Cannabis Products Safety Education:
Food Microbiology 101

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Lecture Overview

- Introduction of microorganisms in the food processing environment
- Managing microorganisms in the food processing environment
- Overview of foodborne pathogens
Types of Hazards in Foods

- **PHYSICAL**
- **CHEMICAL**
- **BIOLOGICAL**
Microorganisms in food

Molds  Bacteria  Parasites  Yeast  Viruses
# Microorganisms in food

<table>
<thead>
<tr>
<th></th>
<th>bacteria</th>
<th>yeasts</th>
<th>molds</th>
<th>viruses</th>
<th>parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foodborne Illness</td>
<td>✔️</td>
<td></td>
<td>*</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Fermentation</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Spoilage</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
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</table>

* Some molds can produce a mycotoxin in certain foods.
Microorganisms in Foods

![Graph showing the growth, survival, and death of microorganisms over time.](image)

- **Growth**
- **Survival**
- **Death**

**Axes:**
- **Y-axis:** \( \log_{10} \text{CFU/g} \)
- **X-axis:** Time (hr)
Microorganisms and processed foods: introduction and control

Sources:
- Water
- Soil
- Air
- Food handlers
- Insects
- Animals
- Surfaces
- Raw ingredients
- Packaging materials

GMPs and SSOPs:
- Sanitation
- Testing
- Facility/equipment design
- Product flow
- Employee hygiene
- Employee training
- Pest control program
- Sourcing
- Inventory

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Microorganisms: major cause of food spoilage

• Most significant type of spoilage
• *Growth* of molds, yeasts, and bacteria
Microorganisms: most are NOT a health hazard

• Some beneficial
  – Fermentation
  – Chemical synthesis
  – Decomposition
Microorganisms: some cause **Foodborne Illness**

• Foodborne disease, foodborne infection, or food poisoning
  – Sickness that arises from consuming contaminated foods or beverages
  – Many different symptoms, no one “syndrome”
1. It has been produced, prepared, packed, or held under unsanitary conditions in which it may have become contaminated with filth or in which it may have been rendered injurious.

2. It consists in whole or in part of any filthy, putrid, or decomposed substance.

3. It bears or contains any poisonous or deleterious substance that may render it injurious to users under conditions of use suggested in the labeling or under conditions of as are customary or usual.

6. The methods, facilities, or controls used for its manufacture, packing, or holding do not conform to, or are not operated or administered in conformity with, practices established by regulations adopted under this division to ensure that the cannabis product meets the requirements of this division as to safety and has concentrations it purports to have and meets the quality and purity characteristics that it purports or is represented to possess.

Microbial Spoilage

Microbial Foodborne Illness
Methods for managing microbial contamination in edible cannabis products

PREVENT

KILL

CONTROL
KILL – inactivate microorganisms

• Many techniques
  • Heat, acid, antimicrobial chemicals, irradiation, ultrasound, pulsed light, high pressure
• Influencers of rate of inactivation
  • Time, temperature, concentration, food composition, target microorganism
• Must be combined target, matrix, and treatment for hazard control

Subchapter 3, Article 3, § 40230, (w)
VALIDATION

Obtain and evaluate scientific and technical evidence that a control measure, combination of control measures, or quality controls procedures as a whole, when implemented, is capable of ensuring the quality of a cannabis product or effectively control an identified hazard
CONTROL – inhibit microbial growth

• Shelf Stability/Quality
  • Inhibit growth of microorganisms that cause spoilage
• Ensure Food Safety
  • Inhibit growth of microorganisms that cause foodborne disease

What factors contribute to microbial survival and growth?
Factors affecting microbial growth

- Nutrients
- Oxygen
- Time
- Temperature
- Acid
- Moisture

- Product formulation
  - pH
  - $a_w$
  - Antimicrobials/preservatives

- Processing
  - Temperature/time

- Packing/storage
  - Atmosphere
  - Storage temperature
Growth Factors – Food (Nutrition)

• Foods we find nutritious
  – also good for microorganisms
Growth Factors - Air

Aerobic

Air

Bacteria

Needs Oxygen

Anaerobic

Oxygen Toxic
Growth Factors - Time

- Called “growth” or “multiplication”
- A cell can divide every 15-30 minutes
  - Under optimal conditions
Temperature Effect on Bacterial Growth

Salmonella spp.

\[
\text{Log}_{10} \text{ CFU/g}
\]

\[
0 \quad 2 \quad 4 \quad 6 \quad 8 \quad 10 \quad 12 \quad 14 \quad 16
\]

Time (h)
pH of Foods

pH Scale

pH 0 - pH 7 - pH 14

pH 2
pH 3
pH 4
pH 5
pH 6
pH 7

High Acid Foods

pH 4.6

Low Acid Foods
Impact of water on food preservation

• No direct relationship between moisture content of food and its tendency to spoil

WHY?
Example: Milk vs. Soy Sauce

• MILK
  • Moisture content ~ 87%
  • Shelf life: 1 -2 weeks and refrigerated

• SOY SAUCE
  • Moisture content ~ 82%
  • Shelf life: long-term and room temperature
Key Basic Definitions

- **Moisture content (% moisture)**
  - The amount of free and bound water in a food
  - “free” water is the amount of water available for biological functions
  - “bound” is the fraction used to hydrate hydrophilic molecules and to dissolve solutes

- **Water activity (A_w or a_w)**
  - The amount of free water in a food
  - Impacts microbial growth and enzymatic activity directly
Impact of solute on water activity ($a_w$)

15 molecules total
15 molecules available

Salt (or sugar)

15 molecules total
5 molecules available

A Measure of Available Water

Image: faculty.clintoncc.suny.edu
Food Deterioration Rate vs. Water Activity

Water Activity - Stability Diagram

- Loss of Crispness
- Powder Caking
- Collapse
- Browning Reactions
- Moisture Sorption Isotherm
- Enzyme Activity
- Mold Growth
- Yeast
- Bacteria

Water Activity

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Moisture Content Relative Reaction Rate
A_\text{w} \text{ examples}

A_\text{w} Scale

Growth of all bacterial pathogens inhibited

Low A_\text{w} foods  

High A_\text{w} foods

Pure H_2O

10% Salt

A_\text{w} 0

A_\text{w} 0.85

A_\text{w} 1.0

0.65

0.93

> 0.95

0.93

10% Salt
Microbial growth niches
• Areas which cannot effectively be cleaned and sanitized

Biofilms
• Bacteria which are attached to a surface and grow
• Form a complex bacterial community that also contains extracellular material
Impact of high microbial load in a food

- Increased spoilage/shortened shelf life
- Thermal processes may be ineffective
- Foodborne illness due to contamination or recontamination with pathogens

Chapter 13
Section 26131

Adulterated Product
Unlawful
Foodborne Illness Acquired in the United States—Major Pathogens

Elaine Scallan, Robert M. Hoekstra, Frederick J. Angulo, Robert V. Tauxe, Marc-Alain Widdowson, Sharon L. Roy, Jeffery L. Jones, and Patricia M. Griffin

January 2011, CDC, Emerging Infectious Diseases

31 major pathogens
9.4 million episodes/year

Photo credits: www.foodsafety.gov
Sources of foodborne pathogens: Enteric organisms

- Microorganisms found in the intestine
- Common to products of animal origin
  - Beef, poultry, eggs, etc.
- Cross contamination to other foods
  - Fresh fruits and vegetables
Sources of foodborne pathogens: Environmental pathogens

Transient Contamination

Product Flow

Resident Contamination

Product Flow
What types of hazards are associated with foods that are similar to manufactured cannabis products?
### FDA identified potential biological hazards: baked goods

Hazard Analysis and Risk-Based Preventive Control for Human Food: Draft Guidance for Industry
Appendix 1: Potential Hazards for Foods and Processes


<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategory</th>
<th>Storage Conditions</th>
<th>Example Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully-Baked Without Filling, No Topping/Frosting</td>
<td>Cakes/Muffins/Brownies/Doughnut</td>
<td>Frozen</td>
<td>Chocolate, Vanilla, Yellow, Marble, Sponge Cake, Pound Cake, Cheesecakes</td>
</tr>
<tr>
<td>Fully-Baked Without Filling, No Topping/Frosting</td>
<td>Cookies</td>
<td>Shelf-Stable</td>
<td>Chocolate Chip, Peanut Butter, Biscotti, Lemon, Butter Cookies, Brownies, Wafers, Oatmeal Cookies, Fruit, Cream or Chocolate-Filled Crisps/Bars, Wafers</td>
</tr>
<tr>
<td>Fully-Baked Without Filling, No Topping/Frosting</td>
<td>Other Pastry Products</td>
<td>Refrigerated</td>
<td>French Toast, Blueberry Pancakes, Waffles</td>
</tr>
<tr>
<td>Fully-Baked Including Fillings, No Topping/Frosting</td>
<td>Bread, Whole/Presliced</td>
<td>Shelf-Stable, Refrigerated or Frozen</td>
<td>Cheese Breads, Raisin Breads; Cornbread, Flavored Biscuits, Chocolate Croissants, Pumpkin Bread, Banana Nut Bread</td>
</tr>
</tbody>
</table>