

Produce Safety – What's Going on Here?

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IN THE NEWS...



Objectives

- Demonstrate how various types of fresh produce become contaminated, using information from research, foodborne outbreak investigations and tracebacks.
- Identify preventive and intervention measures throughout the food chain that increase produce safety.
- Identify opportunities for the Environmental Health community to protect consumers of fresh fruits and vegetables.

Changing Outbreak Profiles

- Outbreaks then (Classic)
 - Local outbreaks with gross mishandling on-site
 - Animal foods and their derivatives as vehicles
- Outbreaks now (Recent)
 - Multi-state outbreaks with a complex food chain
 - Enhanced recognition & response
 - Recognizing unlikely food vehicles in addition to animal foods

1998 – 2006 Produce Outbreaks

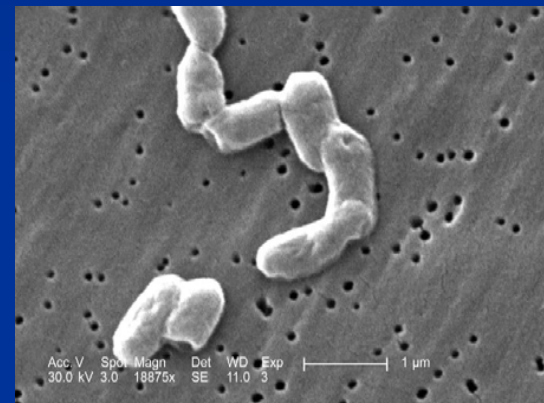
- Five (5) commodity groups make up > 75% of produce-related outbreaks
 - Lettuce (Includes: Iceberg^{a,b}, Romaine^a, Mesclun^{a,c}, Spinach^a)
— 30%
 - Tomatoes^b 17%
 - Cantaloupes^b 13%
 - Herbs (Basil^c, Parsley^{a,d}) 11%
 - Green Onions^e 5%
- Other outbreaks include raspberries, strawberries, almonds, etc.

^a *E. coli* O157:H7 ^b *Salmonella* ^c *Cyclospora* ^d *Shigella* ^e Hepatitis A

Most Common Pathogens on Produce

■ *Salmonella enterica*

- Commensal organism in lower gut of mammals
- High survival rate in the environment
- Forms biofilms
- Heat tolerant
- Overall incidence of *Salmonella* unchanged from baseline 1996-1998 but significant increases in *S. Enteritidis*, *S. Newport* and *S. Javiana* (MMWR 56(14) 336-339)



Most Common Pathogens on Produce

- *Escherichia coli* O157:H7
 - Commensal organism in lower gut of mammals
 - Cattle and other animals are reservoirs
 - Survives well in the environment
 - Forms biofilms
 - pH resistant
 - Incidence of *E. coli* O157:H7 declined from the 1996-1998 baseline in 2003 and 2004 but increased in 2005 and 2006 ([MMWR 56\(14\): 336-339](#))



Likely Sources of Biological Contamination in Fresh Produce

- Water
- Soil
- Manure
- Infected People
- Dirty Equipment
- Cross-Contamination



Water as a Source of Produce Contamination

- Irrigation
 - Irrigation by spray, flooding or drip
 - Spray irrigation – 90% of lettuce plants contaminated with *E. coli* O157:H7
 - Surface irrigation – 19% of lettuce plants contaminated (Solomon et al, 2002. JFP, 65(4): 673-676)



Water as a Source of Produce Contamination

- Fertigation & Chemigation
 - *E. coli* O157:H7 & *Salmonella* can survive several days in pesticide solutions (Guan et al, 2005, JFP, 68(2): 296-304)
- Transporting, cooling, washing/rinsing produce
 - Water should be adequate to its use
- Cleaning equipment



How Else Can Water and Weather Be a Factor?

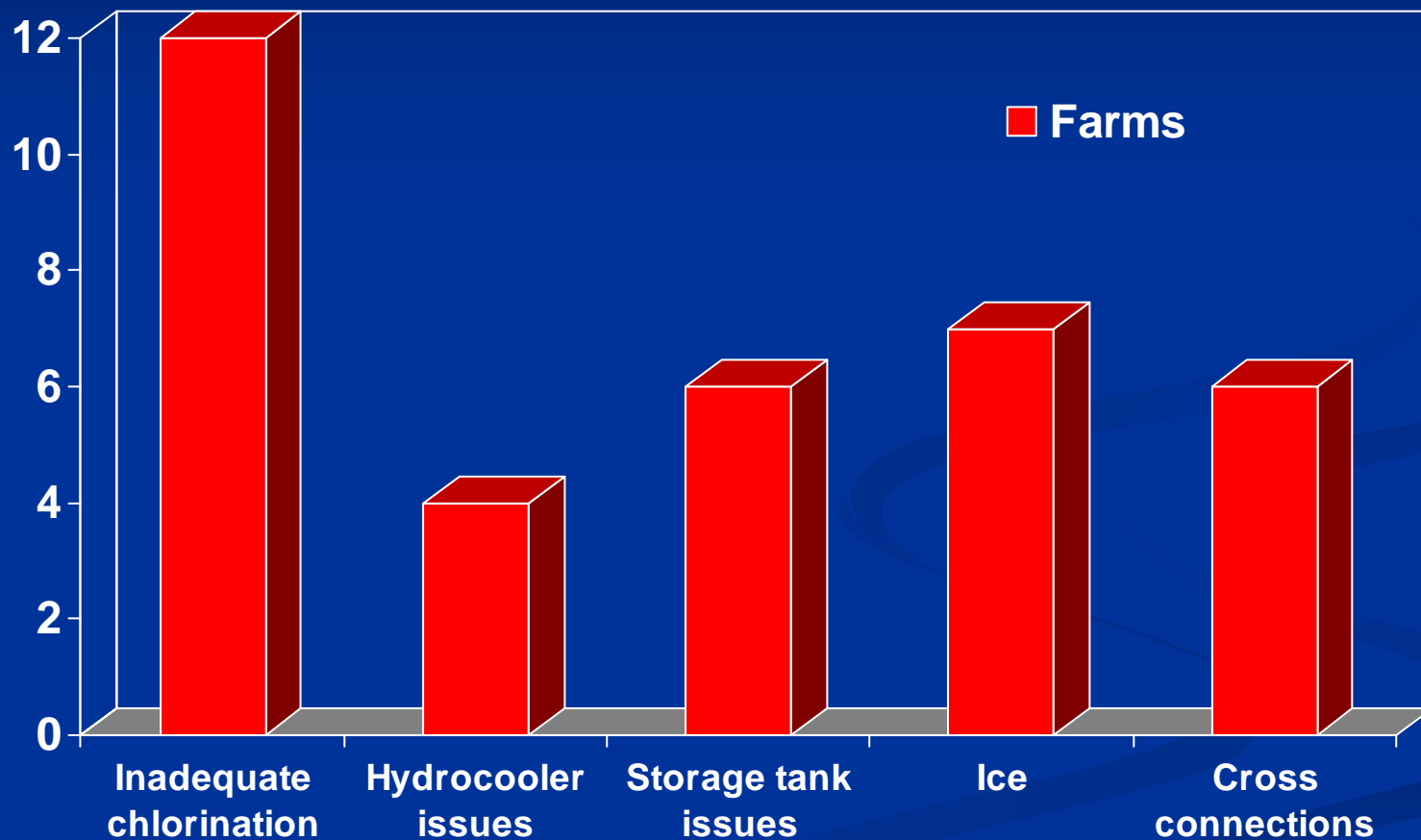
- Drought attracts animals to irrigation ditches/ponds for water and field plants for food
- Heavy rains splash contaminated soil onto plants
- Flooding can wash contamination from lagoons & feedlots into waterways used for irrigation
- Unseasonably warm weather can promote pathogen growth in water, in soil, on plants

How is water contaminated?

- From runoff from nearby domesticated animals and their lagoons, feedlots, ranches into rivers
- From feral/domestic animals with direct access to creeks, ditches, rivers, ponds
- From sewage flows into waterways
 - Storm sewers carrying sewage overflow, sewage treatment plants, failed septic systems
- From contaminated groundwater for wells
- From wells in poor repair

FDA Traceback Findings

Water Issues



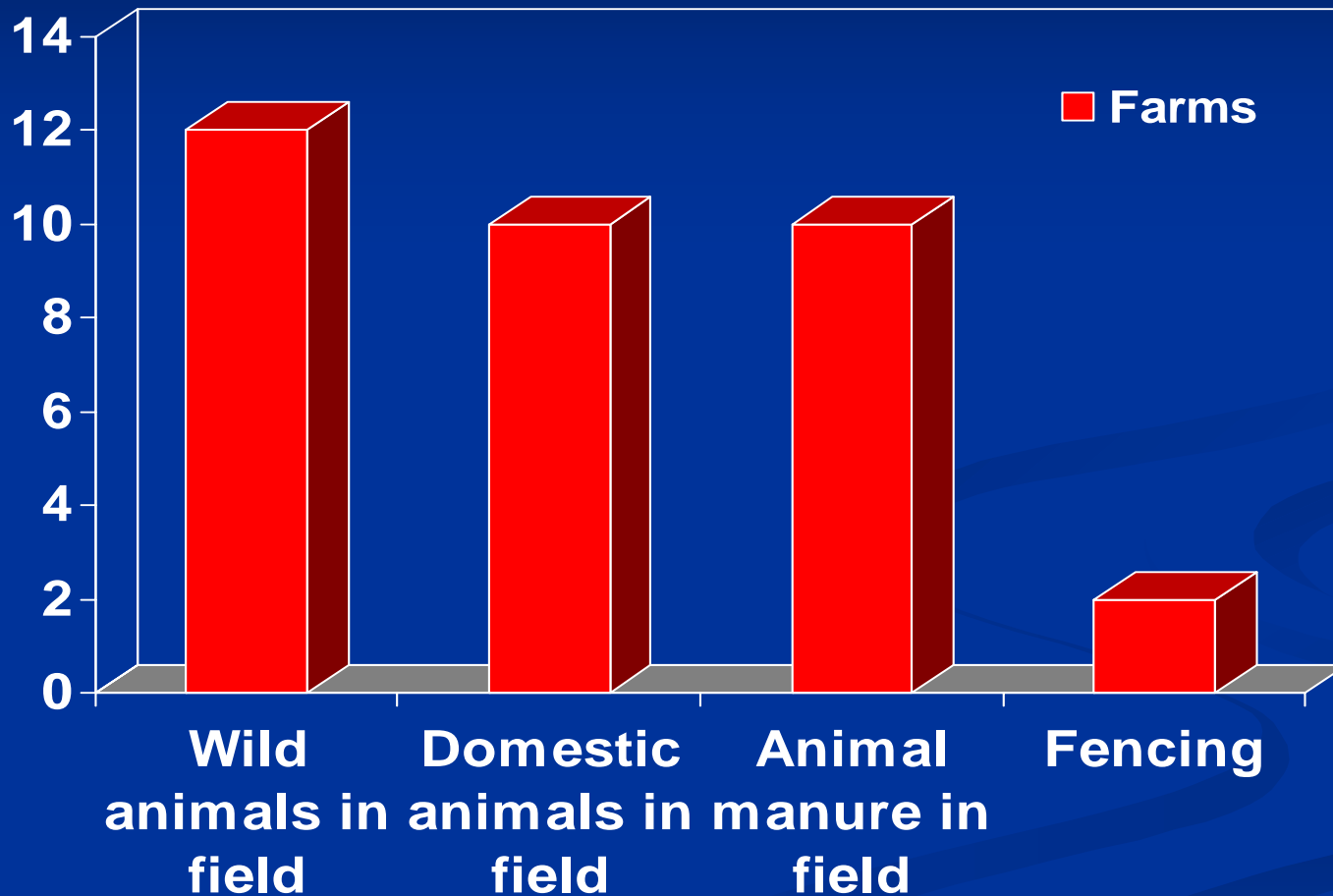
Soil Can Harbor Pathogens

- Pathogens survive in the environment (Islam, 2004. JFP 67(7) 1365)
- Soil can be a source of pathogens from:
 - Irrigation with contaminated water
 - Previous land use
 - Use of adjacent land
 - Feral animal droppings
 - Proximity of populated areas

Manure and Compost

- Animals are reservoirs for foodborne pathogens which are shed in feces
 - Cattle, wild animals, birds, amphibians, human, etc.
- Adequate composting of manure destroys pathogens
- Organic produce is no more nor less contaminated than regular produce
- Domestic, wild & feral animals in fields contaminate produce

FDA Traceback Findings Animal Management Issues



Infected People Can Contaminate Produce

- Field workers need access to toilet facilities
- Migrant labor camp septic and water systems need to be in good repair
- Convenient handwashing facilities are important
- No bare hand contact with RTE Produce
- Food Code says exclude anyone with vomiting, diarrhea or jaundice (V, D or J)

Equipment

- Harvesting
- Packing
- Transportation
- Processing
- Retail



Cross-Contamination

- When does cross-contamination occur?
 - No or inadequate sanitizer residual in flume or wash water
 - Harvest, processing or preparation equipment is not sanitized at frequent intervals
 - Contaminated RTE produce is stored in water to “crisp” or “firm up”
 - Contaminated raw animal products drip onto or contact RTE produce during transportation or storage

Surveillance Sampling of Fresh Produce

- FDA Survey of Imported Produce (1999)
 - FDA Survey of Imported Fresh Produce available at <http://www.cfsan.fda.gov/~dms/prodsur6.html>
- FDA Survey of Domestic Fresh Produce (2001)
 - FDA Domestic Produce Sampling Survey available at <http://www.cfsan.fda.gov/~dms/prodsur9.html>
- USDA/AMS Survey of Fresh Produce (2005)
 - USDA/AMS Microbiological Data Program (2005) available at <http://www.ams.usda.gov/science/MPO/MDPSumm05.pdf>

Ecology of Enteric Pathogens on Plants

- Most human pathogens can persist in the environment
- Intrinsic & extrinsic factors affect pathogen's ability to attach & proliferate (*Aruscavage et al. 2006. J. Food Sci. 71(8): R89*)
 - Motility of the pathogen
 - Waxy cuticle of plants
 - Leaching of nutrients by plant
 - Interaction with epiphytic organisms
 - pH of the plant tissue

Pathogen Survival on Fresh Fruits and Vegetables

- Pathogens attachment to plant within 30-60 min.
 - Where water and nutrients are available
 - Over veins, at roots where plants leach nutrients and water
 - At cracks, cuts, stomata, punctures, bruises
- Once attached, pathogens are VERY difficult to remove

Pathogen Survival on Fresh Fruits and Vegetables

- Biofilm formation
 - Biofilms are a polysaccharide matrix secreted by bacteria that surround and attach them to the surface
 - Biofilms protect pathogens against environmental stress, desiccation, and bacteriocidal agents
 - *Salmonella*, *E. coli* O157:H7 *Listeria* form biofilms
 - Biofilms can be formed with other bacteria

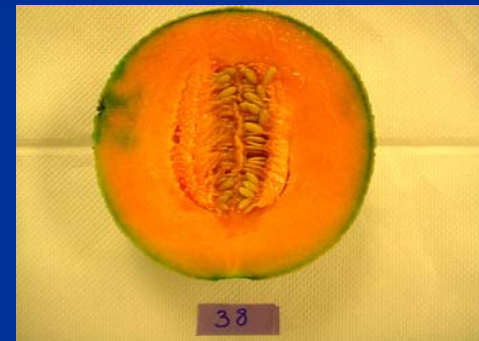
Pathogen Entry into Fresh Fruits and Vegetables

■ Cuts and bruises

- Plant cellular fluids and nutrients attract pathogens
- Plant pathogens can aid foodborne pathogens
 - Fungal infections alter environment by increasing pH and make it more suitable for *Salmonella* and *E.coli* O157:H7
 - Soft rot degrades cell walls and alters leakage from the plant - freeing nutrients and fluids
 - Enzymes degrade cell materials and provide new carbon sources for other pathogens

Pathogen Entry into Fresh Fruit and Vegetables

- Infiltration occurs:
 - When outside water enters the fruit or vegetable
 - In produce with air cells
 - Temperature differential (water colder than produce)
 - Causes air in cell to contract
 - Draw water in through pores, channels, bruises



Interventions Against Pathogen Entry

- Packers, processors and retailers should use water that is about 10°F warmer than produce to prevent infiltration
- Chemical disinfectants in water are critical to keep water pathogen free
 - Most disinfectants provide a 4-6 log reduction of pathogens in water
 - Chemicals are NOT effective against internalized and attached pathogens

Pathogen Entry into Fresh Fruits and Vegetables

- Uptakes of pathogens by roots, flowers, stem scars (experimental evidence only)
 - Spinach grown in soil containing bioluminescent-labeled *E. coli* showed internalization in roots (Warriner et al, 2003. JFP 66(10): 1790-1797)
 - Green onions showed uptake of hepatitis A biomarkers when sprayed on leaves, on soil and added to hydroponics solution (Chancellor et al, 2006. JFP. 69(6) 1468-1472)
 - Tomatoes show uptake of *Salmonella* into fruit when flowers were inoculated (Guo et al, 2001. Appl Environ. Microbiol. 67:4760-4764)

Control Strategies for Pathogens in Fresh Produce

- **Preventions (Voluntary)**
 - Good Agricultural Practices (GAPs)
 - Third Party Audits
 - Commodity Specific Guidance (Cantaloupes, Tomatoes, Lettuce and Leafy Greens)
 - Marketing Agreement
 - Purchase specifications
- **Preventions (Mandatory)**
 - Good Manufacturing Practices (GMPs)
 - Food Code (when adopted by state and local agencies)
 - HACCP (for fresh juice)

Control Strategies for Pathogens in Fresh Produce

- Pasteurization, cooking and retorting
- Irradiation (21 CFR 179.26)
 - Approval for inhibiting growth & maturation; dry herbs and spices; seeds for sprouting; insect pests
 - NOT approved for microbial contamination of fresh produce
 - April 4, 2007 – FR Notice for proposed use of “pasteurized” instead of “irradiated”
 - Irradiation may have sensory effect on produce

Control Strategies for Pathogens in Fresh Produce

- Refrigeration
 - Much fresh cut produce supports growth of foodborne pathogens (PHF/TCS food) because of
 - sufficient nutrients
 - water activity (0.97 – 1.00)
 - pH (≥ 4.2)
 - Temperature varies from harvest to consumer
 - Little pathogen growth below 41°F
 - Therefore, refrigeration $\leq 41^\circ\text{F}$ controls rate of growth and maintains quality

Control Strategies for Pathogens in Fresh Produce

- Washing and sanitizing are only partially effective after contamination occurs
- Washing is intended to remove field soil
- Sanitizers can give a 5 log reduction in water
- Sanitizers are less effective against pathogens attached to produce
 - If pathogens are attached
 - If pathogens formed biofilms
 - If pathogens harbor in cracks and crevices
 - If pathogens are internalized

Chemical Sanitizers for Fresh Produce

- Chlorine (hypochlorous acid \leftrightarrow hypochlorite)
 - 1-2 log reduction of pathogens on produce surface
 - Only effective against viruses at high concentrations (>5,000 ppm)
 - Rapidly inactivated by organic debris
 - Chloramines formed

Alternate Chemical Sanitizers for Fresh Produce

- Chlorine dioxide (21 CFR 173.300)
- Acidified sodium chlorite (21 CFR 173.325)
- Ozone (21 CFR 173.368)
- Electrolyzed water
 - Electrolysis of $\text{H}_2\text{O} + \text{NaCl} \rightarrow$ hypochlorous acid
- Organic acids (produce washes)

Novel Methods of Applying Sanitizers (Experimental)

- Vacuum infiltration of H_2O_2 in apples
 - H_2O_2 not approved for use with produce
- Vapor phase treatment of green peppers with ClO_2 (6.5 log reduction)
- Surface pasteurization with hot water on cantaloupes
- 176°F for 3 minutes with Water + H_2O_2 (gives 4 log reduction of *Salmonella* and *E.coli* O157:H7)

Note: surfactants can increase infiltration

Even More Novel Methods to Increase Produce Safety

- Reduce the amount of *E. coli* O157:H7 and other foodborne pathogens in cattle, other reservoirs and the environment
 - Vaccinate people or cattle against foodborne pathogens
 - Change the feed regimen of cattle
 - Control pathogens in cattle with antibiotics
 - Use bacteriophages or bacteria-killing viruses.

Response to Fresh Produce Outbreaks

- Tracebacks
 - Federal and state/local food safety agencies have authority to investigate foodborne outbreaks and do tracebacks to the farm
 - BT Act requires record keeping
 - Need Positive Lot Identity (PLI) with minimum of commingling
 - Thoroughness and timeliness are critical

Response to Fresh Produce Outbreaks

- Recalls
 - Limit continued sale of contaminated produce
 - Voluntary by the industry
 - Verification audits will show how/if product is removed from display or use
 - Extremely resource intensive
 - Witnessing destruction prevent use of recalled product

Recommendations for Handling Produce in Stores & Restaurants

- Prevent cross-contamination during storage/prep
- Wash hands thoroughly before handling produce
- Wash produce under running, lukewarm water
- Bagged, fresh-cut produce needs **NO** washing unless labeling says otherwise
- Do not work with V, D, J & report to manager
- Use only cleaned/sanitized equipment & utensils
- Refrigerate cut, sliced or diced fresh produce (or bagged fresh-cut) at 41°F or less (if pH > 4.2)
- Acidified fresh produce (i.e., salsas) need pH < 4.2 to hold at ambient temperature

What Can You Do?

- Know where your work fits in with produce safety and what the risk factors are
- Know the environmental ecology of foodborne pathogens
- Apply the “lessons learned” from earlier outbreak investigations and tracebacks
- Leverage your resources

References

- FDA Guide to Produce Farm Investigations, <http://www.cfsan.fda.gov/~dms/prodques.html>
- Guide to Minimize Microbial Food Safety Hazards of Fresh-cut Fruits and Vegetables, <http://www.cfsan.fda.gov/~dms/prodgui3.html>
- Commodity Specific Guidelines for the Melon Supply Chain, <http://www.cfsan.fda.gov/~dms/melonsup.html>
- Commodity Specific Guidelines for the Lettuce and Leafy Greens Supply Chain, <http://www.cfsan.fda.gov/~dms/lettsup.html>
- Commodity Specific Guidelines for the Fresh Tomato Supply Chain, <http://www.cfsan.fda.gov/~acrobat/tomatosup.pdf>

Questions



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