Lecture Objectives

• List and describe the microbial toxins found in foods.
• Explain the potential for environmental toxins to cause unintended food hazards.
• Recognize that many foods contain natural hazards which pose health risks.
• Describe the conditions associated with the microbial, environmental, and natural toxins.

Microbial Toxins in Foods

• Microbial toxins commonly found in foods include:
  • Mycotoxins (fungi)
  • Scombroid (histamine-producing bacteria)
  • Ciguatoxin (algae)
  • Paralytic shellfish poisoning (algae)
• Note: The toxins produced by Clostridium botulinum, Staphylococcus aureus, and Bacillus cereus were discussed in early lectures.

Fungi - Mycotoxins

• Mycotoxins are toxic substances produced by some fungi. The following mycotoxins may be found in foods:
  • Aflatoxin – produced by Aspergillus flavus (seen on corn and under a microscope at right)
  • Ergot – produced by Claviceps purpurea
  • Intestinal irritants – produced by poisonous mushrooms.

Mycotoxin - Aflatoxin

• Aspergillus flavus produces a toxin called aflatoxin which causes an intoxication.
• Found in moldy grains and nuts including corn and pistachios, and also found in peanuts and soy.
• Can cause severe liver damage including cirrhosis, necrosis, and carcinoma.
• Often fatal.
Mycotoxin - Aflatoxin

In the United States we routinely test foods for aflatoxin and human cases are rare. In places where detection is not used, large outbreaks with high numbers of deaths (125 above) can occur. Note the cause of this outbreak was contaminated corn.

Mycotoxins - Ergot

- Ergot is a toxin produced by the fungus Claviceps purpurea that infects rye.
- The toxins have hallucinogenic properties.
- Causes a syndrome known as ergotism or "St. Vitus Dance" which includes spasms and hallucinations.

Mycotoxins - Ergot

- In Salem, Massachusetts in 1692 several women were accused of being witches after exhibiting strange symptoms (hallucinations and spasms).
- 20 people were executed.
- Ergot is known to have infected rye in Salem, MA, leading some to speculate that the "witches" were in fact poison victims.

Mycotoxins - Mushrooms

- Poisonous mushrooms often look similar to hallucinogenic mushrooms.
- Persons who abuse mushrooms often mistakenly eat the wrong ones.
- The mushrooms commonly produce gastrointestinal irritants (compounds that produce rapid, transient nausea, vomiting, abdominal cramping, and diarrhea).
- Some of the mushrooms are deadly.

Poisonous Mushrooms

- In this outbreak in 2012, a caregiver accidentally used poisonous mushrooms to make a soup for elderly patients.
- Four people died and several others became ill.

Scombroid Poisoning

- Intoxication is caused by ingesting large amounts of the chemical histamine which is produced by bacteria in seafood.
- Tuna, mahi-mahi, sardines, etc.
- Usually results from fish being held at high temperatures for long time periods (temperature abuse).
- Toxin is heat-stable.
- In other words, it may not be destroyed by cooking.
- Symptoms include dizziness, burning, rash, headache, and can be fatal.
- Severe cases may require treatment with fast-acting antihistamines.
Scombroid Poisoning – Tuna Steaks

Imported tuna was a common food in these outbreaks but elevated levels of histamine were not detected in remaining samples. The source remains unknown.

Algal Toxins

• The algae rarely cause disease and foodborne infection due to algae is rare. Most cases are due to the following two types of toxins:
  • Ciguatoxin
  • Paralytic Shellfish Poisoning (PSP toxins)
  • Amnesic Shellfish Poisoning.

Ciguatoxin - Algae

• Ciguatoxin is produced by algae (dinoflagellates – in photo at right).
• The algae are eaten by fish, which are in turn eaten by larger fish, causing the toxin to accumulate to dangerous levels in large fish (a process known as bioaccumulation).
  • Prevention is eating smaller fish.
• Symptoms include nausea, diarrhea, vomiting, headache, excessive sweating, weakness, itching, etc.
• There is no specific treatment and disease is rarely fatal.

Ciguatera – Algae (continued)

• Human cases of ciguatera (the disease caused by ciguatoxin) usually occur following ingestion of barracuda, snapper, jack & grouper.
• Cases are common in Hawaii and Puerto Rico.
• However, if the fish are shipped cases can occur anywhere. In the report at right, cases occurred in New York City. The distributor of the fish is not named but reports show that they had already been issued a warning!

Shellfish Toxins - Algae

• Produced by several types of algae including the species that causes “red tide”.
• The toxins are heat-stable (in other words, cooking does NOT destroy them).
• Infects mussels, clams, oysters, crabs, lobsters and scallops.
• Symptoms can be confused with shellfish allergies:
  • Numbness, tingling occur first.
  • Headache, dizziness, nausea.
• In severe cases, muscle paralysis and respiratory failure occur.
  • Death occurs within 2-25 hours.

Paralytic Shellfish Poisoning - Algae

• Most PSP cases occur in colder climates where the toxin (from the algae) accumulates in the shellfish.
• Saxotoxin is most common.
• Death can occur within 3 to 4 hours due to respiratory paralysis.

Amnesic Shellfish Poisoning - Algae

Caused by domoic acid, this toxin produced by algae can cause severe neurological damage, including loss of short term memory.

Environmental Toxins

• Industrial processes can release contaminants into the environment.
• Polluted air, water, and soil can result in contaminated produce, dairy, meats, and seafood.
• Some environmental contaminants can cause health problems.

Environmental Toxins - Persistence

• Persistence of toxins refers to the extent to which the toxin lingers in the environment or in the body.
• Contaminants present for a short time or eliminated by the body pose little health risk.
• Contaminants which persist may also bioaccumulate.

Environmental Toxins - Bioaccumulation

• Some toxins do not breakdown in the environment.
• These toxins move up through the food chain and they accumulate.
• Each level has a higher concentration than the one below.
• Eventually humans consume a food which contains high levels of a toxin such as mercury in tuna.

Environmental Toxins - PBTs

• The Environmental Protection Agency has identified a number of persistent, bioaccumulative, highly toxic chemicals it is committed to removing from the environment.
• These compounds pose a health risk to both humans and ecosystems through food and water.
• The top priority PBTs (persistent, bioaccumulative, toxins) are shown at right.
Environmental Toxins - PBTs

- Benz[a]pyrene – product of incomplete combustion – exposed due to fires, smoked foods, etc.
- Alkyl-lead – fuel additive – banned from automobiles but used in limited capacity (racing, marine, aircraft).

Environmental Toxins – PBTs (continued)

- Mercury – discussed on next slides.
- Octachlorostyrene – formed during the production of magnesium.
- PCBs – discussed on next slides.
- Dioxins and Furans – discussed on next slides.

Environmental Toxins - Mercury

- Mercury is an element and it is used in the production of many products:
  - Chemicals
  - Pharmaceuticals
  - Switches
  - Thermometers
  - Light bulbs
- Once mercury enters the environment, microorganisms convert it to methylmercury which is the highly toxic mercury that builds up in fish and shellfish.

Lecture Note - Mercury

- Mercury is used in many pharmaceuticals as a preservative.
- Added to multi-use vials to prevent the growth of microorganisms.
- The form of mercury used in these applications is ethyl mercury (not methylmercury).

Methyl mercury Poisoning – Minamata Disease

- Between 1932 and 1968, a petrochemical and plastics manufacturer dumped an estimated 27 tons of mercury in Minamata bay (Japan).
- Poisoning the fish and the people who ate the fish.
- Over 900 deaths.
- Over 2 million people suffer(ed) chronic health problems.

Environmental Toxins - PCBs

- PCBs are chlorinated hydrocarbons that were used in 100s of industrial and commercial applications.
- PCBs are known to cause cancer in animals.
- PCBs were banned in 1979 in the United States but they do not breakdown and can be found:
  - In the environment
  - In wildlife tissues
  - In the food chain.
- PCBs exert toxic effects on the following body systems (in addition to causing cancers):
  - Immune system
  - Endocrine system
  - Reproductive system
  - Nervous system

- Mercuric chloride is used as a disinfectant. It can cause kidney damage and death.
Environmental Toxins – Dioxins and Furans

- Refers to a family of toxic substances that have similar chemical structures.
- They are the byproducts of industrial processes or are created during burning:
  - Burning of waste
  - Burning of wood
- Found in the food chain in meat and dairy.
  - Due to accumulation in the environment.
- Health effects include the following:
  - Chloracne (below), and other skin conditions.
  - Immune system damage
  - Developmental damage
  - Reproductive damage
  - Cancer

Dioxin Poisoning – Yusho Disease

- In 1968 in Japan a number of patients were reported to have symptoms including acne-like eruptions, pigmentation of the skin, and eye discharge.
- The cause of the disease was later found to be rice oil (Yusho means oil disease) contaminated with dioxin-related compounds.
- A total of 1961 people are registered as yusho patients.
- Despite the knowledge gained from this outbreak, the same thing happened in Taiwan in 1979.

Natural Toxins

- A number of plants contain natural toxins.
  - Many of these toxins are designed to protect the plants from insect damage.
  - These toxins are not harmful if ingested in small amounts.
  - The most common are:
    - Goitrogens
    - Cyanogenes
    - Solanine

Natural Toxins - Goitrogens

- Goitrogens can cause enlargement of the thyroid gland by blocking the uptake of iodine.
- Found in very small amounts in a large number of foods:
  - Cabbage
  - Bok choy
  - Turnips
  - Mustard greens
  - Kale
  - Brussels sprouts
  - Cauliflower
  - Broccoli
  - Kohlrabi
  - Radishes

Natural Toxins - Cyanogens

- Some foods contain cyanogens which can convert to cyanide:
  - Apricot pits
  - Peach pits
  - Apple seeds
  - Lima beans
  - Cassava
  - Lima beans with low levels of cyanogenes are used in foods.
  - Most people do not eat seeds (a few will not hurt you) and pits of fruits.

Cyanogen Poisoning – Cassava - Konzo

- Konzo disease is a neuromotor disease caused by exposure to cyanogen poisons in cassava.
  - Altered gait
  - Spastic movements
  - Cognitive disorders
- Occurs when cassava is not processed properly to break down the cyanogens.
Natural Toxins – Cyanogens - Laetrile

Despite the warnings that laetrile, derived from apricot pits is NOT a cure for cancer and is in fact poisonous, a quick search in Amazon results in a product for sale.

Natural Toxins - Solanine

- Solanine is a narcotic-like poison found in potatoes:
  - Largely in the leaves and stems but to a limited amount in the peel.
  - Poisoning is rare except in times of food shortage.
  - Symptoms include:
    - Vomiting
    - Diarrhea
    - Abdominal pain
    - Convulsive twitching
    - Confusion
    - Hallucination
  - Death is rare unless the person is dehydrated.

Lecture Summary

- Lecture Note: Information used in this lecture on Environmental Toxins was adapted from the Environmental Protection Agency Website (www.epa.gov).
- Foods are susceptible to toxic contamination from microbial, environmental, and natural toxins.
- The symptoms depend on the toxin present and there are few treatment options.
- Protecting the food supply from toxic contamination requires adherence to regulatory guidelines.