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Mites and the implications on human health

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Abstract

Introduction: The infestation by mites of stored products is of great economic importance and public health, with consequences to human health.

Objectives: To describe the mite species associated to food and stored products that cause implications to human health as well as to analyze the loss of quality and nutritional composition of infested food.

Method: Literature review in LILACS-BIREME, SciELO and MEDLINE databases for publications in English, Portuguese and Spanish with the descriptors “mites”, “foods”, “storage mites”, “store product mites”, “dust mites”, “quality control”, “quality foods”, “chemical composition”, “chemistry”, “allergens” and “health”. There were identified 80 articles, but only 55 were related to the objectives of the study. Sixteen references were mentioned in the articles that were found after checked for relevance. Results and discussion: The activity of the mites causes loss of sanitary quality, weight and nutritional composition of the infested products, with great economic loss in the grain industry. Inhalation, ingestion or contact of mites, byproducts of metabolism and feces may sensitize susceptible individuals and cause asthma, allergic rhinitis, contact dermatitis, enteritis and lead to anaphylaxis. The monitoring of temperature and humidity is essential for the control of mites, as well as better conservation and hygiene of the units of grain storage.

(Nutr Hosp. 2015;31:944-951)

DOI:10.3305/nh.2015.31.2.7772

Key words: Mites. Store product mites. Food quality. Chemistry. Allergens.
Abbreviations

COPD - chronic obstructive pulmonary disease
GM-CSF - colony stimulating factor granulocyte / macrophage
IgE - immunoglobulin E
IL-6 - Interleukin-6
IL-8 - Interleukin-8
MCP1 - monocyte chemotactic protein-1
TNF -α- tumor necrosis factor

Introduction

The prevalence of allergic diseases such as asthma, rhinitis, contact dermatitis and food allergies has increased substantially in recent decades and can be considered a serious public health problem. It is estimated that 10-20% of the world population has asthma, allergic rhinitis or contact dermatitis and about 6-8% of children under 3 years old and 2-3% of the general population have some type of food allergy.

In this context, house dust mites and of storage products are an important source of allergens that can sensitize predisposed individuals and may or may not be mediated by immunoglobulin E (IgE). The food allergy is defined as an adverse health effect resulting from an immunological response to exposure to a particular food, usually manifested by the production of IgE.

The house dust mites feed basically of dead human tissue, animal dander, fungi, bacteria and pollen of plants. The mites of stored products are more common in rural areas and are found predominantly in grains such as wheat, corn, oats, barley and their byproducts, animal food, hay, straw and in the dust from the processing facilities and grain storage. Sensitization to house dust mites and mites of stored products occurs through inhalation, ingestion or contact with live or dead mites, byproducts of metabolism or feces.

In food, the mite infestation causes loss of quality of stored products because the mites feed basically of the germ of the grain. They also cause losses on nutritional composition and on the stock of seed decreasing the germinative power of the grain. In humans, they cause respiratory diseases such as asthma and rhinitis and contact dermatitis. Mites storage can also cause acute enteritis by ingestion of bacteria and fungi which they are vectors.

In particular, for Lepidoglyphus destructor (Schrank), the conditions that allowed these adaptations and showed that mites isolated in natural environments have a greater genetic heterogeneity to induce a hypopus stage than the lineages developed in laboratory in continuous environmental conditions. The variations in hypopus characteristics in the population of this species probably constitute a selective adaptation to such conditions of life, the evolutionary ecology. Later, a study of Corente and Knülle demonstrated with experimental results that the decrease in quality of food increased the mortality of mites and induced the hypopus stage. The study suggests that it is not the presence of a particular substance that induces the hypopus stage, but the lack of a proper nutritional balance whatever the nature.

Method

This work is a literature review. There were searched the LILACS-BIREME, SCIELO and MEDLINE databases. Scientific papers published in English, Portuguese and Spanish between 2000 and 2014 about house and storage dust mites, quality and nutritional composition of infested food and activity implications of these arthropods on human health were selected. The descriptors “mites”, “foods”, “storage mites”, “store product mites”, “dust mites”, “quality control”, “quality foods”, “chemical composition”, “chemistry”, “allergens” and “health” were used to search the databases.

Eighty articles were identified, but only 55 were related to the study objectives. The first analysis of the articles was conducted by the summary and later by the text. Besides these, 16 references mentioned in the articles that have been found were included due to their relevance for the study.

Results and discussion

Evolutionary Theory

Most mites of stored products known currently belong to the suborder Astigmata, but little is known about the evolutionary origin of these mites. It is known that the human being began to stockpile food with the advent of agriculture around 10 thousand years ago, time enough to allow the evolution of a large complex of genres and species in association with humankind, suggesting that the origin of storage mites was independent for each species and occurred in their natural habitat.

There are speculations that the Astigmata mites were fungivorous and that adaptations on the hypopus stage occurred so that the colonization of other habitats was possible. Knülle tried to reproduce in laboratory the conditions that allowed these adaptations and showed that mites isolated in natural environment have a greater genetic heterogeneity to induce a hypopus stage than the lineages developed in laboratory in continuous environmental conditions. In particular, for Lepidoglyphus destructor (Schrank), a storage mite, the phenotypic expression of hypopus stage was determined by the combination of genetic risk with diet quality, i.e., the interaction between genotype and environment ensures a continuous and uninterrupted development of the specie, in favorable environmental conditions for some individuals, providing the survival and the dispersion to other habitats when it deteriorates. The variations in hypopus characteristics in the population of this species probably constitute a selective adaptation to such conditions of life, the evolutionary ecology. Later, a study of Corente and Knülle demonstrated with experimental results that the decrease in quality of food increased the mortality of mites and induced the hypopus stage. The study suggests that it is not the presence of a particular substance that induces the hypopus stage, but the lack of a proper nutritional balance whatever the nature.

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Regarding to the domestic dust mites, Klimov and O'Connor, in a study using phylogenetic analyzes tests, of alternative topology of house dust mite, as well as of reconstruction of ancestral character and irreversibility of parasitism, suggest that the common ancestor of house dust mites would have suffered a permanent reversal from a parasitic lifestyle to a free life. This would be possible from lineages of free-living mites that specialize more quickly and extinguished more slowly than parasitic lineages. Such evolution would be possible by a combination of characteristics of the common ancestor: tolerance to low humidity, development of powerful digestive enzymes enabling feeding of skin and keratin, and low host specificity with frequent change of hosts.

In 1979, O’Connor suggested that the mites would have contacted humans for the first time by the soil through nest of birds and rodents and later than the first free-living mites in house dust, that they nest in habitats, i.e., inhabited nests of birds or mammals and basically fed of fungus. Regardless of how it happened, it is known that at some point in the evolution of the mites occurred adaptations so that human colonization and stored food possible became possible, making it important to know the species of synanthropic mites.

**Synanthropic species of mites**

There are over 48,000 species of mites described in the literature (Arthropoda: Chelicerata: Arachnida: Acari) but the synanthropic mites, those living close to human settlements, are of greatest interest to the human kind. From the biological standpoint, a mite takes about 30 days (3–4 weeks) to develop from an egg to become an adult and lives on average four months in ideal conditions of temperature (28°C) and relative air humidity (80%). A female produces 50–80 eggs during its life.

Regarding to the allergenicity, mites produce substances with biological activity including hydrolytic and non hydrolytic enzymes, inhibitors of enzymes, regulatory proteins, of storage and of transport varying significantly among different species of mites. At least 24 groups of allergens are described in the literature, four with protease activity (cysteine, trypsin, chymotrypsin and serine) and three with glycosidase activity (α-amylase and chitinase). In a study by Morales and collaborators, the house dust mites showed higher activity of cysteine, while the storage mites showed considerable increase in the activity of serine. Stewart suggests that the difference in the expression of protease would be associated with the base of feeding of these mites, the house dust mites would express cysteine to digest skin cells through the hydrolysis of collagen and keratin, whereas mites of stored products would express serine to digest the starch present in grains and derivatives.

A study of Morales and collaborators demonstrates that the proteases are involved in the pathogenesis of allergy, increasing epithelial permeability and permitting the entry and the distribution of the allergen to the tissues by modulating cell response of the immune system and can induce an inflammatory process. It is believed that contact with small amounts of allergens could induce an immune tolerance as well as a long-term ingestion of small amounts of allergens could gradually compromise the immunologic integrity and cause, at a given time, a sensitization of the individual. It is known that in predisposed individuals, contact with an allergen can induce an allergic response, mediated or not by IgE.

A study by Arlian and collaborators describes the capability of house dust mites and or storage to stimulate cytokine secretion. Another more recent study that evaluated the effect of the extract of stored product mites (Acarus siro L., Chortoglyphus arcuatus (Troupeau), and Lepidoglyphus destructor and Tyrophagus putrescentiae (Schrank) on the endothelial cells of the skin showed that endotoxins and proteins present in the extract of storage mites stimulate endothelial cells of the skin to secrete cytokines and express cell adhesion molecules, but this capability varied among species. *Acarus siro* stimulated a secretion of stimulation factorof colonies of granulocyte/macrophage (GM-CSF), interleukin-6 (IL-6), Interleukin-8 (IL-8) and monocyte chemotactic protein-1 (MCP-1). *Chortoglyphus arcuatus* and *Lepidoglyphus destructor* induce the secretion of IL-6, IL-8 and MCP-1, and the levels increased when co-stimulated by tumor necrosis factor (TNF-α). The *Tyrophagus putrescentiae* stimulated the secretion of IL-8 and MCP-1 in response to increasing doses of extract, whereas only stimulated secretion of IL-6 at the highest dose of tested extract.

The synanthropic mites can be divided into two main groups:

1) **House dust mites**

House dust mites feed primarily of dead human tissue, animal dander, fungi, bacteria and pollen of plants. Carpets, curtains, upholstery, mattresses, bedding and pillows are favorable sites for the habitat of these mites. They cause respiratory diseases such as asthma and rhinitis through inhalation of live or dead mites, feces or byproducts of the metabolism. They can also cause contact dermatitis by contact of human epithelial cells with allergens in the environment.

The main species of house dust mites are *Dermatophagoides farinae* Hughes, *Dermatophagoides pteronyssinus* (Trouseau), *Euroglyphus maynei* (Cooreman) and *Blomia tropicalis* (van Bronswijk, Cock & Oshima). *Dermatophagoides farinae*, *Dermatophagoides pteronyssinus*, *Euroglyphus maynei*belong to the Pyroglyphidae family, while *Blomia tropicalis*belong to the Glycyphagidae family.
2) Mites of stored products

Common in urban and rural areas, storage mites are found predominantly in grains such as wheat, corn, oats and barley\textsuperscript{10,11}, animal feed, hay, straw and in dust from processing facilities and grain storage\textsuperscript{12,13}. In Brazil, the foods infested by food storage mites are: grains, seeds, bran, flour, hay, feed, sausage products, meat and dried fish, dried fruits, cheeses and chocolate powder\textsuperscript{30}.

These mites can contaminate processed foods from grains, such as flour, breakfast cereal and mixtures for bakery\textsuperscript{10,23} and they may induce an anaphylactic shock when ingested by susceptible individuals\textsuperscript{12,24}. Studies have already reported the presence of species of mites of stored products in domestic environment as mattresses, bedding, carpets and furniture\textsuperscript{12,17}.

Commonly found storage mite species are: *Acarus siro*, *Chortoglyphus arcuat\textsuperscript{a}, Tyrophagus putrescentiae*, *Lepidoglyphus destructor*, *Glycyphagus domesticus* (DeGeer), *Aleurophages ovatus* (Troutpeau), *Suidasia medanensis* (Oudemans), *Thyreophagus entomophagus* (Laboulbene)\textsuperscript{12,31}, *Suidasia pontificia* (Oudemans), *Blomia kulagini* (Zakhvatkin) and *Glycycometus malaysiensis* (Fain & Nadchatram)\textsuperscript{32}. *Lepidoglyphus destructor*, *Glycyphagus domesticus* and *Chortoglyphus arcuat\textsuperscript{a} mites belong to the Glycyphagidae family and *Tyrophagus putrescentiae* and *Acarus siro* belong to the Acaridae family\textsuperscript{25}.

**Implications of mites in stored products, in quality and nutritional composition of foods and human health**

Although the stored products may contain allergens of vegetal, animal or microbial\textsuperscript{15}, infestation by mites is one of the main problems associated with grain storage\textsuperscript{33,34} despite the tolerance determined by international organizations be zero or close to zero in mite infestation\textsuperscript{11}.

A study of Thind and Clarke found contamination in 21% of samples of cereals and cereal products purchased in retail stores in the United Kingdom, rising to 38% after being stored for 6 weeks at the home of volunteers. However, due to the limitation of the study, it cannot be said that the products were infested during the storage\textsuperscript{15}.

Pályvos and collaborators, in a study conducted in Greece, determined the species of mites that infested grains like wheat, corn, oats and barley, manufactured agricultural products, dried fruit and powder residue in cooperatives, stores, silos and mills. A total of 55.5% of the samples tested showed contamination by mites of four orders and 15 distinct families. In the study, Astigmata corresponded to 92.7% of the total of mites and the *Lepidoglyphus destructor* was the dominant species in all of the studied sites studied\textsuperscript{11}.

In the Czech Republic, in a study by Stejskal and Hubert, mites constitute the largest group of plagues collected in units of grain storage, more than insects. The most abundant species were *Acarus siro*, *Acarus farris* (Oudemans), *Tyrophagus putrescentiae e Lepidoglyphus destructor*. The study suggests that mites are the most important source of allergens in stored grains and that the control, as a prevention strategy, is still neglected in many countries\textsuperscript{36}.

A study performed in New Zealand by Cotter and collaborators evaluated samples of products derived from grain purchased in shops and gathered in homes. The study didn’t find the presence of mites in the samples of products purchased in stores, but four samples of products obtained in houses showed mites representing 7.4% of the total. The four samples that had mites were stored in cabinets for over a month, indicating that storing flour for long periods increases the risk of contamination and that the ideal to prevent contamination would be to store it in the fridge\textsuperscript{37}.

Under favorable conditions of humidity, temperature, type of deposit, storage time\textsuperscript{16} and type of product stored\textsuperscript{18}, mites can multiply reaching high densities and cause direct or indirect harm to human beings. Usually, mites of stored products infest products containing large amounts of starch (compound of carbohydrates in plants), or glycogen (which is the compound of storage of carbohydrates in fungi and bacteria)\textsuperscript{38,39}. In grains, for example, they use starch as the main power source, degrading it into glucose by the combined action of α-amylases and α-glucosidase\textsuperscript{40}. Some studies have shown that the enzymatic activity of α-amylase and α-glucosidase is present in distinct species of storage mites and that they are able to utilize starch, amylopectin and α-glucosides to obtain energy from grains\textsuperscript{27,38,40}.

For having the ability to feed on starch, mites of stored products can destroy the germ of grains decreasing their quality\textsuperscript{11}. Not only the sanitary quality, but also the nutritional composition of grains is compromised especially in relation to B vitamins and iron\textsuperscript{15}. Besides the sanitary and nutritional loss, mites may cause loss in quantity (weight) in some cereals. In wheat for example, when a large infestation by mites occur, they attack the endosperm and germ of the grain and they feed on starch, reducing the weight of the grain\textsuperscript{11}.

Another change in stored products caused by the activity of these arthropods is the quite characteristic odor observed in storage units that is caused by the secretion of lipids by mites\textsuperscript{11}.

In agriculture they also have importance because they attack the embryo
of some grains causing a significant reduction in the stock of seeds and their germination power.\textsuperscript{14}

In humans, inhalation, ingestion or contact with live or dead mites, byproducts of metabolism or feces can cause damage to human health, for example, respiratory diseases such as asthma, allergic rhinitis, conjunctivitis\textsuperscript{11}, as well as contact dermatitis\textsuperscript{11}, episodes of anaphylaxis\textsuperscript{39} and acute enteritis by the ingestion of food contaminated by fungi and bacteria that the mites may be vectors\textsuperscript{11,16,67}. However, a study by Hubert and collaborators suggests that 95% of mite allergens are associated with faecal particles related to the digestion process of the mite\textsuperscript{41}.

Anaphylactic reactions induced by food infested with mites are being increasingly reported, especially in countries where the climatic conditions are favorable for their proliferation\textsuperscript{40}. In 1993, Erben and collaborators observed for the first time a systemic anaphylaxis by ingestion of food infested by mites\textsuperscript{42}. Years later, a study reported a case of a group of patients who developed generalized allergic reactions after ingestion of foods containing large amounts of mites\textsuperscript{43}. In Brazil, a case report of anaphylaxis by ingestion of conmeal infested by mites was documented\textsuperscript{44}. There was also reported a case by Blomia freemani Hughes of anaphylaxis by ingestion of contaminated pancake flour\textsuperscript{45}. A study of Posthumus and collaborator estimated the incidence of anaphylaxis in around 0.5 to 2%, mostly by the ingestion of cereals (especially wheat) contaminated by mites and their allergens. The study verified that episodes of anaphylaxis usually occur in patients with allergic rhinitis or asthma, who sensitized to dust mites, develop allergic reactions, mediated or not by IgE, after eating wheat flour contaminated by storage mites\textsuperscript{46}.

Sensitization to mites of stored products is more common in rural areas and among workers in the grain storage units, bakeries and supermarkets by exposure to mites, and it has been suggested as an occupational disease\textsuperscript{10,47,48,49,50,51}. There has been reported the increase in cases of asthma and allergic rhinitis in fruit farmers and people living near the orchards of citrus, apple and pear\textsuperscript{48,52,53}, contact dermatitis in farmers that grow hop\textsuperscript{49} and gardeners who grow pepper\textsuperscript{44}. However, the occurrence of occupational allergy in urban areas among workers in bakeries and supermarkets has also been reported. A study of Storaas and collaborators found that storage mites were responsible for 20% of cases of sensitization of allergic rhinitis in bakery workers\textsuperscript{50}. Another study reported that of a supermarket employee that got hives and dermatitis through pork meat, especially ham, infested by Tyrophagus putrescentiae in her workplace\textsuperscript{51}.

Tyrophagus putrescentiae is prevalent in hot and humid climates\textsuperscript{55}. It causes serious economic damages\textsuperscript{38} as well as the reduction of the nutritional content and of the germination capacity of the seeds\textsuperscript{13}. It is found in a wide variety of food of high protein and lipid content\textsuperscript{16} as, for example, cheese, bacon, egg powder, peanut flour\textsuperscript{45,57,58}. In Spain it has a great economic importance, because it feeds on the superficial layer of the typical Spanish cured ham\textsuperscript{56,59}, where the humidity and the heat are essential for the maturation process of the product\textsuperscript{60}. In Brazil there was reported the presence of Tyrophagus putrescentiae in soybean crops in Minas Gerais\textsuperscript{60} and samples of rice and beans sold in bulk in supermarkets in São Paulo\textsuperscript{61}.

When the Tyrophagus putrescentiae mite is ingested through contaminated food, inhaled or handled it can cause diarrhea, urinary tract problems, acute enteritis and allergic reactions\textsuperscript{57,58}. There has also been reported a case of systemic anaphylaxis by the ingestion of food contaminated with the Tyrophagus putrescentiae mite\textsuperscript{46,62}. It can also carry spores of bacteria and fungi such as Aspergillus and Penicillium\textsuperscript{55,57,63}. A study of Franzolin and collaborators demonstrated that the presence of Aspergillus flavus contributed to the growth of the Tyrophagus putrescentiae mite, which has helped to disperse the spores of fungi in samples from uncontaminated corn\textsuperscript{55}.

A study that assessed the prevalence of sensitization by Tyrophagus putrescentiae showed that it is higher in elderly subjects compared to young adults, especially in people with chronic obstructive pulmonary disease (COPD) when the prevalence reached 45.8% of the studied population\textsuperscript{64} and that the allergenic of the Tyrophagus putrescentiae mite induces histamine release in more than 50% of sensitized individuals\textsuperscript{65}.

Acarus siro is a common species in stored grain, with great development in hot and humid climates\textsuperscript{16} and high activity of starch digestion\textsuperscript{66}. But there was also reported in high concentrations in cheese stored in refrigeration rooms\textsuperscript{11}. In Spain, there has also been demonstrated the infestation of Cabrales cheese by Tyrophagus neiswanderi Johnston & Bruce e Acarusfarris\textsuperscript{53}.

Regarding to sensitization, Pytelková and collaborators found that the Acarus siro is potentially allergenic and there can happen cross-sensitization with house dust mites. In this study, the amino acid sequences of the Acarus siro with the Dermatophagoide pteronyssinus showed 66% of comparability\textsuperscript{66}. Another study showed that through the skin test 14% of these sensitized patients to housedust mites were sensitized by the storage mite Threophasus entomophagus (La-boulbene) concomitantly\textsuperscript{67}. A study of Morales and collaborators found that both mites of Pyroglyphidae group as of Glycyphagoidea group had a similar protein sequence; however the enzymatic properties of each species differ significantly from the activity of the proteases\textsuperscript{25}.

Aeuroglyphus ovatus (Troupeau) is also found especially in warm climates, in foods such as wheat grain and its derivatives and preparations with chicken, as well as in dust of storage units, lairs of rodents, chicken coops and barns\textsuperscript{68}. Aeuroglyphus ovatus like Acarus siro, presents great activity on starch digestion and perhaps that is why these two species infest grains and cereals that are one of the major sources of...
starch\textsuperscript{33}. A study that evaluated the immunogenic sites of Aleuroglyphus ovatus suggested that both the inhalation as the contact with mites, and eggs as feces would be immunogenic\textsuperscript{33}. In humans, it is associated to respiratory and contact dermatitis especially in the grain industry workers\textsuperscript{36}.

Solomon found in his work that there is competition between species of mites of stored products, and when the population of primary mites grows a lot, it offers food for the secondary mites (which are predatory mites), rising up to almost eliminate the preyed population. In the study he noted that from January to April appeared the predators due to the seasonal increase of the Tyrophagus putrescentiae species. According to him, this is a natural and biological sequence of species of mites that infest grains\textsuperscript{36}.

A study of Hubert and collaborators evaluated the growth of mites in wheat (Triticum aestivum L.) which naturally possesses an inhibitor of α-amylase which protects the grain from attack by arthropods. The study suggests that the quality of the grain is known by affecting the growth of mite populations and that the inhibitory effect of α-amylase on the population density of mites depends on the stored grain, on the species of mites and on the combination of these two factors thus affecting the growth dynamics of mites\textsuperscript{36}. A previous study evaluated the use of bean (Phaseolus vulgaris L.) in the controlling of storage mites and in domestic dust, since its use appears to suppress the growth of mites. However, some people have food allergy to beans, turning unfeasible its commercial and in large-scale usage\textsuperscript{36}.

**Measures of control of stored products mites**

The main physical agents that determine the quality of the stored products are air humidity and temperature\textsuperscript{34}. So, it is essential that there is a better control of these variables in the grain storage units because of the sanitary importance that the contaminated by mites represents to humans\textsuperscript{31}. Foods that have a high water content are more difficult to control and should be monitored more frequently\textsuperscript{39}. The Brazilian law states that the maximum moisture for flour, cereal starch and bran (15%), potato starch (21%) and manioc starch (18%)\textsuperscript{71}.

Poorly maintained facilities and the lack of preventive hygiene measures before storage of products can be considered the main reasons for the high presence of mites in these environments\textsuperscript{44}. Therefore, change in the physical factors is a simple and environmentally safe method for controlling infestations of mites on stored food\textsuperscript{44}.

For consumers it is recommended to observe the conditions of hygiene of places of commercialization, as well as to store the grain for a maximum of six months in closed containers in a cool, dry place. And if possible, the grains should be kept in refrigerator (0°C to 7°C), with humidity not exceeding 12%. The grains should be washed in running water, and the acts of “choose” and sift the grains can spread the mites through the environment\textsuperscript{44}.

The studies on changes in quality, nutritional composition of food infested by mites and implications on human health are still limited, especially those concerning the nutritional composition. As mites of stored products use starch as an energy source there is loss of quality and nutritional composition, but would it be of utmost importance estimate the loss in order to develop more specific techniques and mechanisms of control. Mites can cause serious implications to human health, but the mechanisms of how this occurs are not well established yet, mainly by the wide variety of species and by cross reaction that seems to exist among some species.

**Conclusion**

Mites of house dust and of stored product, at some point in evolution, have suffered adaptations so that the colonization of human installations and of stored products would be possible. The activity of mites causes loss of sanitary quality, weight and nutritional composition of the infested products, with great economic loss in the grain industry. The inhalation, contact or ingestion of mites, byproducts of metabolism and mite feces can sensitize susceptible individuals and cause asthma, allergic rhinitis, contact dermatitis, enteritis and lead to anaphylaxis when a large quantity of food infested by mites is ingested. It is, therefore, a serious public health problem.

The prevalence of food allergies has increased substantially in the last years and it is necessary to elucidate whether the allergens involved in sensitization are from the food itself or from mites that are present in these foods. The discovery that some mite allergens are enzymes could help to explain the rapid onset of symptoms after the ingestion of large amounts of allergens present in food; however, more studies are needed to clarify these relations. Furthermore, the study about alterations in the quality, nutritional composition of food infested by mites and implications for human health are still limited, especially those concerning the nutritional composition.

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