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 amoebae
- 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

• Aflatoxins\textsuperscript{44}
• Pyrrolizidine alkaloids\textsuperscript{45}
• Phytohaemagglutinin\textsuperscript{46} (Red kidney bean poisoning)
• Grayanotoxin\textsuperscript{47} (Honey intoxication)
• Gempylotoxin\textsuperscript{48} (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 ~ 3 minutes,
in one hour 1 bacteria cell will become one million \((10^6)\).

Spoilage occurs at ~ \(10^7\).
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

<table>
<thead>
<tr>
<th>Classification</th>
<th>Range (°F)</th>
<th>Optimum (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychrophiles</td>
<td>32-68</td>
<td>53</td>
</tr>
<tr>
<td>Mesophiles</td>
<td>68-113</td>
<td>90</td>
</tr>
<tr>
<td>Thermophiles</td>
<td>113-150</td>
<td>120</td>
</tr>
</tbody>
</table>
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 CHOLERAE
- 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
  – Enteropathogenic 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 ENTEROCOLITICIA

- 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)
  – Toxico-infection
  – $10^6$ 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**

- Toxcio 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

<table>
<thead>
<tr>
<th>Organism</th>
<th>Minimum Growth Temp (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bacillus cereus</strong></td>
<td>42</td>
</tr>
<tr>
<td>– <em>Clostridium botulinum</em></td>
<td>38</td>
</tr>
<tr>
<td><strong>Listeria monocytogenes</strong></td>
<td>32</td>
</tr>
<tr>
<td><strong>Salmonella Sp.</strong></td>
<td>43</td>
</tr>
<tr>
<td><strong>Staphylococcus aureus</strong></td>
<td>45</td>
</tr>
<tr>
<td><strong>E. coli 0157:H7</strong></td>
<td>32</td>
</tr>
<tr>
<td><strong>Yersinia Enterocolitica</strong></td>
<td>38</td>
</tr>
</tbody>
</table>
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

Infected 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