Discussion Topics
- Food Microbiology Overview
- Acidified Foods
- Hazards of Fresh Fruits and Vegetables

Food Microorganisms
- Bacteria
- Yeast
- Mold
- Viruses
- Parasites
  - Pathogens – any microorganism that causes disease in humans

Microorganism transfer
- Soil and Water
- Plants and animals
- Raw to processed food / cross contamination
- Person to Food
- Person to Person

Microbial Growth
- Moisture
- Food source
- Time
  - Temperature
  - Oxygen
  - pH
  - Light

Farmers’ Market Food Safety

Food Microbiology Overview
Microbial Growth
- Reproduce by dividing
- Every 20 to 30 minutes
- Generation time

Bacterial Multiplication
- Time: Numbers
  - 0: 1
  - 20: 2
  - 40: 4
  - 80: 16
  - 160: 256
  - 420: 2,097,152

Foodborne Illness
- An illness or disease transmitted to people through food products that results from ingesting foods which contain pathogens, their toxins or poisonous chemicals
- Food will not look, taste or smell bad
- Pathogenic organisms or toxins present in food
- Food allows growth
- Temperature allows growth
- Time to grow and produce toxin
- Food must be eaten

Food Preservation
- Physical treatments
  - Inhibit by Dehydration, Cold storage & Chemical
  - Destroy by Heating & Radiation
  - Reduce by Washing
  - Remove by Filtration

Water activity (Aw)
- Measure of available water
- Ranges from 0 to 1.0
- Inhibits growth
  - Bacteria: <0.91
  - Yeast: <0.87
  - Molds: <0.80
How to lower water activity

- **Bacteria**
  - 15% Salt
  - 50% Sugar

- **Mold and Yeast**
  - 15% Salt
  - 50% Sugar for Yeast
  - 65-70% Sugar for Mold

Temperature

- Keep food out of the temperature danger zone (40-140°F)
  - Keep cold things cold <40°F
  - Keep hot things hot > 140°F

Oxygen

- Vary in the amount needed
  - Aerobic - need air
  - Anaerobic - no air
  - Microaerophilic - little air

- MAP & Vacuum Packaging
  - Control the air in the package

Clarification of Acidity (pH)

- Measured using colorimetric or electrometric methods

Buffering Capacity

- Ability of Food to Resist Changes in pH
  - Varies from food to food
  - Proteins have high buffering capacity
Acidified Foods

- Fermented Foods Preserved by Lactic Acid Bacteria
  - Yogurt, Sauerkraut
- Preservation by Addition of Acid to Low Acid Ingredient

FDA Definition

- Low Acid Food to Which Acid or Acid Food is Added to Produce a Final pH of 4.6 or Less
- Aw >0.85
- Every component must have a pH of <4.6 within 24 hrs

Scheduled Process

- High Acid Foods (pH<4.6) do not require high temperatures
  - Boiling water may be sufficient
  - Low pH prevents outgrowth of spores

Scheduled Process

- Hot Fill Hold
  - Hot Product sealed into container. Held and cooled.
- Atmosphere
  - Produce put into container. Closed and pasteurized.

Required Regulation-FDA

- Register and File a Process
- Register, pH control, sugar, salt, preservative
- Adhere to Filed Process
- Provide Process and pH Records
Regulations - Acidified Foods

- USDA
  - 9 CFR, Part 318 (381)
- FDA
  - 21 CFR Part 114, Part 110 and 108.25

Hazards of Fresh Fruits and Vegetables

Fruit and Vegetable Trends (1987 - Present)

- Important component of U.S. Diet
- Federal initiatives
  - U.S. Dietary Guidelines
  - Food Guide Pyramid
  - Healthy People 2002
  - Nat. Cancer Inst. - Five a Day Program
- 24% Increase in consumption

Increase in Foodborne Illness associated with produce

- The number of people affected more than doubled
- A variety of fruits and vegetables were involved
- 75% related to domestically grown
- Most outbreaks were caused by bacteria

Other causative agents

- Cryptosporidium and Cyclospora parasites
- Hepatitis A and Norwalk viruses

Growers response
- Wider variety of traditional and new produce
- Global production and distribution
  - Food from 130 countries over the world
  - Provides year-round availability
  - Innovative packaging
  - Improved marketing merchandising

Salmonella sp. and E. coli O157:H7 caused most outbreaks
- Poor agricultural practices
- Poor hygiene of workers

USDA – 9 CFR, Part 318 (381)

FDA – 21 CFR Part 114, Part 110 and 108.25

Food Guide Pyramid

Healthy People 2002

National Cancer Institute - Five a Day Program

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Fruit and Vegetable Trends (1987 - Present)
Causes for Increases in Illness

- Changes in social demography
  - Increase in elderly, immuno-compromised & those suffering from chronic diseases
  - Pregnant women and young at high risk

- Changes in food system
  - National and international scale
  - Expose more consumers
  - Harder to trace an outbreak

Changing consumer preferences
- Increased popularity in salad bars
- Increase in meals eaten outside the home
- Increases the risk of produce contamination

Poor handling and preparation practices
- No heat treatment to kill pathogens
- Long storage periods at improper temperatures may allow microbes present to survive and grow

Genetic changes in microorganisms
- Adaptation to stresses in the environment
- Yersinia enterocolitica and Listeria monocytogenes are capable of growing slowly at refrigerator temperatures
- Some bacteria can cause serious human illness when only small numbers of cells are ingested
- E. coli O157:H7 and Salmonella enteritidis

Increase in Outbreaks
- Reduces consumer confidence
- Can cause financial losses
- Respond with third party inspections to verify that produce is being grown, harvested and packaged using good agricultural and management practices (GAP & GMP)

Farm Strategy Focus
- Difficult to completely sanitize produce once contamination has occurred
- Reduce risks by:
  - Preventing contamination before it happens

Basic Principles
- Prevention of microbial contamination of fresh produce
- Accountability throughout all levels of agricultural from growing to packing and transportation

Nebraska Department of Agriculture
Record Keeping
- All farm operations that deal with food safety
- Manure use
- Water test results
- Worker training programs
- Facilitates audits
- Shows growers commitment
- Eases trace backs for contamination or proof that contamination did not occur on the farm

Sources of on-farm contamination
- Soil
- Irrigation water
- Animal manure
- Wild and domestic animals
- Inadequate field worker hygiene
- Harvesting equipment
- Transport containers (field to packing)

Sources of on-farm contamination
- Wash and rinse water
- Unsanitary handling during sorting and packaging
- Equipment used to soak, pack or cut produce
- Ice
- Cooling units (hydrocoolers)

Sources of on-farm contamination
- Transport vehicles
- Improper storage conditions (temperature)
- Improper packaging
- Cross contamination in storage, display and preparation

Site Selection
- Historical use of the land
  - No industrial dumping
  - When has animal waste or biosolids been applied
- Upstream from animal containments
- Identify upstream uses of surface water
  - No runoff from contaminated water or livestock waste

Manure Management
- Improperly aged or treated manure can contribute to risk of foodborne illness
- Pathogens can survive in manure for 3 months or more
- Concerns:
  - Fecal material may come in contact with produce
  - Water may splash pathogens in the manure onto produce
Manure Handling
- Proper and thorough composting
- Incorporation into soil before planting
- Apply manure in the fall
- Avoid top dressing
- DO NOT harvest until after 120 days
- Document rates, dates and location of manure application

Irrigation Method
- Drip irrigation recommended
  - Minimizes risk of crop contamination
- Overhead irrigation
  - Use potable water
  - Examine source of surface water
- Keep records of application methods, rates and dates

Worker Health and Hygiene
- Train to follow good hygienic practices
- Proper handwashing
- Proper use of toilet facilities
- Signs and symptoms of infectious diseases
- No direct contact with produce
- Protection for cuts or lesions
- Proper glove use
- Provide proper attire

Cleaning and Sanitizing procedures
- Rinse surfaces if noticeably soiled
- Wash with warm soapy water
- Rinse with clean water
  - Detergent must be rinsed off because it can reduce the effectiveness of the sanitizer
- Sanitize with proper strength solutions or water greater than 170°F

Correct Concentrations of Various Sanitizers

<table>
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<tr>
<th>Sanitizer</th>
<th>Chlorine ppm</th>
<th>Iodine ppm</th>
<th>Quaternary Ammonia ppm</th>
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<tbody>
<tr>
<td>PPQ</td>
<td>50-100</td>
<td>12.5-25</td>
<td>100-200</td>
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ppm = parts per million
Use test strips to determine the proper strength
Each type of sanitizer requires its own test strip
Obtain from local supplier
Harvest Considerations

- Clean & Sanitize harvest containers:
  - High pressure wash, rinse and sanitize
  - Cover clean bins if not used immediately
  - DO NOT allow people to stand in bins during harvest
  - Remove field soil from outside of bins before moving to packing areas
- Worker Hygiene and Training as before

Storage Facility Sanitation

- Wash, rinse and sanitize storage facilities, equipment and food contact surfaces before harvesting and storing crops:
  - Thoroughly clean before sanitization
  - Dirt and organic matter make sanitizers ineffective
  - Use approved products to sanitize food contact surfaces
- Ensure refrigeration equipment is working properly:
  - Measure and record temperatures at least once a week

Cider and Juice Production

- DO NOT use drops - they may have come in contact with animal feces on the ground
- DO NOT use decayed or wormy fruit
- Wash fruit with clean water or approved sanitizers, using brushes carefully
- DO NOT allow pets in orchard, grove or field and attempt to exclude wild animals
- Strongly consider pasteurizing juice and cider

Postharvest Handling

- Enforce good worker hygiene
- Clean and sanitize packing area and lines daily
- Maintain clean wash water
- Cool product quickly and maintain cold chain
- Sanitize trucks before loading
- Keep animals out of packinghouse and storage facilities

Packing Facility

- Barriers that contaminated water and livestock waste cannot enter packinghouse via runoff or drift
- DO NOT wear field clothes (shoes/boots) in packinghouse
- Enforce good worker hygiene
- Clean all containers before use and discard damaged ones
- Store clean empty containers to protect from contamination
- Wash, rinse and sanitize packing areas and floor at end of each day
Packing Facility

- Take care not to contaminate fresh produce that is washed, cooled or packaged.
- Establish and maintain a pest control program:
  - Maintain a pest control log.
- Block access of pests into enclosed facilities.

Washing Operations

- Use chlorinated water (at appropriate level) or other registered disinfectants to wash produce.
- Change water regularly - monitor the chlorine activity.
- Keep water no cooler than 10°F lower than produce.
- Colder could draw pathogens into produce.
- Wash, rinse, and sanitize the packing line belts, conveyors and food contact surfaces at the end of each day to avoid buildup.

Chlorine levels for specific commodities

- General: 50-500 ppm
- Apples: 100-150 ppm
- Asparagus: 125-250 ppm
- Cantaloupe, honeydew: 100-150 ppm
- Lettuce, cabbage, leafy greens: 100-150 ppm
- Tomatoes, potatoes, peppers: 200-350 ppm

Guide to Measuring Sodium Hypochlorite

5.25% (chlorine) accurately

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<th>tsp/5 gal</th>
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<td>75</td>
<td>1.43</td>
<td>5 1/2</td>
<td>1 1/10</td>
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<td>100</td>
<td>1.90</td>
<td>7 1/4</td>
<td>1 1/2</td>
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<tr>
<td>150</td>
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<td>10 7/8</td>
<td>2 1/4</td>
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Guide to Measuring Sodium Hypochlorite

12.75% (chlorine) accurately

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<tr>
<td>150</td>
<td>1.18</td>
<td>4 1/2</td>
<td>9/10</td>
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Cooling

- Maintain cool temperatures - optimum produce quality.
- Minimize pathogen growth.
- Do not overload refrigeration rooms.
- Keep air cooling and chilling equipment clean and sanitary.
- Keep water and ice clean and sanitary - potable water source.
Transportation

- Inspect transportation vehicles for cleanliness, odors, obvious dirt and debris before loading
- DO NOT use trucks which have carried live animals or harmful substances without thorough cleaning
- Good hygienic and sanitation practices should be used when loading and unloading fresh produce
- Load produce to minimize physical damage
- Maintain proper transport temperatures

Summary

- Keep everything clean and sanitary
  - Surfaces, containers, hands
- Clean Water and Ice source
- Personal Hygiene
- Don’t Cross contaminate
- Proper temperatures
- Proper Manure Management