, eliminating natural habitats of numerous wild species. This has led to the greatest extinction of species since the Cambrian period.

The loss of biodiversity is directly related, not only to a lower diversity of what we eat, but also to a lower number of antigens to which we are exposed, which affects the education of our immune system from birth and, therefore, generates a greater possibility of triggering allergic diseases (Hanski et al., 2012).

The decline in biodiversity is due to several factors. Urbanization, linked to areas where cement predominates, causes heat islands and impacts biodiversity. Intensive agriculture (pesticides, fertilizers) and monocultures (fast-growing crops and easily reared animals) reduce the biodiversity of traditional animal species and farmland.

The loss of variety in the number of species we find in our environment, outside and inside, impacts communities and ecosystems. Different organisms respond differently to changes in climatic conditions; however, this different impact can imply consequences in the different species that interact in each community, affecting, for example, the relationships between plants and pollinating insects, or the relationships between plants and herbivorous animals, among other more complex relationships (Bradshaw and Holzapfel, 2006). Studies such as that of Hanski et al. (2012) reveal the interaction between environmental biodiversity, commensal microbiota and the immune system, observing, in the adolescent population, the relationship between exposure to a less diverse microbiota and the development of food allergic diseases.

As the number of species with which we live is reduced, the number of antigens to which we are exposed is reduced, and, therefore, the appearance of allergies is favored. Biodiversity loss is linked to an increase in food allergies.

3.2 Effects of Western lifestyle on the development of food allergies

3.2.1 Reduction in dietary diversity and dysbiosis (reduction in the variety of species of our microbiota)

The loss of environmental biodiversity is also related to less diversity in our diet. By way of example, dietary fiber intake approximately 10 000 years ago was 150-250 g/day from a huge variety of plants. Nowadays, it is one tenth of that amount (Leach and Sobolik, 2010). There has long been evidence linking high-fiber diets to better health and a lower incidence of food allergy (Morrison and Preston, 2016).

The resulting nutritional deficiencies, obesity and less variety in the microbiome lead directly or indirectly to allergic diseases (Roth-Walter et al., 2017) (Venter et al., 2022). As mentioned above, the lower diversity in the foods we consume results in a lower number of antigens and, therefore, in a lower diversity for the learning of our immune system at early stages of development. In addition, this lower variety has a direct effect on the diversity of our microbiome and, therefore, on our ability to tolerate food. If we limit the learning of our immune system, we reduce our ability to tolerate, which favors the appearance of food allergies.

The loss of diversity in the diet is due to several factors. One of them is the availability of food. Growing conditions must be increasingly extreme due to the changes in the climate that are taking place. To this we must add the growing human population that forces us to produce more on a smaller agricultural area through extensive cultivation techniques. But not all food can be grown in those conditions, which reduces the number of foods available to most of the population.

Furthermore, arable areas are usually located at a long distance from the consumer, which requires the transport of food, in special containers, with chemical preserving agents and with special treatments to increase the storage time or the attractive appearance (for example, the waxing of apples). All these treatments cause a reduction in the biodiversity of the food microbiome, which can affect the microbiome of the human intestine, leading to a profound impact on the intestinal barrier (Wassermann et al., 2022), which favors the appearance of food allergies. Overall, a lower biodiversity of the environment, the soil, the plants, the food and, possibly, less social contact, can affect the microbiome of the skin and the intestine and, therefore, to the immune balance of people, resulting in an allergic sensitization (Haahtela, 2013) (Haahtela et al., 2021) (Borbet et al., 2022).

The microbiota (microbiome) present on the surface of the body (skin and mucous membranes) is decisive for the development of the adaptive immune system after birth. This implies that it has an essential role in the establishment of food tolerance (Zheng et al., 2020). The human gastrointestinal tract contains approximately 100 trillion microorganisms from at least 160 different species, including bacteria, fungi and viruses. The composition of the microbiome is defined early in life, influenced by external factors such as the maternal and environmental environment and diet. Upon reaching adulthood, the microbiome profile usually stabilizes (Walker, 2014). There are more and more studies showing that the alteration of the microbiome, known as dysbiosis, can cause various adverse effects in the body and is especially relevant in the development of food allergy (Ling et al., 2014) (Bunyavanich et al., 2016) (Hua et al., 2016) (Fazlollahi et al., 2018) (Abdel-Gadir et al., 2019) (Goldberg et al., 2020) (Berin, 2021). For example, it has been confirmed that children with food allergy have a different, and less diverse, microbial composition than that of healthy children (Azad et al., 2015) (Savage et al., 2018). Low intestinal microbial wealth at 3 months of age can predict the development of food allergy at 12 months (Azad et al., 2015) (Aitoro et al., 2017) (Blázquez and Berin, 2017). Interestingly, exposure to a dog in the home during the first year of life is systematically associated with protection against food allergy (Peters et al., 2015).

Mckenzie et al. (2017) describes the “gut nutrition-microbiome axis” as an essential link between diet, gut microbiota, and allergic diseases. As an example of this axis, we find Short Chain Fatty Acids (SCFA), metabolites produced by intestinal bacteria through the fermentation of non-digestible fibers, and which have been highlighted as key signaling molecules that allow “cross-communication” between the intestinal microbiome and the host (Morrison and Preston, 2016).

Therefore, dysbiosis is closely related to the development of food allergy. It remains to be determined whether it is the origin or the consequence of this. However, it seems that there are bacterial species that stimulate the production of metabolites that favour immune tolerance and the reduction of food allergies.

3.3 Effects caused by the need to feed an increasingly large population

3.3.1 Use of preservatives and chemical agents

As explained in previous sections, the loss of cultivable area, changes in weather in recent years and population increase (generating the need to produce more in less space and time) have forced us to look for ways of preservation so that food lasts longer. The use of additives, preservatives or plastics to package food is very common nowadays. However, some of them are affecting our immune system, our microbiome, and, therefore, our epithelial barrier, favoring the development of allergic food diseases.

Emulsifiers such as lecithin, carboxymethylcellulose and sorbitol monostearate are food additives that are frequently used to reduce surface tension and obtain a homogeneous dispersion of food (Chassaing et al., 2015) (Pressman et al., 2017) (Viennois and Chassaing, 2018). In animal experimental models, it has been observed that these compounds also thicken the mucus present in the epithelial barriers, trapping the commensal bacteria, avoiding a healthy interaction between the epithelium and the commensal bacteria, altering the microbiota and disturbing the mucus bacterial interactions to induce inflammation of the intestine, as a previous step to allergic sensitization (Chassaing et al., 2015) (Pressman et al., 2017) (Viennois and Chassaing, 2018).

Another preservative that has been linked to allergic diseases is triclosan (TCS), which is a broad-spectrum synthetic antimicrobial agent that forms part of the formulation of household, personal care, and industrial products. In addition, it is frequently found in food and in the aquatic environment (AESAN, 2023). Triclosan was associated with an increased likelihood of food sensitization development in a cohort of 860 children, although the effect was only evident in males (Savage et al., 2012).

Likewise, phthalates can act as adjuvants at levels that are likely to be relevant to environmental exposure, inducing respiratory and inflammatory effects in the presence of an allergen, acting as adjuvants. Likewise, some *in vitro* works indicate that phthalates can alter the functionality of innate and adaptive immune cells (Bølling et al., 2020). Stelmach et al. (2015) showed that high urinary concentrations of monobenzyl phthalate in mothers during pregnancy could increase the risk of food allergy in children during the first 2 years of life.

In summary, in recent years different studies have appeared that have analyzed the relationship between exposure to preservatives, additives and plastic derivatives and the development of food allergy. Many of these compounds have also been described as endocrine disruptors whose effect on the immune system is more studied, highlighting the role of bisphenol A (BPA) and phthalates (AESAN, 2023).

3.3.2 Particles and nanoparticles as secondary human contamination

Finally, and because of the increase in the use of petroleum products, we must consider the activity of PM (Particulate Matter) particles and polluting nanoparticles of water and soil, derived from human activity or derived from the degradation process of containers and plastics.

PM particles are a mixture of solid particles and liquid droplets that are suspended in the atmosphere. They are formed through chemical reactions between gases such as sulfur dioxide, nitrogen oxides, and certain organic compounds originating from industrial processes, combustion engine vehicles, domestic heating, and forest fires. All types of PM particles behave like gases due to their small size and can activate our immune system, favoring the onset of diseases, especially in the respiratory tract and intestinal mucosa. The presence of these particles in the environment or in drinking water has been associated with a greater likelihood of developing food allergy, favoring inflammation, and a decrease in the diversity of the microbiome in the intestine (Chuang et al., 2015) (Pan et al., 2015) (Ngoc et al., 2017) (Tang et al., 2017) (Wang et al., 2017) (Piao et al., 2018).

In the case of microplastics and nanoplastics, petroleum-derived and water-insoluble polymer particles, they are formed when larger “microplastics” are found in nature and are degraded into smaller fragments by the action of ultraviolet rays from the sun, waves, rain, or wind. These microplastics and nanoplastics can accumulate in the water, forming actual islands in the ocean (Monteiro et al., 2018).

Humans are easily exposed to them in everyday life, either by contact, inhalation or ingestion through water, soil, and air. These products can easily penetrate tissues and interact with cells and structural molecules, lasting and activating inflammation, as a preliminary step to allergic sensitization (Wright and Kelly, 2017) (Yee et al., 2021).

In the same way, they can penetrate other living beings by passing through the food chain. At present, increasing levels of plastic are detected in fish and sea creatures. Microplastics have even been detected in drinking water and in foods such as mussels, prawns, fish, salt, sugar, honey, and beer. They have a high absorption capacity in the gastrointestinal tract, and the deleterious effects of microplastics have been observed both *in vitro* and *in vivo* studies (Yee et al., 2021). In experimental animal models, polystyrene microplastics have been shown to reduce intestinal mucus secretion and damage intestinal barrier function (Jin et al., 2019). In fact, when different sizes of spherical fluorescent polystyrene particles (1, 4 and 10 μm) were used in monolayer-grown cell models (CaCo2 epithelial cell line), it was observed that the smallest particles (<1.5 μm) could cross the gastrointestinal epithelial barrier (Stock et al., 2019).

In short, the presence of these products derived from human activity has been found in different sources (both in the air or drinking water, and in species for human consumption), being able to enter our body causing the activation of our immune system and favoring the appearance of food allergies.

Conclusions of the Scientific Committee

Global climate change can influence the occurrence of food allergies by different mechanisms. The increase in temperature is leading to earlier flowering, greater dispersion of pollen in the air and a longer flowering season, which translates into a longer season in which pollen patients suffer symptoms, but also an increase in the prevalence and severity of allergy symptoms related to these allergens. On the other hand, a pollinosis, or sensitization to pollen, means a greater possibility of suffering from food allergy due to the cross-reactivity of common allergens in both sources.

In addition, the increase in greenhouse gas emissions induces the expression of certain allergens, altering their concentration both in pollen and in foods of plant origin directly. The aftermath of the climate crisis contributes to increased levels of outdoor air pollution, pollen exposure and extreme weather events, which together increase the risk of developing or exacerbating allergic disorders.

On the other hand, because of climate change, there has been less biodiversity in the environment and in the microbiota that is present in some foods. This results in a considerable reduction in the number of antigens to which our body is exposed, altering our immune system, and potentially affecting its ability to tolerate.

It has been observed that the reduction in the diversity of foods in our diet, especially in the early stages of development, is associated with a greater predisposition to develop food allergies. Dysbiosis is a consequence of these changes in diet, among other factors, and is directly related to the development of food sensitisations.

Likewise, the need to feed an increasingly increased population, together with the reduction of agricultural land, a consequence of climate change and, therefore, the use of extensive agriculture methods (which reduces the number of possible crops since not all crops can be adapted to this type of agriculture and, therefore, reduces the diversity in our diet) has forced the use of preservative agents (which increase the average life of food) and petroleum derivatives as containers for long transport. The remains of chemical substances present in food can cause an absorption of these products in the intestinal mucosa, with a deterioration of the epithelial barrier and dysbiosis of the intestinal microbiome, which favors the development of food allergies. However, it should not be concluded that we should dismiss the use of agents and products for the healthy maintenance of food. On the contrary, we should support the search for substitutes that guarantee our current lifestyle, without harming our health.

Finally, we must bear in mind that climate change is no longer a problem for future generations. It affects all people, now. If we do not act immediately, its impact will make human health deteriorate. Our body, although having an incredible ability to adapt, will need several generations to do so. That is why it is necessary for us to work to stop or reduce changes in the climate, not only to save our planet, but also to protect our health and our lives. The decisions we make today, including our individual and collective actions and inactions, will affect the entire global population and future generations. Therefore, we have the responsibility to protect people suffering from allergic diseases and the population in general, and to urge both society and public bodies to reduce the impact of climate change on public health.

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