Journal Pre-proofs

Review

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PII: S0963-9969(20)30805-X
DOI: https://doi.org/10.1016/j.foodres.2020.109780
Reference: FRIN 109780

To appear in: *Food Research International*

Received Date: 14 August 2020
Revised Date: 1 October 2020
Accepted Date: 4 October 2020

Please cite this article as: Muthukumar, J., Selvasekaran, P., Lokanadham, M., Chidambaram, R., Food and food products associated with food allergy and food intolerance - An overview, *Food Research International* (2020), doi: https://doi.org/10.1016/j.foodres.2020.109780

Food and food products associated with food allergy and food intolerance - An overview

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Abstract

Immune-mediated food allergy and non-immune mediated food intolerance are categorized as the most common adverse reactions resulting from the ingestion of certain foods. As there is no standard treatment, the possible remedy to avoid exposure to these adverse reactions is adhering to a strict diet that eliminates allergic and intolerant foods. The commonly consumed foods including dairy products, egg, fish, shellfish, tree nuts, peanut, soybean, and wheat-based products are proven to cause food allergy. Foods containing lactose, gluten, high FODMAPs, biogenic amines, and certain food additives leads to potential health risks in intolerant individuals. Besides, there are various foods whose mechanism of action in triggering food allergy and intolerance is yet to be defined. However, the public in-depth understanding of natural foods, processed foods, and packaged food products that induce allergic reactions and intolerance remains low. Therefore, awareness of diet that partially or completely excludes the intake of certain foods associated with these reactions should be widespread among the consumers.

Keywords: Food allergy; Allergens; Food intolerance; Food Sensitivity; Food & food products; Elimination.

1. Introduction

The immediate physiological response such as flatulence, bloating and allergic reactions to routine diet are quite common in our regular life. However, the ingestion of specific food and food products induce a wide range of adverse reactions ranging from mild to life-threatening anaphylaxis. Based on atiology, these adverse reactions are categorized into immune-mediated reactions called as food allergy and non-immune mediated conditions called as food intolerance or sensitivity (Turnbull et al., 2015). Due to the similarity in symptoms, unpredictability occurs between food allergy and intolerance. In case of food allergy, the immune system recognizes certain food proteins as an allergen and generates an immune response that causes various allergies. The prevalence of food allergy ranges from 0.5-9% of the total population and brings about adverse health impacts, especially on juvenile health. Major foods that cause allergy are collectively enlisted as super eight allergens **(Table 1.)**. These include milk, egg, peanut, tree nuts, shellfish, wheat, soybean, fish, and other food products that contain these allergens as a direct or hidden ingredient (Boye, 2012). According to the United States Food and Drug Administration, these foods are responsible for 90% of worldwide food allergy incidences. Apart from the super eight allergens, various foods

including corn, sesame, meat, celery, lupin, honey, quorn, fruits, and vegetables exhibit strong potential to trigger allergic reactions (Fu et al., 2019).

On the contrary, food intolerance is a non-immune mediated adverse reaction. It is categorized into three types viz, enzymatic, pharmacological, and undefined or idiopathic food intolerance. The most common intolerant foods include dairy products, products containing sulfites, salicylates, FODMAPs, biogenic amines, gluten, lactose, and food additives. Indications of food intolerance or sensitivity are varied and the manifestations include dermatological symptoms such as pruritus, swelling, tingling, and angioedema; respiratory symptoms such as bronchoconstriction, dyspnoea, and wheezing; gastrointestinal symptoms including stomach cramps and nausea. Intolerance to certain foods occurs immediately after consumption or sometimes it may take about a few hours to 48 hours (Schnedl et al., 2020). It is also important to mention that allergic and intolerant reactions vary between individuals, countries, climatic conditions, etc.

The poor management of these adverse food reactions often affects the regular lifestyle, disturbs the growth and development of infants and children, leads to severe economic burden in search of alternative foods. On the other hand, allergic and intolerant individuals of all age groups experience nutritional inadequacy, anxiety, and social isolation (Mazzocchi et al., 2017). Dietary intake plays a vital role in inducing these reactions, nevertheless, it can also prevent and reduce the severity of adverse food effects. Dietary avoidance of the foods that trigger allergy and sensitivity is the only prevailing prevention and treatment method. Alternatives and substitutes to allergic and intolerant foods can be consumed by individuals with adverse reactions to fulfill their daily dietary requirements. During the development of such alternative foods, utmost care must be taken in choosing the hypoallergenic formulation, but at the same time, it should compensate the nutritional and sensorial aspects (Skypala & McKenzie, 2019). Also, labelling of direct as well as hidden food ingredients in the processed and packed foods should be mandated. **(Table 2.)** enlists various food products that contain allergens as a hidden ingredient, labelling terms of allergic ingredients and alternative food suggestions.

Although several reviews are reported in the past decade on food allergy and intolerance, most of them focus on clinical studies, diagnosis, and management. A detailed discussion with a solitary concentration on various allergic and intolerant foods is still low. Concerning

this, the following study was framed to create awareness among the consumers of various food and food products that are associated with adverse reactions.

2. Common foods that trigger allergies

This section covers the regularly consumed foods that are associated with allergic reactions. **(Fig.1.)** shows the chemical structure of major allergens. **(Fig. 2.)** illustrates the food and food products that trigger food allergy.

2.1. Milk and milk products

Milk is the common food consumed by people all over the world including infants and children. It is the highly nutritious food produced by the mammary glands of female mammals during postpartum. Milk through breastfeeding is the only food source for infants aged between five to six months followed by the slow introduction of other foods. It serves as the primary source of nutrient supplement fulfilling the nutrients requirements for the growth and development of infants (Walsh, Meyer, Shah, Quekett, & Fox, 2016). Despite this, cow milk ranks first in the food allergy. Casein present in the solid part and whey proteins present in the liquid part of the milk are considered as a major source of allergen (Ramachandran, Yang, & Downs, 2020). Among this either one or rarely both acts as an immune trigger. Infants and children with developing immune system are unable to digest milk proteins which are recognized as an allergen by the immune system. Thus, this allergic condition arises majorly among infants and children which slowly disappears during their developmental stage. In a very rare case, they exist for a lifetime(Hochwallner, Schulmeister, Swoboda, Spitzauer, & Valenta, 2014). Milk allergy is an immediate hypersensitivity reaction that develops various symptoms including swelling, rashes, vomiting, and breathing troubles such as wheezing, cramps, diarrhea, and rarely anaphylaxis. Food products containing casein and whey proteins can be avoided in the diet after the confirmation of milk allergy(Pilolli et al., 2020). However, the elimination of milk from the diet leads to several nutritional deficiencies. Milk obtained from mammals such as goats, sheep, and buffaloes is widely used as the replacement of regular milk for daily dietary intake and dairy products. Besides, the trend of veganism is rapidly increasing; hence, many types of vegan milk sources are commercially available as a substitute for cow milk (Elsabie & Aboel Einen, 2016). Vegan milk sources such as rice, almond, soy, oats, hemp, coconut, etc., are soaked for a few hours in the water, grounded, and filtered to extract milk. Also, vegan-based milk satisfies the nutritional aspects of regular milk and if necessary, the nutritional profile can be further

enhanced by the process of fortification. Nevertheless, it is important to consider other allergy records to prevent cross-reactivity during the selection of an alternative milk source. Most of the common cross reactants of milk are egg, soy, and peanut-based products (Fotschki et al., 2020). Exceptionally, heated or baked milk products are generally recommended as safe (GRAS) for allergic individuals. During the heating process, the proteins present in the milk are denatured or modified, and thus the immune system is not capable of recognizing them as an allergen (Upton & Nowak-Wegrzyn, 2018). Breastfeeding is the best way to prevent infant milk allergy. It is important to highlight that milk allergy is commonly misunderstood with lactose intolerance which has entirely different pathophysiology. Dairy and dairy products associated with non-IgE induced intolerance is discussed in the intolerance section.

2.2. Egg and egg products

Eggs are cheap and easily obtainable food that is enriched with proteins, vitamins, minerals, and fats. They enhance the immunity, strength of the brain, skin, eye, muscle, and heart as well as aids in weight loss management(Réhault-Godbert, Guyot, & Nys, 2019). The outer white part(albumin) and the inner yellow part (yolk) are present inside the eggshell. Both are rich in proteins and protected with different layers of thin membranes. It is commonly consumed in boiled, fried, poached, cooked, or raw form(Clayton, Fusco, & Kern, 2017). Despite many health advantages, the chicken egg appears as one of the important eight food allergens. The prevalence of egg allergy among children is above average level and gradually resolves during their mid-childhood (Dai et al., 2020). Proteins such as ovalbumin, ovomucoid, conalbumin, and lysozyme enzymes are the common allergens present in the egg white, whereas alpha-livetin, vitellus, and apoprotein B are the allergens present in the egg yolk. Alpha-livetin which is a chicken serum albumin is the major source of allergen involved in cross-reactivity (Hemmer, Klug, & Swoboda, 2016). Owing to the high protein content, egg white causes more allergic reactions than egg yolk. Egg white proteins are not heat-labile and it maintains the property of allergenicity even in the processed end products (Onoda et al., 2020). On the contrary, it has been reported that egg white allergy can be prevented by denaturing or inactivating the egg white proteins upon heating i.e. hard-boiling and deep baking(Lambert, Grimshaw, Ellis, Jaitly, & Roberts, 2017). Due to the structural similarity of proteins in chicken and other avian eggs, they are also sensitized by the body as allergen and generates cross-reactivity(Rajani, Martin, Groetch, & Järvinen, 2020). (Abeshu, Lelisa, & Geleta, 2016) evidenced that the gradual introduction of the cooked eggs during the

8th month of the infant reduces the risk of egg allergy during the developmental stage. Symptoms of egg allergy occur immediately after consumption in the form of skin rashes and hives, digestion and its related problems, breathing problems, and anaphylaxis (Ballmer-Weber et al., 2016). To avoid these allergic conditions, proper consultation from experts should be strictly followed during the medication.

2.3. Fish and fish products

Consumption of fish and fish products plays a vital role in human nutrition and also aids to overcome micronutrient deficiencies. They contain higher protein content, healthy fats such as alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), fat-soluble vitamins, and minerals which are essential for a healthy diet (Kvasnicka et al., 2019). Consumption of finned fish triggers various allergic symptoms and causes fatal anaphylaxis. The prevalence rate of these allergic reactions is high in regions where the consumption of fish and fish products is high. Around 40 % of the adults encounter fish related allergies which are usually a lifelong prevailing condition. Allergens are present in muscle, skin, bone, blood, and body fluids of various fish species(Kobayashi, Kuriyama, Nakagawara, Aihara, & Hamada-Sato, 2016). β subtype of parvalbumin is considered as the major fish allergen which triggers the IgE mediated allergic symptoms. The severity level of allergic symptoms induced by fish is directly related to the parvalbumin content, which varies between fish species. Among all the fish, carp possess the highest level of parvalbumin which is 100 times higher than other fish species. It has been reported that food processing techniques such as the application of physicochemical methods could decrease the allergenicity of fish, however, the mechanism involved is still unclear(Fernandes, Costa, Oliveira, & Mafra, 2015). In addition to parvalbumin, fish gelatin, vitellogenin, tropomyosin, and enzymes enolase and aldolase are the major fish allergen that triggers IgE mediated symptoms. They trigger allergic symptoms mostly in dermal and gastrointestinal regions immediately after the intake of fish and its products (Davis et al., 2020). As finned fish and shellfish do not cause much cross-reactivity, avoidance of both is not necessary if either one of them triggers allergic symptoms.

2.4. Shellfish

Shellfish are generally categorized as mollusks and crustacea. They both appear similar in morphology but differ in the type of protein present in them. Crustacea includes crabs, lobsters, prawns, etc. whereas mollusks include mussels and oysters, snail and abalone,

squids, and octopus. All over the world, they are consumed either in raw, partially cooked, or completely cooked forms as baked, steamed, and fried food. They are rich in proteins, omega 3 fatty acids, vitamin B12, zinc, and other micronutrients that assist in weight loss, boosting the immune system, brain, and heart function(Venugopal & Gopakumar, 2017). Shellfish allergy is usually an onsite reaction and the symptoms range from mild to severe. It is ranked as the third allergen to cause anaphylaxis after peanuts and tree nuts. Tropomyosin, a muscle protein present in the shellfish serves as the main allergen responsible for shellfish allergies. (Gupta et al., 2019). It is important to note that shellfish allergy is completely different from fish allergy as both are commonly misunderstood. Crustaceans cause more allergic reactions than mollusks, therefore, it is not necessary to avoid both if individuals are allergic to either one of them. Individuals with allergic reactions upon ingestion of a particular species of shellfish could also possibly experience allergic reactions to any other species of shellfish (Wang, Warren, Gupta, & Davis, 2020). Shellfish triggered allergic reactions are unpredictable as the small dosage could also cause symptoms such as hives, itches, swelling, breathing troubles, diarrhea, and unconsciousness. The handling practices and inhalation of steam during the cooking process of shellfish may also cause allergic reactions (Pedrosa, Boyano-Martínez, García-Ara, & Quirce, 2015). Cooking and consumption of shellfish at home is a better option than visiting restaurants where the possibility of cross-contamination is high.

2.5. Tree nuts

Tree nuts are the edible seeds that are used to garnish the cooked dishes in small quantities, enhance flavor, and also acts as sources of various vegan milk. Mostly all tree nuts are enriched with essential nutrients and contain 50-60% of fat (Vanham, Mekonnen, & Hoekstra, 2020). However, they are a potent and frequent food allergen which triggers adverse health effects that are rarely fatal. Allergic to a specific nut does not mean that an individual is allergic to all nuts. Cashew, hazelnut, almond, and walnut causes severe allergic reactions. Tree nuts are enriched with several seed storage proteins such as vicilin, legumins,2s albumins, etc., all of which acts as major allergens whereas guard proteins and profilins are considered minor allergens (Geiselhart, Hoffmann-Sommergruber, & Bublin, 2018). Tree nuts are found in both dicots as well as monocots and some of them are phylogenetically related to each other. The cross-reactivity of tree nuts with birch pollen results in the occurrence of mild symptoms around the mouth region and it is termed as oral or pollen food allergy syndrome (Wangorsch et al., 2017). The occurrence of mild symptoms

in this condition is due to the denaturation of allergen proteins during the cooking process as they are heat-labile and easily digested by stomach acids. Various commercial products including baked goods, candies, cereals, soup mixes, high energy bars, and home-made foods contain tree nuts either as a direct or hidden ingredient, and as a result, these products exhibit allergic reactions (Eigenmann et al., 2017).

2.6. Peanuts

Peanuts originating from the legume family are widely used as an ingredient in regular as well as packaged foods. They are enriched with proteins, fatty acids, fibers, water-soluble vitamins especially vitamin B3 and B6, pantothenic acid, minerals, phytoconstituents, antioxidants, and metallic nutrients. They are included in our regular diet in various forms such as individual nut, fillers, and substituents for other expensive food ingredients. The flour obtained from peanuts is rich in protein and contains less carbohydrate content which is generally used in the production of chocolate bars, baked items, and other food products. The oils extracted from peanuts are used for healthy cooking practices(Akram, Shafiq, & Ashraf, 2018). However, peanuts are one of the eight common sources of food allergen that trigger severe allergic symptoms. The severe allergens present in peanuts include Ara h1-11, Ara h1-h3, and h6(Carina Venter, Maslin, Patil, et al., 2016). Even the first exposure or tiny fragments of 2-3 peanuts could trigger the onset of allergy. The associated allergic symptoms include inflammation, itchy feeling in the mouth and throat regions, tongue-tingling, the deadly anaphylactic shock, breathing trouble, and low blood pressure is also noted. The structure of the storage proteins present in peanuts is similar to that of proteins present in tree nuts, soybean, and pea which increases the possibility of cross-reaction(Chan, Greenhawt, Fleischer, & Caubet, 2019). Most of the infants encounter peanut allergy during their first exposure to peanuts, however, the reason is still unclear. One of the possibilities could be the consumption of peanuts by pregnant women, but its exposure to the foetus can be prevented by the elimination of peanut-containing diet during pregnancy. Some studies show that dermal applications containing peanut oil for wound healing could also trigger allergic reactions (Palladino et al., 2018). Highly refined peanut oil is safe for consumption whereas the crude peanut oil is considered allergic as they retain most of the allergens in the end product (Blom et al., 2017). Due to the growing awareness of peanut allergy among the consumers, the consumption of peanuts and its products is gradually decreasing.

2.7. Wheat products

Among cereals, wheat is the most significant source of carbohydrate with high protein content. As a staple food, wheat is utilized in various forms like grounded raw wheat flour, semolina from durum wheat, malt from dried germinated durum wheat, hulled, and parboiled wheat, etc. It is estimated that almost 75% of wheat-based products are used as human dietary food whereas the remaining accounts for livestock feed and non-food related applications (Bird & Regina, 2018). Wheat proteins are classified as albumins (water-soluble), globulins (salt soluble), and gluten. Gluten is the major wheat protein and based on their solubility they are further classified as gliadin (ethanol soluble) and glutenin (acid/alkali-soluble). Gluten induces IgE mediated food allergic reactions, the symptoms of which range from mild to severe based on the dosage of consumption (Cabanillas, 2020). The most allergic reactions are dermatitis, rashes, and redness in the skin; inflammation of skin, lips, and throat; digestion problems including diarrhea, vomiting sensation, abdominal pain, and nasal problems; severe wheat dependent exercise-induced anaphylaxis. The later occurs immediately after the consumption of wheat or its products and depends on the time duration of the exercise after wheat ingestion which is usually about 10-60 minutes (Cianferoni, 2016). As wheat belongs to the cereal family, they may exhibit cross-reactivity with other cereals such as barley, corn, rice, etc. (Srisuwatchari et al., 2020). The prevalence of wheat allergy is significantly lesser than allergic reactions triggered by milk, egg, and peanuts, whereas the prevalence of wheat intolerance is higher than wheat allergy (Thompson, Keller, & Lyons, 2018).

2.8. Soybean products

Soybean originating from the legume family is consumed as food in various forms due to its higher nutritional value. They are generally used as condiments and substitutes for many foods as they compensate for the dietary protein requirement. In addition, they are processed and consumed in many forms such as milk, oil, flour, filler, and food enhancer(Naegeli et al., 2020). The textured soy proteins are widely used as a meat substitute and compensates the textural as well as nutritional aspects of red meat. They are prepared from the fat removed soy flour or by-products obtained from the soybean oil extraction. Soy lecithin is used as a food additive which is generally present as a hidden allergen in various commercial products (Tian et al., 2018). The heat-stable storage proteins such as Gly m 5 (β-conglycinin) and Gly m 6 (glycinin) are the major soy allergens. The symptoms of soybean allergy are usually curable unlike the fatal conditions associated with peanut allergy. The common symptoms include hives, itching rashes, and dermatitis on the skin; digestion problems such as vomiting,

nausea, and cramps on the abdomen; respiratory problems such as hay fever, asthma, and rarely anaphylaxis (Gao et al., 2017). Soy proteins or ingredients are mostly available in commercial foods as a hidden ingredient. Soy-free products are highly recommended for individuals with soy allergy. Soy foods can be replaced with other legume-based food products and soy oils with other vegetable oils such as canola, olive, and corn oils. (Beyer, Franke, Simon, & Treudler, 2016).

2.9. Other common food sources

Apart from the above mentioned, there are other foods that are identified as allergic triggers. Sesame is generally used in food products either as a whole seed or in processed forms such as sesame paste, sauce, and oil, etc. Even though they possess numerous health benefits they are reported to cause allergic reactions due to the presence of storage and structural proteins such as 2s albumins and oleosins, respectively. They cause allergic symptoms in the skin, respiratory, gastrointestinal regions, and rarely anaphylaxis (Adatia, Clarke, Yanishevsky, & Ben-Shoshan, 2017). Lupin is a legume that is generally used as a food ingredient and substitute for soy and wheat-based products. β-conglutin is the major allergen present in lupin. As lupin and peanuts are molecularly related, they can cross-react with other protein-rich allergens including milk, soy, and shellfish (Lima-Cabello, Alché, & Jimenez-Lopez, 2019). Corn belonging to the cereal family is widely used as an important ingredient in the preparation of regular food, processed, and packaged food products. Zein is a highly stable lipid transfer protein that is considered as a potential allergen of corn and corn-based products. It was reported to exhibit cross-reactivity with allergens present in rice, soy, and wheat (Nakamura, Nakamura, Shimizu, Matsunaga, & Kondo, 2019). Celery is used as cooked or raw vegetable and spice for the preparation of foods such as soups, salads, and broths. Api g 1 is the major celery allergen that cross-reacts with birch and mugwort pollen allergy. It is a highly heat-stable protein that leads to the development of spice allergic conditions (Dölle et al., 2018). Mustard is a condiment obtained from various plant seeds belonging to the *Brassicaceae* family. They are used in various foods including baby foods, regular foods, pickles and processed into various products such as mustard sauce, flour, paste, etc. Albumin and globulin proteins such as Sin a 1, Bra j 1, and Sin a2 are the major allergens present in mustard and triggers allergic reactions in the skin and Gastrointestinal tract. They hardly induce cross-reactivity with tree nuts, birch pollen, and other seed allergies (Sharma et al., 2019)

Mammalian and avian meats are highly consumed due to their palates and nutritional values. The muscle and storage proteins present in meats including beef, chicken, mutton, and frog are reported to be associated with allergic reactions similar to that of fish allergy (Wilson & Platts-Mills, 2018). Honey which is widely used for food consumption and medical applications contains pollen and glandular proteins that exhibit cross-reactivity with pollen and insect allergy. The bee venom and insect sting in the unprocessed honey could highly trigger allergic reactions. Although honey associated allergic reactions are rare, they have the potential to create symptoms ranging from simple unceasing cough to fatal anaphylaxis (Jacobson & DePorter, 2018). Fruits and vegetables are common foods consumed by people of all age groups. Allergic reactions to fruits and vegetables are mainly due to their cross-reactivity with pollens which causes various conditions such as birch-fruit-vegetable syndrome, latex fruit syndrome, etc (Vanga, Jain, & Raghavan, 2018). The commonly consumed fruits with the potential to cause allergic reactions include apple, peach, berries, melons, cherry, grapes, banana, tomato, custard apple, mango, pomegranate, and citrus fruits whereas the vegetables that cause allergic reactions include asparagus, avocado, bell pepper, cabbage, carrot, eggplant, lettuce, allium, marrows, and tubers (Hassan & Venkatesh, 2015). **(Fig. 3.)** depicts the cross reactivity of major allergens.

3. Foods associated with intolerance

Food and food products that cause intolerance is discussed in this section. **(Fig.4.)** illustrates the commonly consumed foods that induce intolerant reactions.

3.1. Dairy and dairy products

Most of the dairy products marketed contain lactose which causes lactose intolerance. A lactose-free diet is a commonly suggested treatment to reduce the risk of long-term complications associated with lactose intolerance (Szilagyi & Ishayek, 2018). Yogurt contains all the milk constituents with lower content of lactose. In comparison to other milk products, yogurt is better tolerated by lactose-intolerant individuals as the lactose is partially hydrolyzed into glucose and galactose by the fermentative bacteria. A wide range of fermented milk products such as sour cream, labaneh, kefir, mursik, labaneh, and viili also have similar advantages as that of yogurt due to their low lactose content and higher lactase content (Silanikove, Leitner, & Merin, 2015). Cottage cheese contains low lactose content of 12g/ per day of daily recommended tolerance limit. During the process of butter production, 80-90% of the milk water-soluble components are removed and lactose is one among them as

it is a highly water-soluble molecule. However, clarified butter contains low level of lactose but it is safe for consumption by most of the lactose intolerant individuals (Silanikove et al., 2015). In addition to dairy products, lactose is commonly used as a food additive in non-dairy products due to its lower price, unique flavor, binding properties, etc. (Suri et al., 2019). Those nondairy products include processed meats, bread, protein supplements, breakfast cereals, margarine, gravy stock powder, meal replacements, and various other processed foods. The processed meat products that are produced with milk such as sausage, egg substitutes, breaded fish or meat, and scrambled egg contains a low amount of lactose. Fat and oil-based products prepared with milk such as butter, buttermilk, salad dressings, margarine, etc., contains low lactose content (Misselwitz, Butter, Verbeke, & Fox, 2019). Sweets and desserts that contain lactose such as pudding, cookies, pastries, cheese-filled pastries, coated candies, chocolate bars, and ice creams should be avoided. **(Table 3.)** lists common intolerant dairy products and their lactose content. (Piccolo et al., 2016) analyzed various meat products in which the lactose content was not labeled. The study underlined that the samples contained lactose levels above the detection limit. The authors highly recommended that the producers of lactose-containing products need to label the lactose content to enable the consumers to identify the suitability of that particular product for the daily intake. However, the avoidance of such products may not be practically possible for everyone. Owing to these reasons the consumers outlook for lactose-free products with desirable nutrition and sensory properties is rapidly increasing (Suri et al., 2019). A wide range of lactose-free or reduced lactose milk products is being commercialized while at the same time compromising the nutritional value. These products are treated with the enzyme lactase which hydrolyzes the lactose into easily digestible glucose and galactose to make the resulting product lactose-free without shelf life deterioration (Suri et al., 2019).

3.2. Gluten-containing products

The two major components that are involved in gluten intolerance are the fractions of proteins and carbohydrates. The most important storage protein that exists in the wheat, barley, rye, and oats is gluten which is a complex mixture of other distinctive proteins-gliadin and glutenin (Luongo, Maurano, Bergamo, & Rossi, 2020). The gluten-free diet must exclude bread, cereals, and related food products made with wheat, oat, dinkel, barley, triticale, kamut, and rye flour. Majority of the processed food products such as cheese, pasta, pizza, hot dogs, cream sauces, salad dressings, soup mixes contain thickeners and fillers obtained from gluten derivatives (El Khoury, Balfour-Ducharme, & Joye, 2018).

Unexpectedly gluten may also be present in soy sauce, imitation crab meats, licorice, beer, broth, and malt-based products containing malt extract, malt flavoring, or malt vinegar. Also, various forms of wheat such as cracked wheat, wheat germ, wheat bran, wheat starch, durum, gliadin, semolina, matzo, emmer, semolina, farina, einkorn, faro, spelt, and graham flour should be abstained (Jnawali, Kumar, & Tanwar, 2016). Besides individuals practicing a gluten-free diet must follow safety guidelines to avoid contamination of foods with gluten at the home kitchen and other food establishments. The commonly consumed food products such as bread, biscuits, soups, cookies, bagels, cakes, pasta, etc. are made of wheat and contains gluten. However, avoidance of these products would lead to an entire change in the lifestyle which might not be practicable for all gluten-intolerant individuals. Owing to these limits, the demand for gluten-free products is on the surge. However, it is noteworthy that the gluten-free products must be comparable to that of gluten-containing products with respect to nutritional profile (Gobbetti et al., 2018).

The gluten-free products must adhere to the standards and regulations issued by various national and international bodies. According to the FDA standards and regulations a food product can be labelled as gluten-free if it meets the following essential criteria - a) It must be naturally gluten-free; b) It should not be produced from a gluten-containing grain such as wheat, barley, etc.; c) It should not be manufactured from a gluten-containing grain that has not undergone the gluten removal process; d) If the unprocessed gluten-containing grain is included, the gluten content of the final product should not exceed 20 ppm (Jnawali et al., 2016). The labelling practice should include the ingredients as well as the possibility of gluten cross-contamination during manufacturing and packaging. In case of cross-contact with the gluten, the final product must comply with the standard requirement of <20 ppm. The term gluten-free can be interchanged as *"free of gluten," "no gluten," "without gluten"*. The label may include a voluntary advisory or allergen statement such as *"contains gluten or gluten-containing ingredient"* or *"manufactured on equipped that process other products containing gluten and gluten-containing ingredients"*. However, such an advisory statement does not imply that the product is either safe or non-safe (Gobbetti et al., 2018).

3.3. Food containing biogenic amines

Biogenic amines (BA) are described as biologically active amines, which are low molecular weight organic bases that can be found in a wide range of food and constitute a potential health risk to the consumer. The significant relative precursors and BAs present in the food

are histamine, tyramine, cadaverine, tryptamine, 2-phenylethylamine, putrescine, agmatine, spermidine, and spermine. They are produced by microbial enzymatic decarboxylation of the specific amino acids with the formation of correspondent CO_2 and amines (Tabanelli, Montanari, & Gardini, 2018). Plant and animal-derived foods such as tomatoes, pineapple, bananas, strawberries, citrus fruit, spinach, papaya, cocoa, peanuts, crustaceans, egg white, fish, pork, other additives, licorice, and spices are mentioned to naturally possess the histamine-releasing capacity which increases upon maturation (Sánchez-Pérez et al., 2018). The tissues of the scombroid fish such as anchovies, tuna, mackerel, sardines, etc contain high concentration of the histidine which can be microbially converted into histamine and cause scombroid fish poisoning. In addition, the other fish species belonging to the family *Scombridae* and *Clupeidae* contains high histamine content due to the inappropriate handling and preservation practices (Ishimaru, Muto, Nakayama, Hatate, & Tanaka, 2019). Accumulation of BA is also reported in dry fish, fermented fish, vacuum packaged fish, and fermented cold-smoked fish. European legislation (EC 2073/2005) limits the concentration of histamine to <200mg/kg for fresh fish and <400mg/kg for cured fish products. Lactic acid fermented vegetables such as carrot and beetroot contain various BAs in the level ranging from 1-15 mg/kg. Spoiled foods also accumulate BAs and the most commonly found are cadaverine and putrescine. Fermented meat products contain a higher concentration of tyramine (Perin & Nero, 2017). (De Mey et al., 2014) reported the presence of tyramine at levels exceeding 400 mg/kg in the dry fermented sausage. Sauerkraut a fermented plant-based product contains histamines, tyramine, putrescine whereas spermidine and spermine are found in trace amounts. Most soy-based products are fermented or contaminated by *Bacillus spp*., which possess strong amino acid decarboxylation activity, and therefore, soy products are an excellent source of BAs (Simon Sarkadi, 2017). (Toro-Funes, Bosch-Fuste, Latorre-Moratalla, Veciana-Nogués, & Vidal-Carou, 2015) analyzed various soy products and reported that the mean histamine level in tempeh, sufu, soy pasta, and miso was 3.6 ± 6.1 mg/kg, 448 ± 303 mg/kg, 17 ± 30 mg/kg, and 3.4 ± 1.7 mg/kg respectively. The tyramine level of tempeh, sufu, soy pasta, and tamari was 3.6 ± 6.1 mg/kg, 1190 ± 458 mg/kg, 52 ± 89 mg/ kg and 63 ± 20 mg/kg respectively. **(Table 4.)** enlists various food products and their BA content.

In relevance to dairy products, milk contains a low level of BA, about 1mg/dm^3 whereas the concentration of BA in yogurt ranges between milligram to tens of milligram/ kg. (Perin & Nero, 2017) mentioned that the concentration of BA higher than 1000mg/kg was detected in

cheese. The major BA that occurs in cheese includes tyramine, histamine, tryptamine, putrescine, and cadaverine. Cheeses that are produced with raw milk have higher BA content than in the cheeses that are made with pasteurized, ewe, and goat milk (Benkerroum, 2016). Red wine exhibit high content of histamine whereas the white wine contains a lower level of histamine due to the different fermentation process. The maximum recommended level of histamine in wine is 2 mg/L in Germany, 10 mg/L in Switzerland, 10 mg/L in Austria, 3.5 mg/L in the Netherlands, 8 mg/L in France, 10 mg/L in Hungary, and 5–6 mg/L in Belgium. Microbial contamination during the process of brewing is reported to be associated with a higher amount of histamine and tyramine in beer. In contrast, the natural occurrence of agmatine, spermidine, and spermine in beer as a constituent originated from malt is documented (Simon Sarkadi, 2017). Cider, a fermented alcoholic beverage obtained from apple juice is an excellent source of histamine, tyramine, putrescine as the fermentation process is driven by yeast and LAB microbiota (Ruiz-Capillas & Herrero, 2019).

3.4. Foods containing high and moderate FODMAPs

FODMAPs is an acronym for *"Fermentable oligo- di- and mono-saccharides and polyols"* which refers to the category of short-chain containing carbohydrates(Bellini et al., 2020). It is highly challenging to decrease the intake of FODMAPs rich foods as they are an excellent source of health-related constituents such as dietary fiber and micronutrients. Inappropriate intake of a diet low in FODMAP can cause adverse health impacts. The major FODMAPs include galacto-oligosaccharides, fructans, glucose, fructose, lactose, sorbitol, xylitol, and mannitol. They occur naturally in several plant-based, dairy-based foods, and sweeteners (Ooi, Correa, & Pak, 2019). (Varney et al., 2017) designed the maximum limit for each carbohydrate in the low FODMAPs diet. The maximum limit of α-galacto-oligosaccharides and fructan in seed oligosaccharides, grains, and cereals should be <0.3 g per serving whereas in the fruits and vegetables the maximum content should not exceed 0.2 g per serving. The cut-off value for fructose when present in combination with other FODMAPs should not be above 0.15g per serving. In case of lactose, the recommended maximum limit is <1.0g per serving whereas for mannitol and sorbitol the maximum allowance should not exceed 0.2g per serving. However, the avoidance of foods rich in FODMAPs has not proven to be a suitable remedy for all the IBS patients as it may affect the function of the immune system. The elimination of fructan and galacto-oligosaccharides that possess significant prebiotic activity in the gut could decrease the colonic microbiome. Additionally, the individuals adhering to the low FODMAPs diet could be exposed to an increased risk of the disordered

eating pattern (Staudacher, 2017). Therefore, awareness of the risks associated with the low or FODMAPs free diet is paramount with respect to the nutritional adequacy and disordered eating behavior. **(Table 5.)** enlists various food source that contains high FODMAPs and low/moderate FODMAPs.

3.5. Foods containing additives and chemicals

In food industries, various food additives are utilized to enhance the taste, appearance, and shelf life of processed food products. These food additives are generally categorized as natural additives and synthetic additives both of which are not advisable to intake as food themselves (Trasande, Shaffer, & Sathyanarayana, 2018). Natural and synthetic food additives are further classified depending on their specific role as flavor enhancers, preservatives, thickeners, stabilizers, glazing agents, flavors, emulsifiers, humectants, colorants, and gelling agents. Few among the mentioned are associated with the IgE, immunological and non-immunological mediated adverse symptoms and reactions. Natural food chemicals such as amines are found in banana, fish, chocolate, cheese, and ham, glutamate is found in tomatoes whereas salicylates occur in tomatoes and apples. Artificially incorporated chemicals include antioxidants in oil and margarine; benzoates in soft drinks and cordials; colorants in confectionery, jelly, and spices; monosodium glutamate (MSG) in processed and packaged foods; nitrates in meats; propionates in bread; sorbic acid in processed cheese; sulfites in cordials, soft drinks and dry fruits (Blekas, 2015). However, the mechanism of food additives and chemicals associated with the gastrointestinal and extra-intestinal symptoms are undefined and poorly studied. Therefore, controlled studies to elucidate the symptom provoking mechanism of individual food additives are highly recommended.

Tartrazine is the most studied artificial food colorant (FD&C Yellow #5, or Yellow 5) (E102) which appears as yellow in color is widely used in the food industry. The recommended daily intake (RDI) or the acceptable daily intake (ADI) of tartrazine corresponds to 7.5 mg/kg of body weight/ per day. It is commonly found in baked goods, candies, beverages, and cereals (Khayyat, Essawy, Sorour, & Soffar, 2017). The other coloring agents that are frequently incorporated into foods and associated with adverse reactions include azorubine (E122) in cheese, dry fruits, and alcoholic beverages; sunset yellow (E110) in baked goods, sausages, and cereals; allura red (E129) in beverages, candies, and cereals; erythrosine (E127) in baked goods, candies, sausages, and maraschino cherries; brilliant blue (E133) in baked goods,

beverages, candies, and cereals; brilliant black (E151) in sweets, ice creams, and jams; fast green (E143) in beverages, candies, and ice creams (Ramesh & Muthuraman, 2018).

Salicylates are a chemical compound obtained from the salicylic acid. They occur naturally in a wide range of foods and artificially incorporated into processed foods as a preservative. However natural as well as synthetic forms cause adverse allergic reactions in individuals with salicylate intolerance (Skypala, Williams, Reeves, Meyer, & Venter, 2015). The vegetables that contain salicylates include asparagus, bean sprouts, beetroot, broccoli, brussel sprouts, bok choy, capsicum, cauliflower, celery chilli, choy sum, eggplant, endive, fennel, green beans, leek, corn, cabbage, cucumber, lettuce, mushroom onion, parsnip peas, potato pumpkin, rocket leaves, radish, red kidney beans, spinach, swede tomato, and zucchini. Among these vegetables, beetroot was reported to contain higher salicylate content of 26.93 mg/kg whereas the lower content of 1.28 mg/kg was found in bean sprouts. The fruits that contain salicylates include apple, apricots, avocado, banana, blueberry, cantaloupe, coconut, dry dates, grapes, kiwi fruit, lemons, mandarin, mango, pear, nectarine, olives, orange, passionfruit, pawpaw, peach, persimmon, pineapple, plum, pomegranate, raspberry, strawberry, and watermelon. Among these, the higher salicylate content of 36.90 mg/kg was detected in dry dates whereas the lower content of 2.70 mg/kg was detected in mandarin. Salicylates in herbs and spices range between 2.80 - 604.97 mg/kg. In fruits and beverages, salicylates were reported to be present in the range of 2.04- 51.48 mg/l. The content of salicylates is extremely low in peeled fruits and vegetables in comparison to the fruits and vegetables that are unpeeled (Malakar, Gibson, Barrett, & Muir, 2017).

Benzoic acid and its derivatives are used to enhance the sweet astringent taste of the food products. They occur naturally in a wide range of foods such as vegetables and fruits, fungi, nuts, and spices (Joye, 2018). They are highly found in cocoa, apricots, almonds, cherries, cranberries, snap beans, honey, apple, banana, lemon, watermelon, orange, peach, strawberry, pineapple, and kiwi (Tungkijanansin, Alahmad, Nhujak, & Varanusupakul, 2020) Vegetables such as onion, carrot, cauliflower, celery, garlic, and cabbage contain < 1 mg/kg of benzoic acid. In spices, cinnamon contains <335 mg/kg, about <50 mg/kg is present in nutmeg, salvia, clove, and thyme. Cereals contain 0.5-1 mg/kg and nuts contain < 1 mg/kg. Among the nuts walnut and peanut holds the top with 4mg/kg of benzoic acid (Joye, 2018). During milk fermentation, the level of benzoic acid rapidly increases to 24 mg/L and in ripened cheese, it reaches up to 250 mg/kg. They are also added artificially as a preservative or flavoring agents into soft drinks, chemically leavened baked goods, poultry, and egg

products, meat, fish and fish products, beverages, alcohols, condiments, and as an edible coating in fruits and vegetables (Calzada, del Olmo, Picon, & Nuñez, 2015).

Monosodium glutamate (MSG) is a sodium salt of glutamic acid that enhances the flavor and sensory acceptance of savory foods. MSG is commonly found in pickles, spices and condiments, candies, soups, meats, and bakery products. Besides MSG also occurs naturally in tomatoes, cheeses, malted barley, rice syrup, and gelatin (Ramesh & Muthuraman, 2018). Artificial sweeteners including aspartame, sucralose, saccharin, acesulfame K, and neotame are generally used to enhance the sweetness and cause adverse allergic reactions, behavioral change, and hyperactivity. They are generally found in sugar-free products such as confectionery goods, beverages, dairy products, jams and jellies, and canned foods (Lohner, Toews, & Meerpohl, 2017).

(Table 6.) lists the daily allowance of major intolerant ingredients. However, it is important to mention that once an individual becomes intolerant to a particular ingredient, the food products containing them need not be completely excluded from the diet. Instead, adhering to the elimination diet could significantly reduce the adverse reactions. The three phases involved in the elimination diet include- a) overall elimination of foods containing intolerant ingredients from the diet, b) reintroduction to analyze the tolerance and intolerance level, c) gradual reintroduction of the tolerated foods according to their tolerance level (Varney et al., 2017).

Conclusion

The rising incidence of food allergy and intolerance represents abnormal clinical responses upon consumption of certain foods. In this subject, investigations on unprocessed and unpacked foods are vast whereas the mechanism of various processed and packaged food products that may mediate adverse reactions remains to be elucidated. Nevertheless, most of the commercially available foods may include allergen or intolerant substances as a hidden ingredient. As there is no complete cure reported the possible prevention and treatment method is the partial or complete avoidance of such foods in the daily dietary intake. Despite the dietary elimination of intolerant and allergic foods it is important to follow a balanced diet that compensates for the nutritional profile of the avoided foods. Although adverse reactions related to the consumption of certain foods is better understood by the scientific community, further progress has to be made in the public understanding of various foods associated with food allergy and intolerance.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgment

The authors are thankful to the Vellore Institute of Technology for the constant support of this study.

Funding

The work did not receive any specific grant from funding agencies in public, commercial or not- for- profit sector.

Reference

Abeshu, M. A., Lelisa, A., & Geleta, B. (2016). Complementary Feeding: Review of Recommendations, Feeding Practices, and Adequacy of Homemade Complementary Food Preparations in Developing Countries – Lessons from Ethiopia. *Frontiers in Nutrition*, *3*, 1. https://doi.org/10.3389/fnut.2016.00041

Adatia, A., Clarke, A. E., Yanishevsky, Y., & Ben-Shoshan, M. (2017). Sesame allergy: Current perspectives. *Journal of Asthma and Allergy*, *10*, 141–151. https://doi.org/10.2147/JAA.S113612

Akram, N. A., Shafiq, F., & Ashraf, M. (2018). Peanut (*Arachis hypogaea L.*): A Prospective Legume Crop to Offer Multiple Health Benefits Under Changing Climate. *Comprehensive Reviews in Food Science and Food Safety*, *17*(5), 1325–1338. https://doi.org/10.1111/1541-4337.12383

Ballmer-Weber, B. K., Brockow, K., Fiocchi, A., Theler, B., Vogel, L., Ring, J., … Nutten, S. (2016). Hydrolysed egg displays strong decrease in allergenicity and is well tolerated by egg-allergic patients. *Allergy*, *71*(5), 728–732. https://doi.org/10.1111/all.12852

Bellini, M., Tonarelli, S., Nagy, A. G., Pancetti, A., Costa, F., Ricchiuti, A., … Rossi, A. (2020). Low FODMAP diet: Evidence, doubts, and hopes. *Nutrients*, *12*(1), 148. https://doi.org/10.3390/nu12010148

Benkerroum, N. (2016). Biogenic Amines in Dairy Products: Origin, Incidence, and Control Means. *Comprehensive Reviews in Food Science and Food Safety*, *15*(4), 801–826. https://doi.org/10.1111/1541-4337.12212

Beyer, S., Franke, A., Simon, J. C., & Treudler, R. (2016). Measurement of health-related quality of life in adult patients with birch pollen-associated food allergy. *JDDG: Journal Der Deutschen Dermatologischen Gesellschaft*, *14*(4), 397–403. https://doi.org/10.1111/ddg.12731

Bird, A. R., & Regina, A. (2018, July). High amylose wheat: A platform for delivering human health benefits. *Journal of Cereal Science*, *82*, 99–105. https://doi.org/10.1016/j.jcs.2018.05.011

Blekas, G. A. (2016). Food Additives: Classification, Uses and Regulation. *Encyclopedia of Food and Health*, 731–736. https://doi.org/10.1016/B978-0-12-384947-2.00304-4

Blom, W. M., Kruizinga, A. G., Rubingh, C. M., Remington, B. C., Crevel, R. W. R., & Houben, G. F. (2017). Assessing food allergy risks from residual peanut protein in highly refined vegetable oil. *Food and Chemical Toxicology*, *106*, 306–313. https://doi.org/10.1016/j.fct.2017.05.072

Cabanillas, B. (2020). Gluten-related disorders: Celiac disease, wheat allergy, and nonceliac gluten sensitivity. *Critical Reviews in Food Science and Nutrition*, *60*(15), 2606–2621. https://doi.org/10.1080/10408398.2019.1651689

Calzada, J., del Olmo, A., Picon, A., & Nuñez, M. (2015). Effect of High Pressure Processing on the Lipolysis, Volatile Compounds, Odour and Colour of Cheese Made from Unpasteurized Milk. *Food and Bioprocess Technology*, *8*(5), 1076–1088. https://doi.org/10.1007/s11947-015-1473-4

Chan, E. S., Greenhawt, M. J., Fleischer, D. M., & Caubet, J. C. (2019). Managing Cross-Reactivity in Those with Peanut Allergy. *Journal of Allergy and Clinical Immunology: In Practice, 7*(2), 381–386. https://doi.org/10.1016/j.jaip.2018.11.012

Cianferoni, A. (2016). Wheat allergy: Diagnosis and management. *Journal of Asthma and Allergy, 9,* 13–25. https://doi.org/10.2147/JAA.S81550

Clayton, Z. S., Fusco, E., & Kern, M. (2017). Egg consumption and heart health: A review. *Nutrition*, *37*, 79–85. https://doi.org/10.1016/j.nut.2016.12.014

Dai, H., Wang, F., Wang, L., Wan, J., Xiang, Q., Zhang, H., … Zhang, W. (2020). An epidemiological investigation of food allergy among children aged 3 to 6 in an urban area of Wenzhou, China. *BMC Pediatrics*, *20*(1), 220. https://doi.org/10.1186/s12887-

020-02115-8

Davis, C. M., Gupta, R. S., Aktas, O. N., Diaz, V., Kamath, S. D., & Lopata, A. L. (2020). Clinical Management of Seafood Allergy. *Journal of Allergy and Clinical Immunology: In Practice*, *8*(1), 37–44. https://doi.org/10.1016/j.jaip.2019.10.019

De Mey, E., De Klerck, K., De Maere, H., Dewulf, L., Derdelinckx, G., Peeters, M. C., … Paelinck, H. (2014). The occurrence of N-nitrosamines, residual nitrite and biogenic amines in commercial dry fermented sausages and evaluation of their occasional relation. *Meat Science*, *96*(2), 821–828. https://doi.org/10.1016/j.meatsci.2013.09.010

Dölle, S., Welter, S., Ruppel, E., Lehmann, K., Schwarz, D., Jensen-Jarolim, E., … Worm, M. (2018). Clinical reactivity of celery cultivars in allergic patients: Role of Api g 1. *Clinical & Experimental Allergy*, *48*(4), 424–432. https://doi.org/10.1111/cea.13099

Eigenmann, P. A., Lack, G., Mazon, A., Nieto, A., Haddad, D., Brough, H. A., & Caubet, J. C. (2017). Managing Nut Allergy: A Remaining Clinical Challenge. *Journal of Allergy and Clinical Immunology: In Practice*, *5*(2), 296–300. https://doi.org/10.1016/j.jaip.2016.08.014

El Khoury, D., Balfour-Ducharme, S., & Joye, I. J. (2018). A review on the gluten-free diet: Technological and nutritional challenges. *Nutrients*, *10*(10), 1–25. https://doi.org/10.3390/nu10101410

Elsabie, W., & Aboel Einen, K. (2016). Comparative Evaluation of Some Physicochemical Properties for Different Types of Vegan Milk with Cow Milk. *Journal of Food and Dairy Sciences*, *7*(11), 457–461. https://doi.org/10.21608/jfds.2016.46060

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*(6), 848–869. https://doi.org/10.1080/09540105.2015.1039497

Fotschki, J., Wróblewska, B., Fotschki, B., Kalicki, B., Rigby, N., & Mackie, A. (2020). Microbial transglutaminase alters the immunogenic potential and cross-reactivity of horse and cow milk proteins. *Journal of Dairy Science*, *103*(3), 2153–2166. https://doi.org/10.3168/jds.2019-17264

Gao, Q., Ren, Y. X., Liu, Y. G., Ma, L., Gu, X. H., Zhang, W. X., … Shen, K. L. (2017). Allergy march of Chinese children with infantile allergic symptoms: a prospective

multi-center study. *World Journal of Pediatrics*, *13*(4), 335–340. https://doi.org/10.1007/s12519-017-0024-7

Geiselhart, S., Hoffmann-Sommergruber, K., & Bublin, M. (2018). Tree nut allergens. *Molecular Immunology*, *100*, 71–81. https://doi.org/10.1016/j.molimm.2018.03.011

Giorgi, A. S. De, Raddadi, N., Fabbri, A., Toschi, T. G., & Fava, F. (2018). Potential use of ricotta cheese whey for the production of lactobionic acid by Pseudomonas taetrolens strains. *New Biotechnology*, *42*, 71-76. https://doi.org/10.1016/j.nbt.2018.02.010

Gobbetti, M., Pontonio, E., Filannino, P., Rizzello, C. G., De Angelis, M., & Di Cagno, R. (2018). How to improve the gluten-free diet: The state of the art from a food science perspective. *Food Research International*, *110*, 22–32. https://doi.org/10.1016/j.foodres.2017.04.010

Gupta, R. S., Warren, C. M., Smith, B. M., Jiang, J., Blumenstock, J. A., Davis, M. M., … Nadeau, K. C. (2019). Prevalence and Severity of Food Allergies Among US Adults. The *Journal of American Medical Association network open*, *2*(1), e185630. https://doi.org/10.1001/jamanetworkopen.2018.5630

Hassan, A. K., & Venkatesh, P. (2015). An overview of fruit allergy and the causative allergens. *European Annals of Allergy and Clinical Immunology*, *47*(6), 180–187.

Hemmer, W., Klug, C., & Swoboda, I. (2016). Update on the bird-egg syndrome and genuine poultry meat allergy. *Allergo Journal International*, *25*(3), 68–75. https://doi.org/10.1007/s40629-016-0108-2

Henríquez-Aedo, K., Vega, M., Prieto-Rodríguez, S., & Aranda, M. (2012). Evaluation of biogenic amines content in chilean reserve varietal wines. *Food and Chemical Toxicology*, *50*(8), 2742–2750. https://doi.org/10.1016/j.fct.2012.05.034

Hochwallner, H., Schulmeister, U., Swoboda, I., Spitzauer, S., & Valenta, R. (2014). Cow's milk allergy: From allergens to new forms of diagnosis, therapy and prevention. *Methods*, *66*(1), 22–33. https://doi.org/10.1016/j.ymeth.2013.08.005

Ibáñez, R. A., Lucey, J. A., & Mcsweeney, P. L. H. (2020). Low- and reduced-fat milled curd , direct-salted Gouda cheese : Comparison of lactose standardization of cheesemilk and whey dilution techniques. *Journal of Dairy Science , 103*(2), 1175-1192. https://doi.org/10.3168/jds.2019-17292

Ishimaru, M., Muto, Y., Nakayama, A., Hatate, H., & Tanaka, R. (2019). Determination of Biogenic Amines in Fish Meat and Fermented Foods Using Column-Switching High-Performance Liquid Chromatography with Fluorescence Detection. *Food Analytical Methods*, *12*(1), 166–175. https://doi.org/10.1007/s12161-018-1349-0

Jacobson, M. F., & DePorter, J. (2018). Self-reported adverse reactions associated with mycoprotein (Quorn-brand) containing foods. *Annals of Allergy, Asthma and Immunology*, *120*(6), 626–630. https://doi.org/10.1016/j.anai.2018.03.020

Jnawali, P., Kumar, V., & Tanwar, B. (2016). Celiac disease: Overview and considerations for development of gluten-free foods. *Food Science and Human Wellness*, *5*(4), 169–176. https://doi.org/10.1016/j.fshw.2016.09.003

Joye, I. J. (2018). Acids and bases in food. In *Encyclopedia of Food Chemistry* (pp 1-9). https://doi.org/10.1016/B978-0-08-100596-5.21582-5

Kelis, J., Torres, F., Stephani, R., Tavares, G. M., Fernandes, A., Carvalho, D., … Tuler, Í. (2017). Technological aspects of lactose-hydrolyzed milk powder. *Food Research International*, *101*, 45–53. https://doi.org/10.1016/j.foodres.2017.08.043

Khayyat, L., Essawy, A., Sorour, J., & Soffar, A. (2017). Tartrazine induces structural and functional aberrations and genotoxic effects in vivo. *PeerJ*, *5* e3041. https://doi.org/10.7717/peerj.3041

Kobayashi, Y., Kuriyama, T., Nakagawara, R., Aihara, M., & Hamada-Sato, N. (2016). Allergy to fish collagen: Thermostability of collagen and IgE reactivity of patients' sera with extracts of 11 species of bony and cartilaginous fish. *Allergology International*, *65*(4), 450–458. https://doi.org/10.1016/j.alit.2016.04.012

Kvasnicka, J., Stylianou, K. S., Nguyen, V. K., Huang, L., Chiu, W. A., Burton, G. A., … Jolliet, O. (2019). Human Health Benefits from Fish Consumption vs. Risks from Inhalation Exposures Associated with Contaminated Sediment Remediation: Dredging of the Hudson River. *Environmental Health Perspectives*, *127*(12), 127004. https://doi.org/10.1289/EHP5034

Lambert, R., Grimshaw, K. E. C., Ellis, B., Jaitly, J., & Roberts, G. (2017). Evidence that eating baked egg or milk influences egg or milk allergy resolution: a systematic review. *Clinical & Experimental Allergy*, *47*(6), 829–837. https://doi.org/10.1111/cea.12940

Lima-Cabello, E., Alché, J. D., & Jimenez-Lopez, J. C. (2019). Narrow-Leafed Lupin Main Allergen β-Conglutin (Lup an 1) Detection and Quantification Assessment in Natural and Processed Foods. *Foods*, *8*(10), 513. https://doi.org/10.3390/foods8100513

Lohner, S., Toews, I., & Meerpohl, J. J. (2017). Health outcomes of non-nutritive sweeteners: Analysis of the research landscape. *Nutrition Journal*, *16*(1), 1–21. https://doi.org/10.1186/s12937-017-0278-x

Luongo, D., Maurano, F., Bergamo, P., & Rossi, M. (2020). Microbial transglutaminase: A biotechnological tool to manage gluten intolerance. *Analytical Biochemistry*, *592*, 113584. https://doi.org/10.1016/j.ab.2020.113584

Malakar, S., Gibson, P. R., Barrett, J. S., & Muir, J. G. (2017). Naturally occurring dietary salicylates: A closer look at common Australian foods. *Journal of Food Composition and Analysis*, *57*, 31–39. https://doi.org/10.1016/j.jfca.2016.12.008

Meitinger, M., Hartmann, S., & Schieberle, P. (2014). Development of stable isotope dilution assays for the quantitation of Amadori compounds in foods. *Journal of Agricultural and Food Chemistry*, *62*(22), 5020–5027. https://doi.org/10.1021/jf501464g

Misselwitz, B., Butter, M., Verbeke, K., & Fox, M. R. (2019). Update on lactose malabsorption and intolerance: Pathogenesis, diagnosis and clinical management. *Gut*, *68*(11), 2080–2091. https://doi.org/10.1136/gutjnl-2019-318404

Moghtaderi, M., Nabavizadeh, S. H., & Hosseini Teshnizi, S. (2020). The frequency of cross-reactivity with various avian eggs among children with hen's egg allergy using skin prick test results: fewer sensitizations with pigeon and goose egg. *Allergologia et Immunopathologia*, *48*(3), 265–269. https://doi.org/10.1016/j.aller.2019.10.002

Naegeli, H., Bresson, J., Dalmay, T., Dewhurst, I. C., Epstein, M. M., Firbank, L. G., … Raffaello, T. (2020). Assessment of genetically modified soybean MON 87705 × MON 87708 × MON 89788, for food and feed uses, under Regulation (EC) No 1829/2003 (application EFSA-GMO-NL-2015-126). *European Food Safety Authority Journal*, *18*(5), e06111. https://doi.org/10.2903/j.efsa.2020.6111

Nakamura, H., Nakamura, M., Shimizu, N., Matsunaga, K., & Kondo, Y. (2019). Analysis of allergens in corn-dependent exercise-induced anaphylaxis. *Annals of Allergy, Asthma and Immunology*, *123*(1), 103–105. https://doi.org/10.1016/j.anai.2019.04.005

Onoda, Y., Aoki, Y., Nagai, A., Hasegawa, E., Nakamura, M., Suzuki, K., … Yagami, A. (2020). A case of hen's egg-dependent exercise-induced immediate-type allergy. *Allergology International*, *69*(3), 476–477. https://doi.org/10.1016/j.alit.2020.01.006

Ooi, S. L., Correa, D., & Pak, S. C. (2019). Probiotics, prebiotics, and low FODMAP diet for irritable bowel syndrome – What is the current evidence? *Complementary Therapies in Medicine*, *43*, 73–80. https://doi.org/10.1016/j.ctim.2019.01.010

Palladino, C., Narzt, M. S., Bublin, M., Schreiner, M., Humeniuk, P., Gschwandtner, M., … Breiteneder, H. (2018). Peanut lipids display potential adjuvanticity by triggering a pro-inflammatory response in human keratinocytes. *Allergy: European Journal of Allergy and Clinical Immunology*, *73*(8), 1746–1749. https://doi.org/10.1111/all.13475

Pedrosa, M., Boyano-Martínez, T., García-Ara, C., & Quirce, S. (2015). Shellfish Allergy: a Comprehensive Review. *Clinical Reviews in Allergy and Immunology*, *49*(2), 203–216. https://doi.org/10.1007/s12016-014-8429-8

Perin, L. M., & Nero, L. A. (2017). The relevance of biogenic amines in dairy products. *In Dairy in Human Health and Disease across the Lifespan* (pp. 169-182). Academic Press. https://doi.org/10.1016/B978-0-12-809868-4.00012-1

Piccolo, F., Vollano, L., Base, G., Girasole, M., Smaldone, G., & Cortesi, M. L. (2016). Research of soybean and Lactose in meat products and preparations sampled at retail. *Italian Journal of Food Safety*, *5*(3), 161–164. https://doi.org/10.4081/ijfs.2016.5780

Pilolli, R., Nitride, C., Gillard, N., Huet, A. C., van Poucke, C., de Loose, M., … Monaci, L. (2020). Critical review on proteotypic peptide marker tracing for six allergenic ingredients in incurred foods by mass spectrometry. *Food Research International*, *128*, 108747. https://doi.org/10.1016/j.foodres.2019.108747

Rajani, P. S., Martin, H., Groetch, M., & Järvinen, K. M. (2020). Presentation and Management of Food Allergy in Breastfed Infants and Risks of Maternal Elimination Diets. *Journal of Allergy and Clinical Immunology: In Practice*, *8*(1), 52–67. https://doi.org/10.1016/j.jaip.2019.11.007

Ramachandran, B., Yang, C. T., & Downs, M. L. (2020). Parallel Reaction Monitoring Mass Spectrometry Method for Detection of Both Casein and Whey Milk Allergens from a Baked Food Matrix. *Journal of Proteome Research*, *19*(8), 2964–2976.

https://doi.org/10.1021/acs.jproteome.9b00844

Ramesh, M., & Muthuraman, A. (2018). Flavoring and coloring agents: Health risks and potential problems. In *Natural and artificial flavoring agents and food dyes* (pp. 1-28). Academic Press. https://doi.org/10.1016/B978-0-12-811518-3/00001-6

Réhault-Godbert, S., Guyot, N., & Nys, Y. (2019). The Golden Egg: Nutritional value, bioactivities, and emerging benefits for human health. *Nutrients*, *11*(3), 684. https://doi.org/10.3390/nu11030684

Ruiz-Capillas, C., & Herrero, A. M. (2019). Impact of biogenic amines on food quality and safety. *Foods*, *8*(2), 62. https://doi.org/10.3390/foods8020062

Sánchez-Pérez, S., Comas-Basté, O., Rabell-González, J., Veciana-Nogués, M. T., Latorre-Moratalla, M. L., & Vidal-Carou, M. C. (2018). Biogenic amines in plant-origin foods: Are they frequently underestimated in low-histamine diets? *Foods*, *7*(12), 1–17. https://doi.org/10.3390/foods7120205

Scherf, K. A., Brockow, K., Biedermann, T., Koehler, P., & Wieser, H. (2016). Wheat-dependent exercise-induced anaphylaxis. *Clinical & Experimental Allergy*, *46*(1), 10–20. https://doi.org/10.1111/cea.12640

Sharma, A., Verma, A. K., Gupta, R. K., Neelabh, & Dwivedi, P. D. (2019, August). A Comprehensive Review on Mustard-Induced Allergy and Implications for Human Health. *Clinical Reviews in Allergy and Immunology*, *57*(1), 39–54. https://doi.org/10.1007/s12016-017-8651-2

Silanikove, N., Leitner, G., & Merin, U. (2015). The interrelationships between lactose intolerance and the modern dairy industry: Global perspectives in evolutional and historical backgrounds. *Nutrients*, *7*(9), 7312–7331. https://doi.org/10.3390/nu7095340

Simon Sarkadi, L. (2017). Biogenic Amines in Fermented Foods and Health Implications. In *Fermented Foods in Health and Disease Prevention* (pp. 625-651). Academic Press. https://doi.org/10.1016/B978-0-12-802309-9.00027-3

Skypala, I. J., Williams, M., Reeves, L., Meyer, R., & Venter, C. (2015). Sensitivity to food additives, vaso-active amines and salicylates: A review of the evidence. *Clinical and Translational Allergy*, *5*(1), 1–11. https://doi.org/10.1186/s13601-015-0078-3

Srisuwatchari, W., Piboonpocanun, S., Wangthan, U., Jirapongsananuruk, O., Visitsunthorn,

N., & Pacharn, P. (2020). Clinical and in vitro cross-reactivity of cereal grains in children with IgE-mediated wheat allergy. *Allergologia et Immunopathologia*. https://doi.org/10.1016/j.aller.2019.11.008

Staudacher, H. M. (2017). Nutritional, microbiological and psychosocial implications of the low FODMAP diet. *Journal of gasteroenterology and hepatology*, *32*, 16–19. https://doi.org/10.1111/jgh.13688

Suri, S., Kumar, V., Prasad, R., Tanwar, B., Goyal, A., Kaur, S., … Singh, D. (2019). Considerations for development of lactose-free food. *Journal of Nutrition and Intermediary Metabolism*, *15*, 27–34. https://doi.org/10.1016/j.jnim.2018.11.003

Szilagyi, A., & Ishayek, N. (2018). Lactose intolerance, dairy avoidance, and treatment options. *Nutrients*, *10*(12), 1994. https://doi.org/10.3390/nu10121994

Tabanelli, G., Montanari, C., & Gardini, F. (2018). Biogenic amines in food: A review of factors affecting their formation. In *Encyclopedia of Food Chemistry*, (pp. 337-343). https://doi.org/10.1016/B978-0-08-100596-5.21833-7

Thompson, T., Keller, A., & Lyons, T. B. (2018). When foods contain both a gluten-free claim and an allergen advisory statement for wheat: Should consumers be concerned? *European Journal of Clinical Nutrition*, *72*(7) , 931–935. https://doi.org/10.1038/s41430-018-0141-y

Tian, H., Guo, G., Fu, X., Yao, Y., Yuan, L., & Xiang, A. (2018). Fabrication, properties and applications of soy-protein-based materials: A review. *International Journal of Biological Macromolecules*, 120, 475–490. https://doi.org/10.1016/j.ijbiomac.2018.08.110

Toro-Funes, N., Bosch-Fuste, J., Latorre-Moratalla, M. L., Veciana-Nogués, M. T., & Vidal-Carou, M. C. (2015). Biologically active amines in fermented and non-fermented commercial soybean products from the Spanish market. *Food Chemistry*, *173*, 1119–1124. https://doi.org/10.1016/j.foodchem.2014.10.118

Trasande, L., Shaffer, R. M., & Sathyanarayana, S. (2018). Food additives and child health. *Pediatrics*, *142*(2) e20181410. https://doi.org/10.1542/peds.2018-1410

Tungkijanansin, N., Alahmad, W., Nhujak, T., & Varanusupakul, P. (2020). Simultaneous determination of benzoic acid, sorbic acid, and propionic acid in fermented food by

headspace solid-phase microextraction followed by GC-FID. *Food Chemistry*, *329*, 127161. https://doi.org/10.1016/j.foodchem.2020.127161

Upton, J., & Nowak-Wegrzyn, A. (2018). The Impact of Baked Egg and Baked Milk Diets on IgE- and Non-IgE-Mediated Allergy. *Clinical Reviews in Allergy and Immunology*, *55*(2), 118–138. https://doi.org/10.1007/s12016-018-8669-0

Vanga, S. K., Jain, M., & Raghavan, V. (2018). Significance of fruit and vegetable allergens: Possibilities of its reduction through processing. *Food Reviews International*, *34*(2), 103–125. https://doi.org/10.1080/87559129.2016.1239208

Vanham, D., Mekonnen, M. M., & Hoekstra, A. Y. (2020). Treenuts and groundnuts in the EAT-Lancet reference diet: Concerns regarding sustainable water use. *Global food security*, *24*, 100357. https://doi.org/10.1016/j.gfs.2020.100357

Varney, J., Barrett, J., Scarlata, K., Catsos, P., Gibson, P. R., & Muir, J. G. (2017). FODMAPs: food composition, defining cutoff values and international application. *Journal of gasteroenterology and hepatology*, *32*, 53–61. https://doi.org/10.1111/jgh.13698

Venter, C., Maslin, K., Patil, V., Kurukulaaratchy, R., Grundy, J., Glasbey, G., … Arshad, S. H. (2016). The prevalence, natural history and time trends of peanut allergy over the first 10 years of life in two cohorts born in the same geographical location 12 years apart. *Pediatric Allergy and Immunology*, *27*(8), 804–811. https://doi.org/10.1111/pai.12616

Venugopal, V., & Gopakumar, K. (2017). Shellfish: Nutritive Value, Health Benefits, and Consumer Safety. *Comprehensive Reviews in Food Science and Food Safety*, *16*(6), 1219–1242. https://doi.org/10.1111/1541-4337.12312

Vezir, E., Kaya, A., Toyran, M., Azkur, D., Misirlioğlu, E. D., & Kocabaş, C. N. (2014). Anaphylaxis/angioedema caused by honey ingestion. *Allergy and Asthma Proceedings*, *35*(1), 71–74. https://doi.org/10.2500/aap.2014.35.3718

Walsh, J., Meyer, R., Shah, N., Quekett, J., & Fox, A. T. (2016). Differentiating milk allergy (IgE and non-IgE mediated) from lactose intolerance: Understanding the underlying mechanisms and presentations. *British Journal of General Practice*, *66*(649), e609–e611. https://doi.org/10.3399/bjgp16X686521

Wang, H. T., Warren, C. M., Gupta, R. S., & Davis, C. M. (2020). Prevalence and Characteristics of Shellfish Allergy in the Pediatric Population of the United States. *Journal of Allergy and Clinical Immunology: In Practice*, *8*(4), 1359-1370.e2. https://doi.org/10.1016/j.jaip.2019.12.027

Wangorsch, A., Jamin, A., Lidholm, J., Gräni, N., Lang, C., Ballmer-Weber, B., … Scheurer, S. (2017). Identification and implication of an allergenic PR-10 protein from walnut in birch pollen associated walnut allergy. *Molecular Nutrition & Food Research*, *61*(4), 1600902. https://doi.org/10.1002/mnfr.201600902

Wilson, J. M., & Platts-Mills, T. A. E. (2018). Meat allergy and allergens. *Molecular Immunology*, *100*, 107–112. https://doi.org/10.1016/j.molimm.2018.03.018

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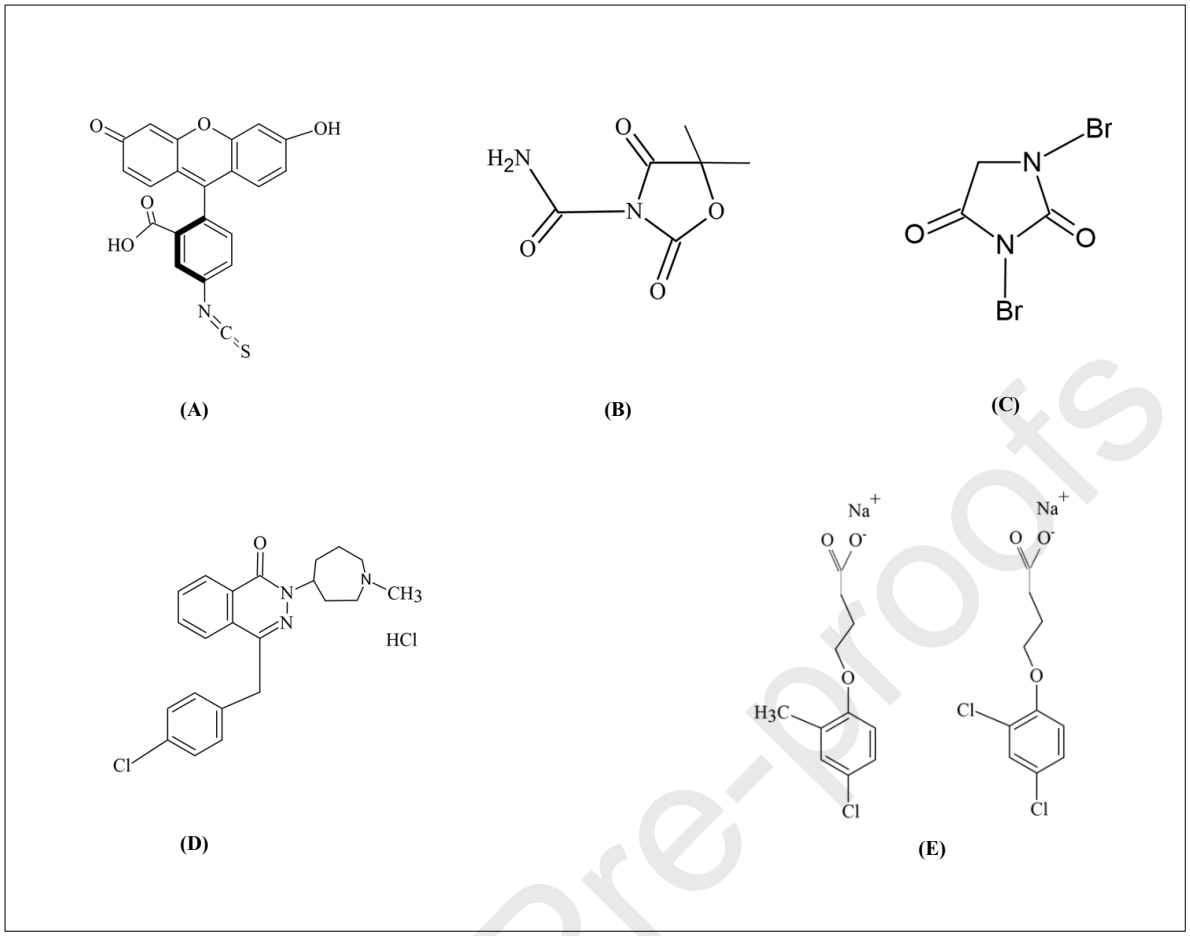


Fig.1. Chemical structure of major allergens- (A) casein, (B) ovalbumin, (C) β-conglycinin (D) whey, (E) legumin.

Fig.2. Food and food products associated with food allergy

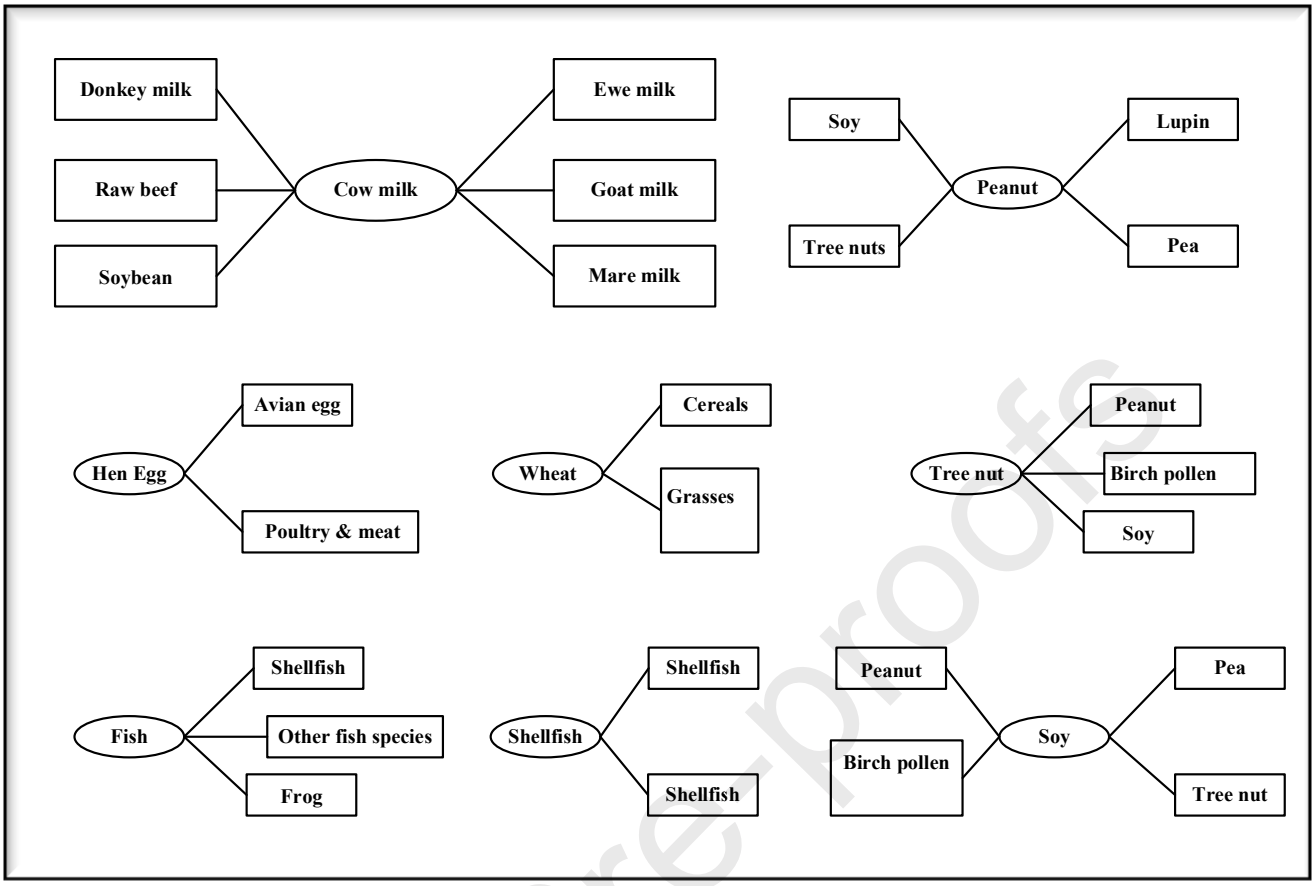


Fig.3. Cross-reactivity of the major food allergens

Fig.4. Food and food products associated with food intolerance.

Table 1. The most common allergic foods and their potential allergens.

Food name	Food type	Major allergen	References
Milk	Animal-derived food	Casein Whey	(Ramachandran et al., 2020)
Egg	Animal-derived food	Ovomucoid Ovo transferrin Conalbumin Lysozymes Ovalbumin Alpha-livetin Vitellus	(Onoda et al., 2020)

		Apoprotein B	
Fish	Animal derived food	Parvalbumins Gelatin Enolase Aldolase Vitellogenin Tropomyosin	(Davis et al., 2020)
Tree nuts	Nuts	Vicilin Legumins	(Geiselhart et al., 2018)
Wheat	Cereal	Albumins Albumins Globulins Gliadin Glutenin	(Cabanillas, 2020)
Soy	Legume	β-conglycinin Glycinin	(Gao et al., 2017)
Peanut	Legume	Cupin Prolamin Profili Bet v-1	(Venter et al., 2016)
Shellfish	Animal-derived foods	Tropomyosin Arginine kinase Myosin light chain	(Gupta et al., 2019)

Table 2. Food products that contain hidden allergens, commonly used labeling terms of allergens, and recommended alternative foods.

Food	**Sources**	**Food products that contain hidden allergens**	**Labeling words used to indicate the presence of allergens**	**Food Alternatives**
Milk	Cow Buffalo Sheep Goats	Protein hydrolysates, chocolates, artificial butter *and* cheese flavor, sausage, meats, beverage mix, nougat, food wax coatings, sherbet, caramel, mayonnaise, natural food flavorings, hot dogs, pre *and p*robiotic products.	Casein, whey, lactoferrin, lactoglobulin, lactalbumin, caseinate, rennet casein, and para casein.	Vegan milk from various beans, nuts, seeds, and grains, vegan products, margarine, dairy-free goods, lactose-free milk, vegan products, cocoa butter, oleoresin, calcium sodium lactate, and extensively heated/ baked milk food products.
Egg	Chicken Goose Duck Turkey	Artificial and natural flavorings, *Macaroni, Marzipan, Marshmallows, Pasta, baking inst*ant *mixes,* fat replacers, probiotic products, and *Surimi.*	Albumin, apo vitelline, dried egg solids, egg white, egg yolk, egg wash, globulin, livetin, lysozyme, ovalbumin, Suffixes of ovo like globulin, mucin, mucoid, transferrin, vitelline, powdered eggs, silici albuminate, and vitelline.	Applesauce, agar-agar, Banana, seeds like chia, flax, tofu, buttermilk, vinegar, and baking soda, yogurt, arrowroot powder, tree nut and peanut butter, carbonated water, soy lecithin, Xanthan gum, and avocados.
Fish	Carp, cod Flounder Halibut herring	Worcester sauce, salad dressings, surimi, pizza toppings, condiments, and fish gelatin.	Fish, Fish parts, isinglass, anchovies, surimi, marine oil, fish oil, split fish, and smelts.	Leafy greens and vegetables, tree nuts and seeds oils, soy, marine algae, egg, tahini, tofu, and meats.

	Mackerel pilchard Redfish salmon sea bass swordfish tilapia Trout Tuna			
Tree nuts	Almond Brazilnuts Cashews Hazelnuts Macadamia Pecans Pine nuts Pistachio Walnuts Shea nut	Artificial and natural flavoring Italian sausage and table sauces, baked foods, and nougat.	**Most of their bot**anical names and their derivative names.	Seed butter, chickpeas roasts, oats, granola, dried fruits, and crisped rice.
Wheat	Wheat grains	All-purpose flour, Alcoholic beverages, Artificial and natural flavoring, varieties of food starch, hydrolyzed vegetable protein, sauces, glucose syrups, and dextrin.	Wheat, wheat granules, Club wheat, triticale, semolina, common wheat, durum wheat, spelt, and botanical names of wheat varieties.	Flours from starchy gluten-free foods like corn, tapioca, rice, potato, oats, quinoa, beer, and hypoallergenic wheat.
Soy	Soybean	Artificial and natural flavoring, baked food products, vegetable starch flour, hydrolyzed plant, and vegetable protein.	Suffixes of soy like albumin, nuts, protein, concentrate, paste milk, fiber, sauce, sprouts, beans, flour, lecithin, granules	Beans, vegan milk, cow milk, meat, fish, legumes, eggs, fruits, greens, and vegetables.

			Soybean, soybean curd, and granules.	
Peanut	Groundnut	Artificial and natural flavoring, hydrolyzed plant, and vegetable protein, baked foods, toppings, candies, global cuisine's fried foods, crackers, and sauces.	Peanut, peanut flour, peanut oil, peanut starch, plant protein, vegetable oil, and hydrolyzed vegetable protein.	Soy nuts, Edible seeds, and their butter, beans, tahini, and hummus.
Shellfish	Shrimp Crab Prawn Crayfish Lobster Clams Mussel Oysters Squid Cuttlefish Octopus Snails Scallops	Fish ink, glucosamine, seafood flavorings, soups, fish stocks, salad dressings, sauces, gumbo, fish stew, surimi, and fish stick.	Barnacle, crab, crustaceans, krill, scallops, snail, squid, clams, oysters, lobster, prawns, shrimp, mollusks, mussels, and their extractives.	Leafy greens and vegetables, tree nuts and seeds oils, soy, marine algae, egg, tahini, tofu, and meats.

Table.3. Common intolerant dairy products and their lactose content

Food	**Raw**	**Processed**	**Packaged**	**Lactose (L) and Gluten content (G)**	**Reference**
Whole milk	✓	-	-	12g/100 mL (L)	(Paige & Huang, 2018)
Milk powder	-		✓	30-31 g/100g	(Kelis et al., 2017)

		-		(L)	
Cottage cheese	-	✓	✓	3.4% (L)	(Krug & Simonne, 2018)
Mozzarella cheese	-	✓	✓	0.0–3.1% (L)	(Moynihan et al., 2016)
Cheddar cheese	-	✓	✓	4.2-8.4 % (L)	(Ibáñez, Lucey, & Mcsweeney, 2020)
Ricotta	-	✓	✓	4.5-5gm/100gm (L)	(Giorgi, Raddadi, Fabbri, Toschi, & Fava, 2018)

Table 4. List of food products that contain various biogenic amines

Food products	**Content of various biogenic amines in mg/kg**						**Reference**
	His	**Tyr**	**Put**	**Cad**	**Spm**	**Smd**	
Canned Tuna	0.33	0.06	0.35	0.07	0.03	0.02	(Meitinger, Hartmann, & Schieberle, 2014)
Cab Sauvignon	8.39	2.61	19.81	5.21	0.67	4.21	(Henríquez-Aedo, Vega, Prieto-Rodríguez, & Aranda, 2012)
Carménère	9.21	3.82	20.09	3.85	0.99	5.41	(Henríquez-Aedo et al., 2012)
Chocolate	0.26	3.11	0.8	0.75	1.95	7.4	(Meitinger et al., 2014)
Danish sausage	9	54	130	180	37	7	(Meitinger et al., 2014)

Fermented cabbage	37.01	60.66	108.9	21.5	1.2	10.98	(Meitinger et al., 2014)
Leerdamer (cheese)	0.02	-	0.07	0.01	0.65	0.95	(Meitinger et al., 2014)
Merlot	6.83	2.51	10.03	1.93	1.94	4.6	(Henríquez-Aedo et al., 2012)
Parmesan cheese	40.64	3.75	0.83	1.98	0.82	0.83	(Meitinger et al., 2014)
Red wine	3.67	1.93	8.5	0.4	0.07	2.08	(Meitinger et al., 2014)
Rosé wine	0.58	0.76	3.28	0.9	-	0.09	(Meitinger et al., 2014)
Salami	8.54	77.14	61.57	6.54	14.09	3.11	(Meitinger et al., 2014)
Soybean milk	-	0.39–1.81	-	0.42	-	-	(Toro-Funes et al., 2015)
Sauv Blanc	1.36	-	5.87	0.62	0.12	0.46	(Henríquez-Aedo et al., 2012)
Tomato (ketchup)	1.11	1-1.15	-	-	-	-	(Toro-Funes et al., 2015)
White wine	0.18	0.41	2.24	0.79	-	-	(Meitinger et al., 2014)

Table 5. Summary of foods that contain high and low/moderate FODMAPs content.

Foods	**High FODMAPs content.**	**Low or moderate FODMAPs content.**
Fruits and fruit products	Apricots, apple, asian pears, blackberries, boysenberry, cherries, clingstone peach, custard apples, nectarines,	Avocado, banana, blueberry, cantaloupe, carambola, dragon fruit, cherries, durian, grapes, dried fruit, grapefruit honeydew

	mango, nashi fruit, peaches, pears, plums, prunes, persimmon, watermelon, white peaches, and tamarillo	melon, lemon, kiwifruit, lime, longon, lychee, orange, mandarin, passionfruit, pawpaw, pineapple, pomegranate, prickly pear, rambutan, raspberry, rhubarb, strawberry, and tangelo.
Vegetables and vegetable products	Artichokes, asparagus, garlic, cauliflower, onion, leek, mushroom, shallot, snow peas, sugar snap peas, and spring onion.	Bamboo shoots, alfalfa, bean sprouts, beans, bok choy, beetroot, broccoli, butternut pumpkin, brussels sprouts, cabbage, capsicum, carrot, celery, chives, choy sum, cucumber, eggplant, endive, fennel bulb, green peas, lettuce, olives, parsnip, potato, pumpkin, radish, rocket, silverbeet, spinach, spring onion, squash, swede, sweet corn, sweet potato, tomato, turnip, and zucchini.
Legumes, nuts, and seeds	Cashews, chickpeas, red kidney beans, borlotti beans, soybeans, lentils, and pistachios.	Almonds, chia seeds, hazelnuts, linseed, poppy seeds, pumpkin seeds, sesame seeds, sunflower seeds, and tahini.
Dairy and dairy products	Cow's milk, custard, dairy desserts, evaporated milk, goat's milk, milk powder, ice cream, sheep's milk, and sweetened condensed milk.	Ripened cheeses-blue vein, brie, cheddar, colby, edam, feta, gouda, butter, mozzarella, parmesan, and swiss cheese, margarine, cream, rice milk, oat milk, lactose-free ice cream, yogurt obtained from cow, sheep, goat milk, lactose-free yogurt, fromage frais, soft

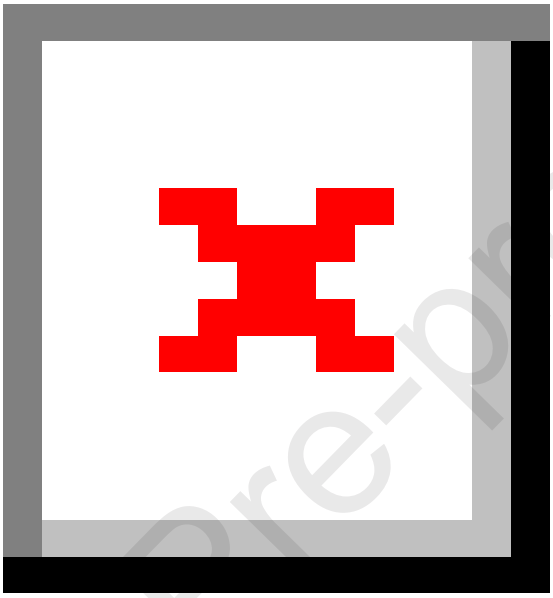
		cheeses- cottage, ricotta, cream cheese, and mascarpone.
Grain and starch-based foods	Barley, kamut, rye, and wheat-based bread, crackers pasta, cereal, couscous, gnocchi, noodles, croissants, muffins, and crumpets.	Buckwheat, corn, gluten-free bread, cracker, and cereal products, oats, millet oat bran, polenta, quinoa, rice, sweet biscuit, grains, and flour-based products that are gluten-free.
Others	Agave, fructose, fructooligosaccharides, fruit juice concentrates, high-fructose corn syrup, honey, isomalt, sorbitol, polydextrose, inulin, and maltitol.	Chewing gum, candy, mint sweetened with sucrose, ginger spices, garlic-infused olive oil, herbs, maple syrup, sugar, glucose, stevia, artificial sweeteners except for sugar alcohols, and regular milk or milk powder as an ingredient in various foods.

Table 6. Dietary allowance of intolerant substances

Intolerant substances	**Recommended daily intake (RDI)/ Acceptable daily intake (ADI)**	**Reference**
Lactose	**12- 18 g/day**	(Suri et al., 2019)
Gluten	10- 50 mg/day Gluten-free products should contain gluten <20 parts per million.	(Gobbetti et al., 2018)
Biogenic Amines	6- 25 mg/meal	(Ishimaru et al., 2019)
FODMAPs	15- 30 g/day	(Bellini et al., 2020)
Monosodium Glutamate	0.6–1.5 g/person/day	(Ramesh & Muthuraman, 2018)

Salicylates	2- 4 mg/day	(Malakar et al., 2017)
Benzoic acid	0.32 mg/kg of body weight/ per day	(Joye, 2018)
Tartrazine	7.5 mg/kg of body weight/ per day	(Khayyat et al., 2017).

Graphical abstract



Highlights

- Intake of certain foods leads to conditions such as food allergy and intolerance.
- Until today dietary awareness of foods that cause adverse reactions remains low.
- Egg, fish, shellfish, tree nut, peanut, and soybean products cause food allergies.
- Gluten, biogenic amine, FODMAP, and additive content of foods induce intolerance.
- Dairy and wheat products commonly cause food allergies as well as intolerance.
- A strict diet eliminating allergic and intolerant foods is of utmost importance.