

Food Hazards

HACCP DEFINES A FOOD HAZARD

- A **SIGNIFICANT** BIOLOGICAL, CHEMICAL, OR PHYSICAL HAZARD THAT CAN CAUSE HARM AND THAT IS **REASONABLY LIKELY TO OCCUR** IF NOT CONTROLLED
 - Significant → Severity
 - Likely to occur → Frequency

BIOLOGICAL HAZARD

- A biological entity that may cause an unacceptable risk to consumer's health through illness.
- Primarily microbiological

FOOD MICROBIOLOGY – THE GOOD, THE BAD, & THE UGLY

- THE GOOD
 - FERMENTED FOOD PRODUCTS
 - NATURAL PRESERVATIVES
- THE BAD
 - PATHOGENS
- THE UGLY
 - SPOILAGE

BACTERIA

- VARIED SHAPES AND SIZES
- SOME PRODUCE HEAT-RESISTANT SPORES
- VARIED OXYGEN & TEMPERATURE REQUIREMENTS
- VARIED HEAT RESISTANCE

Pathogenic Bacteria

- Salmonella spp.
- Clostridium botulinum
- Staphylococcus aureus
- Campylobacter jejuni
- Yersinia enterocolitica and pseudotuberculosis
- Listeria monocytogenes
- Vibrio cholerae O1
- Vibrio cholerae non-O1
- Vibrio parahaemolyticus
- Vibrio vulnificus
- Clostridium perfringens
- Bacillus cereus
- Aeromonas hydrophila
- Plesiomonas shigelloides
- Shigella spp
- Miscellaneous enterics
- Streptococcus

Escherichia coli

- enterotoxigenic (ETEC)
- enteropathogenic (EPEC)
- Enterohemorrhagic (EHEC)
 - O157:H7
- enteroinvasive (EIEC)

VIRUSES

- COMPOSED OF PROTEIN & NUCLEIC ACIDS (PRIMARILY RNA)
- DO NOT
 - GROW ON CULTURE MEDIA
 - MULTIPLY IN FOODS
 - SURVIVE WITHOUT HOST

&

- HOST SPECIFIC

Viruses

- Hepatitis
 - A virus
 - E virus
- Rotavirus
- Norwalk virus group
- Other gastroenteritis viruses

YEASTS

- LARGER THAN BACTERIA
- USUALLY PRODUCE GAS
- GENERALLY HEAT LABILE
 - ASCOSPORES HEAT RESISTANT

MOLDS

- GENERALLY AEROBIC
- VARIED HEAT RESISTANCE
- SALT/SUGAR TOLERANCE
 - GENERALLY HIGHER THAN BACTERIA
- MYCOTOXINS

PROTOZOA

- More highly organized than bacteria
- Do not multiply in foods
- Animal-like in cell composition
- Parasitic in nature
 - Need a host

Parasitic Protozoa and Worms

- *Giardia lamblia*
- *Entamoeba histolytica*
- *Cryptosporidium parvum*
- *Cyclospora cayetanensis*
- *Anisakis* sp. and related worms
- *Diphyllobothrium* spp.
- *Nanophyetus* spp.
- *Eustrongylides* sp.
- *Acanthamoeba* and other free-living amoebae³¹
- *Ascaris lumbricoides*
- *Trichuris trichiura*

FOOD (& WATER) ASSOCIATED PROTOZOA

- GIARDIA
- ENTAMOEBA HISTOLYTICA --
AMOEBIC
- DYSENTARY
- CRYPTOSPORIDIUM PARVUM
- CYCLOSPORA CAYATENENSIS

Natural Toxins

- Ciguatera poisoning
- Shellfish toxins (PSP, DSP, NSP, ASP)
- Scombroid poisoning
- Tetrodotoxin (Pufferfish)
- Mushroom toxins
- Aflatoxins⁴⁴
- Pyrrolizidine alkaloids⁴⁵
- Phytohaemagglutinin⁴⁶ (Red kidney bean poisoning)
- Grayanotoxin⁴⁷ (Honey intoxication)
- Gempylotoxin⁴⁸
(Gastrointestinal illness from consumption of Escolar and Oilfish)

PREVENTION OF MICROORGANISMS

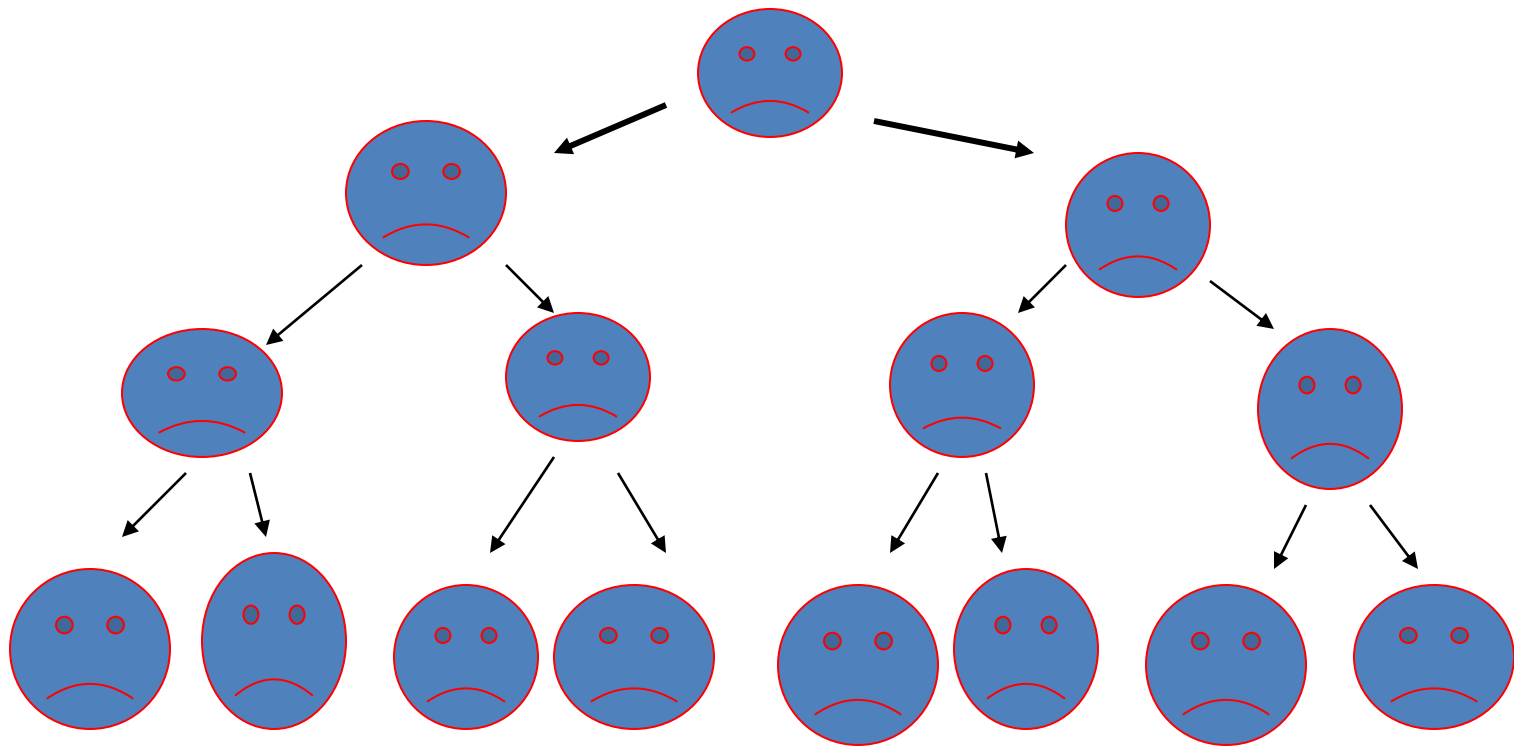
- Prevent
 - Entry
 - Contamination of facility
 - Growth

CHAIN OF INFECTION

- SEEDING OF ENVIRONMENT
 - OUTSIDE SOURCES
- SOURCE OR RESERVOIR
 - MOISTURE
 - CONDENSATE
 - PEOPLE
- TRANSMISSION TO FOOD
 - NOT PROTECTED
- GROWTH SUPPORT IN THE FOOD
 - COMPOSITION
 - TEMPERATURE

Bacteria Reproduction

Via binary fission--splitting into equal parts

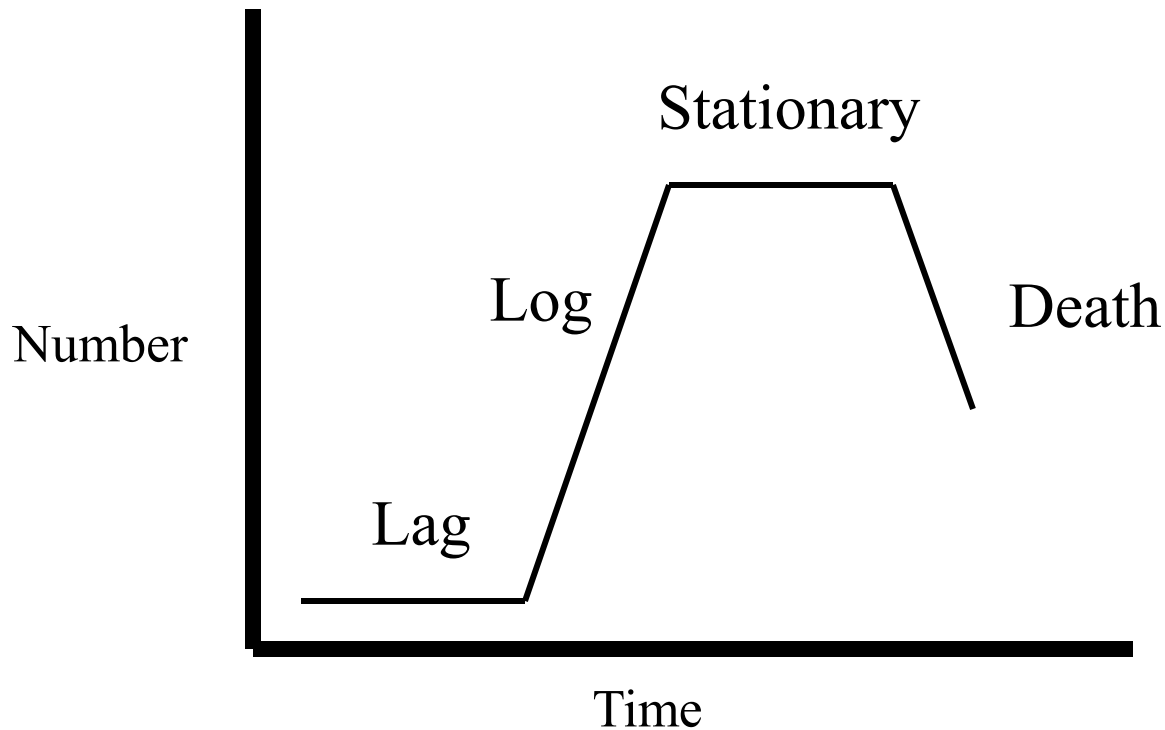


Bacteria Reproduction

If a bacteria's generation time is \sim
3 minutes,

in one hour 1 bacteria cell will
become one million (10^6).

Spoilage occurs at $\sim 10^7$.




Factors that affect microbial growth

1. Temperature

- ❖ grow at temperatures from 32 to 150°F
- ❖ no single bacteria will grow over this entire range.
- ❖ classified according to the range of temperature

Classification	Range (°F)	Optimum (°F)
Psychrophiles	32-68	53
Mesophiles	68-113	90
Thermophiles	113-150	120



FACTORS AFFECTING MICROBIAL GROWTH

2. Moisture -- the water requirement for microbial growth is defined in terms of water activity (a_w) of the medium.

- ✓ Fresh meat has an a_w of 0.99 or higher
- ✓ The minimum a_w for
 - ✓ bacteria to grow is 0.90
 - ✓ Molds -- 0.8 or above
- ✓ a_w reduction is a means of food preservation
 - drying, salting, freezing

Factors that affect microbial growth

3. Oxygen availability –

–Aerobic

Oxygen must be present to grow

Aerobic psychrophiles most common meat spoiler.

–Anaerobic

Cannot grow when oxygen is present

–Facultative

Growth occurs both in the presence or absence of oxygen

Factors that affect microbial growth

4. pH (acidity) --

- normal pH for bacteria growth
 - 6.5
- pH range for most pathogens
 - 4.8 to 7.0

5. **Physical properties**

- Surface area -- the more surface area
- (greater area exposed to oxygen) the more microbial growth

DESTRUCTION OF MICROORGANISMS

- HEAT TREATMENT
 - STERILIZATION
 - PASTEURIZATION
 - TIME & TEMPERATURE
- CHEMICAL AGENTS
 - SANITIZERS, DISINFECTANTS
 - ANTIBIOTICS
 - CONCENTRATION & TEMPERATURE

DESTRUCTION OF MICROORGANISMS

- DEHYDRATION
 - DIRECT EFFECTS
 - CONCENTRATION EFFECT
 - INDIRECT EFFECTS
 - CONCENTRATE SALTS & SUGARS
- HURDLE AGENTS
 - ACIDS, SUGARS
 - CHEMICAL PRESERVATIVES

DESTRUCTION OF MICROORGANISMS

- IRRADIATION
 - LOW ENERGY
 - MICROWAVE
 - ULTRAVIOLET
 - HIGH ENERGY
 - GAMMA, X-RAYS
- COLD PRESERVATION
 - NOT A KILL STEP

FOODBORNE INFECTIONS

- Microorganisms in food
- Ingested into host
- Establishes itself in the host's body
 - Multiplies therein (sometimes)
 - Long incubation period
- Host response
 - Usually fever
 - GI infection

TYPES OF FOODBORNE INFECTIONS

- **INVASIVE INFECTIONS**
 - INVADE BODILY TISSUES AND ORGANS.
- **TOXICOINFECTIONS**
 - Capable of multiplication or colonization in human intestinal tract
 - Produce toxins.

INVASIVE INFECTIOUS BACTERIA

- SALMONELLA
- AEROMONAS
- CAMPYLOBACTER
- SHIGELLA
- VIBRIO PARAHAEMOLYTICUS
- YERSINIA
- ENTERIC-TYPE ESCHERICHIA COLI

TOXICOINFECTIOUS BACTERIA

- VIBRIO CHOLERAEE
- BACILLUS CEREUS (DIARRHEAL-TYPE)
- C. BOTULINUM (IN INFANTS)
- C. PERFRINGENS
- VEROTOXIGENIC E. COLI
 - (E. COLI O157:H7 AND OTHERS).

FOODBORNE INTOXICATION

- Grows/Multiplies in food
 - Impacted by food environment
 - Temperature abuse
- Produces toxin in food
- Toxin ingested
 - Rapid onset
 - Vomiting
 - No fever

FOODBORNE INTOXICATION AGENTS

- CLOSTRIDIUM BOTULINUM
- BACILLUS CEREUS (EMETIC-TYPE)
- STAPHYLOCOCCUS AUREUS

FOOD BORNE PATHOGENS

STAPHYLOCOCCUS AUREUS

- Illness
 - Classic toxin symptoms
- Onset: 1 - 7 hr
- Duration: 24 - 48 hr
- Low mortality
- 6 log growth for toxin production
- Chronic after effects

STAPH. AUREUS

- Sources?
 - Humans and animals are the primary reservoirs
- Implicated foods?
 - Foods that require considerable handling during preparation and that are kept at slightly elevated temperatures after preparation
- Heat stable toxin

SALMONELLA

- Illness
 - GI infection
- Dose:
 - Varied 1 - 100,000
- Onset
 - 5 hr to 5 days (12-36 hr)
- Chronic after effects

SALMONELLA

- Sources
 - You name it
- Implicated foods
 - Poultry and eggs
- Control & prevention
 - Cooking and refrigeration

Shigella

- Dose:
 - 10 cells
- Onset
 - Chronic aftereffects
 - Acute kidney failure

SHIGELLA

- SOURCES
 - Fecal contaminated water
 - unsanitary handling by food handlers
- IMPLICATED FOODS?
 - Salads (potato, tuna, shrimp, macaroni, and chicken), raw vegetables, milk and dairy products, and poultry.

LISTERIA MONOCYTOGENES

- Infection
 - Mild in healthy hosts
 - Severe in high risk hosts
- Dose
 - <1,000
- Onset
 - > 12 hrs.
- Complications/after effects
 - Meningitis
 - Septicemia
 - Encephalitis
 - Spontaneous abortion or stillbirth

LISTERIA MONOCYTOGENES

- Hardy
 - resists the effects of freezing, drying, and heat
- Foods implicated?
 - Ready – To - Eat
- Control/Prevention
 - Sanitation

E. COLI TYPES

- MANY TYPES... VARIED SYMPTOMS
 - Enterpathogenic e.Coli
 - Infantile diarrhea
 - Raw meat and poultry
 - Enteroinvasive e. Coli
 - Effective dose <10
 - Human feces from an ill individual
 - Enterotoxigenic (etc)
 - “Travelers diarrhea”

ENTEROHEMORRAGIC

- Toxicoinfection
- Low infective dose
 - 10 organisms
- Types (6)
 - O157:H7
 - O11
 - O104:H21
- Aftereffects
 - Children: hemolytic uremic syndrome (HUS)
 - Elderly: thrombocytopenic purpura (TPP)

0157:H7

- SOURCES?
 - Anything contaminated with animal feces
- IMPLICATED FOODS?
 - Under cooked ground beef

CAMPYLOBACTER

- GI INFECTION
 - leading cause of bacterial diarrheal illness in the United States
 - heat-labile toxin that may cause diarrhea
- Effective dose
 - 400-500 bacteria
- Implicated foods
 - Raw chicken
 - Raw milk

YERSINIA ENTEROCOLITICA

- Facultative Psychrotroph
- GI infection
 - Fever & abdominal pain
 - Sequelae: arthritis
- Implicated foods?
 - Meats oysters, fish, and raw milk
- Control/prevention
 - Poor sanitation
 - Improper storage

CLOSTRIDIUM BOTULINUM

- Spore former
 - Organism and its spores are widely distributed in nature
- Anaerobe
- Classic intoxication
 - Heat-labile toxin
 - High mortality
- Sausages, meat products, canned vegetables and seafood products

C.PERFRINGENS

- Spore former
- Anaerobe
- Widely distributed in the environment
- Source
 - Temperature abuse of prepared foods
- Associated foods
 - Meats, gravy, & soups

C. PERFRINGENS

- Food infection
 - $>10^8$ vegetative cells
 - Toxico-infection
- Mortality: low

BACILLUS CEREUS

- Facultative spore former
- Infection (diarrheal type)
 - Toxicoinfection
 - 10^6 required for illness
- Intoxication: (emetic type)
 - Heat stable toxin

BACILLUS CEREUS

- Implicated foods?
 - Meats, milk, vegetables, and fish
 - Vomiting-type associated with rice products
 - Sauces, puddings, soups, casseroles, pastries, and salads

Vibrio cholerae O1

- **No major outbreaks** of this disease have occurred in the United States since 1911.
- Sporadic cases occurred between 1973 and 1991
 - Associated with the consumption of
 - Raw shellfish or of
 - Shellfish either improperly cooked or
 - Re-contaminated after proper cooking
- Cholera is generally a disease spread by poor sanitation
- Onset of the illness is generally sudden
 - incubation periods varying from 6 hours to 5 days.
 - Abdominal cramps, nausea, vomiting, mild, watery diarrhea to an acute diarrhea,

Vibrio cholerae Non-O1

- Gastroenteritis
 - Diarrhea, abdominal cramps, and fever are the predominant symptoms lasting 6-7 days
 - Infective dose $>10^4$ cells
- Shellfish harvested from U.S. coastal waters
 - Consumption
 - Raw, improperly cooked, or cooked, re-contaminated

Vibrio parahaemolyticus

- Toxigenic infection
- Source
 - Marine environment of the United States
 - The illness is usually mild to moderate
- Associated foods
 - Fish and shellfish
 - Raw, improperly cooked, or cooked re-contaminated.
- Source
 - A correlation exists between infection and warmer months of the year.
 - Improper refrigeration of seafood

Vibrio vulnificus

- Associated foods
 - Plankton, shellfish (oysters, clams, and crabs), and finfish
- Gastroenteritis
 - Healthy individuals, gastroenteritis usually occurs within 16 hours of ingesting
- Consumption of raw seafood
 - Underlying chronic disease, particularly liver disease

PSYCHROTROPHIC FOODBORNE PATHOGENS

Organism	Minimum Growth Temp (F)
• <i>Bacillus cereus</i>	42
– <i>Clostridium botulinum</i>	38
• <i>Listeria monocytogenes</i>	32
• <i>Salmonella</i> Sp.	43
• <i>Staphylococcus aureus</i>	45
• <i>E. coli</i> 0157:H7	32
• <i>Yersinia Enterocolitica</i>	38

ROTAVIRUS

- Acute gastroenteritis.
 - Infantile diarrhea, winter diarrhea,
 - Self-limiting, mild to severe disease
 - Vomiting, watery diarrhea, and low-grade fever.
 - Infective dose 10-100 viral particles.

ROTAVIRUS

- Rotaviruses is transmitted by fecal-oral route.
 - Person-to-person spread through contaminated hands
 - Asymptomatic rotavirus excretion
 - Close contact environment
 - Infected food handlers contaminate RTE,
 - Salads, fruits, and hors d'oeuvres.
- Controlled by sanitary measures adequate for bacteria and parasites

ROTAVIRUS

- Stable in the environment and have been
 - Estuary
 - 1-5 infectious particles/gal.

ROTAVIRUS

- Group A rotavirus is *endemic* worldwide.
 - Leading cause of severe diarrhea among infants and children,
 - Accounts for half of diarrhea cases requiring hospitalization.
 - > 3 million cases occur annually in the U.S.

NORWALK VIRUS

- Viral gastroenteritis, acute nonbacterial gastroenteritis, food poisoning, and food infection
- Transmission
 - Fecal-oral
 - Contaminated water and foods.
 - Water is the most common source
 - Person-to-person transmission

NORWALK VIRUS

- Transmission
 - Shellfish and salad ingredients.
 - Ingestion of raw or insufficiently steamed clams and oysters poses.
 - Foods other than shellfish are contaminated by ill food handlers.

Hepatitis A

- A
 - in feces of infected people
 - produce clinical disease when susceptible individuals consume contaminated water or foods.
 - Infections source
 - Cold cuts, fruits and fruit juices, milk products, vegetables, salads, shellfish, and iced drinks are commonly implicated in outbreaks.
 - Water, shellfish, and salads are the most frequent sources.
 - Contamination of foods by infected workers in food processing plants and restaurants is common

Hepatitis E

Infective dose is not known.

Transmission

Fecal-oral route.

Waterborne and person-to-person

To date no U.S. Outbreaks have been reported.

CHEMICAL HAZARDS

- Smaller more isolated outbreaks
- Usually accidental/misuse
- Most chronic/long term
 - Toxins usually acute
 - Long term exposure
 - Carcinogens/other toxic effects
-

NATURALLY OCCURRING SUBSTANCES

- Plant sources
 - Mushrooms
 - Solanine (potatoes)
- Animal sources
 - Seafood toxins
- Microorganisms
 - Mycotoxins

SEAFOOD TOXINS

- Causes >74% of chemical food poisoning (CDC)
 - HISTAMINE –SCROMBOID TOXIN
 - NEUROLOGICAL TOXINS

HISTAMINE –SCROMBOID TOXIN

- Microbial deterioration of fish
 - *Morganella morganii*
 - *Klebsiella pneumoniae*
 - *Hafnia alvei*
- Decarboxylation of histidine
- Allergenic type reaction

NEUROLOGICAL TOXINS

- Types
 - Molluscan shellfish
 - Paralytic shellfish poison (saxitoxin)
 - Diarrhetic shellfish poison
 - Neurologic shellfish poison
 - Domoic acid
 - Finfish
 - Ciguatoxin

NEUROLOGICAL TOXINS

- Cause
 - Dinoflagellate contaminated waters
- Control
 - Regulated waters

MYCOTOXINS

- Mold contamination
 - Penicillium
 - Fusarium
 - Aspergillus
 - Claviceps
- Products most affected
 - Aflatoxin
 - Corn, peanuts, cottonseed, other grains
 - Patulin
 - Apples

MYCOTOXINS

- EFFECTS
 - ACUTE -- RARE
 - CHRONIC -- CARCINOGENS

ANTIBIOTICS/HORMONES

- Meat and poultry –
 - FSIS/FDA
- Milk and milk products --
 - NCIMS/FDA

PESTICIDES

- TOLERANCE
 - EPA
- RESIDUES
 - FDA/USDA
- USE AND STORAGE
 - SOPs, GMPs
- Good Agriculture Practices

PHYSICAL HAZARDS

FOOD SAFETY VS. AESTHETICS

PHYSICAL HAZARDS

- FOREIGN OBJECTS
- ESPECIALLY
 - BONES
 - GLASS
 - METAL

PHYSICAL HAZARDS

- Acute
- Small/isolated problems
- Cause
 - Accidental
 - Sabbotage
- Risk assessment extremely difficult

SOURCES OF PHYSICAL CONTAMINATION

- RAW MATERIALS
 - SHOT PELLETS IN MEAT
- POOR DESIGN AND MAINTENANCE OF FACILITIES
- EQUIPMENT MAINTENANCE
- POOR PRACTICES IN OPERATION
- SABBOTAGE