# CHEMICAL AND PHYSICAL HAZARDS: THE "OTHER" FOOD SAFETY RISKS

BY LARRY KEENER

*All foods are potentially susceptible to contamination by these hazards.*

The Hazard Analysis & Critical Control Points (HACCP) concept for food safety requires control over hazardous materials and other substances in foods that would render them injurious to the public health. The primary focus of the strategy is the control and elimination of critical biological, chemical and physical matter from the food supply.

Microbiological hazards are by far the primary food safety concern. On an annual basis, there are upwards of 5,000 deaths and as many as 80 million cases of foodborne disease reported in the U.S. The cost of this human suffering for industry, government and society is estimated at $20 billion per year. Many HACCP plans focus almost exclusively on microbiological control. For example, the U.S. Department of Agriculture's (USDA) mandatory HACCP program focuses on pathogen reduction in meat and poultry products. The U.S. Food and Drug Administration's (FDA) long-standing low acid canned food regulations, considered by many to be the first mandatory HACCP program, focuses exclusively on the control of *Clostridium botulinum*. Similarly, the seafood program is focused on microbial control.

For a majority of U.S. food companies, the detection of extraneous materials or foreign objects in their products is the leading source of consumer complaints, which frequently involve reports of injury or illness. Many of these result in regulatory action, or worse, expensive lawsuits. There are great costs associated with managing and litigating these incidents.

Reports of chemical contamination, while less frequent than either microbiological or physical complaints, can be striking and immediate. The case this past summer involving dioxin in foods in northern Europe is an excellent and compelling example of the devastating impact of dangerous chemical residues in the food supply.

The literature on food safety and HACCP reflects the concern for microbial control. The standard references used by many HACCP authorities are either those of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF), or the International Commission on Microbiological Specifications for Foods (ICMSF). There is an abundance of well-written papers, journal articles and books on the subject of microbial control and food safety. By comparison, there is relatively little in the literature related to control of harmful chemicals and physical matter in the food supply.

In the process of developing a food safety program or HACCP plan, it is important to include both physical and chemical hazards. Presented here are strategies for the identification and control of these hazards. The collective contributions of effective quality control (QC) procedures, sanitation programs, good manufacturing practices (GMPs), and their impact on the control of these hazards will also be discussed.

## PHYSICAL HAZARDS

Physical hazards result from the inadvertent inclusion of harmful extraneous materials in the final product. Typically, extraneous materials are the leading source of consumer complaints. Physical hazards may involve a wide variety of objects, such as those listed in Table 1. Any foreign material with the potential for inducing injury or illness must be considered hazardous. Pits, seeds and stems, and the components of many food ingredients or raw materials must be viewed as hazardous due to their potential for causing bodily harm. Raw materials known to contain such components must be considered sensitive and rated appropriately during the risk assessment process.

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| • Broken glass | • Shards of stainless steel |
| • Nails | • Duct tape |
| • Machinery parts | • Wooden splinters |
| • Wire | • Stones |
| • Seeds and pits | • Metal filings |
| • Building materials | • Jewelry |
| • Plant matter (stems, twigs, bark) | • Ink pens |
| • Pencils | • Paper clips |
| • Staples | • Solder slag |
| • Coins | • Nuts/ bolts |
| • Screws | |

*Table 1. Physical hazards include a wide variety of materials.*

The majority of all reported incidents of illness or injury related to physical contaminants involve dental complaints, oral injury or laceration, trauma to the esophagus, abdomen or other associated organs of the alimentary canal. Fortunately, these incidents are seldom life-threatening. Physical hazards are a matter of

REPRODUCED FROM FOOD TESTING & ANALYSIS, JUNE/JULY 2001, WITH PERMISSION OF THE PUBLISHERS.

public health and must be identified in the HACCP plan.

The primary sources of physical hazards may include the manufacturing environment, raw materials and ingredients, plant equipment, contractors and employees. The strategies employed for the control of foreign materials are as wide-ranging as the sources, and often include on-line visual inspection, in-line metal detection, the use of magnets, on-line automated vision systems, X-ray technology, and screens, filters and sieves. Employee training programs and Good Manufacturing Practices (GMPs) are also cornerstones of a physical hazard control approach. Many companies employ an integrated approach to foreign material control. That is, they use some or all of these elements in a comprehensive strategy to preclude inclusion of harmful extraneous materials in finished products.

Control of physical contaminants begins with the identification of raw materials or components that are at risk. An effective control program must include support from vendors and suppliers. The magnitude of the potential threat will dictate the appropriate control strategy. A vision system or X-ray inspection may be warranted for the control of glass contamination, while a properly calibrated metal detector may be effective against both ferrous and nonferrous metals contaminants. Human inspection may be required for the detection and removal of dangerous pit and stems.

Control of physical hazards should also involve the company's GMP program. Proper training of plant personnel is key to preventing product contamination. Likewise, proper maintenance of the buildings, facilities, grounds and processing equipment will help to further reduce the risk of foreign materials in the finished product. Ultimately, the selection of the proper control strategy and technology will be determined by product characteristics and the nature of the hazard.

### CHEMICAL CONTAMINANTS

Much like the physical hazards, chemical hazards are most often associated with raw materials, ingredients and personnel practices. Unlike physical hazards, chemicals are far more insidious and therefore, more difficult to detect and exclude from a manufacturing process. In fact, many of the ingredients, additives, process aids, flavor and color compounds, sanitizers, lubricants and adhesives commonly used in the food industry are potentially dangerous and capable of causing human illness. When considering chemical hazards, the food safety plan must also include food allergens. Potential sources for chemical hazards associated with foods and food processing operations are listed in Table 2.

In evaluating chemical hazards, it is important to consider the toxicology of the substance under review and the likelihood that it will be harmful to the target population. The risk assessment procedures used in HACCP to identify microbiological hazards should also be employed to identify sensitive ingredients, raw materials packaging components or sanitation chemicals that may be agents in the transmission of chemical residues along the food chain.

Every chemical possesses some degree of inherent toxicity, a property of the chemical that, in many cases, is as distinctive as its physical and chemical properties and that guarantees, within reasonable limits, that the chemical will always behave in the same manner regardless of the species to which it is exposed.

In order to estimate the potential hazard of any chemical, one must begin with the degree or level of toxicity in conjunction with an estimation of exposure:

Hazard = Toxicity (inherent) x Exposure (level x duration)

As expressed, exposure represents the amount of the agent or substance necessary to cause a biological effect. A typical, theoretical dose-response relationship is presented in Figure 1. As illustrated, the response is the number of individuals, expressed as a percentage, responding over a range of low-to-high dosages. For example, when exposed to Vitamins A or D at extremely high doses, a toxic effect is observed in nearly 100% of the exposed population. By contrast, at a low dose there may be zero or only a small percentage of the exposed population showing an adverse effect to its exposure.

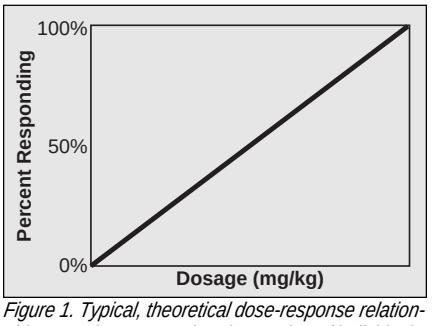


*Figure 1. Typical, theoretical dose-response relationship. Dose is expressed as the number of individuals, as a percentage, responding over a range of low-to-high dosages. (After: D.J. Ecobichon,* Foodborne Disease Handbook, *Vol. 3, 1994.)*

Development and execution of effective chemical control strategies require the efforts of research and development (R&D), manufacturing, sanitation, quality assurance and purchasing personnel, as well as vendors, suppliers, regulators and the company's food safety office. Food companies must work closely with growers, intermediate handlers and transporters to ensure that the chemical integrity of ingredients and raw materials are maintained. Moreover, it is imperative that foods are purchased from safe sources. Many food companies require suppliers to provide "letters of guarantee." These documents are intended to confirm that the supplier is aware of, and fully compliant with, specific food safety regulations

- Packaging materials
- Packaging inks
- Adhesives
- Vitamins (A, D, E, K)
- Oxidizing agents (H202)
- Nut protein
- Dairy products
- Eggs
- Color additives
- Artificial flavors
- Artificial sweeteners
- Lubricants
- Solvents
- Paint
- Belt dressings
- Caustic compounds
- Hydraulic fluids
- Cleaning and sanitizing agents
- Pesticide residues (industrial and agricultural)

*Table 2. Potential sources for chemical hazards associated with foods and food processing operations.*

related to the ingredient or component that they provide. Other companies use much more comprehensive documentation schemes to safeguard against illegal or extraneous chemical residues in the materials that they purchase. These documents are used for chemical control in both packaging materials and foodstuffs and are typically very detailed, requiring specialist skills for their completion. Proper execution of these documents is a requirement of doing business.

If food or food materials are imported, it is essential that they are evaluated in the country of origin prior to shipment to the U.S. Illegal pesticide residues, volatile organic compounds, heavy metals, or dioxins may be issues with foreign-sourced food products. For example, in many countries DDT residues persist in the environment (even though the compound has not been used in agriculture for years) and residues will frequently be detected in crops grown on contaminated soil. There are also a significant number of other economic poisons that are approved for use (direct crop application) outside the U.S. that are in conflict with current U.S. food safety standards.

Packaging materials may also represent a significant source of undesirable chemicals. These materials must be closely reviewed to determine compatibility with finished products. It is important to ascertain whether the packaging components contain recycled materials. Recycled paper products, for example, may contain polychlorinated biphenyls (PCBs), dioxin or other substances that will render them incompatible and unsafe for use with foods or in food production operations. Inks, adhesives and polymers at the food contact surface must be scrutinized to determine the potential for migration or leeching with the corresponding development of migration products within the food. The risk assessment must be extended to all forms of packaging, including metal cans, metal closures, paper overwrappers, flexible packaging, and corrugated packaging materials.

Sanitation and maintenance chemicals also represent potential sources for chemical contamination. The acids, caustics and other substances commonly used for cleaning, disinfecting and maintaining the plant environment and processing equipment are hazardous substances. In addition, many of the compounds used in the sanitation program closely resemble food ingredients in their physical appearance (white, crystalline or granular powders). Thus, it is imperative that cleaning and sanitation compounds are never stored in anything other than their original, labeled containers. Moreover, sanitation chemicals should be stored in a secured area of the plant and away from stored foods, ingredients and packaging materials. Use of sanitation and cleaning chemicals must strictly adhere to labeled instructions and the chemicals should only be used by properly trained or authorized plant personnel.

Use of lubricants, solvents, hydraulic fluids, machinery oil and similar compounds are a fact of life for food processors. It is also true that the use of these materials may give rise to adulterated or dangerous products. First, the processor must assure that only USDA-approved chemicals are received into the plant. Second, the processor should provide training for maintenance personnel and other employees in the proper use and application of maintenance chemicals. Finally, the processor should insure that the design of all sensitive processing equipment is such that the product zones are not at risk of contamination by maintenance chemicals.

## Staying Vigilent is Key

Potential sources of physical and chemical contaminants are pervasive in the growing, transporting, processing, distribution and selling of food products. Physical contamination, involving harmful extraneous materials in processed foods, is the leading cause of consumer complaints for most processors. Chemical contamination is not a common source of complaints; however, when chemical contamination occurs, the results are immediate and often drastic.

Effective control of foreign materials in both the physical and chemical aspects of the food supply must involve all elements of the manufacturing supply chain: growers, sellers, transporters, storage facilities, food processors and retailers. The selection of an appropriate control strategy must consider both the intrinsic characteristics of the product and the nature of the hazard. Control of chemicals within the manufacturing environment is critical for preventing contamination of ingredients, packaging and finished goods. The chemical control program should include maintenance, contractors, sanitation, warehousing, transportation and line workers. Training is key to the success of the chemical control effort. The combined contributions of the sanitation program, the quality control program, and adherence to GMPs are critical to the control and elimination of physical and chemical hazards in food processing operations.

Assessing the safety of food products is a tedious business. Judging the safety of a product from a microbiological perspective is difficult at best. However, it is relatively straightforward, given knowledge of the intrinsic properties of a food, the method of preservation, type of packaging and mode of distribution, to assess its vulnerability to pathogenic organisms. By contrast, chemical and physical hazards have no such limitations or boundaries. All foods are potentially susceptible to contamination by chemical or physical hazards.

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## Bibliography

1. Smith, M. Basic requirements of risk evaluation and standard setting. In *Food Safety and Toxicity*, pp. 229-240. J. DeVries, ed. CRC Press. 1997.
2. Gorham, R.J. Hard foreign objects in food as a cause of injury and disease: a review. In *Foodborne Disease Handbook,* Vol. 3. Marcel-Dekker. 1994.
3. Ecobichon, D.J. *The Basis Of Toxicity Testing* pp. 7-20. CRC Press. 1992.
4. Shibamoto, T. and F.B. Leonard. *Introduction to Food Toxicology*, pp. 1-6. Academic Press. 1993.