Section 2.6
Meat Safety: Handling, Quality Assurance & Processing

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Section Summary

- Meat handling and storage for fresh and frozen product
- Wholesale and retail meat packaging
- USDA product certification
- Consumer perceptions of food safety
- FSIS (Food Safety Inspection Service) legislative and regulatory roles
- Sources of pathogenic contamination and control/reduction methods
- Identifying and selecting a processing facility
Meat Handling Practices

- Quality control during harvest, processing, storage & distribution affects:
  - Safety (microbiological loads)
  - Eating quality (product integrity, aging)
  - Shelf life (microbiological loads, oxidation, freezer burn)
Meat Handling Practices

• Keep product:
  ▶ Cold
  ▶ Clean
  ▶ Moving (first in, first out)
Effects Of Freezing On Certain Meat Attributes

- Freezing does not improve quality; thus, only high quality meats should be frozen.
- Freezing does not kill bacteria, it only slows their growth; hence, good handling practices are still required.
- Because freezing stops the aging process that tenderizes meat, aging should be allowed to proceed to the desired level before freezing.
Effects Of Freezing On Certain Meat Attributes

• Freezing does little to influence human nutritive value

• However, concentrations of some vitamins, minerals, & water soluble proteins are reduced as fat becomes oxidized (particularly in pork and poultry where fat is less saturated) or as purge is released
Factors Affecting Quality of Frozen Meat

In order of impact:

• Frozen storage conditions
• Thawing conditions
• Freezing rate
• Pre-freezing handling

• Minimizing temperature fluctuation, to prevent ice re-crystallization, is of utmost importance to prevent quality deterioration in frozen meats.
Institutional Meat Purchaser Specifications (IMPS) Definitions

• **“Fresh”** - product that has “not been canned, cured, smoked or cooked.”

• **“Chilled”** - “meat product having an internal temperature greater than -2.2°C and held under refrigerated conditions.”

• **“Fresh-Chilled”** - product that has “never been previously frozen.”

• **“Frozen”** - product that “has an internal temperature less than -2.2°C and that is stored at less than -17.8°C.”

Freezing Recommendations

• Fresh meat should be frozen at between -29° to -40°C.

• Product that is frozen too slowly (or, conversely, thawed/tempered too quickly) is subject to cell lysing by large ice crystal formation, leading to oxidative rancidity, dehydration (“freezer burn”), excessive purge formation, & excessive cooking losses.

• Packaging methodology should be considered in conjunction with state of refrigeration.
Meat Freezing Rate

- Freezing rate affects physical & chemical properties of meat & is determined by:
  - Temperature of freezing medium
  - Type & movement of freezing medium
  - Packaging materials
  - Meat composition (fat freezes more quickly)

Meat Freezing Rate

• Slow freezing:
  ▶ Freezing in air is relatively slow.
  ▶ Formation of larger pools of H₂O at crystals & concentrated solutes (eutectic formation) distort muscle structure.

• Fast freezing (cryogenic):
  ▶ Uses condensed gases (e.g., liquid nitrogen, carbon dioxide, liquefied nitric oxide).
  ▶ Little translocation of H₂O, smaller ice crystals, less structure distortion & less drip loss during thawing.

Meat Freezing Methods

- **Still Air:**
  - Air is the heat transfer medium (-10° to -30° C).

- **Plate Freezer:**
  - Product on trays is placed directly in contact with metal freezer plates (-10° to -30° C).

- **Blast Freezer:**
  - Most common is cold air, in rooms or tunnels, equipped with fans to provide rapid air movement (760 meter/min at -30°C).

Meat Freezing Methods

- **Liquid Immersion/Sprays (primarily poultry):**
  - Sodium chloride brine, glycerol & glycols (e.g., propylene).

- **Cryogenic Freezing:**
  - Condensed or liquefied gases (e.g., liquid N₂ = -195°C).
  - Systems generally evaporate liquid N₂ in freezing chambers.

Frozen Meat Storage

- Frozen storage conditions are more important than freezing mechanism for maintained quality.

- All chemical changes in meat could be eliminated by storing at -80°C, but this is not economical.

- Generally, storage temperatures of less than -18°C are recommended.
Frozen Meat Storage

• Fluctuation in temperature during storage must be avoided (large ice crystals form during H₂O migration at greater than -10°C, damaging muscle structure).

• Use of tear-resistant & vapor-proof packaging material to keep moisture in & O₂ out is a must—if not, freezer burn & dehydration will occur.

• Permissible storage time is largely dependent on fat saturation levels.
# Recommended Frozen Storage Times

Optimum quality is affected by freezing rate, length of freezer storage, & freezer storage conditions (i.e., temperature, humidity, packaging).


<table>
<thead>
<tr>
<th>Item</th>
<th>Storage Period (Months)</th>
<th>-12°C</th>
<th>-24°C</th>
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<tbody>
<tr>
<td>Beef</td>
<td></td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Ground beef</td>
<td></td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Lamb</td>
<td></td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Veal</td>
<td></td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Pork (fresh)</td>
<td></td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Pork (cured)</td>
<td></td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>Seasoned pork sausage</td>
<td></td>
<td>0.5</td>
<td>3</td>
</tr>
<tr>
<td>Variety meat</td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Poultry</td>
<td></td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>
Meat Thawing & Refreezing

- Thawing elicits greater damage than does freezing.

- Thawing methods (packaging material intact):
  - Refrigerated temperatures*
  - In warm air
  - In water
  - During cooking
Meat Thawing & Refreezing

- **Refreezing:**
  - May be accomplished without serious deterioration if microbiological loads are low.
  - Practically, freezing & thawing several times reduces quality.

- **Bone darkening (after freezing & thawing):**
  - Leached hemoglobin oxidizes to methemoglobin.
Meat Thawing/Tempering

- **Food safety experts recommend thawing foods in:**
  - Refrigerator (~14-20 hr/kg).
  - Water-tight plastic bag submerged in cold water (~60 min/kg) & changing the water every 30 min, which ensures that it is kept cold—an important factor for slowing bacteria growth.
  - Microwave oven; follow package directions. Leave about 5 cm between food & inside surface of microwave to allow heat to circulate. Smaller items will defrost more evenly than larger pieces. Foods defrosted in microwave oven should be cooked immediately after thawing.
**Meat Thawing/Tempering**

**DO NOT** thaw meat, poultry & fish products on the counter or in the sink without cold water; bacteria can multiply rapidly at room temperature.
Causes Of Foodborne Disease & Reduced Display Life

- Improper storage/holding temperature
- Inadequate cooking
- Poor personal hygiene
- Cross-contamination
- Improper reheating
- Poor storage practices (i.e., storing cooked with raw product)
Quality & Safety Assurance Programs

- Methodology should be quantitative
- Prevent problems; don’t try to solve them once they exist
- Hazard Analysis, Critical Control Point (HACCP) methods
- Total Quality Management (TQM) principles
Environmental Effects Of Processing On Meat Hygiene

Source: Bacon et al., 2000.
## Decontaminating Working Areas

<table>
<thead>
<tr>
<th>Week</th>
<th>Interventions Turned On</th>
<th>Mean TPC</th>
<th>Mean TCC</th>
<th>Mean ECC</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>None</td>
<td>5.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.4&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>B</td>
<td>Carcass OA</td>
<td>5.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.5&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>C</td>
<td>Fabrication Belt OA</td>
<td>4.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.1&lt;sup&gt;de&lt;/sup&gt;</td>
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<tr>
<td>D</td>
<td>Primal OA</td>
<td>5.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>E</td>
<td>Carcass/Belt OA</td>
<td>4.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.8&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>F</td>
<td>All Interventions</td>
<td>4.2&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>2.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.3&lt;sup&gt;cd&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b,c,d,e</sup> Means in the same column bearing different superscript letters differ (P<.05).

Note: OA=Organic Acids; TPC=Total Plate Count; TCC=Total Coliform Count; ECC=<i>E. coli</i> Count.
Chemistry Of Meat Color

Deoxymyoglobin (Purplish red) Fe^{2+}

Oxyhemoglobin (Bright Red) Fe^{2+}

Oxidation

Reduction

Oxidation (Nitrite)

Deoxygenation

Oxygenation

Reduction and Oxygenation

Metmyoglobin (Brown) Fe^{3+}
Vitamin E (α-tocopheryl acetate) supplemented to live fed cattle at 500-1,000 IU/hd/d improves display life of retail beef by maintaining the oxymyoglobin state for longer periods.
Psychrotrophic APC: Strip Steaks From VitE & Non-VitE Supplemented Cattle

[Graph showing the change in APC (log CFU/cm²) over days for Inoculated, Control, and Decontaminated groups with different superscript letters indicating statistical differences.]

Least squares means bearing different superscript letters differ (P < .05)

Source: Zerby, Belk, Sofos, Mc Dowell and Smith, 1997.
Consumer Acceptability: Strip Steaks From VitE & Non-VitE Supplemented Cattle

Inoculated
Decontam.
Control
Non.Vit E
Vitamin E

Least squares means bearing different superscript letters differ (P < .05).

Source: Zerby, Belk, Sofos, Mc Dowell and Smith, 1997.
Meat Packaging

- Packaging should provide protection against:
  - Damage to product
  - Physical & chemical changes
  - Further microbial contamination

- Packaging cannot improve quality

- Packaging should appeal to consumers
Film Properties For Preserving Fresh Meat Quality

• For subprimal cuts (wholesale):
  ▶ Deter growth of micro-organisms
  ▶ Preserve the color of fresh meat
  ▶ Prevent loss of moisture from the product
  ▶ Retain package integrity during shipment & handling
Film Properties For Preserving Fresh Meat Quality

- For retail meats:
  - Allow for development & retention of red, "bloomed" (oxygenated) color of lean
  - Prevent dehydration & moisture loss
  - Possess excellent optical properties (especially clarity)
  - Retain package integrity upon handling
Wholesale Meat Packaging

• Most advanced equipment:
  ▶ Multi-chamber, heat-sealing equipment, speed = 30 pieces/min

• Film bags can be heat-shrink or non-heat-shrink
Wholesale Meat Packaging

• Most commercial bags are 3- or 4-ply laminates:
  ➤ Ethyl vinyl acetate, outer protection
  ➤ Saran, oxygen barrier
  ➤ Irradiated ethyl vinyl acetate, heat sealing properties
Retail Meat Packaging

- Tray-ready
- Case-ready
- Modified atmosphere
  - Uses 80% oxygen or nitrogen, 20% carbon dioxide
  - Peelable or Master-Pak (with $O_2$ scavengers)
- Tray and overwrap
  - Pre-formed styrofoam, overwrapped with oxygen permeable (e.g., PVC) film
New Packaging Technologies
New Packaging Technologies

Case-Ready, Peelable

Vacuum-Packaged

Modified Atmosphere, Case-Ready

Traditional Overwrap
New Packaging Technologies

- CVP Master Pak
- Ossid Overwrap Packaging
- Secure Fresh Master Pak
- Reiser Tray-Lidded Peelable
USDA Product Certification

Live Animal and Carcasses Specifications:

• Allow breed associations, distributors and other industry organizations to group carcasses into specific and uniform breed & quality ranges

• Certification may include quality attributes such as maturity and marbling

• Live animals may be certified for hair coat color and other characteristics
Certified/Process Verified Branded Beef Programs

Of 39 Total Programs (38 Certified, 2 PV or Brandname Beef):

- 26 name breed: 9 Black Angus; 13 Angus; 1 Red Angus; 3 Hereford
- 23 use phenotype description of 51% black; 4 also allow Red Angus genotype
- 38 have minimum marbling score: 1 Slab$^{00}$; 16 Mt$^{00}$; 3 Sm$^{50}$; 6 Sm$^{00}$; 3 Sl$^{50}$; 2 Sl$^{40}$; 7 Sl$^{00}$
- 38 allow only steer &/or steer & heifer carcasses
- 33 have maximum hump height requirement ($\leq 2\,\text{”}$)
- 27 specify “A” maturity only
- 2 specify YG $\leq 2.9$; 10 specify YG $\leq 3.9$; 1 specifies YG $\leq 3.5$; 4 Specify YG $\leq 4.9$
- 4 specify HCW: 2 = 6-950; 2 = 6-900
- 28 specify muscling $\geq$ moderately thick or thicker

USDA Process Verification Program

• Provides livestock & meat producers opportunity to assure customers of their ability to provide consistent quality products by having their written manufacturing processes confirmed through independent, third party audits.

• USDA Process Verified suppliers can have marketing claims such as breed, feeding practices, or other raising and processing claims verified by the USDA and marketed as "USDA Process Verified."
USDA Process Verification Program

- Program uses International Organization for Standardization's ISO 9000 series standards for documented quality management systems as format for evaluating documentation
- Ensures consistent auditing practices
- Promotes international recognition of audit results
- 20 criteria ensuring product conformance and customer satisfaction
USDA Process Verification
Managed Supply-Chains

- Excel Corporation Verified Pork for Strategic Export Program
- Farmland Industries America’s Best Pork
  (www.ams.usda.gov/lsg/certprog/pork/ABP.htm)
- PM Beef Group LLC
  (www.ams.usda.gov/lsg/certprog/beef/pmbeef.htm)
- Pederson's Natural Farms
- Premium Standard Farms
  (www.ams.usda.gov/lsg/certprog/pork/PSF.htm)
- Pro Pork Associates
- Red Angus Association of America
  Red Angus Feeder Calf Certification Program
  (www.ams.usda.gov/lsg/certprog/beef/RedAngus.htm)
USDA Product Specifications

**Institutional Meat Purchaser Specifications (IMPS):**

- Series 100 Beef; 1000 Beef Portion Cuts
- Series 200 Lamb; 1200 Lamb Portion Cuts
- Series 300 Veal and Calf; 1300 Veal and Calf Portion Cuts
- Series 400 Pork; 1400 Pork Portion Cuts
- Series 500 Cured, Smoked, Fully-Cooked Pork
- Series 600 Cured, Dried, Smoked, Fully-Cooked Beef
- Series 700 Variety Meats and Edible By-Products
- Series 800 Sausage
- Series 11 Goats
North American Meat Processors
-The Meat Buyers Guide

- Reference standards for meat purchasing
- Non-certified
- “Commonly-used” foodservice and institutional meat products
Institutional Meat Purchaser Specifications

- Reference standards for meat purchasing
- Certified by USDA-AMS-LSD
- Used primarily for government meat purchases
  - School lunch program
  - Military

Quality Assurance
Beef Quality Assurance

Mission:
Maximize consumer confidence in and acceptance of beef by focusing the industry’s attention on beef quality through the use of science, research and educational initiatives.
History Of Beef Quality Assurance

- 1982: USDA-FSIS began work on Pre-Harvest Beef Safety Production Program
- 1982-1985: Residue Avoidance Program (RAP)
- Today:
  - QA Programs reach producers in all 50 states
  - Today: 13 states have developed producer certification and verification programs
Where Is The Money Lost?

Total Cost of Non-Conformance = $68.82

Where Is The Money Lost?

Total Cost of Non-Conformance = $100.10

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Waste</td>
<td>$50.96</td>
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<td>Taste</td>
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<tr>
<td>Management</td>
<td>18.23</td>
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<tr>
<td>Weight</td>
<td>6.46</td>
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**TOTAL** $100.10

## TOP 10 QUALITY CHALLENGES

According to Strategy Workshop Participants

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Severity</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low overall uniformity &amp; consistency of cattle, carcasses &amp; cuts</td>
<td>-3.00</td>
<td>1</td>
</tr>
<tr>
<td>Inappropriate carcass size &amp; weight</td>
<td>-2.88</td>
<td>2</td>
</tr>
<tr>
<td>Inadequate tenderness of beef</td>
<td>-2.21</td>
<td>3</td>
</tr>
<tr>
<td>Insufficient marbling</td>
<td>-2.03</td>
<td>4</td>
</tr>
<tr>
<td>Reduced grade/tenderness due to implants</td>
<td>-2.03</td>
<td>T5</td>
</tr>
<tr>
<td>Excess external fat cover</td>
<td>-1.82</td>
<td>T5</td>
</tr>
<tr>
<td>Inappropriate USDA QG mix</td>
<td>-1.48</td>
<td>7</td>
</tr>
<tr>
<td>Too much hide damage due to brands</td>
<td>-1.82</td>
<td>8</td>
</tr>
<tr>
<td>Too frequent &amp; severe bruises</td>
<td>-1.58</td>
<td>9</td>
</tr>
<tr>
<td>Too frequent liver condemnations</td>
<td>-1.64</td>
<td>T106</td>
</tr>
<tr>
<td>Inadequate flavor of beef</td>
<td>-1.06</td>
<td>T10</td>
</tr>
</tbody>
</table>

Injection-Site Lesion Slice-Audits: Cow & Bull Rounds

Source: Roeber et al., 2002.
Injection-Site Lesion Audits
Steer & Heifer Top Sirloin Butts

Incidence of Lesions

Percent Active Fluid-Filled Lesions

Source: Roeber et al., 2002.
Food Safety
Food Safety & Quality Concerns

- Pathogens/foodborne illness
- Antibiotic/pesticide residues
  - New FSIS “surveillance” sampling protocols
- Physical hazards
- Use of hormones & growth promotants
Food Safety & Quality Concerns

• Injection site blemishes:
  ◆ incidence in beef = ~2.5%

• Production related defects:
  ◆ bruises, hide/pelt defects, offal condemnation, etc.

• Eating quality:
  ◆ tenderness, juiciness, flavor
How Do Consumers Perceive Meat Safety?

- FMI Trends reported that “product safety” is “very important” (71%) or “somewhat important” (20%) to consumers in food selection, ranking 3rd.

- Supermarket shoppers were “completely” (15%) or “mostly” (59%) confident that food in the supermarket is safe.

- Hart Research Associates (on behalf of NCBA) reported that 75% of consumers are confident that U.S. beef is safe.

Consumer Perception Of Food Safety

Note: Survey has margin of error of 3.3%.
Consumer Perception Of Ground Beef Safety

Percent of Consumers NOT Confident in Ground Beef Safety

Score of 3 or lower on a 10-point scale

Note: Survey has margin of error of 4.5 %.
Consumer Perception Of
Ground Beef Safety

Percent of Consumers Confident in Ground Beef Safety

Score of 8 or higher on a 10-point scale

Note: Survey has margin of error of 4.5 %.
USDA-FSIS Inspection


- **Residues**: FDA-CVM & EPA sets residue tolerance limits for livestock, drugs & pesticides, respectively; monitored & enforced for meat products by USDA-FSIS.
FSIS: Areas Of Responsibility

- Antemortem inspection
- Postmortem inspection
- Product inspection
- Assurance that all plants adopt & use HACCP
- Assurance that SSOPs are practiced by personnel
FSIS:
Areas of Responsibility

• Verification of HACCP System effectiveness (Salmonella performance standards).
• Oversight of plant protocols for generic E. coli testing.
• Laboratory determinations & assays.
• Control & restriction of condemned products.
• Marking, labeling, & inspection insignia.
• Facilities construction & operational sanitation.
Origin Of HACCP Concept

• 1959, Dr. Howard Bauman for NASA/Pillsbury.
  ◆ 1st Concern: Food crumbs in zero gravity
  ◆ 2nd Concern: Microbiological safety

• “If we had to do a great deal of destructive testing, there was absolutely no way we could be assured that there wouldn’t be a problem.”

• “The only way we could succeed would be to establish control over the entire process: the raw materials, the processing environment, & the people involved.”

Prerequisite Programs

• Facilities
• Production equipment
• Control of raw materials
• Sanitation (SSOPs)
• Chemical control
• Production & quality controls
• Glass control
Prerequisite Programs

- Receiving, storage & distribution
- Traceability & recall
- Complaint investigations
- Labeling
- Training
Help Consumers Understand...

Source: Kain et al., 2002.
Common Microbiological Counts

- **Standard Plate Count (SPC):**
  - Also referred to as “Total Viable” (TPC) or Aerobic (APC) Plate counts
  - Estimates number of live, viable microorganisms which form “colonies” if plated on a nutritive solid substrate & provided with appropriate environmental conditions
  - “Pour” or “Spread” plating can be used
Common Microbiological Counts

- **Total Coliform Count (TCC):**
  - Aerobic & facultative anaerobic, fermentative gram-negative organisms found in the intestinal tract of most animals
  - Indicator organisms for fecal contamination

- **Escherichia coli Count (ECC):**
  - Thermotolerant coliforms indicative of fecal contamination
Common Microbiological Counts

- **Psychrotrophic Count:**
  - Characterizes the number of bacteria able to grow at refrigerated temperatures

- **Lactic Acid Bacteria Count (LAB):**
  - Acid-producing facultative anaerobes/microaerophilic counts

- **Pathogens:**
  - Bacteria that can cause animal or human illness
Common Microbiological Counts

- **Air Samples:**
  - Total estimate of airborne microorganisms

- **Yeast & Mold Count:**
  - Estimates numbers of yeasts & molds

- **Mesophilic Spore Count (MSC):**
  - Estimates numbers of heat resistant, sporeforming organisms
**Logarithmic Bacterial Growth**

<table>
<thead>
<tr>
<th>Log$_{10}$</th>
<th>$10^x$</th>
<th>Colony Forming Units (CFU)</th>
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<tbody>
<tr>
<td>1.0</td>
<td>$10^1$</td>
<td>10</td>
</tr>
<tr>
<td>2.0</td>
<td>$10^2$</td>
<td>100</td>
</tr>
<tr>
<td>3.0</td>
<td>$10^3$</td>
<td>1,000</td>
</tr>
<tr>
<td>4.0</td>
<td>$10^4$</td>
<td>10,000</td>
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<td>5.0</td>
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</tr>
<tr>
<td>6.0</td>
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<td>1,000,000</td>
</tr>
<tr>
<td>7.0*</td>
<td>$10^7$</td>
<td>10,000,000</td>
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</table>

*Spoilage generally occurs at 7.0 log/CFU.*
HACCP Preliminary Tasks

- Assemble the HACCP Team
- Describe the food & its distribution
- Describe the intended use & consumers
- Develop a flow diagram that describes the process
- Verify the flow diagram
Seven Principles of HACCP

Following full implementation of written Prerequisite Programs (GMPs, SSOPs):

• Conduct Hazard Analysis;
• Identify Critical Control Points (CCPs);
• Establish Critical Limits (CLs);
• Monitor the Critical Control Points;
• Determine appropriate corrective actions;
• Establish verification procedures to ensure the system works;
• Maintain accurate record-keeping.
Principle No. 1: Conduct A Hazard Analysis

- At each processing step, identify those hazards (threats to public health) that could be introduced, controlled or enhanced at that step.

- For each identified physical, chemical or biological hazard, determine whether or not the hazard is “significant” (reasonably likely to occur; risk/threat to public health).

- Justify the decision concerning level of “significance” with valid scientific evidence.

- Determine those control measures available to prevent/eliminate/reduce to acceptable levels the risk of the hazard occurring.
Principle No. 2: Determine Critical Control Points

• § 417.1 Definitions: A Critical Control Point (CCP) is a “point, step, or procedure in a food process at which control can be applied & as a result, a food safety hazard can be prevented, eliminated, or reduced to acceptable levels.”

• FSIS considers an acceptable reduction for E. coli O157:H7 to be a reduction to an undetectable level
Beef Multiple Hurdles Systems

Carcass Flow

Steam Vacuuming

Pre-Evisceration Wash

Acetic Acid Rinse

Thermal Pasteurization

Final Wash

Acetic Acid Rinse

Zero Tolerance
Plate Counts By Process Sampling Site

Source: Bacon et al., 2000.
Multiple Hurdles

• Hide-off, only .3% of ECC were below the detectable limit (DL; < .9 log CFU/100 cm²).

• At the post-intervention site, 52.2% of ECC were below the DL.

• At the post-chilling site, 98.4% of ECC were below the DL.

• Between hide-on and post-intervention sites, incidence of Salmonella spp. declined by 14.1% (15.4% to 1.3%).

Source: Bacon et al., 2000.
Control Of Human Pathogens

Bad hamburger linked to death

By The Los Angeles Times

SEATTLE — Food poisoning caused by contaminated hamburger patties — which has struck about 160 people in the Northwest — was blamed for the death of a 7-year-old boy Friday. Washington state health officials said the contamination likely had its roots in a slaughterhouse and not the restaurant chain, where the hamburgers were sold. But most of the bacteria could have been destroyed had it been properly cooked.

State Health Department tests of two contaminated meat samples taken from the Jack in the Box restaurant showed levels of harmful matter so high that “it would be more difficult, though not impossible, to kill all the bacteria through normal cooking procedures,” the

The study's a investigation said that there was no evidence of refrigeration problems at Yuma Co., which got the beef from a slaughterhouse and packaged and shipped the patties to Jack in the Box, or at the rest

Can This Meat Kill You? THE E. coli THREAT IT'S WORSE THAN YOU THINK

Multiple-Hurdle Technology

Steam Pasteurization

Steam Vacuuming

Lactic Acid Rinse

Lactic Acid Rinse

Acetic Acid Rinse

Acetic Acid Rinse

Final Wash

HOT WATER WASH

Colorado State Center for Red Meat Safety
USDA-MARC Commercial Cattle De-Hairing Study

- 240 samples per treatment.

- Incidence of *E. coli* O157:H7 on pre-treatment hides was:
  - 67% for controls;
  - 88% for cattle hides subsequently treated.

Source: Koohmaraie et al., 2002.
USDA-MARC Commercial Cattle De-Hairing Study

• Incidence of *E. coli* O157:H7 on carcasses following treatment was:
  ▶ 50% for controls (pre-intervention);
  ▶ 1.25% for chemically de-haired.

• “Hide intervention should be a priority as a part of comprehensive program to reduce/eliminate pathogens.”

Source: Koohmaraie et al., 2002.
<table>
<thead>
<tr>
<th>Food</th>
<th>Purpose</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh pork</td>
<td>Control <em>Trichinella spiralis</em></td>
<td>0.3 kGy min. to 1 kGy max.</td>
</tr>
<tr>
<td>Dry spices/seasonings</td>
<td>Microbial disinfection</td>
<td>30 kGy max.</td>
</tr>
<tr>
<td>Poultry</td>
<td>Pathogen control</td>
<td>3 kGy max.</td>
</tr>
<tr>
<td>Frozen meats (NASA)</td>
<td>Sterilization</td>
<td>44 kGy min.</td>
</tr>
<tr>
<td>Refrigerated meat</td>
<td>Pathogen control</td>
<td>4.5 kGy max.</td>
</tr>
<tr>
<td>Frozen meat</td>
<td>Pathogen control</td>
<td>7 kGy max.</td>
</tr>
</tbody>
</table>
Irradiation Dose Needed To Reduce Initial Populations Of Selected Pathogens By 90%

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>D-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella</td>
<td>0.4 to 0.8 kGy</td>
</tr>
<tr>
<td><em>E. coli</em> O157:H7</td>
<td>0.2 to 0.4 kGy</td>
</tr>
<tr>
<td><em>Listeria monocytogenes</em></td>
<td>0.4 to 0.48 kGy</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>0.4 to 0.48 kGy</td>
</tr>
<tr>
<td><em>Campylobacter jejuni</em></td>
<td>0.16 to 0.24 kGy</td>
</tr>
<tr>
<td><em>Toxoplasma gondii</em> (parasite)</td>
<td>0.4 kGy</td>
</tr>
<tr>
<td><em>Lactobacillus</em> spp. (spoilage bacteria)</td>
<td>1 to 2 kGy</td>
</tr>
<tr>
<td>Vegetative <em>Clostridium perfringens</em></td>
<td>0.6 to 0.8 kGy</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em> spores</td>
<td>1.2 to 1.8 kGy</td>
</tr>
<tr>
<td><em>Clostridium botulinum</em> spores</td>
<td>2 to 4 kGy</td>
</tr>
</tbody>
</table>

Source: FDA
### Pathogens Accounting For Food-Related Deaths

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salmonella</strong></td>
<td>31%</td>
</tr>
<tr>
<td><strong>Listeria</strong></td>
<td>28%</td>
</tr>
<tr>
<td><strong>Toxoplasma</strong></td>
<td>21%</td>
</tr>
<tr>
<td><strong>Norwalk-like Viruses</strong></td>
<td>7%</td>
</tr>
<tr>
<td><strong>Campylobacter</strong></td>
<td>5%</td>
</tr>
<tr>
<td><strong>E. coli O157:H7</strong></td>
<td>3%</td>
</tr>
</tbody>
</table>

### CDC, 1999

Prevalence Of E. coli O157:H7 On Live Cattle

- Hancock *et al.*, 1997
  - 1.6 % incidence in fecal samples (188 of 11,881)
  - 61 % incidence in feedlots (61 of 100) in 13 states

- Smith *et al.*, 2001
  - 23 % incidence in fecal samples (719 of 3,162)
  - 100 % incidence in pens (29) and feedlots (5)

- Elder *et al.*, 2000
  - 27.8 % incidence in fecal samples (91 of 327)-21 of 29 lots (72%)
  - 10.7 incidence on hides (38 of 355)-11 of 29 lots (38%)
  - 43.4 % incidence preevisceration (148 of 341)-26 of 30 lots (87%)
  - 17.8 % incidence postevisceration (59 of 332)-17 of 30 lots (57%)
  - 1.8 % incidence postprocessing (6 of 330)-5 of 30 lots (17%)
Incidence Of E. coli O157:H7 (2002)

• 54 positives from > 6,240 samples (0.865%)
• 24 recalls as of 11/26/02
  ▶ 19,142,073 total pounds
  ▶ 3 recalls over 100,000 pounds
    ◆ ConAgra (~18.6 Million pounds)
    ◆ Moyer Packing Co. (208,232 pounds)
    ◆ Fairbank Farms (320,000 pounds)
E. coli O157:H7 contamination of beef products:

- All raw beef processors (intact and non-intact) must reassess their HACCP plan

- Based on data from Elders 2000 and Smith 2001 (28 to 100% incidence of E. coli O157:H7 in feces of live cattle), E. coli O157:H7 IS REASONABLE LIKELY TO OCCUR

- CCPs must address pathogen

Note: October 7, 2002.
Antemortem Interventions

• Vaccination
  ◆ Inhibits Intimin
• Competitive exclusion and probiotics
  ◆ *Lactobacillus acidophilus*
  ◆ Colicin producing *E. coli*
• Chlorate supplementation
  ◆ Targets Nitrate Reductase
• Terminal antibiotic treatment
  ◆ Neomycin
• Plant-derived feed additives
  ◆ Tasco™ (Seaweed)
  ◆ Swainsonine (Pigweed)
Transformation of Live Animals to Carcasses

Preharvest

4-10% Positive for *E. coli* O157:H7

“Preharvest food safety is currently one of the hottest areas of research”

Data Estimates Before 2000!

Post-processing

0.05 % Positive for *E. coli* O157:H7
Site-Specific Prevalence For *E. coli* O157

Source: Keene and Elder, 2002. JAVMA.
Percent Prevalence Of Presumptive Positive E. coli O157

Isolates from hides, feces or a combination of hides or feces collected from cattle exposed to one of eight treatments:

<table>
<thead>
<tr>
<th>Treatments</th>
<th>% Presumptive Positive E. coli O157 isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hide</td>
</tr>
<tr>
<td>Control</td>
<td>40</td>
</tr>
<tr>
<td>Lactobacillus acidophilus (LAB)</td>
<td>23</td>
</tr>
<tr>
<td>Neomycin sulfate (Neo)</td>
<td>9</td>
</tr>
<tr>
<td>E. coli O157:H7 Vaccine (Vac)</td>
<td>20</td>
</tr>
<tr>
<td>Vac + LAB</td>
<td>16</td>
</tr>
<tr>
<td>Vac + Neo</td>
<td>7</td>
</tr>
<tr>
<td>Neo + LAB</td>
<td>7</td>
</tr>
<tr>
<td>Vac + LAB + Neo</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: Ransom et al., 2003.
Summary

• Due to microbiological sampling variability between the pens, if the prevalence of *E. coli* O157 in control hide samples was set at 40%, it would require 38 pens to show a significant difference between the controls.

• For treated cattle the prevalence of *E. coli* O157 on hide samples were 17.6 to 33.6 % lower than the controls.

• For treated cattle the prevalence of *E. coli* O157 in fecal samples were 12.9 to 45.8% lower than the controls.

• Neomycin sulfate as a single treatment or in combination with other treatments appeared to be among the most effective treatments tested in this study.

Source: Ransom et al., 2003.
Facility Considerations
Identifying A Processing Facility

• To find a good processor:
  ▶ Talk to other direct marketers, extension personnel or local trade associations in the area and get recommendations
  ▶ Make appointments with processors who are conveniently located and interview them

Selecting A Processing Facility

• Are they operating under federal inspection?
  
  ▶ All meat products offered into commerce must be produced in federally inspected or state inspected (with federal equivalency) facilities
  
  ▶ State inspected products are not approved for interstate commerce

Selecting A Processing Facility

- Do they process “Not For Sale” products?
- What is the core business of the operation?
  - Plants that offer custom slaughter and wild game processing often heavily rely on these entities for cash-flow purposes
Processing Capacity

• Does the facility have the volume capacity necessary to meet your current and future slaughter and fabrication needs?
  ▶ Consider carcass/cut aging parameters, turn-around time and facility cold storage space
Processing Capacity

• Does the facility have the necessary equipment to process and package your products according to your specifications?
  ▶ Processing and packaging equipment can be very costly and can occupy valuable space in any facility
Plant Sanitation

• Would you be comfortable consuming products produced under the current sanitary conditions of the facility?
  
  ▶ If you are not comfortable, don’t expect your customers to be comfortable.
Plant Sanitation

• What food safety interventions are employed in the facility?
  
  ▶ Food borne pathogens have dismantled multi-billion dollar companies; don’t expect to withstand a pathogen-related recall and don’t think it can’t happen to you!