



A Farmer's Guide to Biological, Chemical, and Physical Food Adulteration

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We know that living organisms such as bacteria, viruses, pathogens, and fungi have the potential to make us sick, especially when these are in the food we eat and in concentrations beyond our tolerance. But did you know foodborne illnesses could also result from consuming food that has been *adulterated* by physical, chemical, or other biological hazards not normally found in food or at levels that can make us sick? As a professional food producer it is important to be mindful and attentive to these types of risk factors and to take proactive steps every day to reduce them

What is meant by *adulterated*? “Adulteration” is a legal term for a food product that fails to meet federal or state standards for health and safety as determined in the U.S. by the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA). According to the Federal Food, Drug, and Cosmetic (FD&C) Act



of 1938, when fruits and vegetables have been found to be adulterated, it could mean that the produce 1) contains any poisonous or harmful substance that may cause injury to our health; 2) contains a pesticide chemical residue that is unsafe; 3) contains an unsafe food additive; 4) contains an unsafe color additive; 5) consists, in whole or in part, of “any filthy, putrid, or decomposed substance” or is otherwise unfit for food; or (6) has been prepared, packed, or held under unsanitary conditions (insect, rodent, or bird infestation)

whereby it may have become contaminated with filth or rendered injurious to health.¹ For example, the presence of *Salmonella* on fresh fruits or vegetables will render those products adulterated.

From a legal standpoint, it is important for you, as a commercial food producer, to understand that all unsafe food is adulterated and therefore illegal to sell in the U.S. Specifically, it is unlawful to introduce or deliver for

The Federal Food, Drug, and Cosmetic (FD&C) Act (1938) provides that food is “adulterated” if it meets any one of the following criteria: (1) it bears or contains any “poisonous or deleterious substance” which may render it injurious to health; (2) it bears or contains any added poisonous or added deleterious substance (other than a pesticide residue, food additive, color additive, or new animal drug, which are covered by separate provisions) that is unsafe; (3) its container is composed in whole or in part of any poisonous or deleterious substance which may render the contents injurious to health; or (4) it bears or contains a pesticide chemical residue that is unsafe. (Note: the U.S. Environmental Protection Agency (EPA) establishes tolerances for pesticide residues in foods, which are enforced by the FDA.)

introduction into interstate commerce any food, drug, device, tobacco product, or cosmetic that is adulterated or misbranded, under Title 21, United States Code, Section 301-392, which prohibits such actions. There are, however, two exceptions to this general rule. First, if the poisonous substance is naturally occurring and its quantity in the food does not ordinarily make it harmful to a person's health, the food will not be considered adulterated. Thus, a food that contains a natural toxin at very low levels that would not ordinarily be harmful in small amounts is not adulterated.²

Second, if the poisonous or harmful substance is unavoidable and is within an established tolerance, regulatory limit, or action level, the food will not be considered to be adulterated.³ Examples are oxalate in rhubarb, alkaloids in potatoes, and toxins in mushrooms and in shellfish.⁴ The foods will be considered adulterated at levels above tolerances and regulatory limits, which are

binding on FDA, the food industry, and the courts. Action levels are limits at or above which FDA *may* regard food as adulterated. These are not binding on FDA. FDA has established numerous action levels, which are set forth in its booklet *Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed*. For a free copy, contact the FDA by telephone: (240) 402-2023 or by email: industry@fda.gov; consumer@fda.gov

How Does Food Contamination Occur on a Farm?

Foodborne illness is caused by eating a contaminated food or beverage. A "contaminant" is any substance not intentionally added to food which is present in food as a result of production and processing. Food contamination can occur in four different ways: water, waste, wildlife, and workers. All of these risks may be found on a typical farm. The first step you can take in pre-

Table 1. Examples of Physical Adulteration

Contaminant	Common Source	Potential Injury	Recalls
Wood	Fields, buildings, pallets	Cuts, infection, choking, surgery may be needed.	1994—wood splinters were discovered in diced almonds supplied by Shade Foods, which caused General Mills to shut down production, destroy the boxes of cereal in its possession, and ship the unused almonds back to the food manufacturer.
Insects and other pests	Fields, packing production	Disease, trauma, choking.	2010—Abbott Laboratories recalled their popular Similac baby formula due to the possible presence of small insect parts and beetle larvae.
Glass	Bottles, jars, light bulbs, measuring cups, thermometers, gauge covers	Cuts, bleeding, surgery may be needed for location and extraction.	2013—Nestlé recalled two production codes of Lean Cuisine after three consumers reported finding small fragments of glass in the ravioli portion of the entrée.
Metal: nails, keys, coins, machinery parts, shavings	Machinery, fields, wires, workers	Cuts, infection, choking, surgery may be needed.	2012—Voluntary recall of Frosted Mini-Wheats Bite Size Original due to the possible presence of fragments of flexible metal mesh from a faulty manufacturing part.
Plastic materials	Fields, packing materials, harvest baskets, workers	Choking, cuts, infection, surgery may be needed.	2012—University Creamery voluntarily recalled all ice cream and frozen yogurt because of isolated reports of small plastic foreign objects in the product.

venting a foodborne illness is to prevent the produce on your farm from becoming contaminated and thus unsafe. There are four types of hazards (or contaminants) that can cause a food to be unsafe: physical, biological, chemical, and radiological. This fact sheet will concentrate on the first three.

Physical Contamination

A physical contaminant is anything that can be visibly seen and was not part of the food originally. Physical contamination of food can occur when foreign objects such as glass, metal shavings, pieces of wood, plastic or paint chips, etc. become mixed with food during growing, harvesting, packing, processing, or transporting. It

is unclear how widespread this problem is because most incidents do not cause major injuries and go unreported. However, it is more common than expected. Foreign-object complaints involving injury and illness have been associated with fruits and vegetables.⁵ If any foreign objects get into the food, they can cause injury, disease, or psychological trauma. Be on the lookout for three types of items that can accidentally get mingled into the raw and processed produce: a) pieces of machinery, tools, or equipment that may break off through wear and tear; b) human hair, fingernails, jewelry, or clothing parts; and c) insects, vermin, or dust. Table 1 lists examples of contaminants, common sources, potential injuries, and some recalls due to physical contamination.

Table 2. Examples of Biological Adulteration

Contaminant	Common Source	Clinical Effects	Mode of Acquisition	Outbreak
<i>E. coli</i> O157H7	Can live in the intestines of healthy cattle; found on cattle farms	Severe diarrhea, abdominal pain, and vomiting. Usually, little or no fever is present. More common in children 4 years or younger. Can lead to kidney failure.	Raw fruits and vegetables, undercooked beef, unpasteurized milk and juice, contaminated water.	In 2012, 33 persons infected with Shiga toxin-producing <i>E. coli</i> O157:H7 from pre-packaged leafy greens were reported in 5 states.
Norovirus	Humans	Nausea, vomiting, abdominal cramping, diarrhea, fever, headache. Diarrhea is more prevalent in adults, vomiting more common in children.	Raw produce, contaminated drinking water, uncooked foods and cooked foods that are not reheated properly after contact with an infected food handler.	In 2004 and 2005, 51 outbreaks were associated with leafy greens. Of these outbreaks, 87% of those with known or suspected etiologies were Norovirus.
<i>Salmonella</i>	Zoonotic: cattle, cats, dogs, horses, poultry, turtles	Diarrhea, fever, abdominal cramps, vomiting.	Direct contact with animal or its feces, or food contaminated by infected animals (e.g., raw fruits and vegetables).	In 2012, 127 persons infected with the outbreak strain of <i>Salmonella braenderup</i> associated with mangoes were reported from 15 states.
<i>Listeria monocytogenes</i>	Humans	Fever and muscle aches, sometimes preceded by diarrhea or other gastrointestinal symptoms.	Raw foods, such as uncooked meats and vegetables, soft cheeses, processed meats, and smoked seafood. Unpasteurized (raw) milk and cheeses.	2011, 33 deaths and 147 persons infected with <i>Listeria monocytogenes</i> were reported from 28 states. Listeriosis linked to whole cantaloupes from Jensen Farms, Colorado.

Biological Contamination

Biological contamination of food causes the most food-borne illness and occurs when microorganisms such as bacteria, viruses, and parasites enter food from a variety of sources, including poor human hygiene, contaminated water, and animals, at any point along the production, transportation, or processing route. Note: Human hygiene cannot be stressed enough: workers must not transmit the pathogens found on fecal matter (or in compost with live fecal bacteria) onto produce. Mandatory handwashing and proper handwashing stations are a best practice. Bacteria are single-celled organisms that live independently. A virus is a small infectious agent that can replicate only inside the living cells of an organism. A parasite is an organism that lives in another organism, called the host, and often harms it.

Potential pre-harvest sources of contamination include soil, feces, irrigation water, water used to apply fungicides and insecticides, dust, insects, inadequately composted manure, wild and domestic animals, and human handling. Post-harvest sources of contamination include feces, human handling, harvesting equipment, transport containers, wild and domestic animals, insects, dust, rinse water, ice, transport vehicles, and processing equipment.

While it is unlikely that a single strategy will be successful in eliminating contamination of fresh produce by bacteria, viruses, or parasites, a multi-pronged

approach, including Good Agricultural Practices (GAPs) in field production, adherence to Good Manufacturing Practices (GMPs) during minimal processing, proper harvesting and storage, and antimicrobial treatments, may reduce the risks of outbreaks of foodborne illnesses associated with fresh produce and vegetables. More information about the causes and prevention of foodborne illnesses from microorganisms can be found at the Centers for Disease Control and Prevention's website <http://www.cdc.gov/>. Table 2 lists examples of contaminants, common sources, clinical effects, modes of acquisition, and outbreaks due to biological adulteration.

Chemical Contamination

Chemical contamination can occur from cleaning, disinfecting, or sanitizing fluids that are added to food products by mistake. The chemicals used for cleaning your harvest tools, harvest baskets, packing tables, or farm equipment can contaminate the food product. Chemical contaminants can also be present in foods as a result of the use of agrochemicals, such as residues of pesticides and veterinary drugs, contamination from environmental sources (water, air, or soil pollution), cross-contamination during food processing, migration from food packaging materials, or contamination by natural toxins (e.g., staphylococcal toxins). Modern analytical techniques are becoming sophisticated and

Table 3. Examples of Chemical Adulteration

Contaminant	Potential Injury	Recalls
Oxamyl	Oxamyl has been rated as extremely poisonous to humans.	In November 2011, Hawai'i State Department of Health Food and Drug Branch required the destruction and disposal of approximately 800 pounds of fresh green onions due to the presence of an unapproved pesticide found on the product during routine sampling. A Wai'anae farm was ordered to cease the sale of all suspect product until follow-up testing could show no further illegal pesticide residue.
Methomyl	Categorized by the Environmental Protection Agency as a Restricted Use Pesticide because of its high acute toxicity to humans.	In April 2012, the Hawai'i State Department of Health ordered a farm on O'ahu to cease selling fresh basil that officials said was tainted with an unapproved pesticide.

able to determine known chemical contaminants in food at very low concentration levels. Table 3 lists examples of contaminants, potential injuries, and recalls due to chemical adulteration.

Other Adulteration

Although not as common as the other three types of adulteration issues, economically motivated adulteration—the intentional adulteration of food for economic gain—is a growing concern. Reports on economically motivated adulteration in food indicate that the most fraud-prone ingredients in the food supply are olive oil, milk, honey, saffron, orange juice, coffee, and apple juice. A 2012 report commissioned by the Department of Homeland Security and funded by the National Center for Food Protection and Defense defined food fraud as a collective term that includes “the deliberate substitution, addition, tampering or misrepresentation of food, food ingredients or food packaging, or false or misleading statements made about a product for economic gain.”⁶ Soaking fruits in a tub of water for longer than is normally done for the purpose of rinsing, so that the grower can add weight per pound to the produce and command more money, is an example of economically motivated adulteration.

Allergen Contamination

Allergen contamination can occur when food products are inadvertently contaminated with allergenic proteins that can cause reactions—even life threatening—in individuals having food allergies to those proteins. The

eight most common food allergies are to milk, eggs, fish, shellfish, wheat, soy, peanuts, and tree nuts. Allergens are recognized as an important food safety issue, and as a farmer, you can take all necessary precautions to protect human health and eliminate cross-contamination issues associated with allergens.

Sources

¹ Federal Food, Drug, and Cosmetic (FD&C) Act of 1938. Retrieved from <http://www.fda.gov/REGULATORYINFORMATION/LEGISLATION/FEDERALFOODDRUGANDCOSMETICACTFDCACT/DEFAULT.HTM>

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⁴ Alli, I. (2003). *Food quality assurance: Principles and practices*. CRC Press.

⁵ Hyman, F. N., Klontz, K. C., and Tollefson, L. 1993. Food and Drug Administration surveillance of the role of foreign objects in foodborne injuries. *Public Health Reports* 108:54–59.

⁶ Moore, J.C., Spink, J., and Lipp, M. 2012. Development and application of a database of food ingredient fraud and economically motivated adulteration from 1980 to 2010. *Journal of Food Science*. Apr., 77(4):R118–26. doi: 10.1111/j.1750-3841.2012.02657.x. Epub 2012 Apr 4.