Safety Concerns
Andreia Bianchini, Ph.D.
ROP Workshop

Overview of ROP
- Introduction
- Definition
- Benefits
- Misconceptions and Risks

Types of Processes
- Vacuum packaging
- Cook chill
- Sous vide
- Modified Atmosphere Packaging (MAP)

Safety Concerns
- Microbiology
- Micro Applied to ROP
- Sanitation
Raw foods normally contain microorganisms!!!
Microorganisms and Foods

Microorganisms of concern include:

- Molds
- Yeast
- Bacteria
- Viruses

Source: mpg.de
Molds

- Multicellular, tubular filaments
- Reproduce by fruiting bodies (spores)
- Larger than bacteria and yeasts
- Widely distributed in nature (soil, air)
- Survive on many substances
- Given right conditions will grow on almost any food
- More tolerant to cold than heat
Yeasts

- Unicellular, usually egg-shaped
- Smaller than molds, larger than bacteria
- Reproduction by budding
- Widely found in nature
- Associated with liquid foods with sugar and acid
Bacteria

• Most important and troublesome
• May produce and release enzymes or toxins into the foods
• Single cell, microscopic
• Several shapes and forms
Viruses

- Small infectious agent that replicates only inside of living cells
- While not inside a cell, it exists as a viral particle (virions):
  - Genetic material
  - Protein coat
  - Envelope of lipids, in some cases
- A virion is 1/100 the size of a bacterium
Reproduction of Bacterial Cells

- Reproduction by division (fission)
- Referred as “growth”
- Under optimum conditions a cell divides every 20-30 minutes

http://www.leavingcertbiology.net
Reproduction of Bacterial Cells

*G. stearothermophilus* has a shorter doubling time ($t_d$) than *E. coli* and *N. meningitidis*.

- **Geobacillus stearothermophilus**: $t_d = 20$ minutes
- **Escherichia coli**: $t_d = 30$ minutes
- **Neisseria meningitidis**: $t_d = 40$ minutes
Sporeforming Bacteria

- Bacterial **spores** are resistant to heat, cold and chemical agents
- Vegetative cells are less heat resistant
Factors Affecting Bacterial Growth and Survival

- Nutritional Requirements
- Moisture
- Oxygen Requirements
- Temperature
- pH
- Water Activity

Bacterial Growth
Nutritional Requirements

- Carbon source
- Nitrogen sources
- Sulfur and phosphorus
- Trace elements (i.e. copper, zinc, cobalt)
- Vitamins (i.e. folic acid, vitamin B-12)
Moisture

Passive transport

Active transport

Diffusion
Facilitated diffusion

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http://kmbiology.weebly.com
Water Activity ($a_w$)

- Water availability is important for bacterial growth
- Influenced by water-binding capacity of ingredients
- Most foods:
  - $A_w > 0.95$ which support bacterial growth

https://muse.union.edu
### Water Activity ($a_w$)

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Minimal $a_w$ for Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molds</td>
<td>0.75</td>
</tr>
<tr>
<td>Yeasts</td>
<td>0.88</td>
</tr>
<tr>
<td><em>Clostridium botulinum</em></td>
<td>0.93</td>
</tr>
<tr>
<td><em>Salmonella</em></td>
<td>0.93</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>0.85</td>
</tr>
</tbody>
</table>
Oxygen Requirements

- Aerobes
- Anaerobes
- Facultative anaerobes
Temperature

https://courses.lumenlearning.com/microbiology/
Thermal death curve of microorganisms at different temperatures:

- **60 °C**
  - D value = 132 s

- **75 °C**
  - D value = 9 s

- **55 °C**
  - D value = 1110 s

- **67 °C**
  - D value = 60 s
pH

• It refers to the degree of acidity or alkalinity
• Organisms have a most favorable pH range for growth
  – Yeast and mold: lower pH
  – Bacteria: neutral pH
Sources of Foodborne Organisms

Soil

Water

Modern Farmer Media, 2017

http://www.crystalclearwater.co
Microorganisms

Characteristics and behavior:

• The Good,
• The Bad, and
• The Ugly
The Good

• We add them to foods
• Ferment foods to make flavors and textures we like
  – Examples: yogurt, cheese, sour cream, pickles and bread
The Bad

- Change food and cause them to “go bad” or spoil
The Ugly

- Can make us sick - pathogens
- Illness can range from mild to life-threatening
- Bacterial foodborne illnesses:
  - *Salmonella* spp.
  - *Campylobacter* spp.
  - *Bacillus cereus*
  - *Staphylococcus aureus*
  - *Clostridium botulinum*
  - *Clostridium perfringens*
  - *Escherichia coli*
  - *Listeria monocytogenes*
## The Ugly

<table>
<thead>
<tr>
<th></th>
<th>% from the total cases</th>
<th>% of cases hospitalized</th>
<th>% of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norovirus (viral)</td>
<td>58%</td>
<td>26%</td>
<td>11%</td>
</tr>
<tr>
<td><em>Salmonella</em> non-typhoidal</td>
<td>11%</td>
<td>35%</td>
<td>28%</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em></td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Campylobacter</em> spp.</td>
<td>9%</td>
<td>15%</td>
<td>6%</td>
</tr>
<tr>
<td><em>Staphylococcus</em> aureus</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E. coli O157</em></td>
<td></td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td><em>Listeria monocytogenes</em></td>
<td></td>
<td></td>
<td>19%</td>
</tr>
<tr>
<td>Subtotal</td>
<td>91%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from: CDC, 2011
**Clostridium botulinum**

- Anaerobic microorganism
- Spore is heat resistant
- Some strains are psychrotrophic
- Do not grow or produce toxin below pH 4.5

- Toxin (neurotoxin):
  - The most powerful toxin known by humans
  - 1 nanogram is enough to kill a human
  - Used for cosmetic purpose
Symptoms
- Dryness of the mouth and throat
- Double vision, fixed pupils and difficulty focusing
- Nausea and vomiting
- Progressive paralysis that induces cardiac and pulmonary failure

Mortality rate: 30-60% of the cases

Associated with:
- ROP products
- Domestic canning of meat, fruits and vegetables
Listeria monocytogenes

- Widely spread in nature (ubiquitous)
- Facultative anaerobic organism
- Psychrotrophric
- Only this species is associated with pathogenicity in humans
- High mortality rates (around 20-30%)
- Capable of crossing the placenta barrier
Listeria monocytogenes

• Symptoms:
  – Flu-like disease (headache, fever and gastroenteritis)
  – Could advance to septicemia or meningitis

• Incubation period
  – 2-5 weeks

• Associated with different foods such as:
  – Meats (hams and sausages)
  – Dairy products (raw milk, pasteurized milk and cheeses)
Hazard Controls

Important parameters to prevent/limit bacterial growth:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Clostridium botulinum Type A</th>
<th>Clostridium botulinum Type E</th>
<th>Listeria monocytogenes</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>4.6</td>
<td>5.0</td>
<td>4.4</td>
</tr>
<tr>
<td>$A_w$</td>
<td>0.94</td>
<td>0.97</td>
<td>0.92</td>
</tr>
<tr>
<td>Salt (WPS)</td>
<td>10%</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td>Minimum temp for growth</td>
<td>50°F</td>
<td>38°F</td>
<td>31°F</td>
</tr>
</tbody>
</table>
ROP: Controlling Hazards

- Controlled Atmosphere (CA)
  - Contains about 2-5% $O_2$ and 8-10% $CO_2$
- Modified Atmosphere (MA) and MA Packaging (MAP)
  - Typically, $CO_2$ at about 5-10% is used
- Vacuum packaging
  - All gases removed

What all of these have in common???
Anaerobic Environment!!!
Reduced Oxygen Packaging:

What all of these have in common???

Anaerobic Environment!!!

Hazard Control:

Low temperature/
Limited storage time

Freezing
ROP: Controlling Hazards

Cook Chill Process:

1. Cook
2. Pump
3. Seal (ROP)
4. Blast chill or water bath
5. Store and re-heat
ROP: Controlling Hazards

Cook Chill Process:

1. Cook
   - Temperature: Kills pathogenic vegetative cells
   - Hazard Controls

2. Pump

3. Seal (ROP)
   - Rapid Chilling: Prevent germination of spores

4. Blast chill or water bath
   - Limited Time Refrigeration or Freezing: Prevent/limit growth of pathogenic bacteria

5. Store and re-heat
ROP: Controlling Hazards

Sous Vide (Cook in Bag) Process:

- Food Preparation
- Bagging/Sealing (ROP)
- Cook
- Chill and Storage
ROP: Controlling Hazards

Sous Vide (Cook in Bag) Process:

- **Food Preparation**
- **Bagging/Sealing (ROP)**
- **Cook**
- **Chill and Storage**

**Temperature:**
Kills pathogenic vegetative cells

**Rapid Chilling:**
Prevent germination of spores

**Limited Time Refrigeration or Freezing:**
Prevent/limit growth of pathogenic bacteria

Hazard Controls
ROP: Controlling Hazards

- Cooking
- Rapid Chilling
- Limited Refrigerated Storage
- Freezing