Produce Safety – What's Going on Here?

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National Environmental Health Association
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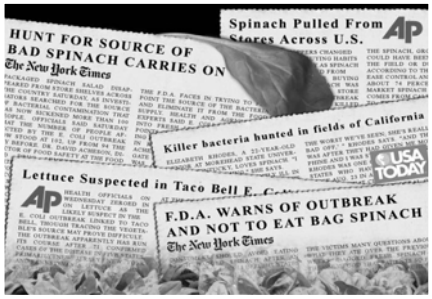
IN THE NEWS…



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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.

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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

FDA 4

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 produce outbreaks include raspberries, strawberries, almonds, etc.

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

FDA 5

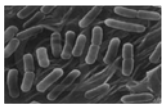
Most Common Pathogens on Produce

- *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)

FDA 6

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)



FDA 7

Likely Sources of Biological Contamination in Fresh Produce

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

FDA 8

Water as a Source of Produce Contamination

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

FDA 9

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

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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

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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

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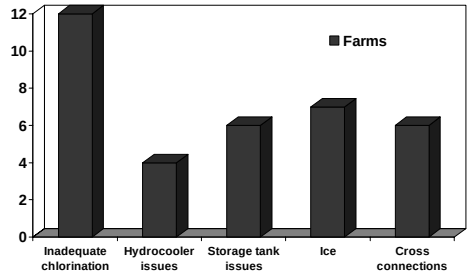
FDA Traceback Findings Water Issues



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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

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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

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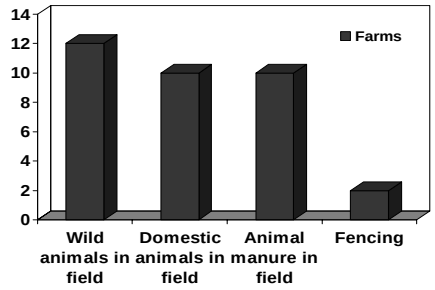
FDA Traceback Findings
Animal Management Issues



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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)

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Equipment

- Harvesting
- Packing
- Transportation
- Processing
- Retail

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Cross-Contamination of Produce

- 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 Attachment on Fresh Fruits and Vegetables

- Pathogens attach to plants 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

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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

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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 a*nd *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

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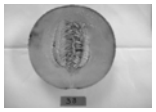
Pathogen Entry into Fresh Fruit and Vegetables

- 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
    - Draws water in through pores, channels, bruises



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Interventions Against Pathogen Entry

- Packers, processors and retailers should use water that is about 10ºF 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

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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)

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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)


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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


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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 41ºF
  - Therefore, refrigeration ≤ 41ºF controls rate of growth and maintains quality


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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

FDA 31

Chemical Sanitizers for Fresh Produce

- Chlorine (hypochlorous acid ↔ 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

FDA 32

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 H_2O + NaCl → hypochlorous acid
- Organic acids (produce washes)

FDA 33

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

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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.

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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

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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 prevents 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 <u>NO</u> 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 41ºF 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

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Questions

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