Pathogen Transfer in Fresh-Cut Operations

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FOOD SCIENCE HUMAN NUTRITION MICHIGAN STATE UNIVERSITY

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AN INTEGRATED APPROACH TO ENHANCE THE MICROBIAL SAFETY OF FRESH-CUT FRUIT AND VEGETABLE PRODUCTS DURING PROCESSING, PACKAGING, AND RETAIL DISTRIBUTION

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PROJECT GOAL

- *To enhance the microbial safety and quality of **ready-to-eat, fresh-cut fruit and vegetable products** via integrated research and outreach/training targeted at the processing, packaging, and distribution phases of the produce chain.*

5 PROJECT MODULES

- **PROCESSING**
  - ***Quantify pathogen transfer and cross-contamination***
- PACKAGING
  - *Develop optimal packaging systems to enhance microbial safety and quality*
- **DISTRIBUTION**
  - ***Evaluate and model potential for pathogen survival/growth during distribution***
- **RISK MODELING**/ECONOMICS
  - ***Quantify risk of pathogen survival, and appropriate intervention strategies***
- EDUCATION/TRAINING
  - *Reduce risk of foodborne illness via high quality training programs*

How Safe is Our Produce?

The Good Old Days

Welcome to the 21st Century

Pre-Harvest Contamination

Cattle Feedlots

Irrigation Water

Wild Animals

Composting Practices

Harvesting is Highly Variable

Processing is Also Highly Variable

- **Commercial Processors**
  - Mechanical
  - Semi-mechanical
  - Manual

- **Foodservice/Supermarkets**
  - Semi-mechanical
  - Manual

Contamination During Processing

- Crates, bins, tarps
- Food contact surfaces during processing
  - Equipment, knives, conveyors, brushes, flume tanks, shredders, shakers, dryers
- Non-food contact surfaces
  - Floors, drains
- Coolers, storage areas
- Personnel
  - Gloves, hygienic practices

Leafy Green Processing

Shredder

Conveyor

Flume tank

Centrifugal drier

Shaker table

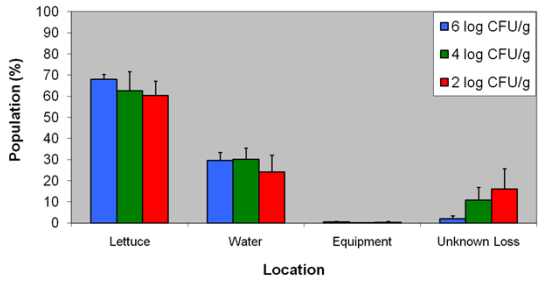
Product ⇨ Equipment and Water

⇨ Sample equipment and water

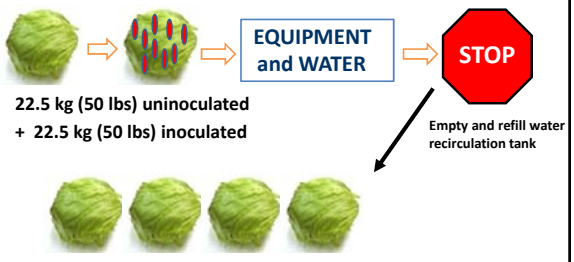
50 lb of *E. coli* O157:H7-inoculated lettuce or spinach

Buchholz et al. 2012. *J. Food Prot*. 75:1184-1197

Distribution of *E. coli* O157:H7 after Centrifugal Drying of Lettuce

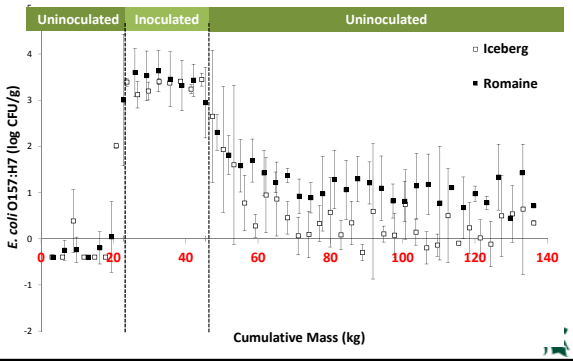


Equipment (and Water) ⇨ Product



Buchholz et al. 2012. *J. Food Prot*. 75:1920-1929

Spread of *E. coli* O157:H7 to Product during Processing of Leafy Greens Containing ~4 log CFU/g

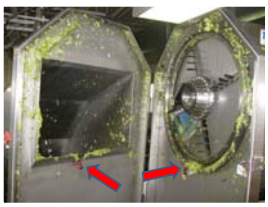


Spread of Contaminated Radicchio

Buchholz et al. 2014. *J. Food Prot*. 77:1487-1494

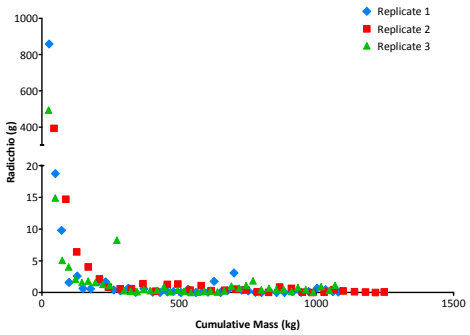
Radicchio Remaining on Equipment Surfaces after Processing 900 kg of Uninoculated Lettuce

Conveyer Belt and Flume Tank

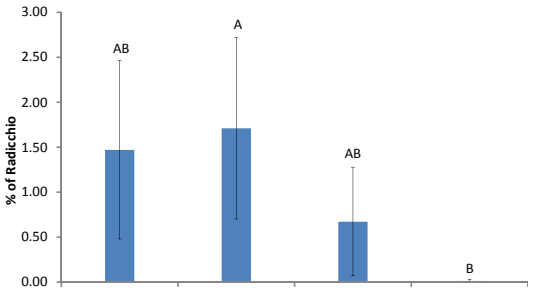


Blade and Interior Surface of the Lettuce Shredder

Spread of Contaminated Radicchio to Iceberg Lettuce during Processing



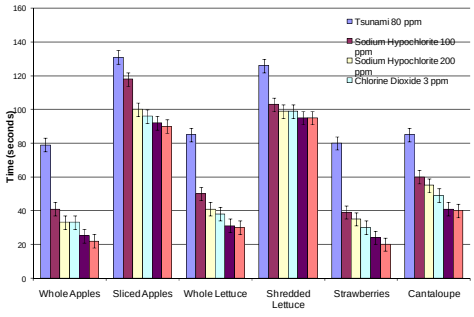
Percentage of Radicchio Recovered from Equipment Surfaces After Processing



http://www.youtube.com/watch?v=8mSKdjxauTw

How well do sanitizers work?

D-values for *L. monocytogenes* on fresh produce exposed to various sanitizers



Rodgers et al. 2004. *J. Food Prot.* 67:766-771

Not well if the organic load in the water is high?

Wash Water Preparation

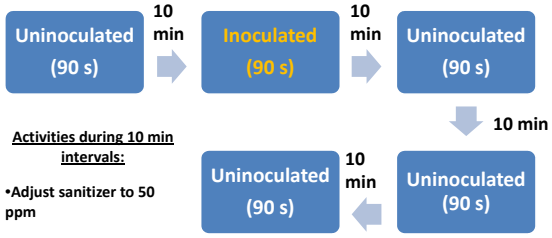
- Organic load (blended iceberg lettuce)
  - 0%, 2.5%, 5%, or 10% (w/v)
- 890 L (235 gal) recirculation tank

Davidson et al. 2014. *J. Food Prot.* 77:1669-1681

Chlorine-Based Sanitizer

- XY-12, at 50 ppm available chlorine
  - Unadjusted, pH 8.10
  - Adjusted to pH 6.5 with Citric Acid (CA)
  - Adjusted to pH 6.5 with SmartWash™ (SW)
- Sanitizer concentration confirmation
  - XY-12: Chlorine Test Kit 321, Ecolab

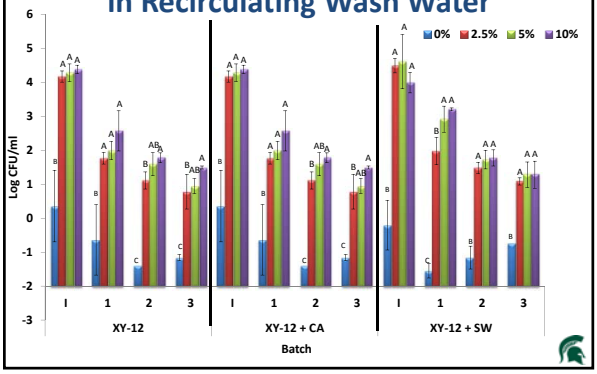
Processing (5.4 kg Batches)



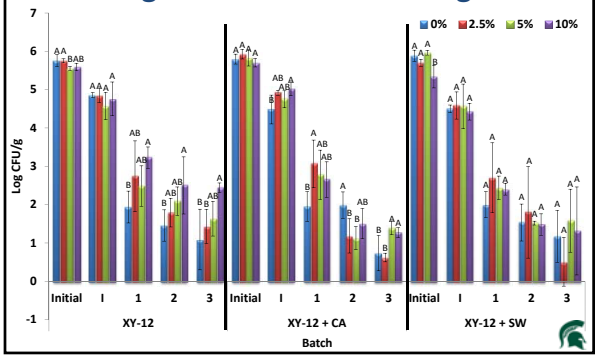
Activities during 10 min intervals:

- Adjust sanitizer to 50 ppm
- Adjust pH to 6.5
- Collect water samples

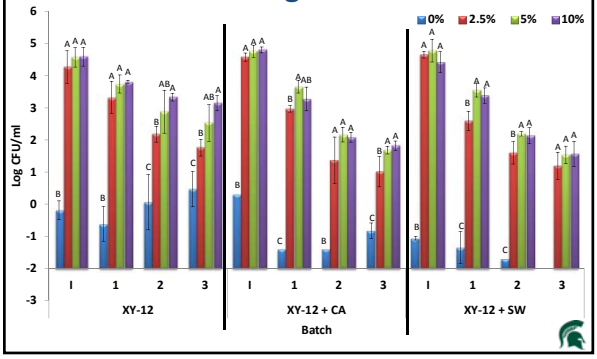
Populations of *E. coli* O157:H7 in Recirculating Wash Water



Populations of *E. coli* O157:H7 on Iceberg Lettuce after Centrifugation

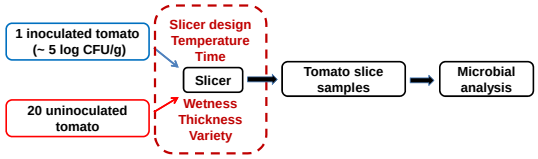


Populations of *E. coli* O157:H7 in Centrifugation Water



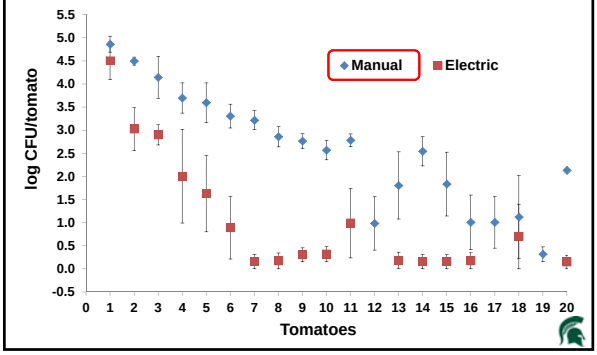
Salmonella Transfer during Tomato Slicing

➢ **Assess the impact of multiple processing variables on *Salmonella* transfer during slicing of tomatoes.**

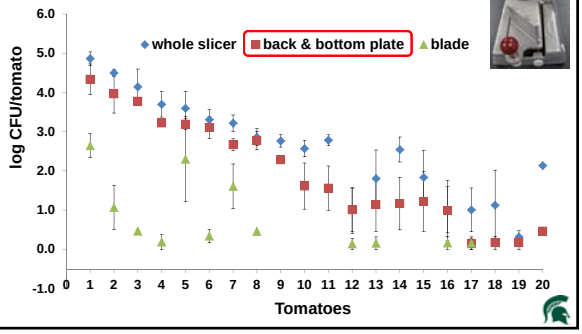


Wang and Ryser. 2015. *Int. J. Food Microbiol.* (submitted)

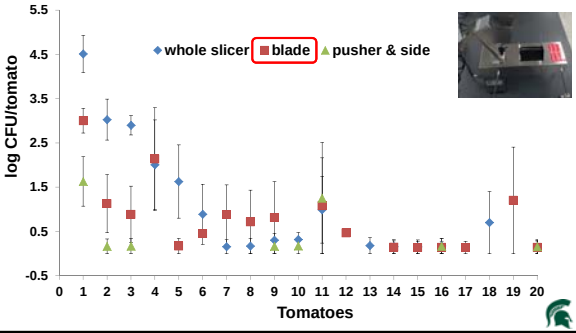
Impact of Slicer Design on *Salmonella* Transfer



Salmonella Transfer to Different Parts of a Manual Slicer



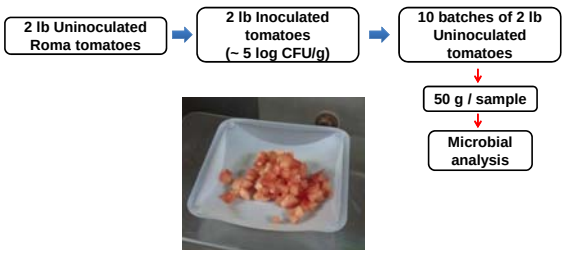
Salmonella Transfer to Different Parts of an Electric Slicer



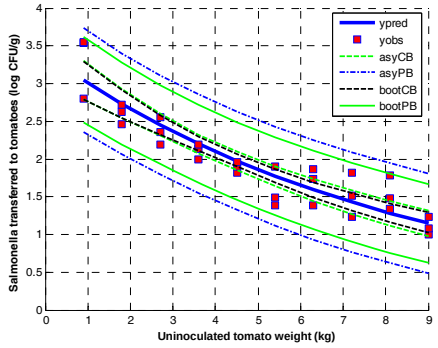
Salmonella Transfer Rate to 20 Uninoculated Tomatoes

Variables	Transfer rate (%)		
Slicer design	Manual **1.11 ± 0.48 A**	Electric **0.45 ± 0.28 A**	
Time	0 min **1.11 ± 0.48 A**	30 min **1.01 ± 0.49 A**	
Wetness	Dry **1.11 ± 0.48 B**	Wet **12.21 ± 2.44 A**	
Temperature	23 °C **1.11 ± 0.48 A**	10 °C **0.1 ± 0.05 A**	4 °C **0.63 ± 0.35 A**
Slice thickness	1/4 " **1.11 ± 0.48 A**	3/16 " **0.69 ± 0.16 A**	3/8" **0.18 ± 0.08 A**
Variety	Torero **1.11 ± 0.48 A**	Rebelski **0.08 ± 0.03 B**	Bigdena **0.07 ± 0.06 B**

Salmonella Transfer during Tomato Dicing

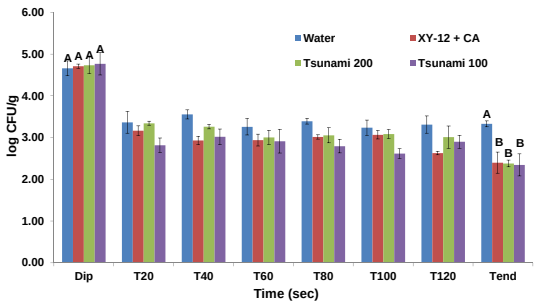


Salmonella Populations Transferred to Uninoculated Tomatoes

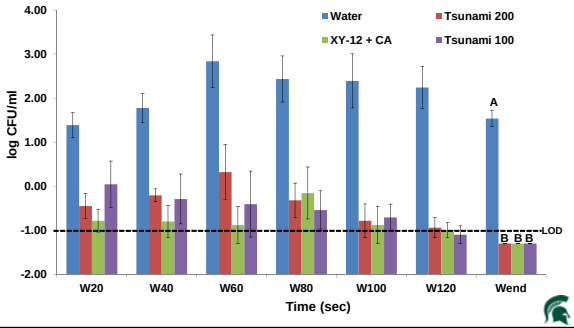


Diced Tomato Washing

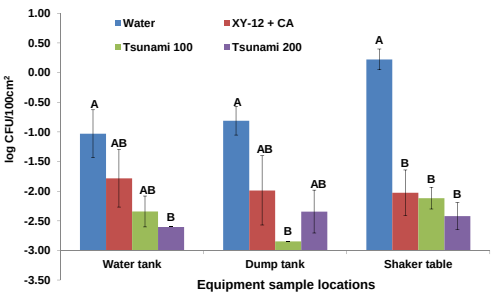
Salmonella Populations on Diced Tomatoes during 2 min of Washing



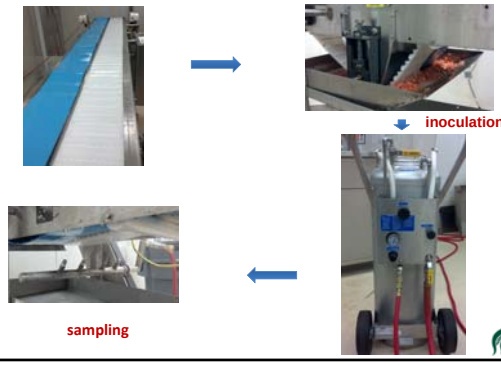
Salmonella Populations in Wash Water during 2 min of Washing



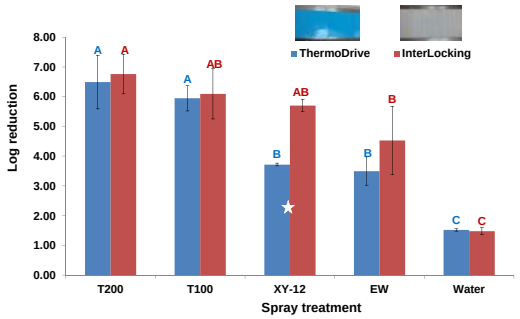
Salmonella Populations on Equipment Surfaces after 2 min of Washing



Salmonella Transfer during Conveying of Diced Tomatoes



Salmonella Reduction after Spray Treatment on Conveyor Belts



Listeria Transfer during Celery Dicing

Kaminski et al. 2014. *J. Food Prot.* 77:756-761

Experimental Design

Uninoculated celery (250 g)

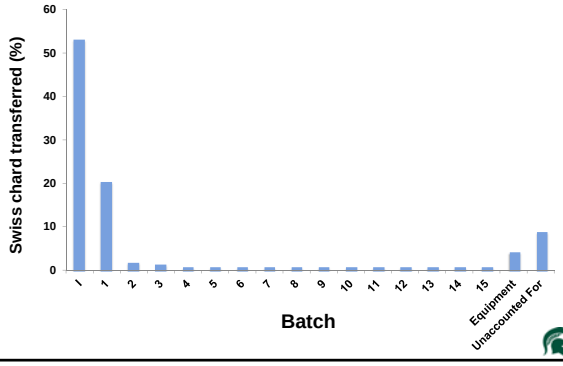
↓

Inoculated celery or Swiss chard (250 g)

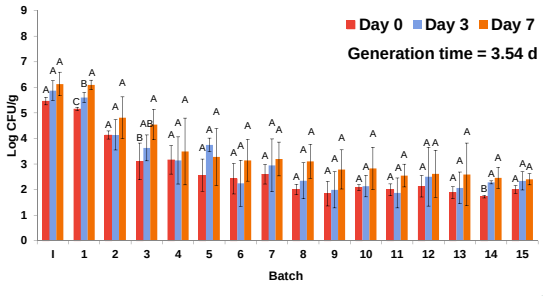
↓

15 batches uninoculated celery (250 g each)

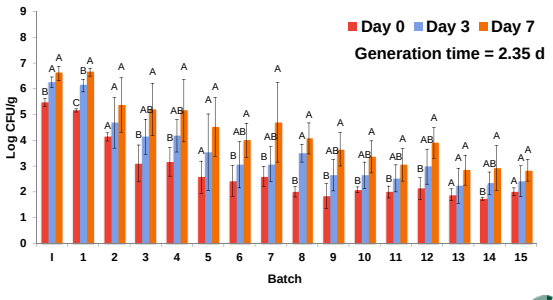
Percentage of Swiss Chard Transferred



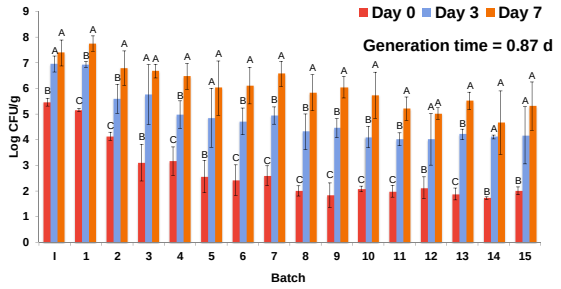
Growth of *L. monocytogenes* in Diced Celery at 4°C



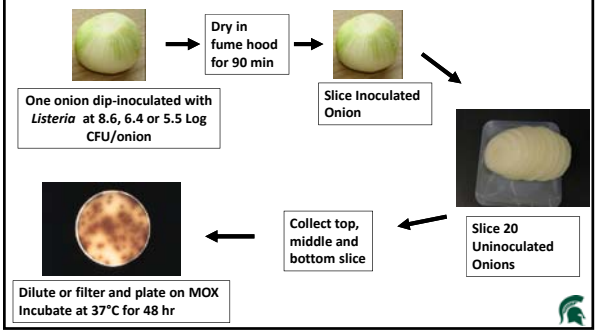
Growth of *L. monocytogenes* in Diced Celery at 7°C

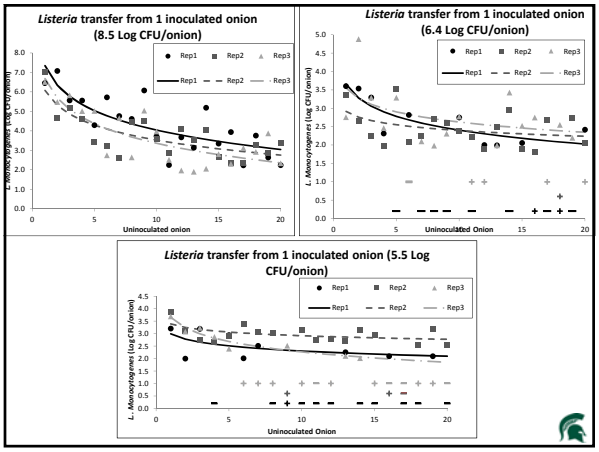


Growth of *L. monocytogenes* in Diced Celery at 10°C

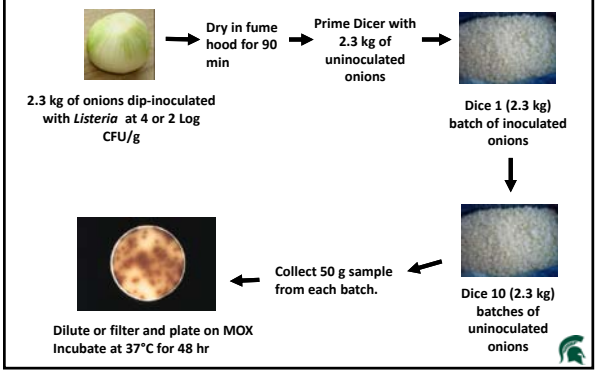


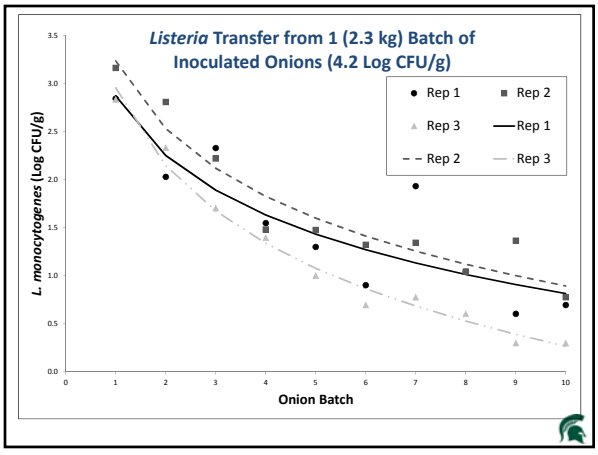
Spread of *Listeria* during Slicing of Onions



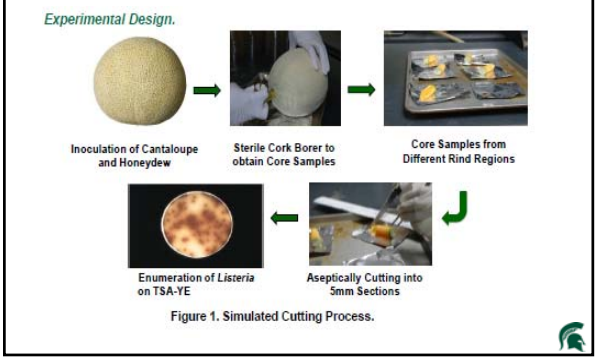


Listeria Transfer during Mechanical Dicing of Onions

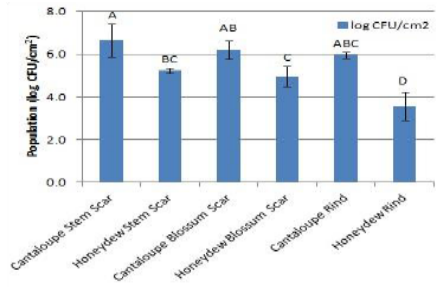




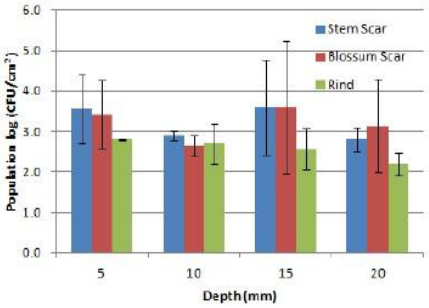
Transfer of *L. monocytogenes* during Coring of Cantaloupe and Honeydew Melon



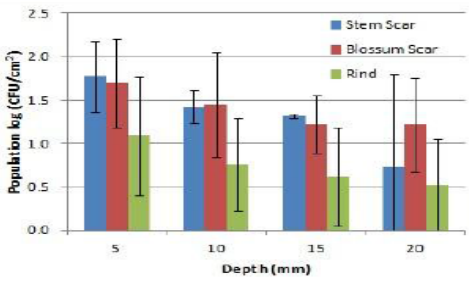
L. monocytogenes on the Rind of Cantaloupe and Honeydew Melon



Transfer of *L. monocytogenes* from the Rind to Cantaloupe Flesh



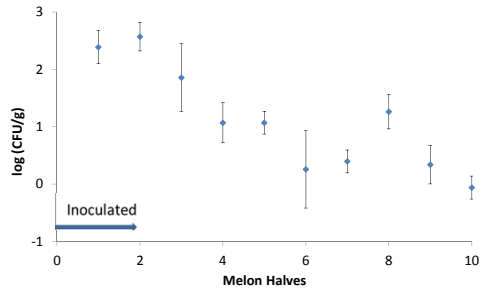
Transfer of *L. monocytogenes* from the Rind to Honeydew Melon Flesh



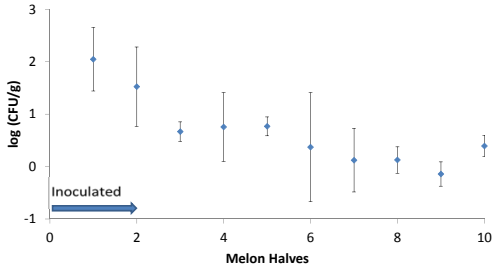
Slicing Experiments

- **Dip-inoculated for 10 min** in a 3-strain avirulent cocktail of *L. monocytogenes* (strains M3, J22F, and J29H) containing 10^9 CFU/ml, air-dried for 1 h and then stored at 4°C for 24 h
- **Two inoculated melon halves were mechanically sliced** using a 0.75 inch manual slicer (Vollrath Redco 401N) **followed by eight uninoculated melon halves**
- Enumeration of *L. mono* on modified TSA-YE and Enrichment with UVM media

Listeria Transfer from Inoculated to Uninoculated Cantaloupe Melon Halves during Mechanical Slicing



Listeria Transfer from Inoculated to Uninoculated Honeydew Melon Halves during Mechanical Slicing



Take Home Message

- A small contamination event in the field can lead to the contamination of large quantities of product after processing.
- New microbial intervention strategies are needed to minimize contamination of fresh-cut produce during washing.
- Changes in processing equipment design can lead to decreased levels of contamination
- The order in which fresh produce is processed may play a role in minimizing contamination

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- Rocky Patil
  - and *many undergraduate assistants*

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  - Urschel Laboratories
  - Dorner Manufacturing
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USDA

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