Fresh Citrus Food Safety
Fungicide Application
Previous Studies
Citrus packinghouse chemicals

• Under laboratory conditions
  • No reduction of *Salmonella*:
    • Imazalil
    • Fludioxonil
    • Pyrimethanil
  • Slow reduction of *Salmonella*:
    • Imazalil and potassium phosphite

Unknown/uncharacterized cross contamination risk
Aqueous mediated cross contamination

Contaminated

Insufficient Antimicrobial Pathogen survival

Pathogen released into water

High risk of cross contamination

Uncontaminated

Sufficient Antimicrobial Pathogen inactivation

Low risk of cross contamination
Preventing Cross-Contamination

It’s a Race Between

Bacterial detachment from contaminated leaf fruit

Bacterial attachment to uncontaminated leaf fruit

Bacterial inactivation in antimicrobial wash

Rate of inactivation

... and complicated by water quality dynamics affecting antimicrobial effectiveness

Slide courtesy of J. Gorny
Summary of informal survey results. Data were received from five individuals; six participated in the ranking. June-July 2016

<table>
<thead>
<tr>
<th>IMZ Concentration (ppm)</th>
<th>PAA (ppm)</th>
<th>Temperature</th>
<th>pH</th>
<th>Time of use of solution</th>
<th>Time of Contact with Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>100, 150, 250, 300, 350, 500</td>
<td>25-85, 30-50, 30-80</td>
<td>60-120, 90-135 (°F)</td>
<td>4</td>
<td>1 days</td>
<td>7 sec</td>
</tr>
<tr>
<td>Min</td>
<td>100</td>
<td>25</td>
<td>60</td>
<td>8 h</td>
<td>5 sec</td>
</tr>
<tr>
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Spray and Flooder Tank

Spray and Flooder Tank
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<th>Soda Ash (Tank)</th>
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<tr>
<td><strong>Concentration %</strong></td>
<td><strong>Temperature (°F)</strong></td>
</tr>
<tr>
<td>1, 2, 3</td>
<td>60, 75, 90, 95, 100, 105, 110, 112, 115 F</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>1</td>
</tr>
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<tr>
<td>1, 2, 3</td>
<td>60, 75, 90, 95, 100, 105, 110, 112, 115</td>
<td>9.5</td>
<td>6 h</td>
<td>5 sec</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>1</td>
<td>60</td>
<td>9.5</td>
<td>6 h</td>
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</tr>
<tr>
<td>Max</td>
<td>3</td>
<td>115</td>
<td>13</td>
<td>3 months</td>
<td>4 min</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>SBC</th>
<th>Concentration SBC (%)</th>
<th>Chlorine (ppm)</th>
<th>Temperature (°F)</th>
<th>pH</th>
<th>Time of use of solution</th>
<th>Time of Contact with Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 2.5, 3, 4</td>
<td>10, 25, 30, 50, 100, 150, 200</td>
<td>60, 75, 95, 105, 110, 115</td>
<td>8, 8.3, 9, 9.5, 10</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Min</td>
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|  |  |  |  |  | Tank | Spray and Flooder | Tank | Spray and Flooder |
|  |  |  |  |  |  |  |  |  |
Recent Results
See other Presentation
Next Steps
Defining Industry Needs

• “Validation”
  – Proving antimicrobial application is sufficient to consistently prevent cross contamination
    • Minimum concentration present at all times in all places
  – Under all conditions of use
    • Product volume, type
    • Impact of time of use (e.g., days, weeks, months)
General Interest

Guidelines To Validate Control of Cross-Contamination during Washing of Fresh-Cut Leafy Vegetables

D. GOMBAS,¹ Y. LUO,² J. BRENNAN,³ G. SHERGILL,⁴† R. PETRAN,⁵ R. WALSH,⁵ H. HAU,⁵ K. KHURANA,⁶‡ B. ZOMORODI,⁷ J. ROSEN,⁸ R. VARLEY,⁹ AND K. DENG¹⁰*
Validating Antimicrobial Use

- Target is “absence of cross-contamination”
- Not a clear procedure, e.g. thermal process
- Not a clear performance standard, e.g. 5-log reduction in 1 min
- “Safe harbor” conditions not understood
Operating conditions may influence the efficacy of washing system to prevent cross-contamination.

- Antimicrobial type & concentration
- Rate of antimicrobial addition
- Rate of water replenishment
- Environmental conditions (pH, temperature, filtration, agitation speed)
- Distance between the products (Water: Product)
- Water mineral hardness
- Insoluble solids (particles)
- Soluble solids (minerals from soil)
Inability to introduce the target pathogen into the processing environment to perform microbial inoculation validation studies

Lack of surrogates known to demonstrate behavior in washing systems similar to target pathogen

Uniqueness of wash water systems to each facility

The difficulty in replicating variability that the wash system can experience in a production day or over time

Obstacles in the validation of leafy green wash water
Laboratory-based studies
Inhibitory Concentrations

- Influence of
  - Water pH
  - Temperature
  - Organic load
  - Solids level

How can these be defined/replicated?
Range of products/volume/practices

- Defining “worst case” challenge
  - Heterogeneity of industry
  - Multiple products and practices
Validating antimicrobial washing as a preventive control for cross-contamination

Option 1

Use of a surrogate
Demonstration that cross-contamination is prevented by the antimicrobial wash.

Option 2

Use of antimicrobial sensors
Demonstration that a critical antimicrobial level is maintained during worst case operating conditions.

Option 3

Validates the placement of the sensors
Demonstration that a critical antimicrobial level is maintained at all locations, regardless of operating conditions.
Option 1:

Microbiological validation using a surrogate
Lowest test level where the surrogate is not detectable on all uninoculated samples (3 trials) is the validated “Critical Limit” for antimicrobial feed rate.
Option 2: Antimicrobial sensor validation
Positioning the sensors to map locations with the lowest antimicrobial level during operation (worst case)

Option 2

Run the system without product or antimicrobial (worst case levels)

Begin product feed (worst case level) minimize the variability and record all variable parameters

Begin the antimicrobial feed rate (lowest level)
Raise it, and wait for equilibrium
Stop when all sensors ≥ established minimum antimicrobial level

The lowest antimicrobial feed rate that achieves equilibrium ≥ the established minimum antimicrobial level at all sensors (in all 3 runs) becomes the “Critical Limit”.
Option 3:

Validation of sensor placement for minimum antimicrobial level
Option 3

Positioning the sensors to map locations with the lowest antimicrobial level during operation (normal)

Begin running the system with product and antimicrobial Record all sensor readings

Run the system under multiple conditions of the variable parameters (as many acceptable variable conditions as possible)

The trial is completed when it is confirmed where the lowest level of antimicrobial exists in the wash system

The highest sensor readings at the monitoring location, when the lowest level sensor was at the established minimum antimicrobial level during the validation trials is the “Critical Limit”.
Monitoring and Verification of Process Controls

Option 1

Validation of the minimum antimicrobial feed rate under worst case conditions

Antimicrobial feed rate needs to be monitored during normal production (≥ Critical Limit)

Option 2

Validation of the sensor positioning to monitor the minimum level of antimicrobial

Option 3

antimicrobial level at the sensor needs to be monitored
Discussion