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Clinical characteristics of allergic reactions to seeds and analysis of prevalence and severity

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Abstract: Seed allergens are widespread factors of food allergy, and for the targeted treatment, accurate identification of the provoking product is necessary. Clinical cases of allergy to seeds, manifested by an allergic syndrome, are quite common. The purpose of the study was to determine the prevalence of allergic reactions to seeds and to study clinical cases better to understand the causes of seed allergies and their prevention. To this end, this study selected 146 published scientific papers relevant to seed allergy and met all the criteria. Of these, 46 studies were studied and analyzed, available in English, and published in the public domain on various databases. The biological characteristics of these seeds, their distribution in the world, and their use in multiple spheres of life were studied in detail. The study's results determined that pumpkin and fenugreek seeds cause the least allergic reactions, followed by poppy, sunflower, and sesame seeds, which provoke the remaining reactions. The degree of damage caused by an allergic reaction can vary from the mildest in the form of hives and food reactions to severe anaphylactic reactions and even death. Thus, collecting complaints, medical history, family, and allergic history is vital to the diagnosis. Still, additional examination methods, such as skin tests, determination of specific immunoglobulin E, and experimental testing with certain seeds, are crucial in the diagnosis.

Keywords: Cross-immunological reactions, Food allergy, Anaphylactic shock, Atopic dermatitis, Treatment.

Resumo: Os alérgenos das sementes são fatores generalizados de alergia alimentar, para cujo tratamento orientado é necessária uma identificação precisa do produto provocador. Os casos clínicos de alergia a sementes, que se manifestam por uma síndrome alérgica, são bastante comuns. O objetivo do estudo foi determinar a prevalência de reações alérgicas às sementes, bem como estudar casos clínicos para melhor compreender as causas das alergias às sementes e a sua prevenção. Para o efeito, este estudo selecionou 146 artigos científicos publicados que eram relevantes para o tema da alergia às sementes e que cumpriam todos os critérios. Destes, foram estudados e analisados 46 estudos, disponíveis em inglês e publicados no domínio público em várias bases de dados. Foram estudadas em pormenor as características biológicas destas sementes, a sua distribuição no mundo e a sua utilização em vários domínios da vida. Os resultados do estudo determinaram que as sementes de abóbora e de feno-grego são as que provocam o menor número de reações alérgicas, seguidas das sementes de papoila, das sementes de girassol e das sementes de sésamo, que provocam as restantes reações. O grau de dano causado por uma reação alérgica pode variar desde o mais ligeiro, sob a forma de urticária e reações alimentares, até reações anafiláticas graves e mesmo a morte. Assim, a recolha de queixas, história clínica, história familiar e alérgica é uma parte importante do diagnóstico, mas os métodos adicionais de exame sob a forma de testes cutâneos, determinação da imunoglobulina E específica e testes experimentais com determinadas sementes são cruciais para o diagnóstico.

Keywords: Reações Imunológicas cruzadas, Alergia alimentar, Choque anafilático, Dermatite atópica, Tratamento

Introduction

The increased consumption of seeds in cooking, cosmetics, and other areas of activity has led to an increase in the number of allergies to them over time [1]. Allergic reactions to seeds such as sunflower, pumpkin, poppy, sesame, and fenugreek are not common but can cause various symptoms, from contact dermatitis to severe anaphylactic reactions. Studying allergic reactions to these seeds ensures patient safety during food intake, identifies allergens that cause life-threatening situations, and develops ways to control them. Understanding the processes and mechanisms of allergies to specific foods helps optimize diagnosis, treatment, and prevention methods. These aspects aim to develop strategies to identify allergenic proteins in seeds and minimize the risk of immediate allergic reactions in humans by properly labeling food products.

Many scientists have also studied the topic of seed allergy, but there are very few cases and recorded diagnoses, which is a problem in this area of research. Among the cases published in the literature, it is worth highlighting a study by Gawryjołek et al. [2], who reported an allergy in the form of an anaphylactic reaction with widespread urticaria, increasing dyspnoea and lip edema in a 2-year-old child who had consumed pumpkin seeds. Furthermore, the child's medical history included an allergy to milk and eggs, thus requiring a diet based on pumpkin pulp. Each test showed an allergic reaction to pumpkin seeds, but the test was negative for pumpkin pulp. Immunoglobulin E was positive for seeds and negative for pulp. In addition, there was an immunoglobulin E reaction to sesame, walnut, and buckwheat.

Joseph et al. [3] described the reaction of a 14-year-old boy who consumed a spread consisting of fenugreek, coriander, garlic, and lemon; 15 min later, he developed abdominal pain and vomiting, urticaria, and chest tightness. The symptoms decreased within an hour after the administration of the antihistamine. As an additional examination, the patient underwent skin testing and immunoglobulin E determination, which was positive. Bant et al. [4] described two cases of allergic reactions to poppy in a male 32 years old, and a female 21 years old. Both patients had an immediate life-threatening allergic reaction after eating a cake and a brownie containing poppy seeds. The medical history revealed that the woman had atopic dermatitis and a positive reaction on skin tests to weed, birch, hazel, and hazelnut pollen. The man's

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allergic history was uncomplicated, and skin tests were negative. In the allergen-specific immunoglobulin E test, the woman was positive for poppy seeds and nut mixtures, and the man was also positive for poppy seeds and nut mixtures. In addition, the man had an allergic reaction to the anesthetics (poppy derivatives – morphine and codeine) used for the skin tests.

Ukleja-Sokołowska et al. [5] conducted a study describing the case of a 40-year-old man who developed an anaphylactic reaction in the form of hives and shortness of breath after eating sunflower seeds. A laryngological examination revealed swelling of the tongue, mouth, and pharynx. A skin test showed a strongly positive result for sunflower seeds and hazelnuts, egg whites, and oranges. In addition, a specific immunoglobulin E test was carried out, which was positive for a mixture of weeds, *Artemisia absinthium*, and *Artemisia vulgaris*. In addition, given the relevance of the topic of allergic reactions to seeds and nuts and the insufficiency of existing data, Ryczaj et al. [6] published a protocol for a future study, which outlines a plan to investigate allergies to sesame tree nuts, and peanuts in Polish children. The study will involve 240 children interviewed and examined according to the research protocol. Complaints, anamnesis, genetic predisposition, results of additional diagnostic methods, such as skin testing and determination of specific immunoglobulin E levels, and oral food tests will be discussed in detail. The prevalence and timing of allergies to sesame, tree nuts, and peanuts will be assessed.

The study aims to determine the prevalence of allergies to pumpkin, fenugreek, sesame, sunflower, and poppy seeds, analyze clinical cases to better understand the risk factors for seed allergies, and develop a prevention plan. The study addresses insufficient research due to the low prevalence of allergic reactions to poppy, sesame, pumpkin, fenugreek, and sunflower seeds.

1. Materials and Methods

The methodology of this theoretical study was based on a systematic review of allergic reactions to sesame, fenugreek, poppy, pumpkin, and sunflower seeds. A literature search relevant to the topic was conducted using available evidence published in reliable databases. The study included research papers published from 2020 to 2024, which included literature reviews, theoretical and case studies, empirical data, and clinical cases. The lack of data in published studies was compensated for by data published before 2020. The following keywords were used to study the topic and search for literature: allergies to seeds, sunflower seeds, poppy seeds, sesame seeds, fenugreek seeds, nuts, bronchial asthma, anaphylactic shock, allergic rhinitis, atopic dermatitis. The research used keywords exclusively in English in databases such as PubMed, Scopus, ScienceDirect, and Google Scholar.

To study the issue, 146 publications available in the above databases were selected. The titles, headings, and abstract screening of each scientific paper were evaluated and additionally reviewed in detail for final inclusion in the list of references of this study. Information was extracted from each relevant article or report, covering the year of publication, research design, country of publication, and the first author's name. However, publications were not considered if they did not meet the selection criteria: they were not available in English, did not correspond to the research topics, were not freely available for reading, had poor quality content, and had inaccuracies in the search databases. At the end of the selection process, 47 materials that met all the criteria remained.

This study analyzed the origin of sunflower, sesame, pumpkin, poppy, and fenugreek seeds, considered their biological type, belonging to a particular genus, prevalence, and use in everyday life, and examined in detail the presence of protein allergens that cause allergic and anaphylactic reactions in humans. Clinical cases for each type of seed published in the current literature that occurred after eating the seeds or any other interaction with them were systematized. The symptoms included itching, hives, swelling of the face, mouth, lips, and tongue, redness or pallor of the skin, shortness of breath, shortness of breath, wheezing or rasping breathing, a feeling of a lump in the throat, hypotension, tachycardia, weakness, nausea, vomiting, diarrhea, headache, a sense of fear or anxiety, fear of death, and loss of consciousness. In addition, the diagnosis of allergic reactions to pumpkin, sesame, poppy, sunflower, and fenugreek seeds is also discussed. Complaints, medical history, allergic history, family history and genetic predisposition, objective data, additional laboratory tests such as immunoglobulin E, skin prick and contact allergy tests, and patch testing in the form of consumption or any other contact with seeds were addressed.

2. Results

Allergy to sunflower seeds: application, biological description, allergens, clinical cases. The popularity of adding various edible seeds to food is increasing since they have a high content of polyunsaturated fatty acids, omega-3, and omega-6 and have some beneficial biological properties for the human body. These seeds include sunflower, pumpkin, sesame, and poppy seeds, among others. However, given the rapid change in dietary habits, sensitization and allergic reactions to these seeds are also increasing, although some are not allergens *per se* [7].

Sunflower (*Helianthus annuus*) is an annual Asteraceae genus plant with a broad flower head, dense, voluminous stem, and a height of up to 3.0 m. The head of the inflorescence is up to 30 cm in diameter on average, consists of 1000-2000 small flowers, and is surrounded by large yellow petals on the outside. The seeds have a soft, oily core surrounded by a pericarp with a hard shell. A distinctive characteristic of sunflowers is their ability to turn towards the sun, which is why they ripen quickly in autumn. Sunflowers were spread worldwide from Central America and have taken root in countries with a predominantly temperate climate. Sunflower seeds are harvested and used in cooking as oil or as an ingredient in dishes. After processing, the shells,

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leaves, and husks are used in agriculture as fertilizer and biomass for heating [5]. Sunflower seeds are also used to feed poultry, ornamental birds, and livestock.

According to the data obtained, Ukleja-Sokołowska et al. [5] determined that allergy to sunflower seeds is extremely rare. Still, dermatitis and anaphylactic reactions have been described in people who have eaten products containing these seeds. For example, an allergic reaction can occur even with sunflower oil, although it is processed to remove proteins that cause allergies and is considered as safe as possible. In addition, sunflower seeds are heat-resistant, so wholemeal breads that contain sunflower seeds can be dangerous for allergy sufferers. Sunflower seed allergens have not been studied sufficiently at the moment. However, scientists have identified and described some species: Hel a 1, Hel a 2, Hel a 3, lipid carrier proteins. Hel a 1 is the leading sunflower allergen, an aeroallergen protein homologous defensin molecule with a molecular weight of 34 kDa. Hel a 2 is a profile that is also an aeroallergen with a molecular weight of 4.7 kDa. Hel a 3 is a protein that belongs to the type 1 lipid carrier and is a non-specific food allergen with a molecular weight of 9 kDa [8]. The 2S-albumin in sunflower contains methionine and an additional protein with a mass of 12 kDa.

Sunflower pollen also contains various allergens that can cross-react with allergens from other plants, such as dandelion, ragweed, chrysanthemum, wormwood, and goldenrod. One of the most severe reactions sunflower engages in is cross-reaction with wormwood pollen allergens [9]. Furthermore, cross-reactivity with other types of allergens may occur due to the interaction of the Hel a 2 protein with similar properties of proteins of other plants and trees (olive tree, ragweed, wormwood). In addition, sunflower pollen can cross-react with its seeds. Lipid transfer proteins, including Hel a 3, are a relatively common plant panallergen, most commonly found in Mediterranean countries. Hel a 3 proteins are generally resistant to heat treatment in cooking and exposure to the digestive system. Conditions in patients with sunflower seeds include contact dermatitis, urticaria, allergic conjunctivitis, rhinitis, bronchial asthma, and oral allergy symptoms [5].

Among the cases described in the scientific literature, a study in which three patients were observed after an anaphylactic reaction to sunflower seeds is worth noting. All of them were confirmed to be allergic to seeds; however, one patient was exposed to sunflower pollen due to an occupation. Allergic rhinitis, conjunctivitis, and bronchial asthma were noted. After the diagnosis of occupational allergy was made and exposure to the allergen was stopped, the symptoms completely disappeared. Later, another case of an allergic reaction to sunflower seeds was described. The study observed three patients who reacted to the seeds with an anaphylactic reaction, and the fourth patient experienced an asthma attack. All the patients were poultry farm workers and had constant contact with seeds. The authors also wanted to identify the prevalence of sunflower allergy and found that out of 84 patients with atopy, only three people were sensitive to the seeds. These data confirm that the incidence of sunflower seed allergy is rare [5].

Atis et al. [10] conducted a study at a plant that processed sunflower seeds. The study found that 23.5 % of employees in contact with sunflower pollen were allergic to it and suffered from rhinitis and conjunctivitis much more often than the control group, which had no contact with the plant. In addition, a case of sunflower allergy in the form of an oral reaction through inhalation of the allergen during bird feeding was described. The diagnosis was confirmed by laboratory tests [5; 11]. A case of food allergy to sunflower was also described in a 22-year-old female patient with distant wheezing, dyspnoea, laryngeal edema, and body rash, who suffered from atopic dermatitis. The researchers identified that the protein that caused the girl's allergy was similar to a lipid carrier protein. A case of a threefold anaphylactic reaction was described in a 46-year-old female patient who had consumed several sunflower seeds at different time intervals. Both mild symptoms of a burning throat and more severe symptoms of nausea, abdominal pain, low blood pressure, and tachycardia were present [12].

Pumpkin seed allergy: application in life, biological species, allergens studied, clinical cases. Pumpkin (Cucurbitaceae) and its seeds belong to the pumpkin family, which were spread from America [13, 14]. Most of the representatives of this family are annuals that curl along the ground and have robust stems with large five-lobed leaves arranged alternately on the stem. Pumpkin flowers are white or yellow with a hollow core and five whole petals. Pumpkin fruits are large and fleshy, with hard brownish-yellow skin and a cavity with the seeds inside. The seeds are oval with a flattened appearance, milky brown, ranging in size from 7 – 25 mm [15-17]. Pumpkin seeds have been widely used in traditional medicine in South Asia and North and South America. Still, due to the rapid development of alternative medicine and the popularity of healthy eating, pumpkin seeds have become an object of research in medicine. The composition and some biological properties have led humanity to an increase in allergic reactions to pumpkin seeds. However, this product was previously not considered an allergen, and no cases were observed. Pumpkin seed allergens have been studied very little; however, scientists have identified proteins with masses ranging between 13 – 87 kDa [7]. A 12 kDa protein that was not homologous with the lipid transporter protein was also isolated, but it caused symptoms characteristic of the indicated protein species.

Pumpkin allergy is considered a very infrequent phenomenon, as few cases have been reported. However, all parts of the pumpkin can cause allergic reactions in people who have come into contact with the fruit. Cases of allergic dermatitis have been described after peeling and cutting pumpkin fruits. Cases of anaphylactic reactions to pumpkin pulp have also been reported in a woman and a child [7; 18]. Of the described allergic reactions to pumpkin seeds, there are only 8 cases. There were reported reactions in adult male fishermen who developed sensitization

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by inhaling pumpkin seed meal while preparing fish bait. The observed symptoms ranged from sore throat and itching in the oropharynx to facial swelling to bronchial asthma, which occurred immediately after eating pumpkin seeds. Rodríguez-Jiménez et al. [19] reported an allergic reaction in a 33-year-old man in the form of an anaphylactic reaction with edema, facial flushing, and dyspnea, who had consumed toasted pumpkin seeds. An allergic reaction to pollen and fresh apples, pears, peaches, and oranges was also present. Caubet et al. [20] described a pediatric case of an 11-year-old boy who developed an anaphylactic reaction with angioedema, bronchial asthma, and urticaria after eating pumpkin seeds. The boy's allergy history also revealed an allergy to fish and atopic dermatitis.

Doll et al. [21] established a case of an allergic reaction in a 70-year-old woman in the form of nausea, anxiety, fear of death, and syncope, which occurred immediately after eating pumpkin seeds. The history also shows that the woman had previously had an anaphylactic reaction with angioedema to mollusks. The researchers, describing cases of food anaphylaxis with parallel detection of mast cells, severity of the reaction, and absence of skin reactions, indicated a clonal disease that is the basis of the allergic reaction. A case of angioedema of the face was also described in an 8-year-old girl who had eaten African pumpkin seeds (a pumpkin of the genus Cucurbitaceae, which is different from the genus *Cucurbita* described in other allergy cases) [7]. Among the latest studies by Gawryjołek et al. [2], it is worth highlighting the case of an allergic reaction in the form of generalized urticaria, lip swelling, and shortness of breath in a 2-year-old child after eating pumpkin seeds. No allergy to pumpkin pulp was detected, but it was known from the allergic history that the child was allergic to cow's milk protein and eggs. Some studies have identified and described seed allergens that cause allergic reactions in patients [22]. Table 1 shows the seed data, the name of the allergen, its molecular weight, and biochemical type.

Table 1: Identified allergens in seeds.

Seeds	Name of allergen	Molecular weight (kDa)	Biochemical type
Sesame seeds	Sess i 1	9	2S Albumin
	Ses i 2	7	2S Albumin
	Ses i 3	45	7S Vicilin-like globulin
	Ses i 4	17	Oleosin
	Ses i 5	15	Oleosin
	Ses i 6	52	11S globulin
	Ses i 7	57	11S globulin
	Ses i 8	14	Profiln
Sesame oil	a	a	Sesamin, sesamol
Poppy	a	45	Possible homolog of PR-10 (Bet v 1) and profilin (Bet v 2)
Sunflower	Xel 2S albumin	12	2S Albumin
	Hel a 3	9	Lipid transfer protein

Source: Patel; Bahna [22].

Sesame seed allergy: region application, biological origin, allergens, clinical cases. Sesame (Sésamum) – is a herbaceous plant in the Pedaliaceae family that can bear fruit for one or two seasons. They have alternate whole or three-part leaves, large axillary bell-shaped flowers, and a fruiting elongated tetrahedral capsule that can open completely. Sesame seeds can be white, black, or yellow and are about 2 – 3 mm in size. This plant is widespread in Africa and India and is grown in tropical and subtropical areas. Sesame seeds are used mainly in cooking, for making halva, hummus, falafels, and baking. In addition, sesame oil is added to cosmetic products, such as lip balms, moisturizers, ointments, soaps, and eye products, as a component of medicines. There are eight well-studied allergens in sesame seeds: Ses i 1, Ses i 2, Ses i 3, Ses i 4, Ses i 5, Ses i 6, Ses i 7, Ses i 8 [22-24]. The primary source of sesame allergy protein is 11S-globulin, which contains two types of allergens: Ses i 6 and Ses i 7. However, Ses i 4 and Ses i 5 allergens cause allergic reactions to a greater extent [25]. Sesame oil allergens, sesamol, and sesamin have also been reported to cause allergic contact dermatitis [26]. Asero et al. [27] isolated two additional protein fragments of sesame that could be potential allergens.

Sesame seeds are one of the most common seeds that can cause an allergic reaction since they are widely used in cooking. The literature describes many cases of allergic reactions to sesame seeds, ranging from the mildest oral allergy syndrome to anaphylactic reactions, including one death. Scientists have also described a case of urticaria in the form of swelling of the oral mucosa, hyperemia, and vesicular rash in a dermatologist 15 min after eating sesame sweets [28]. Every test and treatment with antihistamines confirmed the diagnosis. In addition, cases of bronchospasm in bakers who came into contact with seeds outside of work have been reported [29]. Both patients tested positive for inhalation provocation. A case of remote wheezing and shortness of breath was also reported in a girl who visited her parents' bakery and was exposed to her parents, who were baking sesame bread that day [30]. Her medical history indicated that the patient had not consumed sesame before, and the sensitization came only from inhalation of vapors emitted when baking bread at the bakery [22]. Scientists have also described cases of anaphylaxis to sesame seeds after 1 – 2 h in conjunction with physical exercise [31]. Anaphylactic reactions to sesame oil have been described in several cases, mostly with patients experiencing allergic symptoms upon mere contact with the mucous membrane. However, refined sesame oil is considered safe for allergy sufferers if it has no residual proteins.

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2.1 Poppy seed allergy: Applications in various fields, biological species, allergenic proteins, reported clinical cases

The opium poppy (*Papaver somniferum*) is a plant that belongs to the Poppy family and can bear fruit from one to several seasons. The poppy family has a well-defined stem that secretes milky juice, hairy-bristled dissected leaves, and large red, yellow, or white flowers with a carpel-like ovary in the center. The fruit is a rounded box covered with a flat disc on top. The seeds are tiny, cellular, and grey-black. Poppies are common in temperate, subtropical areas and are well-known in Europe as a source of opium and poppy seeds for culinary purposes, especially in bakeries and confectioneries [32].

The allergens identified in poppy seeds have a molecular weight of 45 kDa and were the main allergens. Studies have shown that such an allergen was similar to the protein profilin, which was isolated in the case of an anaphylactic reaction in a patient after eating poppy seeds. Some cases of allergy to poppy seeds have been described in the literature, ranging from mild itching in the mouth to severe anaphylaxis. However, poppy seeds are not a common cause of allergic reactions. Inhalation of poppy seeds resulted in an anaphylactic reaction in a boy near a person who had eaten poppy seeds [22; 33]. A poppy seed intake and physical activity case has also been described. The case of a generalized allergic reaction in a 17-year-old boy who ate a poppy seed cake was described by a group of researchers led by Panasoff [34]. The symptoms that arose after eating were severe abdominal pain, followed by widespread urticaria and a drop in blood pressure. The anamnesis revealed that the patient had suffered similar allergic reactions since childhood with the use of adrenaline and corticosteroids to manage the condition. Still, examinations did not confirm allergic reactions until the poppy incident.

Moreover, two cases of allergic reaction to poppy seeds were described in a 32-year-old man and a 21-year-old woman in the form of anaphylactic reaction after eating confectionery with poppy seeds. The woman had a history of atopic dermatitis and an allergy to pollen from certain weeds. The man had no allergic history but had elevated immunoglobulin E levels [4]. The case of a 17-year-old girl who consumed a poppy seed cake with a subsequent anaphylactic reaction, nausea, abdominal pain, body heat, dyspnea, and loss of consciousness was described by Oppel [32]. Reactions to poppy seeds in the form of oral edema, itching, and severe allergic contact conjunctivitis have also been reported previously. Few studies have been conducted to investigate the issue of cross-reactivity between seeds and other products, but the cases described are shown in Table 2.

Table 2: Possible cross-allergic reaction of seeds with other products

Seeds	Foods and pollen that can cause an allergic reaction
Sunflower	Brazil nut, mustard, pistachio, wormwood pollen
Poppy	Buckwheat, kiwi, rye, sesame seeds, nuts (especially hazelnuts)
Pumpkin	Rosaceae family (apple, apricot, cherry, pear)
Sesame seeds	Kiwi, peanuts, poppy seeds, swarming grain, nuts

Source: Patel; Bahna [22].

In the present study, another case of blue poppy allergy was investigated. A 40-year-old patient consumed a cake with a layer of blue poppy 'Gypsy Mazurka', after which 15 – 20 min later, he experienced swelling of the lips and eyelids. The whole face, and 40 min later, rashes characteristic of urticaria appeared on the entire body's skin. A skin prick test performed two months after the incident using native blue poppy, 30 min after application to the skin of the forearm, showed a blister up to 8 mm in diameter and erythema up to 30 mm, which was considered strongly positive. A test to determine IgE titers to blue poppy was not performed. These manifestations proved the patient's intense allergic reaction to blue poppy, although it is not considered a common allergen, and allowed a definitive diagnosis to be made.

2.2 Allergy to fenugreek: Overall application, biological species, allergens, clinical cases

Fenugreek (*Trigonella foenum-graecum*) is a plant of the Legume family that bears fruit for one season and is used as a seasoning in Southern Europe, the Mediterranean, and Western Asia, as well as an additive in natural remedies, coffee substitute, artificial wedge syrup, and cheese in baked goods [35, 36]. Fenugreek allergy occurs mainly due to a cross-reaction of an allergic reaction to peanuts, although cases of primary fenugreek allergy have been described [37, 38]. The main proteins that cause an allergic reaction in fenugreek have a molecular weight of 12 – 74 kDa, similar to peanut allergens [39].

Only a few cases of an allergic reaction to fenugreek have been described in the literature, so its prevalence is rare [40]. It is known that patients with peanut sensitivity can also react to 7S vicillin-type and 11S legumin-like fenugreek allergens [3]. Among the cases of an allergic reaction to fenugreek, it is worth noting the detection of angioedema, facial flushing, nausea, vomiting, diarrhea, abdominal pain, and shortness of breath after eating Chinese vegetable soup that contained fenugreek [41]. In addition, two other cases of immediate allergic reactions have been reported after using fenugreek powder. The first case occurred after inhalation of the powder, which led to fainting, distant wheezing, and rhinorrhea. The second case was after applying fenugreek paste to the scalp for cosmetic purposes. The patient developed distant wheezing, head numbness, and facial swelling, and the patient also noted a history of bronchial asthma [42].

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2.3 Diagnosis of allergic diseases to seeds

An interview and a thorough history are important in the diagnosis of allergies. However, seeds may be included in some products that the patient may not be aware of. In this regard, seed allergy should be considered in patients with food allergies. Using skin samples for seeds is uncommon, as some data may be inaccurate. For example, some patients with seed allergy may have negative skin tests, while others may have positive ones [41]. The results are similar for specific immunoglobulin E, which may not provide precise results and valuable prognostic data. As described by Patel and Bahna [22], skin testing or determination of specific immunoglobulin E alone cannot be used to establish a definitive diagnosis. Testing by experimental consumption or contact with seeds, combined with other diagnostics, are the most informative methods of diagnosing allergy to a particular product. However, the experiment should be well-planned and designed to avoid bias, using a blinded diagnostic method and placebo. Furthermore, the doctor conducting the study should be prepared for any patient reaction and be able to provide appropriate assistance on time.

3. Discussion

Sunflower, pumpkin, fenugreek, poppy, and sesame seeds are often used in cooking, which increases the risk of allergic reactions. Thus, Galleani et al. [43] determined that sunflower is one of the most popular seeds consumed as an ingredient in bakery products, salads, sauces, and main dishes, as well as the increase in allergic reactions to sunflower, although they are rare. The first reports of an allergic reaction to seeds were described as early as 1970. However, more clinical cases are needed to improve the study of the issue, and there are not many published in the literature. Thus, the researchers assessed the clinical manifestations and the state of the immune system of patients diagnosed with sunflower seed allergy. The data of 47 patients observed in the allergy department were collected for about five years. Patients were interviewed for sunflower allergy after eating the seeds or tested positive for sensitization by skin tests with sunflower and had positive immunoglobulin E. Most of the patients had a positive skin test reaction and a history of atopic dermatitis.

In contrast, in addition to sunflower allergy, other patients had a positive reaction to peanuts, peaches, and nuts. Symptoms and clinical manifestations ranged from minor, in the form of food allergy and urticaria, to significant, in the form of anaphylactic and other reactions that the patients themselves underestimated. The severity of symptoms could increase with repeated use of the allergen in the same person. The levels of immunoglobulin E associated with sunflower seeds were similar to those of lipid carrier proteins. Still, no significant differences in the severity of the reaction based on sensitization to these proteins were found. Based on this, the results showed the variability of clinical manifestations of an allergic reaction to sunflower seeds, especially with repeated use, and the expansion of the list of drugs, in addition to epinephrine, to stop anaphylactic reactions. The researchers also insist on avoiding using sunflower seeds and any contact with them in patients with an allergic reaction to them as a preventive measure. Comparing the scientific work of the researchers with the present study, it is possible to conclude that the data have similarities.

As shown in the study by Gawryjołek et al. [2], pumpkin and its seeds are increasingly used in children's menus and adult cooking to enrich them with nutrients. Every day, more than 30 % of teenagers and children consume various seeds and nuts, including pumpkin seeds. However, there is evidence in the literature that pumpkin seeds can cause an allergic reaction in the form of anaphylactic conditions that can be life-threatening. The allergy to zucchini, melon, and cucumber, which are representatives of the Cucurbitaceae family and pumpkin, is well studied. Still, allergy to the latter is rare, so it is not well analyzed. The modern scientific literature describes only a few cases of allergic reactions to pumpkin and its seeds, and most often, cases are recorded among children. The researchers studied the issue of anaphylactic reactions to pumpkin seeds but with good tolerance of its pulp. For instance, a 2-year-old child had an anaphylactic reaction after eating pumpkin seeds, with widespread urticaria, severe shortness of breath, and swelling of the lips. Due to the child's allergy to eggs and cow milk protein associated with immunoglobulin E, the child was on an elimination diet, with pumpkin pulp as the basis. Skin testing showed positive results for pumpkin seeds but negative for pumpkin pulp, and the specific blood test immunoglobulin E was also elevated for seeds and negative for pulp. The child was also tested for allergies to other foods and had positive results for immunoglobulin E to buckwheat, sesame, and walnuts. Using these data, the child was finally diagnosed with a severe anaphylactic reaction to pumpkin seeds. From the conclusions of the study by the researchers, it is worth highlighting that an anaphylactic reaction to pumpkin seeds can occur in a patient with a good tolerance to pumpkin pulp. The allergens that cause reactions in pumpkin seeds are still poorly analyzed. The similarity of pumpkin seed allergen proteins to other seeds and nuts allergen proteins indicates that the patient may have a cross-reaction to different products.

Nemni [1] also compared the literature on sesame, sunflower, pumpkin, poppy, flax, quinoa, and other seeds and found that seed allergy is poorly understood, as not many clinical cases are described in the literature. However, many studies in the scientific literature on allergies to sesame seeds exist. For example, in Israel, sesame ranks second regarding the prevalence of allergic reactions in children, and in Saudi Arabia, it ranks third. In addition, sesame and sunflower oils have been the cause of allergies in some clinical cases. Many seeds cross-react with each other or with other foods, so it is crucial to seek out allergic reactions considering this data. Specific immunoglobulin should also be determined in combination with other examination methods. The conclusions reached by the researchers include the fact that allergic reactions to various seeds are due to many proteins, including lipid transfer proteins, included in their composition and cause, in most cases, a

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severe reaction. Sesame seeds should be included in all lists of the most common allergens and labeled on all product composition labels. During diagnosis, allergists should conduct a thorough interview and study of the family and allergic histories, especially in cases with an allergic reaction without a clear understanding of the cause. Sensitization to some seeds occurs mainly through the respiratory tract, so it is worth paying attention to pollen allergies.

Dano et al. [44] studied the problem of allergic reactions to sesame. However, insufficient information is available to compare the data with other types of allergens, especially in nutrition. This study examined the medical histories of patients treated at a university-based hospital with allergic reactions to sesame seeds. It took into account data from already published scientific papers on the subject. The study aimed to determine the maximum amount of food consumed that would not cause adverse reactions (NOAEL) and to establish the minimum amount of food that would cause severe reactions (LOAEL). The study involved 14 patients, combined with 21 cases previously reported and published in the literature, for 35 patients with an allergic reaction to sesame seeds. The most sensitive patient received a 1.02 mg dose of sesame protein and had an allergic reaction. It was found that the highest dose of sesame that a patient can receive during diagnosis is 0.3 – 3,000 mg of sesame protein, which will help reduce the patient's hospital stay during diagnosis. This article concludes that sesame allergy is a common phenomenon, and the study of NOAEL and LOAEL for sesame will help diagnose and prevent immediate allergic reactions. Establishing a threshold for sesame content in products indicated on the label will help to establish greater trust in labeling among patients and reduce the amount of time and costs for diagnosing and treating unexpected allergic conditions in hospitals. Comparing this study with the present one, it is possible to note similarities between the prevalence of sesame allergy and the need to optimize preventive measures without 100 % exclusion of the product from the diet.

Conclusions

The consumption of seeds in the modern world is increasing in the fields of cooking, cosmetics, and medicine. The seeds are added to many products, such as bakery products, salads, sauces, and national dishes. The widespread use of seeds increases the prevalence of allergic diseases and immediate allergic reactions to seeds. The results of this study are summarised below: the prevalence of allergy to fenugreek, poppy, sunflower, and pumpkin seeds is low, as few clinical cases have been reported and described. However, sesame is considered a relatively potent allergen, and it is included in allergen lists mainly in Asia, Canada, Australia, New Zealand, and Europe. From the clinical cases studied, it is worth noting that the symptoms of allergic reactions to these seeds range from mild as urticaria and hyperemia to severe as anaphylactic reactions with hospitalization. The pumpkin, sunflower, poppy, sesame, and fenugreek seeds studied belong to different plant species and genera but can cause allergies in combination with each other or other types of foods due to cross-reactions and the similarity of allergenic proteins.

In addition, it is worth highlighting the diagnosis of allergic reactions, which includes a comprehensive approach in the form of a detailed interview, a detailed collection of life and family history, genetic predisposition, and allergology history. The patient should also be examined using additional methods such as skin testing, specific immunoglobulin E, and experimental testing under the supervision of a doctor, with the potential allergen being ingested or applied to the skin. Allergies to seeds such as fenugreek and poppy seeds may be underestimated because they are rare and poorly studied but can cause severe anaphylactic reactions in patients. A limitation of this study was the lack of data, available publications, empirical studies, and clinical cases to assess and analyze seed allergies.

Further research on seed allergies will help develop more effective methods of diagnosis, treatment, and prevention, as well as reduce the risk of allergic reactions and the frequency of exacerbations among the population.

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