Produce Safety – What’s Going on Here?

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IN THE NEWS...

HUNT FOR SOURCE OF BAD SPINACH CARRIES ON

Spinach Pulled From Stores Across U.S.

The New York Times

Hunters searched for the source of the bacteria contamination that sickened more than 100 people. Officials said today that the number of people affected by the E. coli outbreak stood at 102. Up from 94 the day before. Dr. David Acheson, director of food safety at the food and drug administration, said the outbreak was "out of control." He said the outbreak was "a common occurrence." The worst we've seen, he said, was in 1995.

F.D.A. WARNS OF OUTBREAK AND NOT TO EAT BAG SPINACH

Lettuce Suspected in Taco Bell E. Coli Outbreak

The New York Times

F.D.A. WARNS OF OUTBREAK AND NOT TO EAT BAG SPINACH

Spinach pulled from stores across the U.S.

The New York Times
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\textsuperscript{a,b}, Romaine\textsuperscript{a}, Mesclun\textsuperscript{a,c}, Spinach\textsuperscript{a}) 30%
  - Tomatoes\textsuperscript{b} 17%
  - Cantaloupes\textsuperscript{b} 13%
  - Herbs (Basil\textsuperscript{c}, Parsley\textsuperscript{a,d}) 11%
  - Green Onions\textsuperscript{e} 5%

- Other outbreaks include raspberries, strawberries, almonds, etc.

\textsuperscript{a} E. coli O157:H7 \textsuperscript{b} Salmonella \textsuperscript{c} Cyclospora \textsuperscript{d} Shigella \textsuperscript{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
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

- Inadequate chlorination
- Hydrocooler issues
- Storage tank issues
- Ice
- Cross connections

Farms
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

- Wild animals in field
- Domestic animals in field
- Animal manure in field
- Fencing

Farms

14
12
10
8
6
4
2
0
Wild animals in field
Domestic animals in field
Animal manure in field
Fencing
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 Domestic Fresh Produce (2001)**

- **USDA/AMS Survey of Fresh Produce (2005)**
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
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
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 ($\geq 4.2$)
  - Temperature varies from harvest to consumer
  - Little pathogen growth below 41°F
  - Therefore, refrigeration $\leq 41°F$ 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 ↔ 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 $\text{H}_2\text{O} + \text{NaCl} \rightarrow \text{hypochlorous acid}$
- Organic acids (produce washes)
Novel Methods of Applying Sanitizers (Experimental)

- Vacuum infiltration of $\text{H}_2\text{O}_2$ in apples
  - $\text{H}_2\text{O}_2$ not approved for use with produce
- Vapor phase treatment of green peppers with $\text{ClO}_2$ (6.5 log reduction)
- Surface pasteurization with hot water on cantaloupes
  - 176°F for 3 minutes with Water + $\text{H}_2\text{O}_2$ (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

- Commodity Specific Guidelines for the Melon Supply Chain, [http://www.cfsan.fda.gov/~dms/melonsup.html](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](http://www.cfsan.fda.gov/~dms/lettsup.html)
Questions