Sanitation & Hygiene in Food Processing

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Sanitation

- Equipment
- Environment
- Air
- Water

Bilmar Foods 1998

- Frankfurters
- Listeria monocytogenes
  80 Cases 21 deaths (6 stillbirths)

Recall: 17m kg of Product
Direct loss: $76m
Loss sales: $200m
Litigation: $5m

…modern sanitation was one of the greatest public health accomplishments of the late 19th and early 20th centuries.
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Pilgrim’s Pride 2002
- deli meats
- *Listeria monocytogenes*
- 14m kg recall
- 46 cases 10 deaths (3 stillbirths)
- >$100m loss

Canadian Federal Food Safety Agencies
- CFIA (Can. Food Inspection Agency)
  - Inspection Services for HC, AAFC, and DFO
  - Food safety inspections and audits
- Health Canada (HC)
  - Health hazards in the food supply
  - Food safety policies and recalls
- Agriculture and Agrifood Canada (AAFC)
  - Research and regulatory support for agriculture and food production
- Department of Fisheries and Oceans
  - Sustainable use of fisheries resources, facilitate marine trade and commerce

John Tudor & Sons 2005
- Deli meats
- *Escherichia coli* O157
- >150 cases
- 1 death

Canadian Federal Food Legislations
- Legislations with focus on food safety
  - Canada Agricultural Products Act
  - Fish Inspection Act & Regulations
  - Meat Inspection Act & Regulations
  - Food and Drug Act & Regulations
  - Consumer packaging and labeling Act

Sanitation is Important
35% of foodborne illness cases attributed to poor sanitation
- 19% Poor personnel hygiene
- 16% contaminated equipment/environment

Provincial Food Inspection Agency (Ontario)
- Three ministries involved in food safety:
  - OMAFRA (Ont. Min. of Agriculture, Food, and Rural Affairs)
  - MOH (Min. of Health)
  - OMNR (Ont. Min. of Natural Resources)
### Municipal Level

- Municipal By-Laws affecting food safety
  - Building codes with appropriate sanitary env.
  - Potable water
  - Environmental and health issues affecting the food industry (waste water, emissions etc.)
  - Food service establishments
  - Retail stores

### Code of Practice

- Sanitary facilities
- Air quality
- Water quality
- Facility Construction
- Sanitation procedures
- Hygiene and Health requirements
- Training

### Regulations

**Food & Drugs Acts 1985**

7. No person shall manufacture, prepare, preserve, package or store for sale any food under unsanitary conditions.

### Facility

- Drains
  - Sufficient number and construction
- Floor slopes uniformly to the drain
- Walls
  - Hard
  - Smooth
  - Constructed to enable cleaning
- Food contact Surfaces
  - Non-absorbent
  - Free from pitting, crevices and loose scale
  - Capable of withstanding repeated cleaning.

### Cold Stores

- Reduce the risk of condensation
- Relative humidity
- Air flow

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**Codex Alimentarius Commission**

**Sanitary and Phyto sanitary (international) Standards**

[http://www.cfis.agr.ca/english/regcode/gpfh/gpfhc_e.shtml](http://www.cfis.agr.ca/english/regcode/gpfh/gpfhc_e.shtml)
Sanitation Program
An effective sanitation program for equipment and premises is in place to prevent contamination of food.

- Each processor ‘should’ have and implement a written SSOP or similar document that is specific to each location

Sanitation Performance Standards (SPS)
- Standards based on The Food Code.
- Address the conditions within the facility
- Used in conjunction with SSOP’s

SSOP plans
- Provide a schedule for sanitation procedures
- Provide a foundation to support a routine monitoring program
- Encourage prior planning to ensure that corrections are taken when necessary
- Identify trends and prevent recurrent problems

Sanitation Monitoring Program
“Each processor ‘shall’ monitor the conditions and practices during processing with sufficient frequency to ensure, at a minimum, conformance with these conditions and practices specified in the [GMP] that are appropriate to the plant and food being processed.”

Sanitation Testing
- Monitoring: Elements of the sanitation program are being performed correctly (e.g. sanitizer concentration, contact time).
- Verification: Long term effectiveness of the sanitation plan (e.g. microbiological testing).

- Ensure that everyone, from management to production workers, understands sanitation
- Provide a consistent training tool for employees
- Lead to improved sanitation practices and conditions in the plant.

See http://foodsafety.unl.edu/html/sop.html#appendix-a
### Sanitation Monitoring Forms

- **Why Monitor Sanitation Control Procedures**
  - "... to develop a culture throughout the food industry in which processors assume an operative role in controlling sanitation in their plants."

- **Sanitation Monitoring Forms**
  1. Specific sanitation conditions or practices to be monitored
  2. Space to record observations and measurements at the prescribed frequency

### Monitoring

<table>
<thead>
<tr>
<th>Monitoring</th>
<th>Sanitation Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual inspection in good light</td>
<td>ATP (low risk areas)</td>
</tr>
<tr>
<td>Protein residue tests</td>
<td>Product contact surfaces</td>
</tr>
<tr>
<td>ATP bioluminescence</td>
<td>24-48h to obtain results</td>
</tr>
<tr>
<td>• Indirect measure of viable cells</td>
<td>• Contact plates</td>
</tr>
<tr>
<td>• Automated logging</td>
<td>• Swab samples</td>
</tr>
<tr>
<td>BioTrace</td>
<td>• Sticky tape</td>
</tr>
<tr>
<td>BioControl</td>
<td>Total Aerobic Count</td>
</tr>
<tr>
<td></td>
<td>Spoilage microflora</td>
</tr>
<tr>
<td></td>
<td>Fecal indicators</td>
</tr>
</tbody>
</table>

### Microbiological Criteria

- **Meat Processing Lines**
  - Total Aerobic Counts <10 cfu/cm²
  - Enterobactereaceae <1 cfu/cm²

- **No specific criteria**
- **Trend analysis**
- **ATP tests: 0 – 5000 cps acceptable**
Sanitation Control Procedure

• Sanitation part of pre-requisite programs

• Can also be incorporated into HACCP plan

• Maintain sanitary conditions usually related to the entire processing facility or an area

5 Steps

Five Steps of Cleaning and Sanitizing

1. Dry clean
2. Pre rinse
3. Apply detergent
4. Post rinse
5. Sanitize

SCP vs CCP’s

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Control</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathogen Survival</td>
<td>Time &amp; temperature for smoking fish</td>
<td>CCP</td>
</tr>
<tr>
<td>Contamination with pathogens</td>
<td>Wash hands before touching product</td>
<td>Sanitation</td>
</tr>
<tr>
<td>Contamination with pathogens</td>
<td>Clean and sanitize food contact surfaces</td>
<td>Sanitation</td>
</tr>
</tbody>
</table>

Physically removing soils

• Brushes -- proper stiffness
• Pads -- proper cutting properties
• Pressure spray -- moderate pressure

Training is Key to the Success of Sanitation

• Important to get staff involved

• Training must be focused and practical

• Records of training and incentives provided.

• Staff involved in developing plan, implementation, monitoring and verification.

Pads, brushes and brooms should be dedicated to tasks for which they are designed

• Optimizes cleaning effectiveness

• Minimizes cross contamination between areas of the plant
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Pre Rinse

- Rinse until visually free of soils.
- Use lowest effective pressure to minimize aerosols and condensation.
- Lower pressure reduces risk of cross contamination and machine damage.

Types of Detergents

- General Purpose (GP)
- Alkaline
- Chlorinated (chlorinated alkaline)
- Acid
- Enzyme

Detergent application methods

- Soak tanks
- Foam
- Automated systems
  - CIP (clean in place)
  - parts washers
- Manual (pails)

Chemical Sanitation

- Effectiveness Based on:
  - Exposure Time
    - More microorganisms - Longer exposure time
    - Colonies die in logarithmic pattern
    - Different types of organisms die at different rates
  - Temperature
    - Generally, the hotter the temperature, the more effective the chemical sanitizer

Effectiveness of Chemical Sanitizers

- Concentration
  - Follow label
  - More not necessarily better
- pH
  - Differs depending of Type of Sanitizer
- Cleanliness
  - Soil can react with sanitizers and neutralize them

5th Step!
Sanitizing follows proper cleaning
1. Dry clean
2. Pre rinse
3. Detergent application
4. Post rinse
5. Sanitizing

Step 6?: Rinse
Pros: Remove residues and reduces the generation mutants
Cons: No residual antimicrobial activity

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Effectiveness of Chemical Sanitizers

- Water Hardness
  - Calcium and Magnesium in hard water neutralize Quats
  - Can add chelating agent
- Bacterial Attachment
  - Attachment to surfaces make bacteria more resistant to sanitizers

Endospores

- Outer spore coat: Physical barrier
- Cortex, SASP: Glassy structure to protect DNA

Viruses

DNA viruses  RNA viruses

Enveloped viruses

Sanitizer Resistance

- Gram negative bacteria more tolerant to sanitizers.
- Outer membrane forms physical barrier
- Less stable at alkali pH

Protozoa

Cyclospora

Pitting Provides Sites for Bacterial Attachment

HOLE IN A HEAT-EXCHANGER PLATE
Biofilms

Ideal Sanitizers
- Destroy vegetative microorganisms
- Work well in different environments
- Dissolve in water
- Inexpensive, easy to use, readily available
- Should not irritate skin
- Should not have offensive odor

Antimicrobial Tests
(Required for EPA Registration)

<table>
<thead>
<tr>
<th>Product</th>
<th>Test</th>
<th>Required Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>General disinfectant</td>
<td>AOAC Use Dilution</td>
<td><em>Sal. cholerasuis</em> ATCC 10708, <em>Staph. aureus</em> ATCC 6538</td>
</tr>
<tr>
<td>Hospital disinfectant</td>
<td>AOAC Use Dilution</td>
<td><em>S. cholerasuis</em> ATCC 10708, <em>S. aureus</em> ATCC 6538, <em>P. aeruginosa</em> ATCC 1542</td>
</tr>
<tr>
<td>Sporicidal</td>
<td>AOAC Sporicidal</td>
<td><em>B. subtilis</em> ATCC 19659, <em>Cl. sporogenes</em> ATCC 3584</td>
</tr>
</tbody>
</table>

Sanitizer Concentrations Commonly Used in Food Plants

<table>
<thead>
<tr>
<th>Sanitizer</th>
<th>Food Contact Surface</th>
<th>Non-Food Contact Surfaces</th>
<th>Plant Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>100-200 ppm</td>
<td>400 ppm</td>
<td>30 ppm</td>
</tr>
<tr>
<td>Iodine</td>
<td>25 ppm</td>
<td>25 ppm</td>
<td></td>
</tr>
<tr>
<td>Quats</td>
<td>200 ppm</td>
<td>400 ppm</td>
<td>80 ppm</td>
</tr>
<tr>
<td>Chlorine dioxide</td>
<td>100-200 ppm</td>
<td>100-200 ppm</td>
<td>4-3 ppm</td>
</tr>
</tbody>
</table>

Food Contact Surface Sanitizer
AOAC Germicidal Detergent Sanitizer Test

99 ml Sanitizer Solution
25°C
(minimum of 7.5 x 10^7 CFU/ml)

Add 1 ml of *E.coli* or *S. aureus*
30 second Contact Time

Enumerate Survivors

CFIA Approved List
http://www.inspection.gc.ca/eng/ppc/reference/v2e.shtml

Types of Sanitizers
- Chlorine
- Chlorine dioxide
- Ozone
- Iodophores
- Quaternary ammonium compounds
- Trisodium phosphate
- Peroxyacetic acid
Chlorine

• Sodium or Calcium Hypochlorite
• Cheap
• Well established in the food industry
• Chlorous acid antimicrobial form

Chlorine Dioxide (ClO₂)

Powerful oxidizing agent (2.5 x greater than chlorine)
• Relatively stable in the presence of organics.
• Does not form chloroamines as a side reaction.

• pH dependent
  pH 6  Chlorous acid
  pH < 6 Chlorine gas (toxic)
• Sequestered by organic material
• Carcinogenic chloroamines can be produced.
• Unstable at high temperatures
• Corrosive

• Limited efficacy against viruses
• Unstable at temperatures > 30°C
• Used to decontaminate Post-Office affected by anthrax letters.

Ozone

• Effective against vegetative cells, spores and fungi.
• Limited efficacy against viruses
• Can leave chlorine odor
• Mechanisms still unknown but primarily oxidation of proteins.

• Generated on site via passing air through high voltage fields.
• Powerful oxidizing agent.
• Poor solubility (max 6ppm in water)
• Negligible residues (used for treating bottled water)
Iodine Compounds

- Iodophors
  - Iodine alcohol solutions and Aqueous iodine solutions
- Less germicidal than chlorine, but broader effective pH range (2-5).
- Low concentrations pass chambers test
- More effective on viruses than other sanitizers

Iodine Compounds - Advantages

- Less corrosive than Chlorine
- Stable when Concentrated
- Effective in hard water
- Can prevent mineral deposits
- Good Hand-dipping agent
- Amber color - Good indicator of active iodine

Disadvantages of Iodine compounds

- More expensive than Chlorine
- Off-flavors in Foods
- Vaporize at 50°C
- Stain and discolor equipment
- Not as effective as Chlorine in low temperature environments
- Foam formation (CIP)

Ionic Compounds

- Trisodium Phosphate
- Quaternary Ammonium Compounds (QAC’s or QUAT’s)
- Organic Acids

Trisodium Phosphate (TSP)

- TSP inactivates bacteria by pH effect.
- 8% w/v TSP: pH 12
- Strips membranes from cells
- Gram positive bacteria more resistant than Gram negative.

QACs

- Non-corrosive
- Stable at high temperature
- Effective against yeast, molds and Gram positive bacteria.
- Less effective against Gram negative and viruses.
- Inactivated by surfactants
- Residual activity
QACs: Mode of Action
1. Adsorption to bacterial cell surface
2. Diffusion through outer layers of cell
3. Binding to cytoplasmic membrane
4. Disruption of cytoplasmic membrane
5. Release of cell constituents (K+, large Mol.Wt. materials)
6. Coagulation of cell contents and cell inactivation

Peroxy acid compounds
- Low Foam - CIP
- Antimicrobial activity over broad temperatures
- Combine sanitizing and acid rinsing in one step
- Non-corrosive
- Tolerant to organic matter
- Effective against Biofilms

- Gram positive bacteria sensitive
- Potential problem of generating resistant mutants.

QAS Pumps
- Trans-membrane efflux pump
- Linked to drug resistance
- Sanitizer rotation

Resistance to Biocides
- Prions
- Bacterial spores
- Protozoa cyst/oocysts (e.g. Cryptosporidium)
- Mycobacterium
- Non-enveloped viruses
- Fungi
- Vegetative bacteria
- Lipid-enveloped viruses

Relative Biocidal Activity
- Endospores
- Mycobacterium
- Non-enveloped viruses
- Protozoa oocysts
- Mycobacterium
- Non-enveloped viruses
- Fungi
- Vegetative cells
- Enveloped viruses

- Peroxyacids, glutaraldehyde, formaldehyde, chlorine dioxide, ethylene oxide
- Phenolics, Iodophors, Hypochlorites
- Quaternary Ammonium Compounds, Organic Acids

Sources of Contamination

Ready-to-Eat

- *Listeria monocytogenes*
- Raw materials
- Endemic: Drains, cold stores, difficult to clean areas

Fresh Cut Produce

- *Listeria monocytogenes*
- *Salmonella*
- *E. coli O157*

- Hepatitis A
- *Cyclospora*
- *Cryptosporidium*

Environment vs Raw Material

Traditional view

- Post-process contamination
  - *Listeria monocytogenes*

- Raw material
  - *Salmonella*
  - *E. coli O157*

Meat

- *Salmonella*

- *Campylobacter*

- *E. coli O157*

Molecular Epidemiology

- Track and Trace Sources of microbial contamination.
- DNA typing of isolates taken from different sites.
Forensic Science

- Fingerprints can be used to differentiate individuals

Molecular subtyping using restriction endonucleases

- Restriction endonuclease (“molecular scissors”)
- DNA sequence recognized by restriction endonuclease

Forensic Science

- Dr Alec Jeffreys
- DNA fingerprinting

Molecular Typing of Pork and Beef Chain

- Surfaces contaminated in the first 30 mins of processing
- Contamination derived from holding area and transporter
- Sanitizer resistance predicted by genetic lineage

Holding Area and Transporter

- Difficult to sanitize
- Short-lived benefits
- Increased sanitation decreases endemic populations

Source: A. Noller and M.C. McEllistrem
Fresh-Cut Produce

- Field acquired contamination
- Wash water
- Bagging station

Hand washing

- most common source of contamination leading to illness is the fecal-oral route
- contaminated after using the restroom
- bacteria and viral contamination transferred via contaminated food or utensils

Food Handler

- Salmonella
- E. coli O157
- Staphylococcus aureus
- Enteric viruses (Norwalk, rotavirus)
- Hepatitis A

Hand Washing Standards

- designated sink in the food preparation area for hand washing
- Hot and cold running water
  - hot water must have a minimum temperature of 43 °C
  - Liquid soap is preferred
  - Fingernail brush
- Only disposable paper towels or air dryer are authorized for drying hands

Personal Hygiene and Identifying Unhealthy Personnel

- Supervisors
  - must identify unsanitary and unhealthy personnel
  - Observation is an effective means of identifying health risks
  - look for cuts/burns on fingers, hands, and arms; oozing sores, pimples, or boils; and significant coughing or sneezing
  - Workers not allowed around food if they are experiencing fever, vomiting, or diarrhea

Hand washing

1. Wet hands thoroughly with warm water
2. Apply soap generously
3. Lather & Rub Hands Thoroughly for at least 30 seconds
4. Rinse Thoroughly
5. Dry with Paper Towel
6. Safe Hand Washing

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Reduction in microbial loading on hands using different sanitizers

Mean change (log_{10} CFU)

<table>
<thead>
<tr>
<th>Sanitizer</th>
<th>Mean Change (log_{10} CFU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soap</td>
<td>0</td>
</tr>
<tr>
<td>Iofophor</td>
<td>1.5</td>
</tr>
<tr>
<td>4% CHG</td>
<td>2.5</td>
</tr>
<tr>
<td>70% alcohol</td>
<td>4</td>
</tr>
</tbody>
</table>

Hand rubs for lightly soiled hands

Gloves

- **Advantages**
  - Minimize direct bare hand contact with product.
- **Disadvantages**
  - Discourage hand washing

- Easier to monitor/ enforce than hand washing
- Failure to change gloves may enhance risks

HANDWASHING

WHEN TO WASH HANDS

- AFTER TOUCHING THE BODY (NOSE, MOUTH, HAIR, ETC.)
- AFTER USING THE RESTROOM
- AFTER EATING, DRINKING, OR SMOKING
- AFTER HANDLING SOILED EQUIPMENT
- AFTER TOUCHING RAW MEAT
- BEFORE AND AFTER PUTTING ON GLOVES
- AFTER TAKING OUT THE GARBAGE

Hand washing by food handlers

- 52% supervisors could describe the hand washing procedure
- 48% of workers could demonstrate code-compliant hand washing

Future Prospects

- Anti-microbial contact surfaces (e.g. silver zeolite)
- Biological control
  - Bacteriophage
  - Competitive exclusion

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Competitive Exclusion

- *Enterococcus durans*
- *Lactococcus lactis* subsp. *lactis*

- Inhibit growth of *Listeria monocytogenes* in drains

On-farm Sanitation

Protect water sources from manure contamination.
Clean, sanitize and chlorinate frequently.

Summary

- Sanitation is key to reducing foodborne illness outbreaks.

- Success depends on SSOP, SAP and staff training

- Novel sanitation methods to decontaminate reservoirs of contamination

Other Webber Training Teleclasses

- February 23 — The Building as a Source and Vector of Problematic Microorganisms
- March 9 — Pandemic Influenza
- March 21 — Leadership in a Healthcare Environment
- March 30 — Critical Design for Acute Care

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