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LITERATURE REVIEW

The presence of aeroallergens in food products: a potential risk for the patient with allergic rhinitis

Florin-Dan Popescu, Mariana Vieru

Department of Allergology, "Nicolae Malaxa" Clinical Hospital, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

ABSTRACT

Clinical entities of food allergy in allergic rhinitis patients due to IgE-sensitization to cross-reactive aeroallergen and food allergen components are well described, but less data are available regarding allergic reactions to foods containing aeroallergens, either due to food contamination, such as oral mite anaphylaxis, or due to their natural presence in the edible products, such as pollen grains in honey and bee products. There are some potential risks for allergic rhinitis subjects due to ingestion of food products containing domestic mite, insect, fungal and pollen allergens. The knowledge of these risks is useful for the allergists and ENT specialists, especially in the context of climate changes with warmer periods facilitating mite growth in flours, and of increase use of phytotherapy and apitherapy products containing pollen grains.

KEYWORDS: aeroallergens, allergic rhinitis, food allergy.

INTRODUCTION

Food allergy may be associated with allergic rhinitis. Clinical entities due to IgE sensitization to cross-reactive aeroallergen and food allergen components are well described[1], but less data are available in the scientific literature regarding allergic reactions to foods containing aeroallergens, either due to food contamination, such as oral mite anaphylaxis, or due to their natural presence in the edible products, such as allergic reactions to pollen grains present in honey and other bee products. The discussion on this topic will include the potential risks for allergic rhinitis patients due to ingestion of food products containing domestic mite, insect, fungal and pollen allergens.

DOMESTIC MITE ALLERGENS IN FOODS

Mite allergens are the most relevant indoor inducers of allergic diseases worldwide, asthma and allergic rhinitis being major global health problems contributing significantly to socio-economic burden. Oral mite anaphylaxis (OMA) is a relatively new hypersensitivity syndrome characterized by severe allergic symptoms, typically anaphylaxis (with clinical variants of mite ingestion-associated exercise-induced anaphylaxis or anaphylaxis mimicking acute asthma, but not as isolated oral allergy syndrome). OMA occurs immediately (10-60 minutes, sometimes up to 120 minutes) after eating foods contaminated with mites, in patients with allergic rhinitis with/without asthma, with IgE-sensitization to house dust mites. OMA is more prevalent in subtropical and tropical regions where mites grow easily in warm and humid environments, but isolated cases were also reported in United States of America (in several locations: Birmingham, Charlottesville, Detroit, Massachusetts, Minnesota, New Orleans, Philadelphia), Japan, and Europe (most cases in Canary Islands, Spain, and a couple of cases in

Corresponding author: Florin-Dan Popescu, MD, PhD, Associate Professor, Department of Allergology, "Carol Davila" University of Medicine and Pharmacy Bucharest, Romania, Address: "Nicolae Malaxa" Clinical Hospital, 12 Sos. Vergului, District 2, 022441, Bucharest, Romania
e-mail: florindanpopescu@allergist.com
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Belgium). In the literature, there are two fatalities reported as being associated with the ingestion of foods contaminated with mites[2-5].

The species of domestic mites (*Astigmata* order, *Acari* subclass) associated with OMA belong to the *Pyroglyphidae* family (house dust mites): *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae* (more common); *Echimyopodidae* family: *Blomia tropicalis*, *Blomia freemani*; and storage mites from the *Acaridae* family: *Tyrophagus putrescentiae*, *Tyrophagus entomophagus*, *Aleuroglyphus ovatus*, *Acarus siro*, and *Suidasiidae* family: *Suidasia medanensis*, *Suidasia nesbitti*. Responsible allergen components are probably allergen molecules from Group 2 (thermostable, resistant to digestion) cross-reactive among species, while those from Group 1 are masked by binding to prolamins from flour and those from Group 10 are not involved. An OMA risk factor is the ingestion of more than 500 mites *per* gram of flour, having in mind that a usual microscopic analysis of flour contaminated with mites may even reveal 5000-50000 mites *per* gram. Aspirin and other non-steroidal anti-inflammatory drugs (NSAIDs) can be cofactors for OMA[1-3,5].

Foods contaminated with mites are usually food preparations with wheat and/or corn flour, including: pancakes (most commonly named pancake syndrome or pancake anaphylaxis), including takoyaki and okonomiyaki, but also donuts or beignets, sponge cakes, pizza, pasta, homemade bread, white sauce with wheat flour, pané foods, croquettes, cornmeal cakes and polenta. Mites preferably grow in cooking flours containing high amounts of wheat, at room temperature, especially after eight weeks of storage. Since exposure to low temperatures inhibits the growth of mites, it is recommended to store the flour in refrigerated containers, and storage should not exceed 20 weeks. Other foods that may be contaminated with mites when stored for long periods of time at ambient temperature are cheese, ham, chorizo and salami. Patients with oral mite anaphylaxis present also an increased prevalence of NSAIDs hypersensitivity, manifested as urticaria and angioedema. Even if no salicylates were detected in mite-contaminated wheat flour, the opisthonotal gland secretion from house dust mites contains a salicylaldehyde analog 2-formyl-3- hydroxybenzyl formate, and allergenic extracts of mites may inhibit COX-1 *in vitro*[1-3,5-7].

OTHER ANIMAL ALLERGENS IN FOODS

Insects represented by domestic cockroaches, especially *Blattella germanica*, are important urban indoor airborne allergen sources. Cross-reactivity between inedible (*Blattella germanica*) and edible (mealworm, cricket, grasshopper) insect allergens is possible, and it was revealed that shrimp allergic patients are more likely at risk of food allergy to mealworm and other insects[8-10]. There is a report of anaphylaxis to ingested mopane tree worm (edible caterpillar of the *Gonimbrasia belina* African moth) in an adolescent with IgE sensitization to house dust mites and cockroaches, which suggests cross-reactivity due to glutathione transferases (Der p 8, Der f 8, Bla g 5) or tropomyosins (Der p 10, Der f 10, Bla g 7)[11]. Based on cross-reactivity studies, there is a realistic possibility that house dust mite and crustacean allergic patients may react to food containing insects, such as the yellow mealworm (*Tenebrio molitor*)[12]. Moreover, several termite proteins, including hemocyanin and tropomyosin homologs of Blag 3 and Bla g 7, were shown to cross-react with cockroach allergens[13]. According to US Food and Drug Administration (FDA), the limits of insect contamination at which a food product is considered "adulterated" are for chocolate: 60 or more insect fragments per 100 grams when six 100-gram subsamples are examined or any subsample containing 90 or more insect fragments; for wheat flour: 75 or more insect fragments *per* 50 grams; for peanut butter: 30 or more insect fragments *per* 100 grams; for canned citrus fruit juices: 5 or more fly eggs *per* 250 ml; for tomato paste: 30 fly eggs *per* 100 grams[14]. Cocoa beans are susceptible to attack by several species of storage beetles and moths[15]. Lentils can also be attacked by a wide range of insect species. Lentil pest *Bruchus lentis* proteins may be a cause of IgE-mediated rhinoconjunctivitis and asthma in patients eating or inhaling infested legume particles[16]. Estimations of entomologists suggest an unintentional annual consumption of 500 g insect fragments[17].

Contamination of foods with aeroallergens from *mammals* is also possible, but there are no reports of food allergic reactions due to this. Dispersion of aeroallergens from furred animals, such as cats and dogs, and also horses, able to generate large amounts of airborne allergens[18], may contaminate food products improperly stored. Regarding rodent hairs, according to US FDA, the limits are, for example, for curry powder: 4 or more *per* 25 grams, and for ground paprika: average of more than 11 *per* 25 grams[14].

FUNGAL ALLERGENS IN FOODS

Respiratory allergy to moulds is relatively common. *Alternaria alternata* contamination of tomatoes (black spots), raw mushrooms, dried fruits, old flour may be a risk for food allergic reactions in patients with respiratory allergy to the fungi. *Mucor racemosus* is another mold found on soft fruit, fruit juice and marmalade. *Penicillium chrysogenum/ notatum* is cross-reactive with *Penicillium camemberti, Penicillium roqueforti*, *Penicillium nalgiovense* used for the production of special types of

cheese, dry and fermented sausages or salami varieties[19-21]. *Fusarium venenatum*, used to produce an edible mycoprotein, is cross-reactive with *Alternaria alternata* and *Cladosporium herbarum*, due to ribosomal proteins P2 Fus c 1, Alt 5, and Cla h 5. Anaphylaxis was reported immediately after eating a mycoprotein burger produced from *Fusarium* in an adult patient with allergic rhinitis to *Alternaria* sp[22-24].

A fatal case of anaphylaxis was reported in a teenage boy allergic to fungi due to ingestion of pancakes made with a 2-year-old opened packaged flour mix heavily contaminated with *Fusarium, Penicillium*, *Mucor* and *Aspergillus* spp[25].

Honey bee products, including bee pollen supplements, may be contaminated with fungi (up to 6% of composition), such as *Aspergillus* and *Cladosporium* spp, and may cause anaphylaxis in patients with IgE sensitization to such molds[26,27].

POLLEN ALLERGENS IN FOODS

Pollen allergy represents a significant cause of allergic morbidity worldwide. The most common outdoor allergens responsible for respiratory allergies are the pollen grains of anemophilous plants, such as of grasses, trees and weeds.

Edible honey bee products, such as honey and royal jelly, contain pollen grains of many types, especially from entomophilous plants, including important ones from the *Asteraceae* family, such as sunflower *Helianthus annuus*, cornflower *Centaurea cyanus*, dandelion *Taraxacum officinale*. Such *Compositae* pollen-containing bee products were reported to induce food allergic reactions, from oral allergy syndrome to anaphylaxis, in patients with *Asteraceae* weed pollen allergic rhinitis/rhinoconjunctivitis, especially with IgE sensitization to mugwort (*Artemisia vulgaris*) and ragweed (*Ambrosia elatior*) pollen, due to cross-reactivity between pollen of wind-pollinated weeds and other *Asteraceae* insect-pollinated plants, involving common allergenic components such as profilins, polcalcins, lipid transfer proteins[27-32]. In patients with birch pollen allergic rhinitis, honey containing *Betula* pollen grains, taken so it could dissolve slowly in the mouth, present mild itching in the mouth, but no severe systemic allergic events[33]. It is noteworthy that bee products may contain not only pollen from entomophilous plants, but also from anemophilous trees or herbaceous plants that grow in the same area[1,27].

The mugwort-chamomile association consists in primary respiratory IgE sensitization to mugwort (*Artemisia vulgaris*) pollen and secondary allergic symptoms, from allergic contact conjunctivitis to anaphylaxis, in patients exposed to infusion or tea of camomile (*Matricaria chamomilla* var. *recutita*), both of which belong to the *Asteraceae* family. The incidence of mugwort-chamomile association is frequently underestimated. Patients with allergic rhinitis to *Artemisia* pollen sometimes present allergic reactions to chamomile, but most patients with chamomile allergy are IgE sensitized to mugwort pollen. The possible cross-reactive component in this association is Art v 1 defensin, while Bet v 1 homologue (Mat c 1) and high molecular weight allergens may also have a role, but probably not the vegetable panallergens profilins[1,34-38]. Moreover, also due to fears of cross-reactivity, patients with allergic rhinitis to ragweed (*Ambrosia artemisiifolia*) pollen should avoid taking *Echinacea* supplements[39]. Severe anaphylaxis was reported after gargling with an infusion of *Calendula*, another *Asteraceae* plant with ethnopharmacological uses[40,41]. Other reports not related to the mugwort-chamomile association and pollen sensitization are of airborne allergic contact dermatitis caused by exposure to volatile oils in the vapours rising from hot chamomile tea, and systemic allergic dermatitis caused by sesquiterpene lactones, such as matricin and desacetylmatricarin[42,43].

The mugwort-sunflower association consists of food allergy to consumption of *Helianthus annuus* seeds in patients with allergic rhinitis to *Artemisia vulgaris* pollen. There was a report of anaphylaxis to *Helianthus* pollen contaminated commercial peeled sunflower seeds in a patient sensitized to mugwort pollen, and another of oral allergy syndrome to sunflower seeds in a case of airborne allergy to pet food seed particles. *Helianthus annuus* belongs to the *Asteraceae* family and its pollen allergen component Hel a 4 is an Art v 1-like allergen[44-46]. In a recent case of anaphylaxis after consumption of sunflower seeds, in an adult patient with IgE sensitization to mugwort pollen, hypersensitivity to Hel a 3 LTP and defensin-like proteins, both cross-reactive with *Artemisia vulgaris* pollen allergen components, were suspected as a cause of anaphylaxis[47].

Hypersensitivity reactions to ceremonial use of oral corn pollen in Navajo Native Americans were previously reported, with clinical manifestations of oral allergy syndrome, rhinoconjunctivitis and bronchospasm[48]. An adult patient with seasonal allergic rhinitis and intermittent asthma, sensitized to grass pollen, was more recently reported with urticaria to corn silk (*Stigma maydis*) infusion, used as traditional herbal medicinal product. He presented high levels of serum specific IgE to rPhl p 1, revealing true sensitization to *Pooideae* pollen, without IgE sensitization to ribonuclease rPhl p 5 and profilin rPhl p12, but with high levels of specific IgE against polcalcin rPhl p 7, a calcium-binding protein likely to cross-react with Zea m 7 from maize pollen[49,50].

Dietary supplements with pollen grains of bee-pollinated plants may induce allergic IgE-mediated reactions and rarely non-allergic adverse reactions as well.

Since almost forty years, honey bee pollen containing *Asteraceae* pollen grains, including dandelion, have been reported to induce immediate systemic allergic reactions in patients allergic to short ragweed, a member of the same plant family[51]. Severe anaphylaxis after ingesting bee pollen was also reported in a patient with no history of allergies[52]. Other more recent cases of anaphylaxis occurred in adult and preschool patients with mugwort (*Artemisia vulgaris*) and other pollen allergic rhinitis, including a case previously treated with allergen immunotherapy[26,53]. Almost two thirds of the patients with atopy and IgE sensitization to olive tree, grass and mugwort pollen have positive skin tests to one or more of the bee pollen extracts[54]. Because allergic rhinitis is generally caused by anemophilous plants, rather than entomophilous plants, the presence of airborne pollen in honey bee pollen products may contribute to the risk of allergic reactions, particularly if the pollen supplements contain a substantial amount of airborne pollen to which the patient is sensitized. Other suggested mechanisms include cross-reactivity between the common epitopes on entomophilous and anemophilous pollen grains from the same botanical family, especially *Asteraceae* (*Compositae*) family[55].

The association between bee pollen supplements and allergic eosinophilic gastroenteritis has been reported in the literature, though very rarely. An adult woman with personal history of seasonal rhinoconjunctivitis and honey intolerance, with heartburn and abdominal pain, developed eosinophilic gastroenteritis three weeks after starting ingestion of bee pollen[56]. Honey bee pollen supplement was also considered as a cause of eosinophilic gastroenteropathy in a young child without allergic rhinitis[57]. Other non-IgE adverse reactions to dietary bee pollen supplements included a phototoxic skin reaction to a product also containing ginseng and goldenseal[58], and renal failure after prolonged administration (five months)[59]. Moreover, pyrrolizidine alkaloid content of bee pollen may have hepatotoxic potential[60].

CONCLUSIONS

In **conclusion**, the knowledge and awareness of all these potential risks for the allergic rhinitis patient due to ingestion of food products containing animal, fungal and pollen aeroallergens, even if they are less important compared to food allergies due to cross-reactivities, is useful for the allergists and ENT specialists, especially in the context of climate changes with warmer periods facilitating mite growth in flours, and of increased use of phytotherapy and apitherapy products containing pollen grains.

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