Fresh Produce Supply-Chain Food Safety

UCGAPs research update on food safety associated with vegetable crops

2 September 2011
UCCE Santa Maria Grower Workshop

Trevor Suslow
Department of Plant Sciences
Center for Produce Safety Advisory Board & Technical Committee
tvsuslow@ucdavis.edu 530-754-8313

Food Safety Management Goes from Farm to Fork
Develop a Better Appreciation of Food Safety Needs Across the Farm to Fork Supply-Chain

Why the Concern for Food Safety of Edible Horticultural Products?

- Overview of Food-borne Illness in U.S.
- UCGAPs Brief Research Topics
- Rapid Response Case Example
- Systems-Approach: Case Example
U.S. Foodborne Illness

- **CDC ESTIMATES** (Scallan et al., 2011)
  - Major foodborne pathogens (31 organisms)
  - 9.4 million cases/year (6.6 to 13 million)
  - 56,000 hospitalizations (40,000 to 76,000)
  - 1,200 deaths (710 to 2,300)

- Unspecified illness
- 20 to 61 million cases/year

- Combined about 1 in 6 ill every year – most very mild but many severe

---

Reported outbreaks linked to FDA-regulated foods, by agent, 1996-2009 (N=532 outbreaks)

- Bacterial: 70.1%
- Chemical/Toxin: 17.5%
- Parasitic: 4.3%
- Viral: 4.1%
- Unknown: 4.0%

Source Credit FDA/CFSAN 2011
Reported outbreaks linked to FDA-regulated foods by vehicle, 1996-2009 (N=532 outbreaks)

- 16.4% Produce
- 12.0% Seafood
- 5.8% Dairy
- 4.1% Egg
- 3.9% Processed foods
- 3.9% Sprouts

Source Credit: FDA/CFSAN 2011

Reported illnesses linked to FDA-regulated foods, by vehicle, 1996-2009 (N=29,750 illnesses)

- 37.7% Produce
- 24.3% Seafood
- 18.1% Dairy
- 6.5% Egg
- 1.3% Processed foods
- 1.3% Sprouts

Source Credit: FDA/CFSAN 2011
Types of produce associated with outbreaks, 1996-2009 (N=87)

Source Credit FDA/CFSAN 2011

78 Produce Outbreaks 1999-2010
Attribution by Commodity

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Count</th>
<th>Other Commodity</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce/Romaine</td>
<td>19</td>
<td>Basil</td>
<td>3</td>
</tr>
<tr>
<td>Spinach</td>
<td>3</td>
<td>Basil or mesclun</td>
<td>2</td>
</tr>
<tr>
<td>Cabbage</td>
<td>1</td>
<td>Cilantro</td>
<td>2</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>15</td>
<td>Celery</td>
<td>1</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>7</td>
<td>Parsley</td>
<td>1</td>
</tr>
<tr>
<td>Melons</td>
<td>3</td>
<td>Green onions</td>
<td>2</td>
</tr>
<tr>
<td>Honeydew</td>
<td>2</td>
<td>Mango</td>
<td>2</td>
</tr>
<tr>
<td>Squash</td>
<td>1</td>
<td>Table grapes</td>
<td>2</td>
</tr>
<tr>
<td>Cucumber</td>
<td>1</td>
<td>Jalapeño/Serrano</td>
<td>1</td>
</tr>
<tr>
<td>Raspberries/berries</td>
<td>7</td>
<td>Snow Peas</td>
<td>1</td>
</tr>
<tr>
<td>Sprouts</td>
<td>30</td>
<td>Snap Peas</td>
<td>1</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>Unknown</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: FDA CFSAN
**Where does Fresh-cut produce fit in the picture?**

<table>
<thead>
<tr>
<th>Year</th>
<th>Outbreaks</th>
<th>Illnesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2001</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>3</td>
<td>230</td>
</tr>
<tr>
<td>2003</td>
<td>3</td>
<td>125</td>
</tr>
<tr>
<td>2004</td>
<td>3</td>
<td>532</td>
</tr>
<tr>
<td>2005</td>
<td>4</td>
<td>255</td>
</tr>
<tr>
<td>2006</td>
<td>4</td>
<td>436</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>1638</td>
</tr>
</tbody>
</table>

* Fresh-cut produce: fresh produce that has been processed by peeling, slicing, chopping, shredding, coring, trimming, or mashing, with or without washing or other treatment, prior to being packaged for consumption.

Source Credit FDA/CFSAN 2010

---

**From the Beginning, Variable Risks Along the Supply-Chain were Recognized**

- Season
- Site Selection
- Pre-season field sanitation
- Variety
- Pre-harvest sanitation
- In-season field sanitation
- Crop Management
- Harvest Logistics
- Process Control Handling and Treatment
- Cold Chain and Distribution Control

Trevor Suslow tvsuslow@ucdavis.edu
# Commodity-Specific GAPs and Food Safety Audit Checklists

- Melon
- Tomato
- Stone fruit
- Mushroom
- Lettuce & Leafy Greens
- Culinary Herbs
- Green Onions
- Sprouts
- Almond
- Citrus
- Strawberry
- Watermelon
- Blueberries
- Asparagus

---

# Key Areas for All Scales of Farming and Shipping

- Water –
  - Preharvest & Postharvest
- Workers –
  - Hygiene & Training
- Waste –
  - Manure & Compost
- Wildlife –
  - Intrusion & Fecal
- Record-keeping
- Traceability
Key Grower Concerns

- Setback distances
- Water testing/assuring quality
- Mitigation of animal intrusion
- Impacts of pathogen testing
- On-farm verification requirements

UCGAPs: Research and Extension Program

Trevor Suslow
Department of Plant Sciences
Center for Produce Safety - Advisory Board & Technical Committee
tvsuslow@ucdavis.edu 530-754-8313

Microbial Food Safety of Edible Horticultural Crops
http://ucgaps.ucdavis.edu

Founding Member of the National GAPs Program at Cornell University

Trevor Suslow tvsuslow@ucdavis.edu
UCGAPs: Research and Extension Program

Key Research Commodities & Issues 2007-2011
- Lettuce, Spinach, Spring Mix, Melons, Tomato, Stone Fruit, Carrots, Table Grapes
- Preharvest and Postharvest Water
- Soil survival and Role of N-management
- Bioaerosols
- Rapid Response on-farm assessments

Produce Safety Risk Assessments

- Survival and epidemiology of E. coli in the phyllosphere of diverse leafy green crops.
  - Funding Agency: California Leafy Greens Research Board

- Establishment of critical operating standards for chlorine dioxide in disinfection of dump tank and flume water for fresh tomatoes.
  - Funding Agency: Center for Produce Safety

- Survival of Salmonella enterica and Escherichia coli O157:H7 on cilantro in relation to sequential cutting and re-growth.
  - Funding Agency: Center for Produce Safety

Alejandro Tomás-Callejas
Detection of *Salmonella* and *E. coli O157:H7* on leafy greens after post-contamination exposure to environmental stress

- Survival from realistic levels of contamination
- Survival on diverse ‘mini-greens’/spring mix
- Sampling scheme validations
- Efficiency of commercial test kits
  - Sources of False positives
  - Causes of False negatives

**Example of outcome - Salmonella out-survives E. coli**

Funding source: CA Leafy Greens Research Program
USDA SCRI
Gabriela Lopez-Velasco

Survival of *Salmonella enterica* on tomato through foliar pesticide applications

- Evaluation of *Salmonella* survival and growth in commercial fungicides and insecticides solutions under lab and field conditions
- Identification of pesticides that promote or inhibit *Salmonella* growth and/or survival
- Field trials to determine survival rate after open-field exposure on tomato surfaces and following post-harvest processing for fresh tomato market

Funding source: USDA NIFSI
Gabriela Lopez-Velasco
Root uptake and systemic transport of *Salmonella enterica* in melon and other cucurbits

Evaluation of rate of internalization of *Salmonella enterica* after soil contamination

Example of Key Finding:

- **No systemic transport in field under furrow or drip**

Evaluation of the potential for internalization of bacterial food borne pathogens in carrot roots.

Funding source: Center for Produce Safety
CA Melon Research Board

Gabriela Lopez-Velasco
OBJECTIVE

To evaluate the potential for the internalization of bacterial food borne pathogens in carrot roots from contaminated irrigation water.

Example of Rapid Response: RR15

Bird Impacted Spring Mix: 2011
Molecular Detection - Results

<table>
<thead>
<tr>
<th>Distance from center</th>
<th>Salmonella (Normal processing)</th>
<th>Salmonella (Temp Abuse)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epicenter</td>
<td>0/4</td>
<td>0/4</td>
</tr>
<tr>
<td>20 feet</td>
<td>0/4</td>
<td>0/4</td>
</tr>
<tr>
<td>40 feet</td>
<td>0/4</td>
<td>0/4</td>
</tr>
<tr>
<td>60 feet</td>
<td>0/4</td>
<td>0/4</td>
</tr>
<tr>
<td>Control</td>
<td>0/4</td>
<td>0/4</td>
</tr>
<tr>
<td>Soil</td>
<td>0/4</td>
<td>N/A</td>
</tr>
<tr>
<td>Rinse Water (Temp Abuse)</td>
<td>N/A</td>
<td>0/4</td>
</tr>
</tbody>
</table>
On-Farm Assessments of Storm-Related Flooding on Planting and Replant Decisions

Trevor Suslow
UCD; Dept. of Plant Sciences
tvsuslow@ucdavis.edu
http://ucgaps.ucdavis.edu

LGMA Best Practices ‘Metrics’ after a Flooding Event


<table>
<thead>
<tr>
<th>Time Interval Before Planting Can Commence Following the Receding of Floodwaters</th>
<th>60 days prior to planting provided that the soil has sufficient time to dry out.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appropriate soil testing can be used to shorten this period to 30 days prior to planting.</td>
</tr>
<tr>
<td></td>
<td>Manner that accurately represents the production field and indicates soil levels of micro</td>
</tr>
<tr>
<td></td>
<td>What tests? Test for what?</td>
</tr>
</tbody>
</table>
Soil Field Sampling

- 3 scoops per location composited per block
- Total 22 samples

Lettuce Field Sampling

- 50 plants per location composited per block
- Flooded Lettuce
- LGMA Buffer
- Control

Field Sampling

- Control
- C1
- C2
- C3
- C4
- C5
- C6

Location

- B1
- B2
- B3
- B4

Road
**Plant Harvesting**

- Field sampling divided in 22 blocks, 20 beds wide and 52 feet long (16 meters)
- 50 plants per location composited per block (total of 1100 plants) and divided in 3 subsamples of 150g each
- Inside and outside leaves harvested and processed separately (total of 132 samples combined)
  - Inside leaves composited per block (5-6 leaves per plant, total ~6600 leaves)
  - Outside leaves composited per block (2 leaves per plant, total ~2200 leaves)

---

**Averages Among all Block Outcomes**

<table>
<thead>
<tr>
<th></th>
<th>Flooded</th>
<th>Buffer</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coliforms</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Inside</td>
<td>7.96</td>
<td>7.83</td>
<td>7.81</td>
</tr>
<tr>
<td>Plant Outside</td>
<td>2.26</td>
<td>5.56</td>
<td>8.38</td>
</tr>
<tr>
<td>Soil Bed</td>
<td>2.17</td>
<td>2.31</td>
<td>2.20</td>
</tr>
<tr>
<td>Soil Furrow</td>
<td>1.85</td>
<td>1.29</td>
<td>1.29</td>
</tr>
</tbody>
</table>

| **E. coli**    |         |        |         |
| Plant Inside   | 8.29    | 5.60   | 2.65    |
| Plant Outside  | 5.56    | 1.26   | 1.26    |
| Soil Bed       | 1.43    | 1.43   | 1.43    |
| Soil Furrow    | 1.43    | 1.43   | 1.43    |

Detection Limit: 1.26

### Coliforms
- Detection Limit: 1.26

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection Limit</td>
<td>1.26</td>
<td>1.26</td>
<td>1.26</td>
</tr>
<tr>
<td>Soil Furrow</td>
<td>1.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil Bed</td>
<td>1.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Outside</td>
<td>1.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Inside</td>
<td>2.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### E. coli
- Detection Limit: 1.43

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection Limit</td>
<td>1.43</td>
<td>1.43</td>
<td>1.43</td>
</tr>
<tr>
<td>Soil Furrow</td>
<td>1.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil Bed</td>
<td>1.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Outside</td>
<td>1.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Inside</td>
<td>2.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Trevor Suslow tvsuslow@ucdavis.edu
Summary of 2011 RR-16 Key Learning’s

- Defining flood impacted area visually alone not reliable
- T-Coliform counts in soil may help but not E. coli
- Appears to have good distinction in E. coli on plants
- Younger tissues appear better place to sample
- Flooding of this location did not result in readily detectable pathogen presence

Salmonella and E.coli O157:H7 Can Survive and Even Grow In Some Foliar Materials from a Contaminated Water Source
Peroxide + PerAcetic Acids

- Recognized efficacy
- Water treatment for spray tanks and lines
  - Reported to be effective in drip lines
- 1/100 to 1/1000 use rates
- No disinfection by-products
- Post-cleaning disinfectant of bins, totes, belts

Example of Peroxide only formulation

Example of hard-surface PAA cleaner

Portable Peroxide Sprayers for Surface Disinfection

- Hydrogen peroxide
- Broad germicidal claims
- Principle is sound
- Cleaning first is critical
- UCGAPs has not evaluated
Summary

- Fresh fruits and vegetables have been associated with significant foodborne illness
  - Illness to Total Servings per Year ratio is staggeringly small
- Pathogens associated with diverse fruits and vegetables are a reality
- Prevention of contamination throughout the supply chain is preferred over attempts at postharvest disinfection
- Better Cold Chain Control is essential to minimize risks

Current Suslow Lab: Who really gets the work done
Thank you for your support and cooperation