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# Food allergies and intolerances – A review

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**Abstract:** In recent years, food allergies and intolerances have had a growing presence in the population. This may be due to either genetic predisposition or allergy that develops later in life. In addition, an increase in the recorded cases can also be caused by improved diagnostic and detection methods and discovering new allergens. The article provides an overview of the most common food allergies and intolerances and their symptoms.

**Keywords:** allergens; allergenicity of food proteins; cross-reactivity; immunoreactivity; overview

Food allergies are defined as adverse immunogenic reactions to antigens contained in the diet consumed. An allergic reaction occurs immediately after ingestion of food and is often caused by only a minimal amount of the allergen. Observed symptoms include gastroenterological (abdominal pain, bloating, vomiting, diarrhoea), respiratory (sneezing, shortness of breath, cough, asthma), or skin (itching, urticaria, swelling, eczema) symptoms. In the most severe form, anaphylactic manifestations can occur with loss of consciousness (Špičák and Panzner 2004).

Medical data predict the prevalence of food allergy in 1–4% of the adult population and up to 8% in children. Although up to 60% of allergies occur in childhood, some symptoms of allergies disappear in adulthood. But even so, the number of individuals with allergies is in the millions across Europe (Špičák and Panzner 2004).

Food intolerances are non-immunologic reactions to food, often by an enzymatic failure in the gastrointestinal tract. Food allergies and intolerances should be differentiated in distinguishing adverse effects on food, although they may have similar symptoms. Allergens are naturally occurring proteinaceous substances that cause an individual's hypersensitivity to an inappropriate immune system response. The threshold concentration for inducing an allergic reaction is individual. From a chemical point of view, allergens are primarily low-molecular-weight proteins and glycoproteins, well soluble in water, resistant to gastric acid and enzymes, and resistant to higher temperatures. Strong allergens include complex protein and glycoprotein molecules. Their presence in the intestine can trigger an immune system response that, under certain circumstances, generates antibodies in which specific immune system cells are involved. The autoimmune reaction is genetically determined, and there is an immune response against an antigen that has a similar structure to that of the body's own tissue (Cleveland Clinic 2015).

About 90% of people with allergies are allergic to 8 types of food, so-called Big 8. These include: cow's milk, eggs, wheat, soybeans, peanuts, tree nuts, fish and shellfish. Allergies to mustard, celery, lupine, sesame and molluscs also can pose a problem. Some additives like sulphur dioxide and sulphites can also cause aller-

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gy. All these allergens are subject to the legislative designation according to Regulation (EU) No 1169/2011, Article 21. In addition to the above-mentioned allergens, allergies to poppy seeds and buckwheat are rising in the Czech Republic.

Intolerances are negative reactions of the body that are not reactions of the immune system. They are caused by low-molecular-weight substances that occur naturally in foods such as lactose, galactose, histamine or certain additives. Symptoms of food intolerance arise over a longer period of time and do not include an immune response (NHS 2019).

The enzyme lysozyme derived from egg, used as an antimicrobial and that occurs in specific products may also cause allergy problems. In milk or cheese, lysozyme may inhibit listeria, and some bacteria, for example, in meat, fruit juices. The use of egg white also finds application in viticulture as an alternative to sulphites and a tannin precipitator, which cause bitterness and astringent taste of wine (Liburdi et al. 2014; Peñas et al. 2015). If left in residual amounts in the product, it may be hazardous and cause an allergic reaction (Stockley and Johnson 2015).

## CEREALS (GLUTEN)

Wheat is the most important and dominant cereal grain in Europe and North America. In this case, the allergic reaction is caused by gluten (70–80% of cereal grain proteins), one of the most technologically important proteins. The majority of gluten components are protein fractions such as prolamins and glutelins (called gliadin and glutenin in wheat). Similar proteins like in wheat endosperm are found in other cereals such as rye, barley, to some extent also in oats (Rosell et al. 2014). From the technological point of view, the gluten in the wheat dough, after its kneading with water, causes a gel-like structure, characterised by the elasticity (glutenins) and ductility (gliadins) of the dough, which makes it possible to produce a soft pastry. The prolamins of these cereals can cause health risks in part of the population, both in terms of celiac disease and allergies (Simonato et al. 2001).

The diseases associated with gluten intolerance can have different causes, different mechanisms of origin, symptoms and can be of autoimmune or non-immune origin. Autoimmune diseases associated with the presence of gluten include celiac disease, dermatitis herpetiformis Duhring and gluten ataxia. In celiac disease, small intestine cells are damaged by an immune reaction that is triggered by the presence of gluten. This disease may occur as early as in childhood when consuming gluten-containing foods but may occur at any older age when the intestinal barrier cells (enterocytes) are damaged. The intestinal mucosa is damaged, and the small intestine loses the ability to absorb nutrients and some vitamins and minerals. Celiac disease is manifested by diarrhoea, flatulence, abdominal pain, joint pain, weight loss, fatigue, anaemia symptoms, increased liver tests, enlarged nodules. Osteoporosis may also be associated with celiac disease (Di Stefano et al. 2013), a higher risk of developing some tumours, impaired blood coagulation, malnutrition, and development of milk sugar (lactose) intolerance, or severe intestinal failure. Therefore, the treatment of celiac disease is based on strict adherence to a gluten-free diet, which leads to gradual disappearance of clinical symptoms and reduced risk of complications associated with the disease.

Dermatitis herpetiformis Duhring is a skin form of celiac disease and is manifested by blistering of the skin, mainly in the area of the knees and elbows (Salmi et al. 2011).

Gluten ataxia leads to an autoimmune damage of the cerebellum responsible for coordinating movement and is manifested by impaired coordination of gait and other movements. The gluten fraction omega-5-gliadin is the cause of wheat-dependent exercise-induced anaphylaxis (WDEIA). For all forms of celiac disease and gluten allergies, a lifelong gluten-free diet should be followed to exclude all food products that may contain gluten, such as cereal flour (e.g. wheat, barley, rye, oats). In addition to pasta, dumplings with primary cereals, it is also necessary to exclude foods that could contain gluten in hidden form, e.g. various sauces, porridge, roux, sausages, canned meats, pâtés, ketchups, mayonnaise, ice cream, instant products, cereal coffee, confectionery, grain distillates, beers (Penagini et al. 2013; Saturni et al. 2010).

Problematic cereals can be replaced by gluten-free raw materials such as rice, maize, sorghum, millet, pseudocarbohydrates such as buckwheat (Wijngaard and Arendt 2006), amaranth (Saturni et al. 2010), teff or naturally gluten-free potatoes, nuts, oilseeds, pulses, fruits, vegetables. Another possibility is the technological treatment of cereals and their products, for example, deproteinisation of starch (removal of toxic amino acid sequences) or genetic modification of cereals.

Another choice could be using oats, but there are still no clear opinions on the consumption of oat products in the professional community. Some studies report its lower toxicity to celiacs or only about 10–20% of prolamines in oat proteins, while for risky cereals, the lev-

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els of prolamines are significantly higher (30–50%), and therefore oat consumption may be tolerated by some celiacs to some extent (Sjöberg et al. 2014; Tapsas et al. 2014). In addition, oat products can increase the nutritional value for celiac patients. Oats contain 17–24% of protein and have high fibre content, especially β-glucan (3–7%), which positively affects the digestive tract function and has prebiotic effects. They are involved in the regulation of blood pressure, elimination and transport of bile acids. They improve the profile of blood lipids, affect blood postprandial glucose level and slow down insulin secretion (Daou and Zhang 2012).

Gluten-free bakery products have higher fat and energy content and lower fibre content. These products contain also less protein compared to conventional bread. Gluten-free bakery products using starch in recipes are also less favourable source of some minerals and B-group vitamins. For this reason, it is recommended to fortify gluten-free products with fibre, some B-group vitamins and calcium. It cannot be unequivocally argued, on the basis of the nutritional composition, that gluten-free products have a health benefit to a person who does not have an indicated disease of any form of celiac disease or allergy and therefore they do not bring any significant nutritional benefits to the healthy population.

Rice, maize, sorghum or millet have lower protein content from 11% to 15%, but fibre, some B-group vitamins and minerals (potassium, zinc, magnesium, iron) are beneficial. Pseudocarbohydrates then contain higher amounts of proteins, fibre, and minerals.

## MILK (GALACTOSE, LACTOSE, PROTEINS)

Milk intolerance can take several forms, either due to susceptibility to galactose, lactose or milk proteins. For some people, milk can be a complex mixture of allergens. Galactose is a simple unobjectionable monosaccharide, but a higher level of galactose-1-phosphate (its metabolite) can cause serious health problems. Galactose is normally metabolised to glucose by the enzyme galactose-1-phosphaturidyltransferase (GALT). In classical galactosaemia, the enzyme GALT is absent, and galactose is not converted to glucose but to galactose-1-phosphate. Galactose-1-phosphate accumulates in the liver, kidneys, brain, intestine and eye lenses (Adam et al. 2015). The recommended dose of galactose is 50–500 mg per day. Processed 'lactose--free' dairy products are unsuitable because lactose in these dairy products is enzymatically hydrolysed to glucose and galactose (Adam et al. 2015).

The enzyme lactase in the intestine cleaves lactose into D-glucose and D-galactose. Fresh milk is more difficult to digest than fermented dairy products. Lactose doses up to 10 g per day are usually tolerated by adults (Nouza and Nouzová 2016). Symptoms of this disease may occur several days after ingestion of milk and may include loss of appetite, refusal of food, vomiting, diarrhoea, and if left untreated, liver or eye damage or general sepsis may occur. The treatment is aimed at fully eliminating the consumption of milk, milk products and foods with higher galactose content, including fermented ones and lactose-free dairy products. Higher galactose content was also found in legumes, viscera, egg yolk and nuts. Higher consumption of cabbage and some fruits is not recommended either. The amount tolerated is about 13 mg of galactose per 100 g of food; in children, the limits on consumption of these foods are even stricter (Adam et al. 2015).

Lactose intolerance is caused by a lack of lactase. In the intestine, lactase hydrolyses lactose to glucose and galactose. Lactose intolerance to milk very often occurs in the population of Asia, Africa and South America and is less common in Europe. It may occur, for example, more in celiacs or due to inflammation in the intestine. Its symptoms include diarrhoea, flatulence and abdominal pain. In this case of lactase intolerance, it is necessary to eliminate milk and milk products with higher lactose content from the diet. Fermented dairy products are tolerated where milk lactose is digested technologically by enzymes or hydrolysis. For example, hard cheeses and some cottage cheese contain significantly less lactose. For the population with lactose intolerance, milk can be replaced by herbal drinks. Another option is to supply the body with the enzyme lactase as a supplement in tablets (Rosolen et al. 2015).

Protein allergy such as allergy to alpha-lactalbumin, beta-lactoglobulin, bovine serum albumin and casein is the most common form of milk allergy and may occur at an infant age. In the mild form, it can cause digestive problems. In more severe cases, it can lead to asthma, atopic eczema. With the development of the digestive system and intestinal microflora throughout life, mostly in adulthood, this allergy disappears; only in a minority of the population, it persists in the long term. In the case of allergic subjects, it is necessary to exclude cow's milk products as well as products that are technologically processed or from which allergenic proteins are not completely removed during these processes. Technological processing may affect the immunoreactivity and allergenicity of proteins. In the case of milk, it has

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been found that during the processing of dairy products, bakery and meat products containing milk, destruction of allergenic proteins is insufficient. Alpha-lactalbumin and beta-lactoglobulin lose immunoreactivity, while bovine serum albumin, lactoferrin and alpha-casein are resistant to enzymes and heating (Wróblewska and Kaliszewska 2012). Enzyme hydrolysis is currently the most successful method for the preparation of hypoallergenic and non-allergenic foods. It is mainly used for infant formulas. The method is based on the division of proteins into peptides or individual amino acids (Von Berg 2007).

Casein and lactoferrin are relatively resistant to both enzymes and heating. There is no decrease in allergenicity even after 15 min of heating to 120 °C, whereas whey proteins from the albumin and globulin family are sufficient to heat to 80 °C for 30 min (Gomaa and Boye 2015).

The enzymes chymotrypsin and trypsin were used to hydrolyse beta-lactoglobulin under high-pressure conditions. It has not been shown that enzymatic hydrolysis by these enzymes selectively removes allergenic beta-lactoglobulin. However, such conditions can be chosen that could lead to rapid production of hydrolyzates with reduced allergenicity, which can be used to produce hypoallergenic foods (Chicón et al. 2008).

Another study (Beran et al. 2009) deals with the effect of isostatic pressure on tryptic and chymotryptic hydrolysis of alpha- and beta-casein, bovine serum albumin, beta-lactoglobulin, alpha-lactalbumin. At the same time, control tests were carried out on hydrolysed samples at atmospheric pressure. A significant reduction in residual immunochemical reactivities of the high-pressure hydrolysates (500 MPa) was found compared to the control samples hydrolysed at atmospheric pressure (Beran et al. 2009).

The consumption of goat's, sheep's or other mammalian milk is not recommended as a replacement for cow's milk because of their high cross-reactivity to cow's milk proteins. Alternatively, vegetable drinks (cereal, rice, buckwheat, coconut) or beverages with oil seeds, nuts and soy beverages are well-known replacements. But some of them, such as soy, can also cause other allergies. The nutritional value of these drinks varies depending on the raw material and ingredients used and the preparation technology. Vegetable drinks are not suitable as a substitute for cow's milk in children because they do not have enough calcium. They usually contain less protein and do not have enough energy. Therefore, they are fortified with fat, sugar, maltodextrin, stabilisers, inulin, calcium and vitamins in order to approximate the composition of the classic milk. From the allergenic point of view, rice drink is the least problematic.

## EGG

In eggs, the main allergens may include egg white proteins (ovomucoid and ovalbumin) and yolk proteins (apovitelins, livetin, serum albumin). While ovomucoid is resistant to thermal denaturation and enzyme hydrolysis, ovalbumin denatures by heating, and if subjects are sensitive to this protein only, they can consume boiled eggs. The degree of sensitivity can be discerned by the response to boiled eggs (Gomaa and Boye 2015). Thus, the reduction of the immunoreactivity of egg proteins can be achieved by enzymatic hydrolysis and heating (Ballmer-Weber et al. 2016). Egg allergy typically occurs only in childhood and disappears at the age of around 10 years. The reaction depends on the composition of the intestinal microflora, on digestive enzymes and possibly also on the genetic predisposition (Koplin et al. 2012). An allergic reaction can cause inflammation of the skin, airways and digestive system. Even very small amounts of these proteins may induce severe anaphylactic reactions. Antihistamines can be used as prevention of allergic reaction, and a first aid kit is needed in patients with a high risk of anaphylaxis. Immunotherapy is not performed in the Czech Republic because of its large side effects. Abroad, immunotherapy is used only in specialised centres.

The replacement of eggs is dependent on the planned method of their use. Various mixtures of native and modified starches, emulsifiers or proteins of plant or animal origin are used for technological purposes. Dried eggs can be used, for example, in bakery products as a substitute for beaten eggs. Whey treated with ultrasound can also be used to improve the whipping and bread volume (Tan et al. 2015). At home, eggs can be replaced by higher fibre ingredients that swell, bind water well and are able to form a spongy or gel-like mass. Such properties are to be found, for example, in psyllium fibre, linseed flour or chia (Spanish sage) seeds. Fruit puree, boiled potatoes, soy or oat flour can be used to improve the viscosity of sauces and desserts. Egg lecithin in egg yolk, which is used as an emulsifier in food, can be replaced by soya, sunflower, and rapeseed lecithin.

## PEANUTS (GLOBULINS, ALBUMINS)

Peanuts are groundnuts and occur as roasted, salted or in various forms (peanut butter, snack products, pastries, biscuits, wafers). They are a constituent of muesli

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sticks, or they are processed into peanut oil. Peanut allergens are proteins (globulins, albumins), and a very small (trace) amount of peanuts consumed can cause an anaphylactic shock. These proteins are relatively thermally and enzymatically resistant, and the allergic reaction may still increase with roasting (De Meulenaer et al. 2007; Cabanillas et al. 2012; Cai et al. 2016).

## TREE NUTS (PROTEIN)

Tree nut protein can be very allergenic, causing serious problems and particularly affecting the respiratory system with a risk of an anaphylactic reaction. This applies to many nuts such as hazelnuts, walnuts, pecans, Brazil, cashews, macadamias, pine nuts. Cross-reactive nut allergens (especially in hazelnuts) homologous to birch proteins are not resistant to heat and digestive enzymes. They can cause only mild symptoms in the oral cavity – oral allergy syndrome. A patient can also react to a homologous allergen in fruits (apple) and vegetables (celery, carrots). In food, nuts can also be found in the hidden form as a supplement to bakery and confectionery products, in must, mixtures, sticks, ice cream, cheese, pâtés, and therefore the consumption of these products should be completely excluded. Similar to peanuts, tree nut proteins are usually very resistant to strong heating and are thus thermally stable. Allergens can also be found in sesame, sunflower seeds and coconut (Bartolomé et al. 1997; Costa et al. 2014; Cabanillas et al. 2016; Costa et al. 2016; Zhang et al. 2016).

## APPLES

Apple allergens are specific proteins whose content in the apple depends on the variety, degree of ripeness and storage method, the stored apples being more allergenic than freshly harvested apples. Apples are best stored in a clean and cool environment at 2–5 °C at 85–90% humidity. It is believed that the most allergenic is the skin. Apple allergy is often caused by agents involved in the protection of fruits against bacterial and fungal diseases. Allergens in apples are often cross-reactive with allergens in birch pollen. Allergic reactions are usually mild and manifested by itching and burning in the mouth and throat. In serious cases, severe allergic reactions such as swelling may occur. When heated to a high temperature or when enzymatic hydrolysis of the fruit is carried out, the allergic reaction decreases. More serious allergy is evoked by the thermostable allergen of the apple Mal d 3. This allergen does not cross-react to birch pollen, and it is less common in this latitude, unlike the countries of southern Europe. Gene manipulation experiments were also carried out, where the main allergen in apples was probably suppressed (Savazzini et al. 2015; Ahammer et al. 2017).

## CELERY

Celery allergens are very risky, and they are caused by five specific proteins. The major allergenic protein is Api g1 from the PR-10 family of proteins (pathogenesis-related protein). The same group, FAD oxidoreductase, includes the allergens Api g2, Api g4 (profilin) and Api g5 (University of Manchester 2017).

Celery allergy is one of the most common allergies associated with pollen allergy in Central Europe. Cross-reactions also occur in carrots, parsley due to the homology of allergenic proteins. After heat treatment, the allergenic potential of thermoresistant celery allergens is preserved (Jankiewicz et al. 1999; Faeste et al. 2010).

## MUSTARD

Mustard is derived from different varieties of mustard plant seeds, and its major allergen-specific protein comes from the group of storage proteins high in sulphur-containing amino acids. This allergen is very resistant to high temperatures and it is also resistant to proteolysis. The allergen is very difficult to inactivate. Allergic reactions, including anaphylaxis, can be very unpleasant (Monreal et al. 1992; Pałgan et al. 2018).

The major allergen of white mustard used in the production of plain mustard is the protein referred to as Sin a1, which belongs to the group of storage proteins, and is also assigned to amylase inhibitors. Minimum doses of the Sin a1 protein causing an allergic reaction may be in micrograms. Another important allergen is Bra j1 (Monsalve et al. 2001). Both proteins are resistant to proteolysis by trypsin, chymotrypsin and pepsin. They withstand temperatures above 88 °C.

## LUPINE

The main lupine allergen is the globulin protein fraction, which is often associated with allergies to soy, peanuts, beans, peas. Cross-reactions may also occur with food additives or some herbs. Lupine is a herb that is grown in several varieties depending on the food use. It is processed into flour, scrap, granulates, fibre or concentrates and isolates. It can be used in foodstuffs as emulsifiers, foaming agents, binding agents or for a gelling effect. It is also used to replace eggs

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or milk. Allergic reactions can be manifested by rhinitis, swelling, urticaria, asthma or anaphylaxis. Lupine allergens are probably also highly resistant to higher temperatures, i.e. boiling, microwave heating and extrusion (Moneret-Vautrin et al. 1999; Duranti et al. 2008; Villarino et al. 2016).

## SOYA

Soybean production has increased in recent years, especially in the USA, South America, and China. It belongs to one of the most widespread crops or has extensive use in food products. It has suitable technological properties such as good water absorption, emulsifying ability to create texture, reduced fat sorption during frying. Soy flour affects colouring and stability, for example, in bakery products, improves dough processing and nutritional value, contains about 50% protein. It is used in both full-fat and non-fat versions or with a high proportion of lecithin in a range of products (bread, pastry, crackers, cereals, cakes, pasta, pizzas, tortillas, biscuits, minced meat products where it increases meat binding). The soya concentrate with high protein content (70%) can be used in meat products, baked goods or for special purposes. The soy isolate with a protein content of up to 90% can be used in high-protein foods, beverages as a substitute for cow's milk, sauces, soups or snack products.

The main soybean allergens in the protein family are glycinin and beta-conglycinin, and other possible allergens from the storage proteins (Demonte et al. 1997). They are thermally stable and foods containing both soy and fat which are exposed to high temperatures form highly allergic complexes. Soybean oil is not allergenic. Allergic symptoms of soy products are dependent on structure and resistance to technological processing and the ability of the digestive system. Although soy flour is used in products in very small quantities to improve the functional properties of the products, even trace amounts can cause allergy sufferers with anaphylactic reactions. Therefore, it is important that any allergens be labelled as a precautionary measure on the product packaging. Due to the frequent use of soy and soy raw materials in a number of products, there is an effort of manufacturers to reduce the allergenicity of soy by thermal, physical, chemical or gene manipulation techniques. Especially the cultivation locality and variety have an influence on the allergen content in soybean. Ways to reduce allergenicity and degradation of antinutritional substances in soy are based on fermentation using different fermentation cultures or on germination (soy sauce, miso, tempeh) (Frias et al. 2008). Another way to significantly reduce soybean allergenicity is to partially replace the fermentation by enzymatic hydrolysis (proteolysis), where the major allergens are degraded by the type of enzyme used and the fermentation culture being affected. In some cases, sensory acceptance has improved, while elsewhere, bitter taste has been reported. The water binding of the hydrolysates has decreased, and the emulsifying and foaming properties have improved (Katz et al. 2014; Geng et al. 2017).

## BUCKWHEAT

In recent years buckwheat has been grown mainly in China, Russia, Kazakhstan and USA. In Europe, production areas are mainly in Poland and France (Ahmed et al. 2014; Prakash and Yadav 2016). In the Czech Republic, it is rather a minor crop. Buckwheat brings many benefits to the body. Depending on the growing conditions and variety, buckwheat contains approximately 9–19% protein, which is divided according to solubility into individual fractions. The most important buckwheat storage proteins are albumins and globulins which represent about 50–76% of all buckwheat proteins and have a high biological value (Bárta et al. 2004). For example, buckwheat products display a relatively high fibre content in the processing, and most fibre is contained in the husks and bran (Thi et al. 2014). The fat content in buckwheat is about 2–3%, with a high proportion of unsaturated fatty acids. Buckwheat is also a better source of usable minerals and vitamins than cereals such as wheat (Christa and Soral-Śmietana 2008). Besides that, buckwheat also contains polyphenolic substances and rutin with antioxidant properties that have beneficial effects on the human body (Gorinstein et al. 2008; Ahmed et al. 2014; Giménez-Bastida et al. 2015; Gonçalves et al. 2016). Eating buckwheat contributes to lowering cholesterol and may prevent hypertension. Buckwheat helps maintain blood flow, flexibility of the vessel walls, and prevents the formation of free radicals in the body. The fibre and inositol contained in buckwheat can contribute to lowering blood sugar levels and insulin responses, thereby reducing the risk of diabetes as well as preventing the formation of gallstones due to reduced bile acid secretion. Lignan content may protect against cancer or cardiovascular diseases (Christa and Soral-Śmietana 2008; Ahmed et al. 2014). Buckwheat thus brings many benefits to the body, but for persons allergic to buckwheat proteins it can be very risky and can also lead

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to an anaphylactic shock, which can be life-threatening. For sensitive persons, inhalation of buckwheat dust when processed into flour can cause allergies such as itching, swelling of the mouth and throat. Allergy can also manifest itself as skin inflammations, redness of the skin, urticaria. Abdominal pain and gastrointestinal complaints have been reported. Repeated contact with buckwheat dust in the mill can cause mucosal swelling, allergic rhinitis, asthma, shortness of breath due to airway swelling (Wieslander and Norback 2001; Davis 2009; Heffler et al. 2011). Buckwheat allergies are more common in people from East and Southeast Asia (Japan, China, Korea), and are probably related to the dietary habits in these countries (Wieslander and Norback 2001; Lee et al. 2016). The cases of buckwheat allergies are rising significantly in Europe due to increasing consumption, especially among celiacs who consume more buckwheat products as a result of their illness, when they cannot consume products from wheat flour and other gluten-containing flours (Badiu et al. 2013). However, it should be noted that buckwheat is not hazardous to celiacs and is otherwise suitable for a gluten-free diet since buckwheat proteins do not contain any amino acid sequences toxic to celiac disease patients. Processed buckwheat in the form of flour is used in a variety of products such as bread, pastry, cereal mash, flakes, pasta, extruded products and as a dietary supplement containing rutin.

## FISH

The main fish allergen parvalbumin is found in both freshwater and sea fish. Parvalbumin causes a general allergic reaction, is highly thermoresistant and cross-reactive. Allergies can also be caused by toxins or parasites (parasitic worms). The risk of allergy is reduced by freezing fish directly on the boat, which kills possible parasites. Allergic reactions may be manifested, for example, by skin inflammation or respiratory problems, especially in persons processing fish meat such as fishermen at sea or chefs (Bernhisel-Broadbent et al. 1992; Swoboda et al. 2007; Fernandes et al. 2015).

## SEAFOOD

The consumption of seafood such as mussels, cockles, oysters, squid, sepia, shrimps, crawfish, crabs, lobsters is rising in the Czech Republic, so this allergy will occur more often. If an allergy occurs, then it has similar symptoms to a fish allergy. The major allergen in seafood is the muscle protein tropomyosin, which is relatively heat resistant and therefore, during heat treatment, allergenicity only partially decreases. Sometimes cross-reactions may occur (Jeebhay and Cartier 2010; Lopata et al. 2010; Pedrosa et al. 2015). Patients allergic to mites may have a cross-reactive food allergy to shrimps due to the similarity of the mite allergen Der p 10 and tropomyosin in shrimp.

The prevalence of allergies to fish and seafood is dependent on demographic and geographical conditions. In Europe, the incidence is estimated to be up to 0.2% for fish, for molluscs it can be up to approximately 5%. The impact of the locality refers to whether it is a maritime country such as Portugal, Finland and other countries where the consumption of seafood is significantly higher than in inland countries. Therefore, only estimates are given and they may be underestimated (Burney et al. 2010; Tsabouri et al. 2012; Sharp and Lopata 2014; Telmo et al. 2015).

## ADDITIVES – SULPHUR DIOXIDE, SULPHITES

Sulphur dioxide ($SO_2$) is a toxic gas with a strong odour. $SO_2$ and sulphites are natural products of the decomposition of sulphur amino acids and are taken together in the diet or may be intentionally added. $SO_2$ is produced during fermentation with yeast as a by-product, which is released into the fermenting wort and occurs in the finished product. Sulphur dioxide is used in beer as an antioxidant, affects the aroma and taste, it masks the old taste and has antimicrobial activity (Guido 2016). Accepted daily intake for humans is up to 0.7 mg $SO_2$ $kg^{-1}$ body weight. Estimation of the average daily intake of sulphites from food is problematic due to the inconsistency of analytical methods of determination and variability of the diet.

As a by-product of fermentation, the $SO_2$ content in beer ranges from 2 mg $L^{-1}$ to 20 mg $L^{-1}$ and affects the aroma and taste of the beer. It is a product of amino acid metabolism. The $SO_2$ content may rise up to 20 mg $L^{-1}$ during fermentation and then decrease again. The maximum sensory acceptable concentration of total $SO_2$ content in beer is thus up to 20 mg $L^{-1}$. Higher concentrations result in unpleasant taste and cause unpleasant irritation of the mucous membrane and can be very dangerous if a certain limit is exceeded. According to the EU Regulation, the $SO_2$ concentration should not exceed 20 mg $L^{-1}$. The $SO_2$ content in beer is dependent on the brewer's yeast strains used, as some strains produce more $SO_2$ and others less. Further, the formation of $SO_2$ is dependent on technological

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parameters, temperature and pressure during fermentation, aeration of wort, fermentation rate, and storage conditions (Guido 2016).

Sulphur dioxide is used in wine production and contributes to both microbiological and sensory quality of wine. It is also an antioxidant that suppresses oxidation processes. By slowing down the fermentation process, sulphur dioxide also partially protects the wine from the appearance of wine haze and prevents the weathering of the wine. Due to the toxicity of sulphur dioxide, its amount in the products must be strictly controlled. Sulphurisation of must is carried out according to the health of the grapes. If the grapes are healthy, the must is only slightly weakened; when the grapes are affected by rotting, the spread is stronger. This process can be partially replaced by high pressure, inactivating microorganisms and reportedly improving the taste of wine (Häberle et al. 2017).

Sulphur dioxide is also used in the technological process of production of conserved fruit or pickled vegetables to preserve the original colour, smell, shape and taste and prevent surface browning caused by the activity of enzymes. It is used in the production of various spreads, plum jam, ketchup, juices, concentrates. Sulphites may be included in packaging to protect the product against microbial contamination. The use of sulphites and sulphur dioxide at higher doses may cause damage to the mucosa of the stomach and intestines. The prevalence of this hypersensitivity is not exactly known; it is a maximum of tenths of a percent of the entire population. However, this hypersensitivity is severe in asthmatics and leads to the risk of severe asthma exacerbations. Children are also more at risk as skin inflammation, eczema, urticaria, bronchitis, abdominal pain and diarrhoea may occur in direct or repeated contact with allergen (Vally et al. 2009; Häberle et al. 2017).

## CONCLUSION

The recent increase in the number of allergies is a complex problem that has no simple explanation. Better diagnostics, improved hygiene and few contacts with allergens in childhood, chemicals in the environment, gut microbiota composition, unhealthy lifestyle and many other factors can affect the prevalence of allergies. The symptoms of allergic reactions in foods vary in intensity depending on the sensitivity of the individual to a particular type of allergy. Mild non-specific symptoms may occur as well as severe symptoms of anaphylactic shocks, which in extreme cases may be life-threatening. Accordingly, main food allergens are listed in Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25th October 2011. As a result, food product manufacturers need to comply with the rules on product labelling, not just when it comes to energy and nutrition information (proteins, fats, carbohydrates), but also in case of possible allergens present.

## REFERENCES

Adam S., Akroyd R., Bernabei S., Bollhalder S., Boocock S., Burlina A., Coote T., Corthouts K., Dalmau J., Dawson S., Defourny S., De Meyer A., Desloovere A., Devlin Y., Diels M., Dokoupil K., Donald S., Evans S. et al. (2015): How strict is galactose restriction in adults with galactosaemia? International practice. Molecular Genetics and Metabolism, 115: 23–26.

Ahammer L., Grutsch S., Kamenik A.S., Liedl K.R., Tollinger M. (2017): Structure of the major apple allergen Mal d 1. Journal of Agricultural and Food Chemistry, 65: 1606–1612.

Ahmed A., Khalid N., Ahmad A., Abbasi N.A., Latif M. S. Z., Randhawa M.A. (2014): Phytochemicals and biofunctional properties of buckwheat: A review. The Journal of Agricultural Science, 152: 349–369.

Badiu I., Olivieri E., Montagni M., Guida G., Mietta S., Pizzimenti S., Caminati M., Yacoub M.R., Tombetti E., Preziosi D., Quecchia C., Minetti S., Facchetti S., Fassio F., Massaro I., Corradi L., Turi M. C., Colagiovanni A., Pascolini L., Rossi F.W., Losappio L., Sansone L., Imbesi S., Leto Barone S., Mistrello G., Heffler E. (2013): Italian study on buckwheat allergy: Prevalence and clinical features of buckwheat-sensitized patients in Italy. International Journal of Immunopathology and Pharmacology, 26: 801–806.

Ballmer-Weber B.K., Brockow K., Fiocchi A., Theler B., Vogel L., Ring J., Szépfalusi Z., Mazzina O., Schaller R., Fritsché R., Vissers Y.M., Nutten S. (2016): Hydrolysed egg displays strong decrease in allergenicity and is well-tolerated by egg allergic patients. Allergy, 71: 758–732.

Bárta J., Kalinová J., Moudrý J., Čurn V. (2004): Effects of environmental factors on protein content and composition in buckwheat flour. Cereal Research Communications, 32: 541–548.

Bartolomé B., Méndez J.D., Armentia A., Vallverdú A., Palacios R. (1997): Allergens from Brazil nut: Immunochemical characterization. Allergologia et Immunopathologia (Madr), 25: 135–44.

Beran M., Klubal R., Molik P., Strohalm J., Urban M., Klaudyova A.A., Prajzlerová K. (2009): Influence of high-hy-

https://doi.org/10.17221/151/2020-CJFS

drostatic pressure on tryptic and chymotryptic hydrolysis of milk proteins. High Press Research, 29: 23–27.

Bernhisel-Broadbent J., Scanlon S.M., Sampson H.A. (1992): Fish hypersensitivity: I. *In vitro* and oral challenge results in fish-allergic patients. Journal of Allergy and Clinical Immunology, 89: 730–737.

Burney P., Summers C., Chinn S., Hooper R., Van Ree R., Lidholm J. (2010): Prevalence and distribution of sensitisation to foods in the European Community Respiratory Health Survey: A EuroPrevall analysis. Allergy, 65: 1182–1188.

Cabanillas B., Crespo J.F., Maleki S.J., Rodriguez J., Novak N. (2016): Pin p 1 is a major allergen in pine nut and the first food allergen described in the plant group of gymnosperms. Food Chemistry, 210: 70–77.

Cabanillas B., Pedrosa M.M., Rodríguez J., Muzquiz M., Maleki S.J., Cuadrado C., Burbano C., Crespo J.F. (2012): Influence of enzymatic hydrolysis on the allergenicity of roasted peanut protein extract. International Archives of Allergy and Immunology, 157: 41–50.

Cai Q., Zhang W.J., Zhu Q.Q., Chen Q. (2016): Influence of heat treatment on the structure and core IgE-binding epitopes of rAra h 2.02. Food Chemistry, 202: 404–408.

Cleveland Clinic (2015): Food Problems: Is It an Allergy or Intolerance. Available at https://my.clevelandclinic.org/health/diseases/10009-food-problems-is-it-an-allergy-or-intolerance (accessed Mar 19, 2020).

Costa J., Carrapatoso I., Oliveira M.B., Mafra I. (2014): Walnut allergens: Molecular characterisation, detection and clinical relevance. Clinical and Experimental Allergy, 44: 319–341.

Costa J., Mafra I., Carrapatoso I., Oliveira M.B. (2016): Hazelnut allergens: Molecular characterisation, detection, and clinical relevance. Critical Reviews in Food Science and Nutrition, 56: 2579–2605.

Daou C., Zhang H. (2012): Oat beta-glucan: Its role in health promotion and prevention of diseases. Comprehensive Reviews in Food Science and Food Safety, 11: 355–365.

Davis C.M. (2009): Food allergies: Clinical manifestations, diagnosis, and management. Current Problems in Pediatric and Adolescent Health Care, 39: 236–254.

De Meulenaer B., De La Court M., Acke D., De Meyere T., Van De Keere A. (2007): Development of an enzyme-linked immunosorbent assay for peanut proteins using chicken immunoglobulins. Food and Agricultural Immunology, 16: 129–148.

Demonte A., Carlos I.Z., Lourenço E.J., Dutra de Oliveira J.E. (1997): Effect of pH and temperature on the immunogenicity of glycinin (*Glycine max* L.). Plant Foods for Human Nutrition, 50: 63–69.

Di Stefano M., Mengoli C., Bergonzi M., Corazza G.R. (2013): Bone mass and mineral metabolism alterations in adult celiac disease: Pathophysiology and clinical approach. Nutrients, 5: 4786–4799.

Duranti M., Consonni A., Magni C., Sessa F., Scarafoni A. (2008): The major proteins of lupin seed: Characterisation and molecular properties for use as functional and nutraceutical ingredients. Trends in Food Science & Technology, 19: 624–633.

Faeste C.K., Jonscher K.R., Sit L., Klawitter J., Løvberg K.E., Moen L.H. (2010): Differentiating cross-reacting allergens in the immunological analysis of celery (*Apium graveolens*) by mass spectrometry. Journal of AOAC International, 93: 451–461.

Fernandes T.J.R., Costa J., Oliveira M.B.P.P., Mafra I. (2015): An overview on fish and shellfish allergens and current methods of detection. Food and Agricultural Immunology, 26: 848–869.

Frias J., Song Y.-S., Martinez-Villaluenga C., Vidal-Valdeverde C., Gonzalez de Mejia E. (2008): Fermented soyabean products as hypoallergenic food. The Proceedings of the Nutrition Society, 67: e39.

Geng T., Stojšin D., Liu K., Schaalje B., Postin C., Ward J., Wang Y., Liu Z.L., Li B., Glenn K. (2017): Natural variability of allergen levels in conventional soybeans: Assessing variation across North and South America from five production years. Journal of Agricultural and Food Chemistry, 65: 463–472.

Giménez-Bastida J.A., Piskula M.K., Zieliński H. (2015): Recent advances in processing and development of buckwheat derived bakery and non-bakery products – A review. Polish Journal of Food and Nutrition Sciences, 65: 9–20.

Gomaa A., Boye J. (2015): Impact of irradiation and thermal processing on the immunochemical detection of milk and egg allergens in foods. Food Research International, 74: 275–283.

Gonçalves F.M.F, Debiage R.R., da Silva R.M.G., Porto P.P., Yoshihara E., Peixoto E.C.T.M. (2016): Fagopyrum esculentum Moench: A crop with many purposes in agriculture and human nutrition. African Journal of Agricultural Research, 11: 983–989.

Gorinstein S., Lojek A., Číž M., Pawelzik E., Delgado-Licon E., Medina O.J., Moreno M., Salas I.A., Goshev I. (2008): Comparison of composition and antioxidant capacity of some cereals and pseudocereals. International Journal of Food Science & Technology, 43: 629–637.

Guido L. (2016): Sulfites in beer: Reviewing regulation, analysis and role. Scientia Agricola, 73: 189–197.

Häberle M., Geier J., Mahler V. (2017): Contact allergy and intolerance to sulphite compounds: Clinical and occupational relevance. Allergo Journal International, 26: 53–66.

Heffler E., Nebiolo F., Asero R., Guida G., Badiu I., Pizzimenti S., Marchese C., Amato S., Mistrello G., Canaletti F.,

https://doi.org/10.17221/151/2020-CJFS

Rolla G. (2011): Clinical manifestations, co-sensitisations, and immunoblotting profiles of buckwheat-allergic patients. Allergy, 66: 264–270.

Chicón R., Belloque J., Alonso E., Martín-Álvarez P.J., López-Fandiño R. (2008): Hydrolysis under high hydrostatic pressure as a means to reduce the binding of β-lactoglobulin to immunoglobulin E from human sera. Journal of Food Protection, 71: 1453–1459.

Christa K., Soral-Śmietana M. (2008): Buckwheat grains and buckwheat products – Nutritional and prophylactic value of their components – A review. Czech Journal of Food Sciences, 26: 153–162.

Jankiewicz A., Baltes W., Bögl K.W., Dehne L.I., Jamin A., Hoffmann A., Haustein D., Vieths S. (1999): Influence of food processing on the immunochemical stability of celery allergens. Journal of the Science of Food and Agriculture, 75: 359–370.

Jeebhay M., Cartier A. (2010): Seafood workers and respiratory disease: An update. Current opinion in allergy and clinical immunology, 10: 104–113.

Katz Y., Gitierrez-Castrellon P., González M.G., Rivas R., Lee B.W., Alarcon P. (2014): A comprehensive review of sensitisation and allergy to soy-based products. Clinical Reviews in Allergy & Immunology, 46: 272–281.

Koplin J.J., Dharmage S.C., Ponsonby A.L., Tang M.L., Lowe A.J., Gurrin L.C., Osborne N.J., Martin P.E., Robinson M.N., Wake M., Hill D.J., Allen K.J. (2012): Environmental and demographic risk factors for egg allergy in a population-based study of infants. Allergy, 67: 1415–1422.

Lee S.-Y., Ahn K., Kim J., Jang G.C., Min T.K., Yang H.J., Pyun B.Y., Kwon J.W., Sohn M.H., Kim K.W., Kim K.E., Yu J., Hong S.J., Kwon J.H., Kim S.W., Song T.W., Kim W.K., Kim H.Y., Jeon Y.H., Lee Y.J., Lee H.R., Kim H.Y., Ahn Y., Yum H.Y., Suh D.I., Kim H.H., Kim J.T., Kim J.H., Park Y.M., Lee S. (2016): A multicenter retrospective case study of anaphylaxis triggers by age in Korean children. Allergy, Asthma & Immunology Research, 8: 535–540.

Liburdi K., Benucci I., Esti M. (2014): Lysozyme in wine: An overview of current and future applications. Comprehensive Reviews in Food Science and Food Safety, 13: 1062–1073.

Lopata A.L., O'Hehir R.E., Lehrer S.B. (2010): Shellfish allergy. Clinical and Experimental Allergy, 40: 850–858.

Moneret-Vautrin D.A., Guérin L., Kanny G., Flabbee J., Frémont S., Morisset M. (1999): Cross-allergenicity of peanut and lupine: The risk of lupine allergy in patients allergic to peanuts. Journal of Allergy and Clinical Immunology, 104: 883–888.

Monreal P., Botey J., Pena M., Marin A., Eseverri J.L. (1992): Mustard allergy. Two anaphylactic reactions to ingestion of mustard sauce. Annals of Allergy, 69: 317–320.

Monsalve R.I., Villalba M., Rodriguez R. (2001): Allergy to mustard seeds: The importance of 2S albumins as food allergens. Internet Symposium on Food Allergens, 3: 57–69.

NHS (2019): Food intolerance. National Health System website for England. Available at https://www.nhs.uk/conditions/food-intolerance/ (accessed Mar 19, 2020).

Nouza M., Nouzová A. (2011): Advances in Immunology (Pokroky v klinické imunologii). Solutio, Czech Republic, MEDON. Available at https://www.imunologie.cz/wp-content/uploads/2016/10/clanky-Pokroky-v-klinicke-imunologii.pdf (accessed Apr 17, 2016). (in Czech)

Pałgan K., Żbikowska-Gotz M., Bartuzi Z. (2018): Dangerous anaphylactic reaction to mustard. Archives of Medical Science, 14: 477–479.

Pedrosa M., Boyano-Martínez T., García-Ara C., Quirce S. (2015): Shellfish allergy: A comprehensive review. Clinical Reviews in Allergy & Immunology, 49: 203–216.

Penagini F., Dilillo D., Meneghin F., Mameli C., Fabiano V., Zuccotti G.V. (2013): Gluten-free diet in children: An approach to a nutritionally adequate and balanced diet. Nutrients, 5: 4553–4565.

Peñas E., Di Lorenzo C., Uberti F., Restani P. (2015): Allergenic proteins in enology: A review on technological applications and safety aspects. Molecules, 20: 13144–13164.

Prakash S., Yadav K. (2016): Buckwheat (*Fagopyrum esculentum*) as a functional food: A nutraceutical pseudocereal. International Journal of Current Trends in Pharmacobiology and Medical Sciences, 1: 1–15.

Rosell C.M., Barro F., Sousa C., Mena C. (2014): Cereals for developing gluten-free products and analytical tools for gluten detection. Journal of Cereal Science, 59: 354–364.

Rosolen M., Gennari A., Volpato G., Volken de Sousa C.F. (2015): Lactose hydrolysis in milk and dairy whey using microbial β-galactosidases. Enzyme Research, 2015: 806240.

Savazzini F., Ricci, G., Tartarini S. (2015): Apple allergens genomic and biotechnology: Unravelling the determinants of apple allergenicity. In: Poltronieri P., Hong Y. (eds): Applied Plant Genomics and Biotechnology. Great Britain, Woodhead Publishing Limited: 35–54.

Salmi T.T., Hervonen K., Kautiainen H., Collin P., Reunala T. (2011): Prevalence and incidence of dermatitis herpetiformis: A 40-year prospective study from Finland. The British Journal of Dermatology, 165: 354–359.

Saturni L., Ferretti G., Bacchetti T. (2010): The gluten-free diet: Safety and nutritional quality. Nutrients, 2: 16–34.

Sharp M.F., Lopata A.L. (2014): Fish allergy: In review. Clinical Reviews in Allergy and Immunology, 46: 258–271.

Simonato B., Pasini G., Giannattasio M., Peruffo A.D., De Lazzari F., Curioni A. (2001): Food allergy to wheat products: The effect of bread baking and *in vitro* digestion on wheat

https://doi.org/10.17221/151/2020-CJFS

allergenic proteins. A study with bread dough, crumb, and crust. Journal of Agricultural and Food Chemistry, 49: 5668–5673.

Sjöberg V., Hollén E., Pietz G., Magnusson K.E., Fälth-Magnusson K., Sundström M., Holmgren Peterson K., Sandström O., Hernell O., Hammarström S., Högberg L., Hammarström M.L. (2014): Noncontaminated dietary oats may hamper normalization of the intestinal immune status in childhood celiac disease. Clinical and Translational Gastroenterology, 5: e58.

Stockley C.S., Johnson D.L. (2015): Adverse food reactions from consuming wine. Australian Journal of Grape and Wine Research, 21 (S1): 568–581

Swoboda I., Bugajska-Schretter A., Linhart B., Verdino P., Keller W., Schulmeister U., Sperr W.R., Valent P., Peltre G., Quirce S., Douladiris N., Papadopoulos N.G., Valenta R., Spitzauer S. (2007): A recombinant hypoallergenic parvalbumin mutant for immunotherapy of IgE-mediated fish allergy. Journal of Immunology, 178: 6290–6296.

Špičák V., Panzner P. (2004): Allergology (Allergologie). 2$^{nd}$ Ed. Prague, Czech Republic, Galen publishing: 348. (in Czech)

Tan M.C., Chin N.L., Yusof Y.A., Taip F.S. (2015): Improvement of eggless cake structure using ultrasonically treated whey protein. Food and Bioprocess Technology, 8: 605–614.

Tapsas D., Fälth-Magnusson K., Högberg L., Hammersjö J., Hollén E. (2014): Swedish children with celiac disease comply well with a gluten-free diet, and most include oats without reporting any adverse effects: A long-term follow-up study. Nutrition Research, 34: 436–441.

Thi Ngoc Linh N., Anh Khoa D.V., Halas V. (2014): Buckwheat as valuable feed and food resource. Nova Journal of Medical and Biological Sciences, 2: 1–8.

Tsabouri S., Triga M., Makris M., Kalogeromitros D., Church M.K., Priftis K.N. (2012): Fish and shellfish allergy in children: Review of a persistent food allergy. Pediatric Allergy and Immunology, 23: 608–615.

University of Manchester (2006): Allergy Information for: Celery, Celeriac (*Apium graveolens*). InformAll: Communicating about Food Allergies. Available at http://research.bmh.manchester.ac.uk/informall/allergenic-food/?FoodId=18 (accessed Apr 2, 2017)

Vally H., Misso N.L., Madan V. (2009): Clinical effects of sulphite additives. Clinical and Experimental Allergy, 39: 1643–1651.

Villarino C.B., Jayasena V., Coorey R., Chakrabarti-Bell S., Johnson S.K. (2016): Nutritional, health and technological functionality of lupin flour addition to bread and other baked products: Benefits and challenges. Critical Reviews in Food Science and Nutrition, 56: 835–857.

Von Berg A. (2007): The concept of hypoallergenicity for atopy prevention. Nestle Nutrition Workshop Series Pediatr Program, 59: 49–56.

Wieslander G., Norback D. (2001): Buckwheat allergy. Allergy, 56: 703–704.

Wijngaard H.H., Arendt E.K. (2006): Buckwheat. Cereal Chemistry, 83: 391–401.

Wróblewska B., Kaliszewska A. (2012): Cow's milk proteins immunoreactivity and allergenicity in processed food. Czech Journal of Food Sciences, 30: 211–219.

Zhang Y., Lee B., Du W.X., Lyu S.C., Nadeau K.C., Grauke L.J., Zhang Y., Wang S., Fan Y., Yi J., McHugh T.H. (2016): Identification and characterisation of a new pecan [*Carya illinoinensis* (Wangenh.) K. Koch] Allergen, Car i 2. Journal of Agricultural and Food Chemistry, 64: 4146–4151.

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