

FOOD SAFETY

The terms *food quality* and *food safety* are often used interchangeably, it is important for the food industry professional to distinguish between them. Food quality is the extent to which the all the established requirements relating to the characteristics of a food are met. Food safety is the extent to which those requirements relating specifically to characteristics or properties that have the potential to be harmful to health or to cause illness or injury are met. Some food quality characteristics (e.g., counts of total bacteria, coliform bacteria) can be used as indicators of food safety, although they are not considered specifically as food safety characteristics. This distinction between food quality and food safety needs to be made, primarily because of the much greater importance that must be attached to protecting consumers from food-borne illnesses or injuries. A food that does not conform to the food safety requirements automatically does not conform to the food quality requirements. On the other hand, a food can conform to the food safety requirements, but not conform to the other quality requirements.

Food safety as part of food quality

In the food industry, food safety principles and practices have always been integrated into activities identified within quality assurance or quality control programs, or within quality management systems; therefore, these programs and systems can address both food quality and food safety simultaneously. The more recent use of HACCP systems in some food companies has resulted in a well-defined set of activities that are specifically devoted to food safety. The principles and practices of the HACCP system are similar to those of quality systems and, therefore, the specific activities required by the HACCP system can be integrated within quality systems. A food company that operates with a quality management system can be expected to have an HACCP system that is devoted specifically to food safety as an integral part of its quality management system. A food company that does not operate with the HACCP system must continue to incorporate food safety activities and GMPs within its existing quality program or quality system.

Food safety

Food safety is the assurance that food will not cause harm to the consumer when it is prepared and eaten according to its intended use. All requirements relating to the safety characteristics of a food must be met; there must be no unacceptable health risk associated with a food. The assurance that a food will not cause harm, injury, or illness is determined by:

1. whether all harmful substances present in the food have been eliminated, reduced to an established acceptable level, or prevented from exceeding the acceptable level; and
2. the food has been prepared, handled, and stored under controlled and sanitary conditions in conformance with practices prescribed by government regulations. The harmful substances in foods are food safety hazards. The prescribed conditions and practices for preparing, handling, and storing food are considered GMPs.

Systems and programs for food safety

For decades, the food industry has depended on the use of quality programs based on inspection and testing of food products for hazards, and on GMPs for addressing food safety. Since the late 1980s, there has been widespread use of the HACCP system specifically to achieve food safety; the system addresses food safety primarily on the basis of prevention or elimination of unacceptable hazard levels. The GMPs, which were used to address food safety requirements prior to the use of the HACCP system, have been incorporated into prerequisite programs for the HACCP system. A food company that does not operate with the HACCP system must continue to use the GMPs.

Food laws and regulations

The legal requirements for food safety and food quality have been established by many national governments, with the objective of protecting consumers and ensuring that foods are fit for human consumption. These requirements are contained in food laws and regulations, the scope of which varies from one country to another. In the U.S. and Canada, food laws and regulations govern all aspects of food safety and some aspects of food quality. The food laws and regulations of the U.S. are likely the most extensive of any country. It is essential that food industry professionals be familiar with the laws and regulations that govern their specific industry sectors in their countries.

The legal framework of food laws and regulations of a particular country depends on the overall government regulatory system of that country. These food laws and regulations are intended to ensure that foods do not cause harm, illness, or injury; are not adulterated or misbranded; and are wholesome and fit for human consumption. Food laws and regulations apply to all foods produced domestically, as well as all foods imported into a country; foods cannot be imported if they do not conform to the food laws and regulations of the importing country.

Food laws protect consumers from illnesses and injury by prohibiting the presence of any poisonous or harmful substance in foods that are intended for human consumption. For example, in the U.S., adulterated food is regulated primarily under the FDCA, which covers all aspects of food safety and certain aspects of food quality. In addition, food laws protect consumers from fraud and deception by prohibiting false or misleading information relating to foods. For example, in the U.S., misbranded food is prohibited under the FDCA.

Enforcement of food laws and regulations

The responsibility for enforcing food laws and regulations is assigned to government regulatory agencies. These enforcement activities fall into two categories. First, they include inspection and audit of establishments that process, handle, and store food to ensure that the required sanitary and controlled conditions are followed; audits are used by some regulatory agencies that enforce HACCP-based regulations. Second, they include inspection and analysis of

foods for harmful substances to ensure that there is conformance to established limits and tolerances.

Despite efforts of government agencies to enforce food laws and regulations, misbranded foods or foods that cause harm or have the potential to cause harm sometimes enter the food distribution chain or the consumer market. Whenever a misbranded food is detected, a harmful substance or agent is detected in a food, it is determined that there is a likelihood for a harmful substance or agent to be present in a food, or an actual food-borne illness or injury occurs, food companies and government regulatory agencies take the necessary action to protect consumers against these violations. These situations often result in the food being recalled from the marketplace. In addition, if it is determined that adulterated or misbranded food has been produced as a result of negligence on the part of a food company, legal action can be taken against the company.

Food standards

In addition to food laws and regulations, food standards also establish requirements for the safety and quality of foods; however, unless a food standard is part of food regulations, it is not a legal requirement. The Codex Standards are the best examples of food standards. The Codex Alimentarius Commission has the mandate to implement the joint Food and Agricultural Organization (FAO)/ World Health Organization (WHO) Foods Standards Program. This has resulted in the Codex Alimentarius, a collection of standards for food quality, food suitability, and food safety. These food standards have been adopted by countries worldwide and are intended primarily to protect consumers and to facilitate international food trade. They include codes of practice such as The Codex General Principles of Food Hygiene, standards for maximum residual levels (MRL) for pesticides and for veterinary drugs in foods, and standards for specifications for food additives.

Food safety and hazards in foods

The safety of a food can be related directly to certain harmful substances that are present in the food; these substances are food safety hazards. Any substance that is reasonably likely to cause harm, injury or illness, when present above an established acceptable level, is a food safety hazard. An unacceptable level of a food safety hazard in a food presents a health risk to the consumer. Food-borne illnesses from food safety hazards occur frequently; each year a relatively large number of deaths attributed to these hazards occur among North American consumers.

There are three recognized categories of food safety hazards: biological hazards, chemical hazards, and physical hazards. The origin of these hazards in foods can be from naturally occurring substances or agents in foods, from deterioration or decomposition of foods, or from contamination of the foods with the hazard at various stages of their production, harvesting, storing, processing, distribution, preparation, and utilization. For many hazards, government regulatory agencies have established an acceptable level of the hazard in a food; the Codex Alimentarius has also established acceptable levels of certain hazards as part of its Food

Standards Programme. For some hazards, such as pathogenic bacteria (e.g., *Salmonella* spp.), there is zero tolerance; this means that the presence or the detection of the hazard in the food is unacceptable. The strategies used to address hazards in foods include the prevention or elimination of hazards, or the reduction of hazards to acceptable levels. These strategies are employed in the HACCP system.

Food safety hazards and health risk

For a known food safety hazard, the extent of the harmful effects of the hazard on the health of the consumer is established by risk analysis and by hazard analysis. Risk analysis is usually conducted by a national food or health regulatory agency and addresses a public health concern regarding a particular food safety hazard associated with a sector of the food industry. A risk analysis is comprised of risk assessment, risk management, and risk communication. A primary objective of risk analysis is to establish a national food safety objective for a hazard in a food. The food safety objective for a hazard is the maximum frequency and concentration of a hazard in a food at the time of consumption that provides the appropriate level of protection from the hazard. The food safety objective can be considered as the maximum acceptable level for the hazard in a food.

At the level of production, processing, handling, or storage, a food company performs hazard analysis as part of the development of an HACCP plan for the food. Hazard analysis is the first of the seven HACCP principles, and is performed to determine the health risk associated with a hazard present in a food when it is produced, processed, handled, or stored, according to an established sequence of steps at a particular location. Once a food safety objective for a hazard has been established by risk analysis, it must be considered during the hazard analysis step of HACCP plan development.

Biological hazards in foods

1. Pathogenic bacteria

Food-borne pathogenic bacteria are responsible for a large proportion of food poisoning incidents in North America. Therefore, the importance of this group of hazards must be emphasized. More than forty different pathogenic bacteria are known; however, a large proportion of the reported cases of food poisoning can be attributed to the following pathogenic bacteria: *Salmonella* spp., *Escherichia coli* 0157:H7, *Listeria monocytogenes*, *Clostridium perfringens*, *Clostridium botulinum*, *Staphylococcus aureus*, and *Campylobacter jejuni*.

Food poisoning from these organisms occur frequently, with symptoms that include headache, muscle pain, nausea, fatigue, chills or fever, stomach or abdominal pain, vomiting, and diarrhea. Numerous severe and fatal illnesses occur as a result of food poisoning from pathogenic bacteria; infants and the elderly are particularly vulnerable. The foods that are commonly involved in these food poisoning incidents include meat and poultry and their products, seafood and seafood products, egg and egg products, milk and dairy products, fruits and vegetables and their products, low-acid canned foods, and water.

2. Viruses

Foods can be the medium for transmission of certain viruses. Examples of viruses that are known to be food safety hazards are the hepatitis A and E viruses, the Norwalk group of viruses, and rotavirus.

3. Parasites

Several human parasites can be transmitted by foods. The most common human parasites include parasitic protozoan species (e.g., *Entamoeba histolytica*, *Giardia lamblia*, *Cryptosporidium parvum*), and parasitic worms (*Ascaris lumbricoides*, *Taenia solium*, *Trichinella spiralis*).

Chemical hazards in foods

1. Permitted food additives

Government regulations permit numerous chemical and biochemical substances to be added to foods at specified maximum levels. These substances are intended to impart some improved nutritional effect (e.g., vitamin fortification) or some specific technical function (e.g., preservative action, sensory attribute, stabilizing effect, etc.). Permissible food additives with their established levels for use can be found listed in government food regulations. In addition, the Codex Alimentarius contains specifications of permitted food additives. Although food additives are permitted by government regulations, many can be harmful if they are present in the food at levels above the maximum established, and are therefore, potential chemical hazards. In some instances, a permitted food additive present below the maximum allowable level in a food can be a health hazard for specific segments of the population. For example, sodium bisulfite is a permitted food additive in some foods; however, individuals who are asthmatic could be at risk from foods containing sodium bisulfite. The labels on the containers containing the foods must clearly indicate the presence of the additives for the benefit of individuals who may be at risk from these additives.

2. Naturally occurring harmful compounds

It is well known that many foods contain as their normal or inherent components naturally occurring substances that can be harmful if they are present in excess of certain levels; examples are oxalate in rhubarb, alkaloids in potatoes, toxins in mushrooms and in shellfish. In the U.S., the FDCA considers foods containing these naturally occurring substances to be adulterated only if the harmful substance is present in sufficient quantity that is likely to cause illness.

3. Unavoidable contaminants

Some foods can contain naturally occurring harmful substances that are not normal or inherent components of the foods. These substances are considered unavoidable contaminants in the food and cannot be removed through processing or manufacturing practices; examples are aflatoxins from molds in peanuts and in some cereals. If the normal level of a naturally occurring harmful

substance in a food is increased to an unsafe level as a result of mishandling of the food or by any other action, then the harmful substance can be considered as an added harmful substance.

4. Agricultural residues

Agricultural residues are a group of residual chemical or biochemical substances found in foods and are directly attributable to certain substances that have been approved for use in the production of crops and livestock for food. They include residues of permitted pesticides, herbicides, fungicides, drugs, hormones, and antibiotics. Some of these residues are considered as added harmful substances attributable to human actions and are regulated by governments. The Codex Alimentarius establishes maximum residual levels (MRL) for various harmful pesticides and veterinary drugs.

5. Industrial contaminants

Several harmful chemicals that enter the environment as a result of industrial activity have been shown to be present in foods. These substances include heavy metals (lead, mercury, arsenic), organo-chlorinated compounds such as polychlorinated biphenyls (PCBs), and are considered as industrial or environmental contaminants.

6. Chemical residues

In food processing operations, some chemical compounds that are not permitted substances in food are used during certain operations and care must be taken to prevent unintentional contamination. These substances include chemical compounds used for cleaning and sanitizing food contact surfaces of processing, handling, and storage equipment, and for lubricating certain parts of food processing equipment.

7. Prohibited chemicals

No chemical substance is permitted for use in a food unless it meets all of the requirements that are covered in the applicable food laws and regulations.

8. Food allergens

Certain foods are known to contain inherent components that cause serious immunological, allergic responses in a relatively small proportion of food consumers. These foods are entirely safe for most consumers who are not sensitive to the allergens. The following foods and some of their products are generally considered to be the most common food allergens: peanuts, soybeans, milk, eggs, fish, crustacea, tree nuts, and wheat. Some other foods (e.g., sesame seeds) are also known to cause allergenicity occasionally. In addition, sulfites (including bisulfites and metabisulfites) used as ingredients in certain foods can produce nonimmunological allergic reactions in certain sensitive individuals.

Physical hazards in foods

Physical hazards include organic or inorganic substances, commonly referred to as foreign objects, foreign matter, or extraneous materials. Hard and sharp physical hazards are of particular concern. Depending on their size and dimensions, hard and sharp physical hazards can cause injury to the mouth or teeth, or can cause serious injuries if swallowed. In addition, some physical hazards, depending on their size, shape, and texture, have the potential to cause choking if swallowed. Physical hazards in foods can be particularly harmful to infants.

Certain hard and sharp foreign objects that are natural components of food (e.g., prune, date or olive pits; fish bones nutshells) are not considered physical hazards since it is expected that the consumer will be aware that these objects are natural components of the foods. However, if the food carries a label stating that the hard and sharp object has been removed (e.g., pitted prunes), the presence of the hard and sharp object in the food represents a hazard, since it is not expected by the consumer.

The common hazards considered as avoidable physical hazards in foods include broken glass, pieces of hard or soft plastic materials, stones, pieces of metal, pieces of wood, and personal articles.

1. Broken glass

In a food plant, the common potential sources of broken glass include light bulbs, glass containers, and gauges with glass covers. Every effort must be taken to protect or eliminate these sources of broken glass, and to protect food from contamination with this hazard. In addition, many foods are packaged, distributed and sold in glass containers. For these foods, the glass packaging itself can be a source of broken glass.

2. Plastic

Both hard and soft plastic foreign objects are sometimes found in foods. In some food plants, some utensils and tools used for cleaning of equipment are made from hard plastic material; this type of plastic can become brittle from use over an extended period of time, and pieces can adulterate foods. The common sources of soft plastic foreign objects in food are plastic material used for packaging food and gloves used by employees who handle food.

3. Metal pieces

The most common sources of metal pieces in a food plant are food processing equipment, metallic cleaning tools, and equipment maintenance activities. In many food plants, magnets are used to eliminate some metals from foods, and metal detectors are used to detect the presence of metals in foods.

4. Wood pieces

The most common sources of wood pieces in a food plant are wood structures and wood pallets. The presence of these sources should be avoided whenever possible in food processing and production.

5. Stones

Many plant foods and particularly field crops such as peas and beans can contain small stones that become incorporated with the foods during harvesting. In addition, in food processing plants, a common source of stones is concrete structures, particularly concrete floors.

6. Personal articles

A variety of personal articles can become foreign objects in foods, resulting from unintentional adulteration by employees during preparation, handling, processing, and packaging. Personal articles that have been found in foods include jewelry, pens or pencils or their parts, Band-Aids, and ear plugs.

Other food safety concerns

In addition to the known food safety hazards that can be classified as biological, chemical and physical hazards, there are several other specific food safety concerns. These include concerns relating to the safety of foods from biotechnology and particularly from genetically modified organisms, the safety of irradiated foods, and the safety of some herbal supplements and botanical products. The safety of these foods, like all other foods, is covered by food laws and regulations. In the food industry, the established food safety principles and practices must also be applied to these food safety concerns.