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Ingredient and labeling issues associated with allergenic foods

Foods contain a wide range of food ingredients that serve numerous technical functions. Per capita consumer exposure to most of these food ingredients is rather low with a few notable exceptions such as sugar and starch. Some food ingredients including edible oils, hydrolyzed proteins, lecithin, starch, lactose, flavors and gelatin may, at least in some products, be derived from sources commonly involved in IgE-mediated food allergies. These ingredients should be avoided by consumers with allergies to the source material if the ingredient contains detectable protein residues. Other food ingredients, including starch, malt, alcohol and vinegar, may be derived in some cases from wheat, rye or barley, the grains that are implicated in the causation of celiac disease. If these ingredients contain gluten residues, then they should be avoided by celiac sufferers. A few food ingredients are capable of eliciting allergic sensitization, although these ingredients would be classified as rarely allergenic. These ingredients include carmine, cochineal extract, annatto, tragacanth gum and papain. Food manufacturers should declare the presence of allergenic food ingredients in the ingredient listings on product labels so that allergic consumers can know to avoid these potentially hazardous products.

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Many substances are added to foods for a variety of technical functions, ranging from coloring and flavoring to nutrient and antimicrobial purposes. A list of common categories of food ingredients is contained in Table 1. Some food ingredients serve more than one function. Sucrose, for example, can act as a sweetener, a bulking agent and a preservative. Although perhaps 20 000 or more food ingredients are used on a worldwide basis, the intake of specific food ingredients is typically rather small with a few exceptions such as sucrose.

Food ingredients are sometimes implicated as causative factors in food allergies and intolerances. For the purposes of this review, the discussion will be limited to the role of food ingredients in the causation of IgE-mediated food allergies and celiac disease. However, various food additives, including most notably the various salts of sulfite and tartrazine, have been implicated in food intolerances (1). Some common food ingredients are derived from commonly allergenic foods (Table 2). Obviously, if these ingredients contain protein from the source material, they are likely to be allergenic to consumers who are allergic to the source foods. Other food ingredients may have the potential to directly elicit allergic sensitization, although this situation is less common given the low degree of consumer exposure to most food ingredients.

Labeling regulations must be sufficient to protect the allergic consumer. The ingredient statement on the food package must include a description of all of the ingredients contained in the composite food product.

Food ingredients derived from known allergenic sources

Edible oils

Edible oils are often derived from known allergenic sources, including peanuts, soybeans, sunflower seeds and sesame seeds. Other sources of edible oils, including olive, canola (rapeseed) and corn, are rarely allergenic. However, highly refined oils contain no detectable protein residues. In several double-blind, placebo-controlled food challenge (DBPCFC) studies, highly refined peanut, soybean and sunflower seed oils have been demonstrated to be safe for ingestion by individuals allergic to the source food (2–5). However, some caution should be noted with respect to advice to patients regarding edible oils. The oils that were determined to be safe in the DBPCFC studies were refined by extraction with hot solvents, bleaching and deodorizing. Less highly refined oils may not always be safe. Other investigators have documented allergic reactions to peanut oil in some peanut-allergic patients, which seems to indicate that certain commercial peanut oils may contain residual peanut allergens (6). Furthermore, cold-pressed peanut oil, which is made by mechanical squeezing rather than solvent extraction, is available commercially in some countries and may not always be safe because the process may not always remove all of the protein or the allergens (7). Sesame seed oil appears to contain protein residues that could present a hazard to sesame seed-allergic individuals (8). Foods may also occasionally contain oils derived from

various tree nuts, such as walnuts. These tree nut oils may also contain residual protein on occasion that could be hazardous to tree nut-allergic individuals (9). An extensive review on the allergenicity of edible oils is available (10).

Protein hydrolysates

Protein hydrolysates are often made from commonly allergenic sources including soybeans, wheat, peanuts, whey and casein. If the proteins are extensively hydrolyzed, as is the case with hypoallergenic infant formulas, then the hydrolysates are converted mostly to a mixture of amino acids that would have no predicted reactivity to patients with allergies to the source material (11). However, even with hypoallergenic infant formula, a small number of cow's milk-allergic infants will react adversely to formulas based upon extensively hydrolyzed casein (12, 13). Of course, in this situation, the formula is serving as the sole source of nutrition for the infant and exposure is great. More commonly with foods intended for older children and adults, protein hydrolysates are used for flavor enhancement and other technical functions. When flavor enhancement is the sole technical attribute that is sought, extensively hydrolyzed products are used, and the risk to allergic consumers is probably slight. But when other attributes are sought, such as emulsification, less extensively hydrolyzed proteins are used. These partial hydrolysates are definitely capable of eliciting an allergic reaction in consumers allergic to the food source from which the hydrolysate was derived. For example, hot dogs formulated with a partially hydrolyzed casein ingredient, used for both emulsification and flavoring purposes, elicited adverse reactions in cow's milk-allergic children (14).

Lecithin

Lecithin is a commonly used food ingredient that has emulsifying and other useful properties in food formulations. Lecithin is a naturally occurring phospholipid. Lecithin is most often derived from soybeans, but can occasionally be derived from eggs, both of which are commonly allergenic sources. Lecithin is documented to contain residual protein (15, 16), although the amount of protein probably varies from lot to lot. Some allergists encourage soybean-allergic patients to avoid lecithin, while others do not. With the widespread use of lecithin in formulated foods, its avoidance can add great difficulties to the implementation of a soybean avoidance diet. The amount of information on the allergenicity of lecithin is scant. Evidence exists to indicate that commercial lecithin does contain soybean allergens (15, 16). However, the amount of soy allergens in commercial lecithin may be insufficient to elicit allergic reactions in most soybean-allergic individuals. However, when lecithin is used as a direct ingredient of formulated foods, it is recommended that the presence and source of the lecithin be declared on the ingredient statement.

Table 1. Common categories of food ingredients

Category	Examples
Preservative (antimicrobial)	Potassium sorbate, sodium benzoate
Preservative (antioxidant)	Butylated hydroxyanisole (BHA), propyl gallate
Preservative (antibrowning)	Potassium metabisulfite, sulfur dioxide
Flavors	Ethyl vanillin, cinnamic aldehyde
Colors	Tartrazine, carmine
Sweeteners	Sucrose, corn syrup
Non-caloric sweeteners	Aspartame, sucralose
Enzymes	Papain
Nutrients	Vitamin A, calcium gluconate
Starches and complex carbohydrates	Cornstarch, modified starch
Anticaking agent	Sodium aluminosilicate
Emulsifying agent	Lecithin
Sequestrant	Citric acid
Stabilizers and gums	Gelatin, locust bean gum, tragacanth gum
Acidulents	Phosphoric acid, hydrochloric acid
Leavening agents	Sodium bicarbonate
Flavor enhancers	Monosodium glutamate

Starch

Starch is extensively used in the formulation of a wide variety of food products. Starch is most frequently derived from corn, an uncommonly allergenic food. But, starch can also be derived from wheat, which is a commonly allergenic food and a food that is also implicated in the causation of celiac disease. Starch may contain trace levels of protein, although the proteins present in starch may be primarily proteins associated with the starch granule that are involved in starch biosynthesis. Starch granule proteins have not been associated with either IgE-mediated allergic reactions or celiac disease. Proteins in the albumin fraction of wheat have been identified as the principal allergens in IgE-mediated wheat allergies of the non-occupational type (17). The gluten fraction of wheat is responsible for the provocation of celiac disease (18). The levels of wheat albumins or gluten in wheat starch are unknown. The allergenicity of wheat starch to wheat-allergic

Table 2. Food ingredients derived from known allergenic sources

Ingredient	Allergenic sources(s)
Edible oils	Soybean, peanut, sunflower seed, sesame seed, cottonseed, tree nut
Protein hydrolysates	Soybean, peanut, milk, wheat
Lecithin	Soybean, egg
Starch	Wheat
Lactose	Milk
Flavors	Soybean, peanut, wheat, tree nut, milk, egg, fish, crustacean shellfish, others
Gelatin	Fish

subjects has not been clinically evaluated. Starch may also be derived from a variety of other sources, besides corn and wheat, including potato and tapioca. Although some of these other non-wheat sources of starch including corn and potato are known to be allergenic, the allergenicity of starch derived from these sources has not been documented.

Lactose

Lactose is a disaccharide derived from milk. Lactose intolerance is a well-defined metabolic food disorder (19). However, commercial lactose may contain trace residues of milk protein. The nature of these proteins has not been investigated but they would most likely be whey proteins since lactose is contained in the whey fraction of milk. Several whey proteins, including lactoglobulin and lactalbumin, are known milk allergens (20). However, allergic reactions to lactose have not been documented.

Flavors

Many of the ingredients used in foods are flavoring agents. A large number of different flavoring substances are used in foods. Commercial flavoring formulations can often contain dozens, if not hundreds, of different chemicals. Flavoring substances are rarely derived from known allergenic sources (21). Even when flavoring substances are derived from known allergenic sources, they may not contain proteins or allergens derived from those sources. In other cases they would contain such low levels of allergens and be used in such low concentrations in the formulated food that they would be unlikely to provoke allergic reactions even in potentially sensitive individuals.

Only a few reports exist of allergic reactions to flavors (21, 22). IgE-mediated allergic reactions from flavoring substances are even more rare. Gern et al. (14) described the cases of several milk-allergic individuals who had reactions to either hot dogs or bologna. These reactions were traced to the presence of milk proteins, specifically partially hydrolyzed casein, in the natural flavoring used in the formulation of the hot dogs and bologna. The presence of milk protein in the natural flavoring used in a dill pickle-flavored potato chip was the cause of allergic reactions in two milk-allergic consumers (23). The presence of peanut flour in the natural flavoring of a packaged soup elicited a severe reaction in a peanut-allergic patient (24). More such episodes may have occurred. Since the use of substances derived from allergenic sources is usually not revealed on food labels, physicians would not easily be able to identify flavoring components as the causes of allergic reactions.

Gelatin

The gelatin used in foods is most typically derived from beef and pork, which are rarely allergenic foods. However, gelatin derived from fish skins is used in some food applications, especially kosher foods. Skins from a variety of different fish are used as sources of fish gelatin. However, one of the most common sources is codfish skin. Cod is one of the most commonly allergenic fish (25). The presence of fish allergens in fish skin has not been documented. However, some muscle tissue may adhere to fish skins and the muscle tissue would definitely contain allergens. The gelatin-making process involves rather dramatic modification of the fish proteins. However, the impact of that processing on any fish allergens that might be present has not been documented. No allergic reactions have been documented to fish gelatin in processed, packaged foods. However, recent studies have indicated that both gelatin- and fish-allergic patients may have IgE antibodies that react with fish gelatin (26).

Food ingredients derived from cereal grains associated with celiac disease

Celiac disease is associated with ingestion of the gluten fractions of wheat, rye, barley and related grains (18). Celiac sufferers must avoid ingestion of these proteins and are often advised to avoid food ingredients derived from wheat, rye, barley and related grains (27).

Starch

As noted above, starch may be derived from wheat. The presence of wheat gluten in wheat-derived starch is a possibility but it has not been well documented. Although many celiac sufferers endeavor to avoid ingestion of wheat starch, the necessity of this avoidance is not well established.

Malt

Malt is derived from barley. Since malt is made from the sprouting seeds of barley, malt may contain the hordein (gluten) fraction of barley. Celiac sufferers are often advised to avoid malt as a result.

Alcohol

Alcohol can be derived from many sources but a common source is rye. Alcohol is often used a solvent in the formulation of flavors and other food ingredients. Although alcohol may be derived from rye, distilled rye alcohol is unlikely to contain any detectable protein, including the secalin (gluten) fraction. Although some celiac sufferers attempt to avoid rye alcohol in foods and alcoholic beverages, the wisdom of this approach is questionable.

Vinegar

Vinegar is often made from wheat. Vinegar has widespread uses as a food ingredient for its acidulent function. The process used to make vinegar would not be expected to allow the presence of detectable wheat protein in vinegar. Analysis of commercial vinegar samples confirmed that no wheat gluten was detectable in this product (28).

Food ingredients that may elicit allergic sensitization

Although not derived from known allergenic sources, some food ingredients are capable of eliciting allergic sensitization on rare occasions. Because of the low exposure to these food ingredients among most consumers, such sensitization is uncommon. As noted earlier, the following examples will be restricted to food ingredients capable of eliciting IgE-mediated reactions.

Carmine

Carmine and the related food ingredient, cochineal extract, are natural colorants with an intense red hue. Carmine and cochineal extract are derived from dried female insects of the species, *Dactylopius coccus* Costa, which lives as a parasite on the prickly pear cactus. Carmine does contain protein residues derived from this insect. Carmine has been implicated as a cause of allergic reactions in multiple case reports (29, 30). Many of these patients were sensitized from exposure to carmine in cosmetics or by ingestion of Campari™ (29, 31). A review on the allergenicity of natural colorants including carmine was recently published (29).

Annatto

Annatto is a natural colorant whose most common use is to provide the yellow color in some cheeses. A single case report of an IgE-mediated allergic reaction to annatto exists (32). This patient had a positive skin test to annatto extract, and an IgE-binding protein was identified in the annatto extract. As a seed extract, annatto probably contains protein residues, although the amount of such residues has not been assessed.

Gums

Many different types of gums are used in foods, including guar, tragacanth, xanthan, carrageenan, acacia, locust bean and alginate. Several of the most popular food gums including guar, tragacanth, acacia and locust bean are derived from legume sources. Several other members of the rather large legume family are commonly allergenic, including peanut and soybean. The food gums are primarily composed of complex polysaccharides, although residues of proteins can occur in the gums on occasion. Cross-reactivity with peanut or soybean allergy has not been described for any of the legume-based gums.

Allergic reactions from the ingestion of gums are rather infrequently reported. Several case reports of allergic reactions from gum tragacanth have appeared (33, 34), but no investigations have occurred on the nature of the allergens. Carrageenan has been implicated in a case of anaphylaxis resulting from its use in a barium enema (35), but allergic reactions have not been described from its use as a food ingredient.

Papain

Papain is a proteolytic enzyme used occasionally in the processing of foods. Papain is also the active ingredient in some commercial meat tenderizers. Allergic reactions to the ingestion of papain as an ingredient of foods or beverages have been rarely reported in the medical literature (36–39). A few individuals appear to have developed allergic sensitization to papain as a result of chemonucleolysis treatment with chymopapain. After chemonucleolysis, 36% of patients developed sensitization to chymopapain as evaluated by the skin-prick test (40). Some physicians advise these patients to avoid ingestion of papain and other exposures to papain (40). The prevalence of sensitivity to ingested papain among such patients is unclear. However, two of 15 chemonucleolysis patients in one study who became sensitized to chymopapain through the procedure experienced allergic reactions after ingestion of papain in a food or drug (36). Mansfield & Bowers (37) described a single patient with a severe systemic, IgE-mediated allergic reaction to papain used as a meat tenderizer. This individual had also experienced allergic reactions that may be attributable to the use of papain in beer. This individual had been exposed to papain only through foods and beverages. Subsequently, Mansfield et al. (38) evaluated the prevalence of papain allergy among 475 pollen-allergic subjects attending their allergy clinic. Five of the 475 patients (1.05%) had allergic reactions to papain as confirmed by a positive skin-prick test followed by a positive double-blind, placebo-controlled oral challenge. Three of these subjects had histories suggestive of papain-induced allergic reactions to meat tenderizers. In contrast, none of 25 individuals without pollen allergies had positive skin tests to papain (38).

Labeling issues associated with food ingredients

Since specific avoidance diets are the only effective

means to prevent allergic reactions to foods, the ingredient declaration on food labels transmits extremely important information to food-allergic consumers. These consumers must rely upon the completeness and accuracy of the ingredient declaration in making purchasing decisions. Of course, many foods are eaten in foodservice situations where the ingredient declarations on the food packages are not readily available. Because of those situations, it should not be surprising that many of the most severe food-allergic reactions occur in foodservice settings (41, 42). However, with packaged foods, the ingredient declaration assumes paramount importance in the protection of food-allergic consumers.

Ingredient labeling regulations differ significantly from one country to another. However, complete ingredient disclosure is not required by regulatory authorities anywhere in the world. This situation is somewhat understandable because formulated foods can contain dozens of individual ingredients, many of which are added at very low levels, such as the individual components of flavorings. However, from the perspective of the allergy community and for the protection of food-allergic consumers, the food industry should be widely encouraged to adopt certain labeling practices that may not be in force in all parts of the world. The presence of known allergenic foods, especially commonly allergenic foods, should always be declared in the ingredient statement. If an ingredient is derived from a commonly allergenic food, the source of that ingredient should be identified, e.g. hydrolyzed peanut protein, soybean lecithin, natural flavor (contains milk) or lactose (from milk). The only exceptions should be made for ingredients which contain no detectable protein from the allergenic source and which have been proven clinically to be safe, e.g. highly refined edible oils. If an ingredient is known to be allergenic even on a rare basis, such as carmine or papain, then it should be declared on the ingredient statement.

Recently, the Codex Alimentarius Commission has established a list of commonly allergenic foods including milk, eggs, fish, crustacean shellfish, peanuts, soybeans, wheat and tree nuts. The Commission has advocated that these foods should always be declared on the ingredient listing regardless of how much of the ingredient might be used in the formulated product. Furthermore, the Commission has advocated that the sources of any ingredients derived from these commonly allergenic foods should be revealed on the ingredient statement unless it can be clearly demonstrated that the ingredient is not allergenic. Finally, the Commission has recommended that the so-called 25% rule (where the individual ingredients of a component of a formulated food do not need to be declared on the ingredient listing unless the component constitutes more than 25% of the finished product) be modified to a 5% rule. All of these recommendations are quite positive and will be helpful to food-allergic consumers. But each individual country must adopt these recommended regulations before they can be enacted.

Some countries also allow precautionary labeling such as "may contain peanuts" and similar statements. Precautionary labeling usually results from the sharing of equipment within the food industry for products with several different formulations. If the shared equipment cannot be adequately cleaned, then use of precautionary labeling is prudent. However, the current regulatory situation relative to precautionary labeling varies widely around the world, which may confuse food-allergic consumers as they travel or purchase imported packaged foods. In Canada, Australia and New Zealand, precautionary labeling (specifically "may contain...") is expressly allowed and is widely encountered on packaged foods. In these countries, any of the commonly allergenic foods may appear in such precautionary statements. In the United Kingdom, precautionary labeling takes the form of "may contain nut traces" which is used to identify the potential existence of peanuts or the various tree nuts (even though peanuts are legumes and not nuts). The UK regulation does not provide for warnings about the possible presence of other commonly allergenic foods including milk, eggs, soybeans, etc. In the United States, precautionary labeling is not specifically allowed but the regulatory authorities have allowed such statements to be used voluntarily. In the US, many different statements of this type appear on food labels, including "may contain", "manufactured on shared equipment with" and "manufactured in the same facility as". The use of multiple statements in the US has some potential for consumer confusion. In the remainder of the world, we are not aware of the use of precautionary labeling even though similar manufacturing circumstances undoubtedly exist in those countries.

While precautionary labeling may be a good idea, its use should be strictly controlled. The food industry may choose to use this type of labeling more widely than would be necessary. In the US, the regulatory authorities have indicated that precautionary labeling cannot be used as a substitute for good manufacturing practices. That means that if the processor can effectively clean the shared equipment sufficiently, then precautionary labeling should not be used as a substitute for effective cleaning. If precautionary labeling is used too widely by the food industry, as has happened in some food categories in Canada, a consumer backlash may occur. Precautionary labeling should only be used in circumstances where contamination is documented, uncontrollable, sporadic and potentially hazardous.

References

1. Bush RK, Taylor SL. Adverse reactions to food and drug additives. In: Middleton E, Reed CE, Ellis EF, Adkinson NF, Yunginger JW, Busse WW, editors. Allergy – principles and practice, Volume II. St. Louis: Mosby, 1998;1183–1198.
2. Hourihane JO'B, Bedwani SJ, Dean TP, Warner JO. Randomized, double-blind, crossover challenge study of allergenicity of peanut oils in subjects allergic to peanut. Br Med J 1997;**314**: 1084–1088.
3. Taylor SL, Busse WW, Sachs MI, Parker JK, Yunginger JW. Peanut oil is not allergenic to peanut-sensitive individuals. J Allergy Clin Immunol 1981;**68**:372–375.
4. Bush RK, Taylor SL, Nordlee JA, Busse WW. Soybean oil is not allergenic to soybean-sensitive individuals. J Allergy Clin Immunol 1985;**76**:242–245.
5. Halsey AB, Martin ME, Ruff ME, Jacobs FO, Jacobs RL. Sunflower oil is not allergenic to sunflower-seed-sensitive patients. J Allergy Clin Immunol 1986;**78**:408–410.
6. Olszewski A, Pons L, Moutete F, et al. Isolation and characterization of proteic allergens in refined peanut oil. Clin Exp Allergy 1998;**28**:850–859.
7. Hoffman DR, Collins-Williams C. Cold-pressed peanut oils may contain peanut allergen. J Allergy Clin Immunol 1994;**93**:801–802.
8. Kanny G, de Hauteclocque C, Moneret-Vautrin DA. Sesame seed and sesame seed oil contain masked allergens of growing importance. Allergy 1996;**51**:952–957.
9. Teuber SS, Brown RL, Haapanen LAD. Allergenicity of gourmet nut oils processed by different methods. J Allergy Clin Immunol 1997;**99**:502–507.
10. Hefle SL, Taylor SL. Allergenicity of edible oils. Food Technol 1999;**53**(2): 62–68, 70.
11. Businco L, Dreborg S, Einarsson R, et al. Hydrolysed cow's milk formulae. Allergenicity and use in treatment and prevention. An ESPACI position paper. Pediatr Allergy Immunol 1993;**4**:101–111.
12. Bock SA. Probable allergic reaction to casein hydrolysate formula. J Allergy Clin Immunol 1989;**84**:272.
13. Saylor JD, Bahna SL. Anaphylaxis to casein hydrolysate formula. J Pediatr 1991;**118**:71–74.
14. Gern JE, Yang E, Evrard HM, Sampson HA. Allergic reaction to milk-contaminated "non-dairy" products. N Engl J Med 1991;**324**:976–979.
15. Muller U, Weber W, Hoffmann A, Franke S, Lange R, Vieths S. Commercial soybean lecithins: a source of hidden allergens? Z Lebensm Unters Forsch 1998;**207**:341–351.
16. Gu X, Beardslee T, Zeece M, Sarath G, Markwell J. Identification of IgE-binding protein in soy lecithin. Int Arch Allergy Immunol (submitted).
17. Varjonen E, Savolainen J, Mattila L, Kalimo K. IgE-binding components of wheat, rye, barley and oats recognized by immunoblotting analysis with sera from adult atopic dermatitis patients. Clin Exp Allergy 1994;**24**:481–489.
18. Ferguson A. Gluten-sensitive enteropathy (celiac disease). In: Metcalfe DD, Sampson HA, Simon RA, editors. Food allergy – adverse reactions to foods and food additives, 2nd edn. Boston: Blackwell Science, 1997:287–301.
19. Suarez FL, Savaiano DA. Diet, genetics, and lactose intolerance. Food Technol 1997;**51**(3):74–76.
20. Savilathi E, Kuitunen M. Allergenicity of cow milk proteins. J Pediatr 1992; **121**:S12–S20.
21. Taylor SL, Dormedy ES. The role of flavoring substances in food allergy and intolerance. Adv Food Nutr Res 1998; **42**:1–44.
22. Taylor SL, Dormedy ES. Flavoring and colorings. Allergy 1998;**53 (Suppl 46)**:80–82.
23. St Vincent JCM, Watson WTA. Unsuspected source of cow's milk protein in food. J Allergy Clin Immunol 1994;**93**:209.
24. McKenna C, Klontz KC. Systemic allergic reaction following ingestion of undeclared peanut flour in a peanut-sensitive woman. Ann Allergy Asthma Immunol 1997;**79**:234–236.
25. Aas K. Studies on hypersensitivity to fish. A clinical study. Int Arch Allergy Appl Immunol 1966;**29**:346–363.
26. Sakaguchi M, Toda M, Ebihara T, et al. IgE antibody to fish gelatin (type 1 collagen) in patients with fish allergy. J Allergy Clin Immunol 2000;**106**: 579–584.
27. Hartsook EI. Celiac sprue: sensitivity to gliadin. Cereal Foods World 1984;**29**: 157–158.
28. Hefle SL, Schneekloth-Goodwater K, Taylor SL. Gluten content of various foods and food ingredients. J Allergy Clin Immunol 1998;**101**:S92.
29. Lucas CD, Taylor SL, Hallagan JB. The role of natural color additives in food allergy. Adv Food Nutr Res 2001;**43**:195–216.
30. Baldwin JL, Chou AH, Solomon WR. Popsicle-induced anaphylaxis due to carmine dye allergy. Ann Allergy Asthma Immunol 1997;**79**:415–419.
31. Kagi MK, Wuthrich B, Johansson SGO. Campari-Orange anaphylaxis due to carmine allergy. Lancet 1994;**344**: 60–61.
32. Nish WA, Whisman BA, Goetz DW, Ramirez DA. Anaphylaxis to annatto dye: a case report. Ann Allergy 1991; **66**:129–131.
33. Danoff D, Lincoln L, Thomson DMP, Gold P. "Big Mac attack". N Engl J Med 1978;**298**:1095–1096.
34. Brown ED, Crepea SB. Allergy (asthma) to ingested gum tragacanth. J Allergy 1947;**18**:214–215.
35. Tarlo SM, Dolovich J, Listgarten C. Anaphylaxis to carrageenan: a pseudo-latex allergy. J Allergy Clin Immunol 1995;**95**:933–936.
36. Hall BB, McCullough JA. Anaphylactic reactions following the intradiscal injection of chymopapain under local anesthesia. J Bone Joint Surg 1983;**65A**:1215.
37. Mansfield LE, Bowers CH. Systemic reaction to papain in a nonoccupational setting. J Allergy Clin Immunol 1983; **71**:371–374.
38. Mansfield LE, Ting S, Haverly RW, Yoo TJ. The incidence and clinical implications of hypersensitivity to papain in an allergic population, confirmed by blinded oral challenge. Ann Allergy 1985;**55**:541–543.
39. Wiewrodt R, Stein J, Kühn A, Buhl R, Casparv W. Sensitizations due to aspergillus derived enzymes and papain in patients with Crohn's disease. J Allergy Clin Immunol 1995;**95**:328 (abstract).
40. Moneret-Vautrin DA, Feldmann L, Kanny G, Baumann A, Roland J, Pere P. Incidence and risk factors for latent sensitization to chymopapain: predictive skin-prick tests in 700 candidates for chemonucleolysis. Clin Exp Allergy 1994;**24**:471–476.
41. Yunginger JW, Sweeney KG, Sturner WQ, et al. Fatal food-induced anaphylaxis. J Am Med Assoc 1988;**260**:1450–1452.
42. Sampson HA, Mendelson L, Rosen J. Fatal and near-fatal anaphylactic reactions to foods in children and adolescents. N Engl J Med 1992;**327**:380–384.