Characterization and mitigation of bacteriological risks associated with packing fresh-market citrus

OR

What You Should Know about Dump Tanks and Flooders

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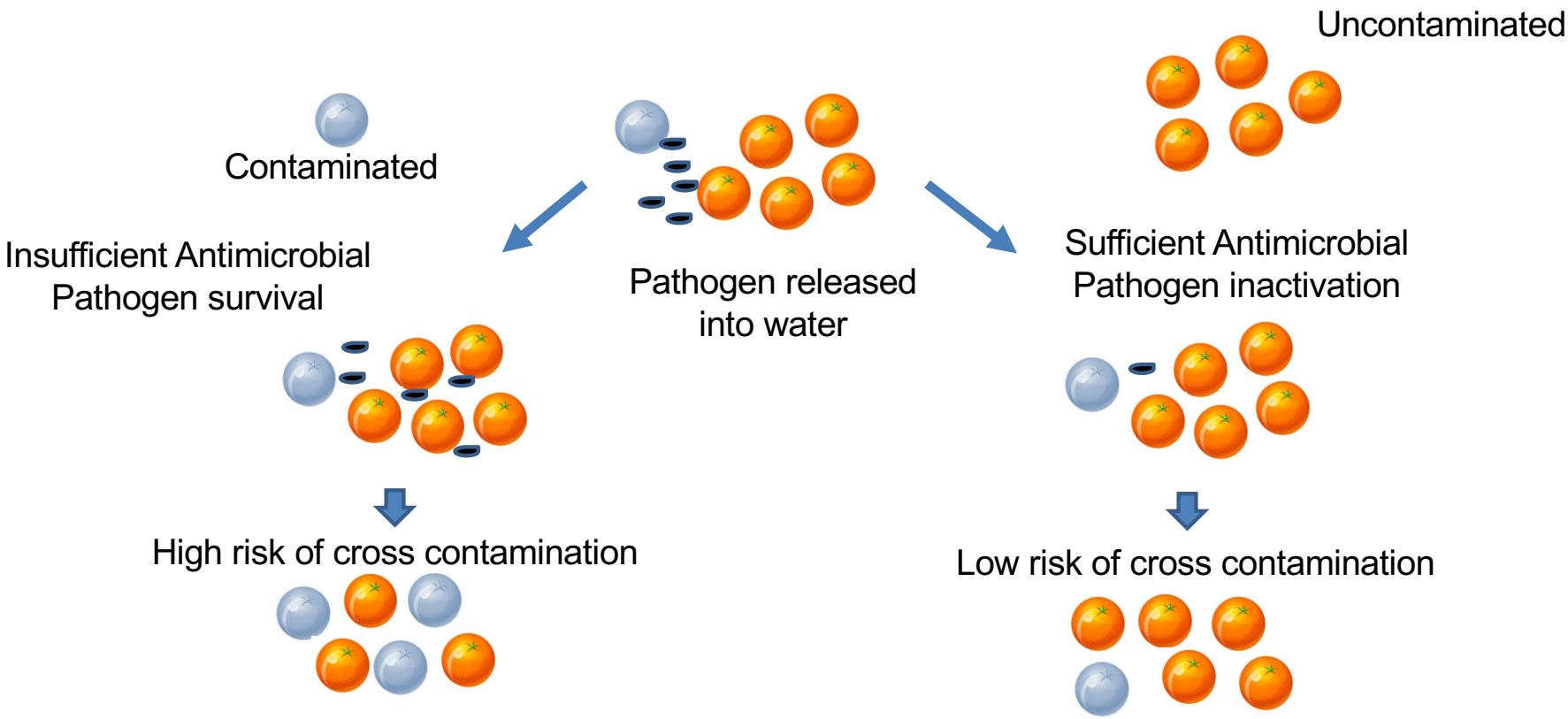
Critical need for data in support of "Adequate Sanitary Quality"

Aqueous mediated cross contamination



"Adequate Sanitary Quality"

Pre-Storage Lemon Packline

Receipt

- Chlorinated dump tank
- Sizer
- Pre-grade

3% soda ash tank

- Spray potable water
- Brush rollers

Imazalil + PAA Recirculating

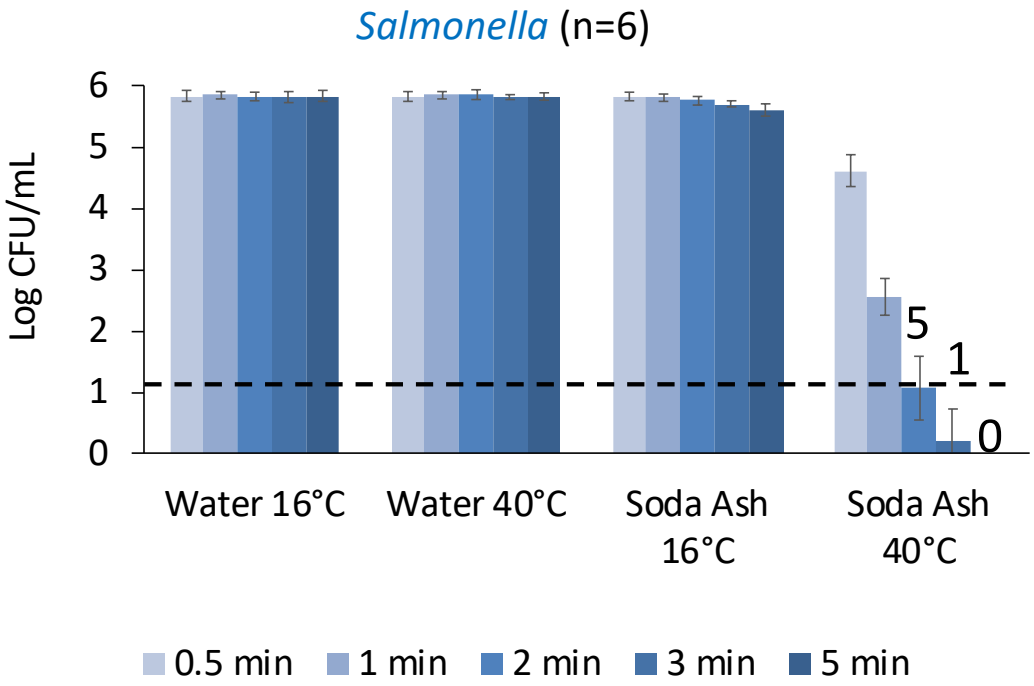
Storage wax

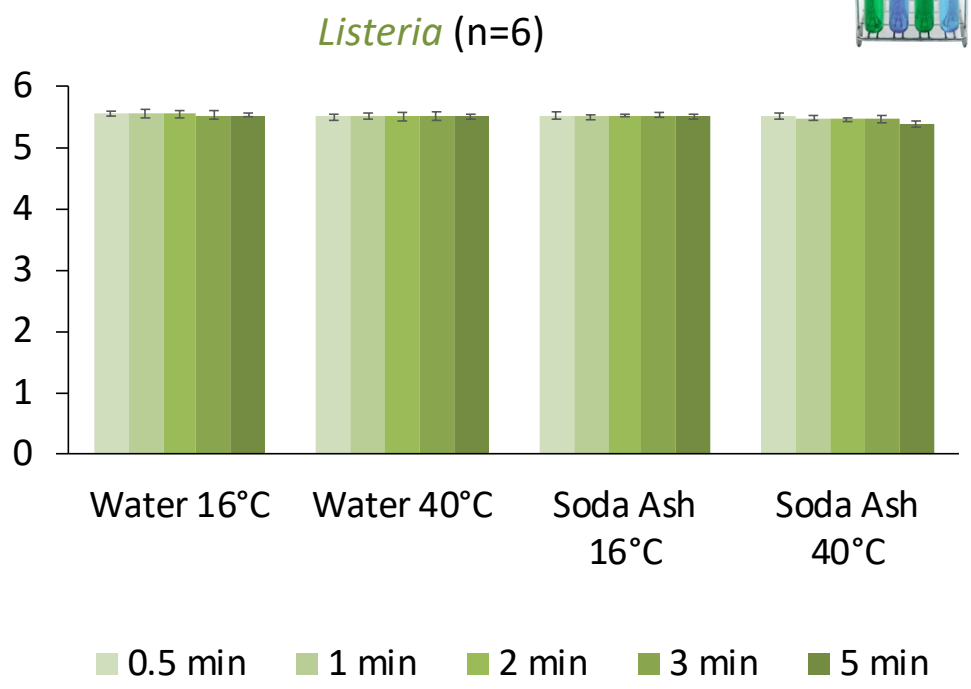
- Storage
- 52°F (11°C);
- 24 h to 120 days

Citrus Industry Use Survey

- Soda Ash
  - 1 to 3%
  - 60 to 115°F (16 to 46°C)
  - pH 9.5 to 13
  - Exposure
    - Seconds to minutes
  - Use
    - Week to months
- Imazalil
  - 100 to 500 ppm
  - 60 to 135°F (16 to 57°C)
  - Exposure
    - Seconds
  - Use
    - Day to weeks
- Peracetic Acid (PAA)

Survival of *Salmonella* and *Listeria* in water (pH 7.90) and 3% soda ash (pH 11.30) at 16 or 40°C (60/104°F)

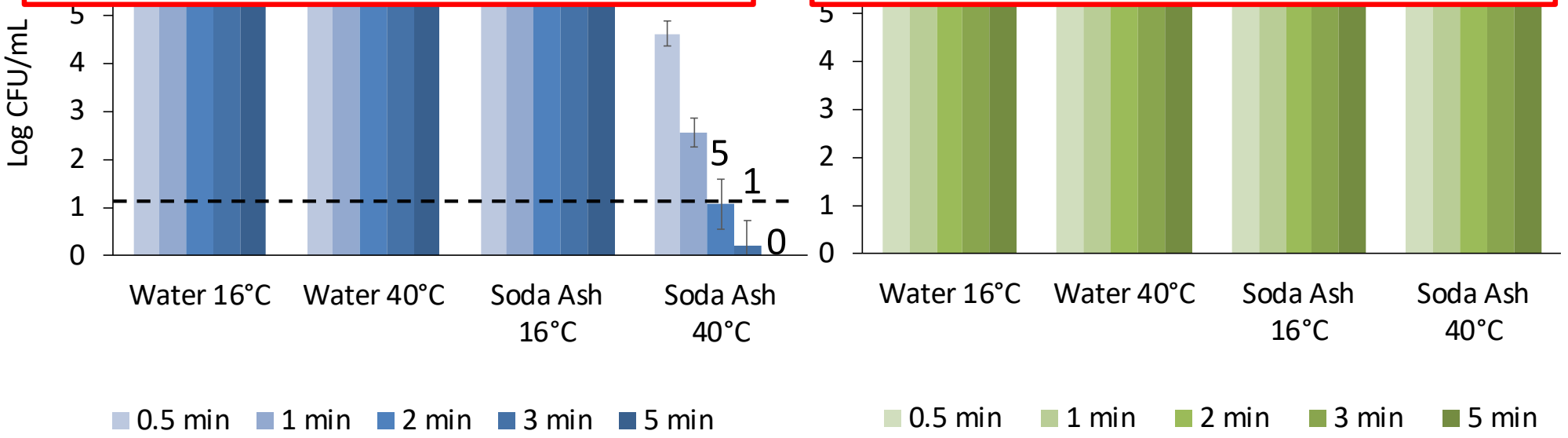




Survival of *Salmonella* and *Listeria* in water (pH 7.90) and 3% soda ash (pH 11.30) at 16 or 40°C (60/104°F)

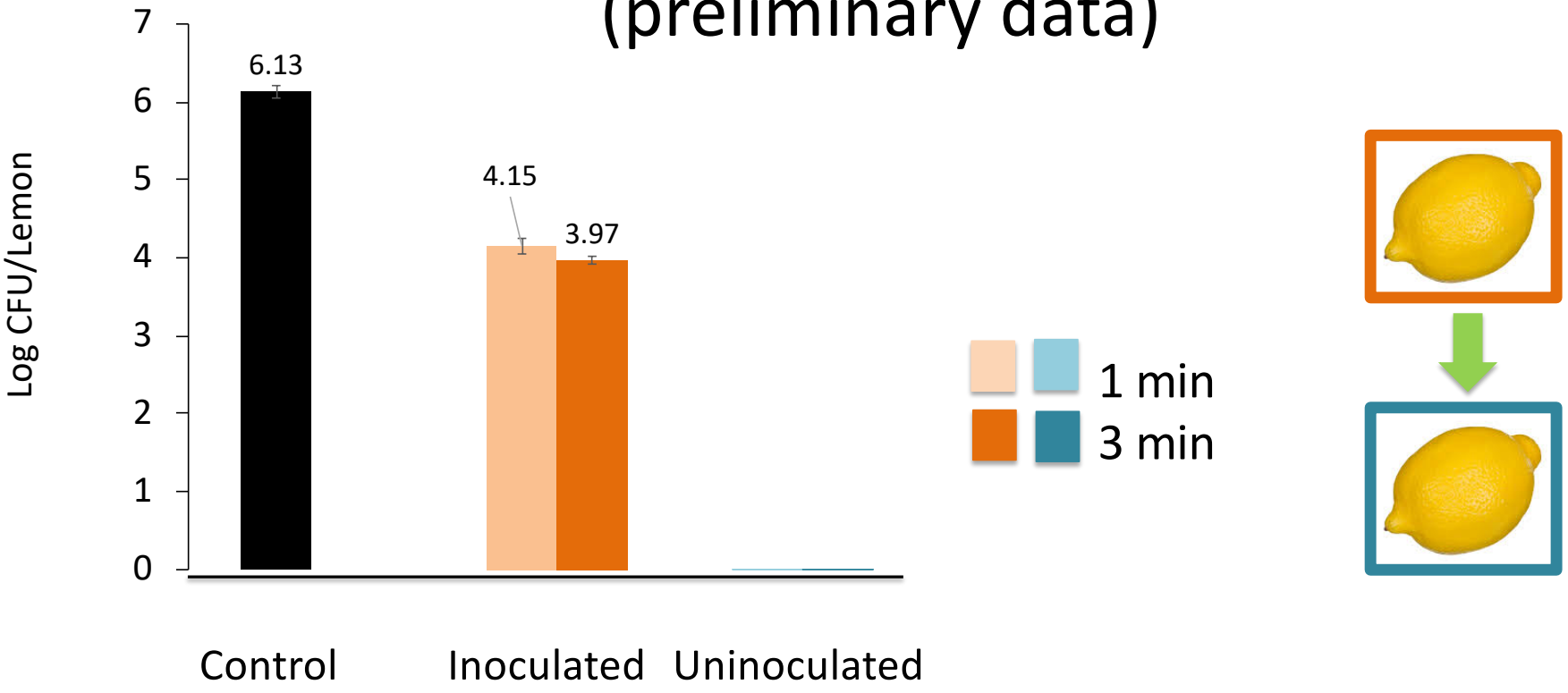
≥5 log reduction of *Salmonella* in ≥3 min at 40°C/104°F

No reduction of *Listeria* in 5 min at 40°C/104°F

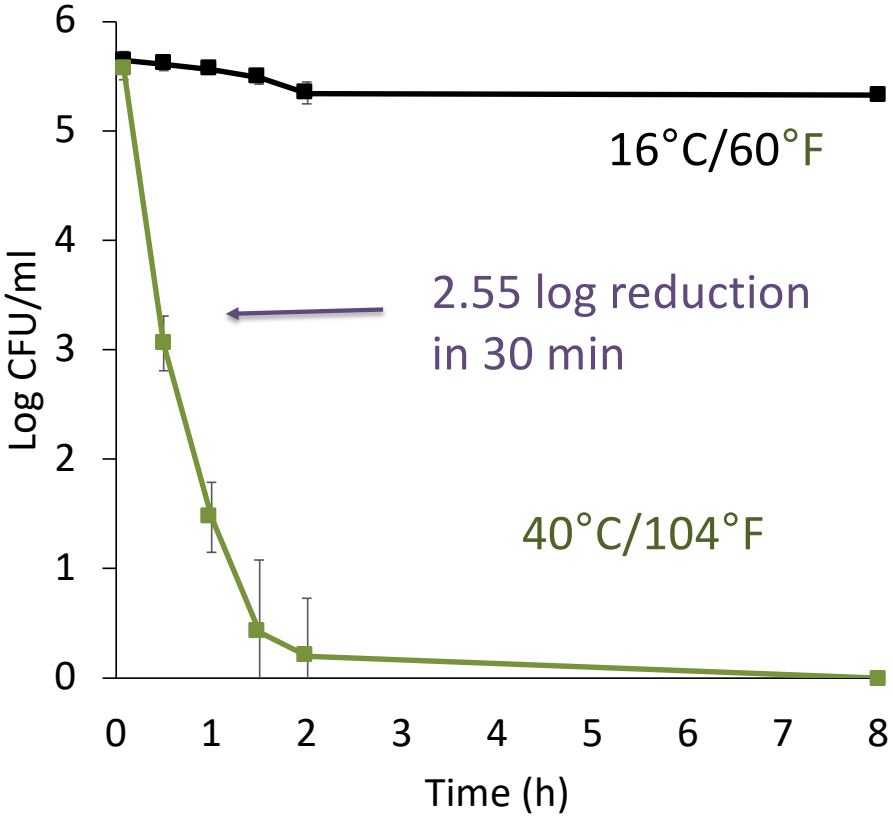


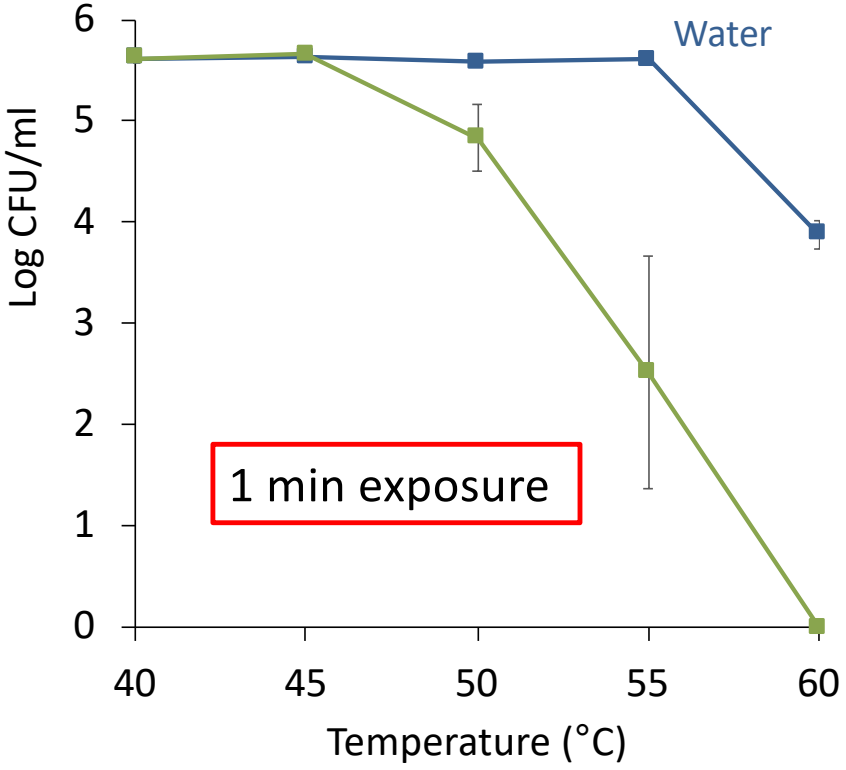
Transfer of *L. monocytogenes* from inoculated to uninoculated lemon: 3% soda ash at 40°C/104°F

(preliminary data)



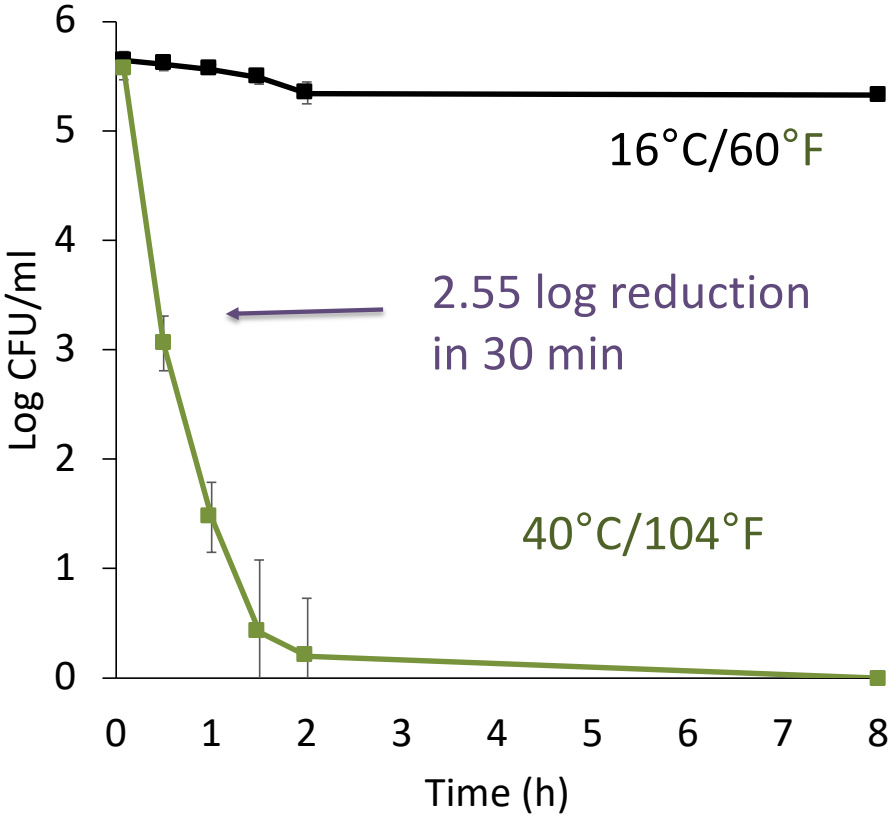
Survival of *Listeria* in 3% soda ash pH 11.30 (n=6)



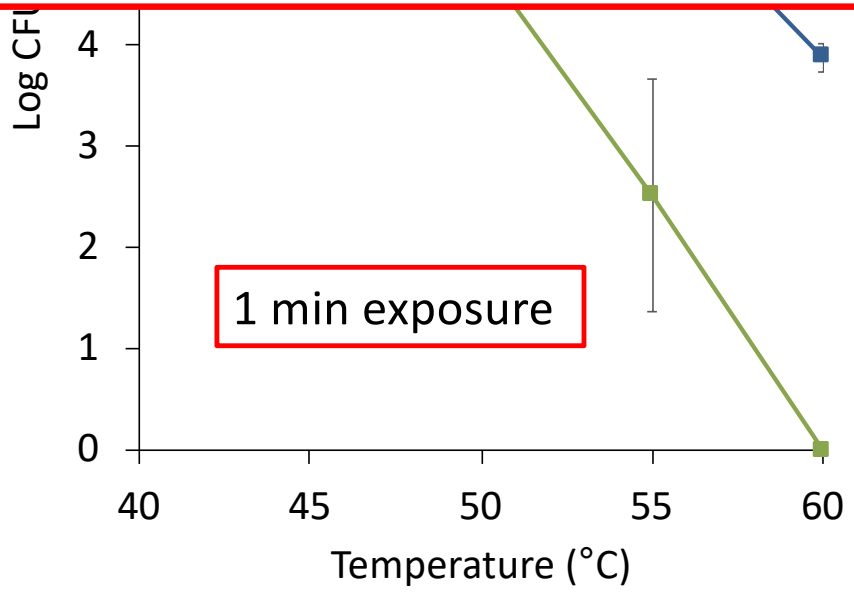


60 to 140 °F

Survival of *Listeria* in 3% soda ash pH 11.30 (n=6)

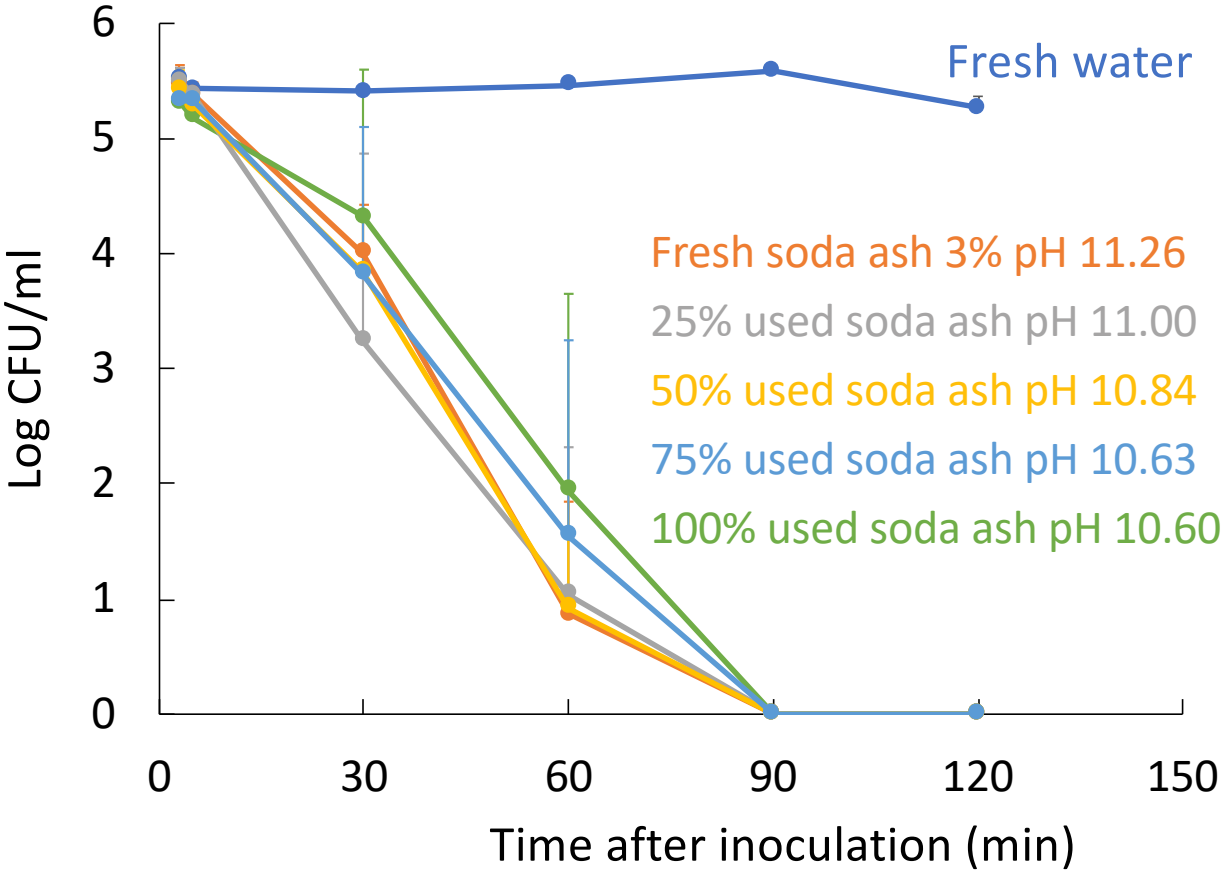


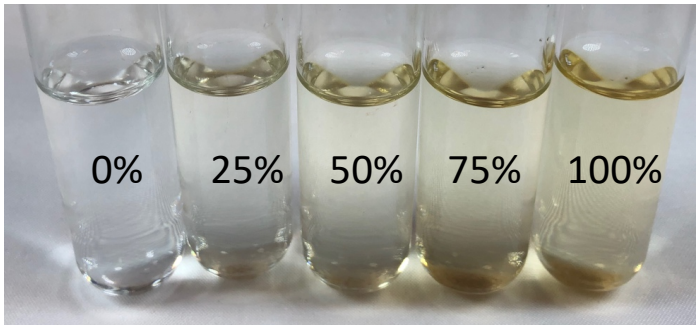
≥5 log reduction of *Listeria* in soda ash in 1 min at 60°C/140°F



60 to 140 °F

Inactivation of *Listeria* in used 3% soda ash 40°C/104°F

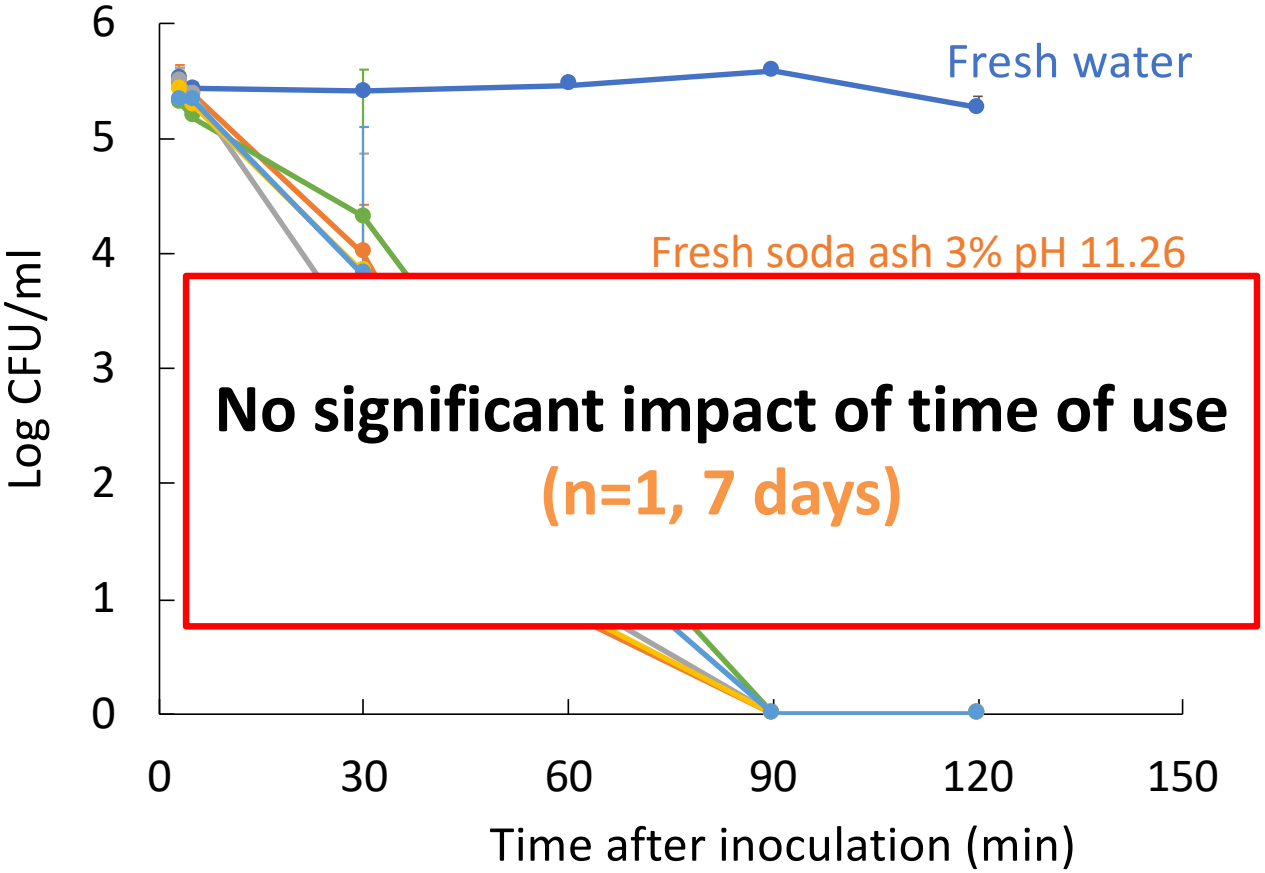


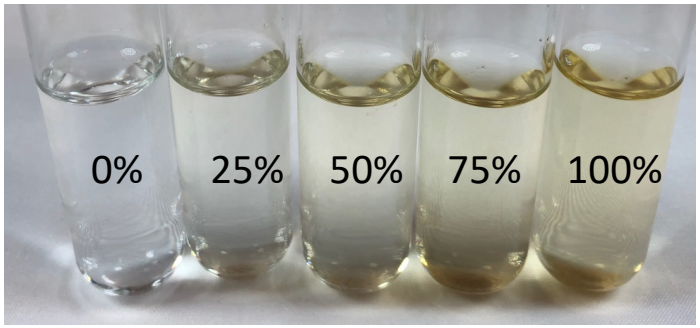


Soda ash turbidity

Fresh → Used (7 days)

Inactivation of *Listeria* in used 3% soda ash 40°C/104°F





Soda ash turbidity

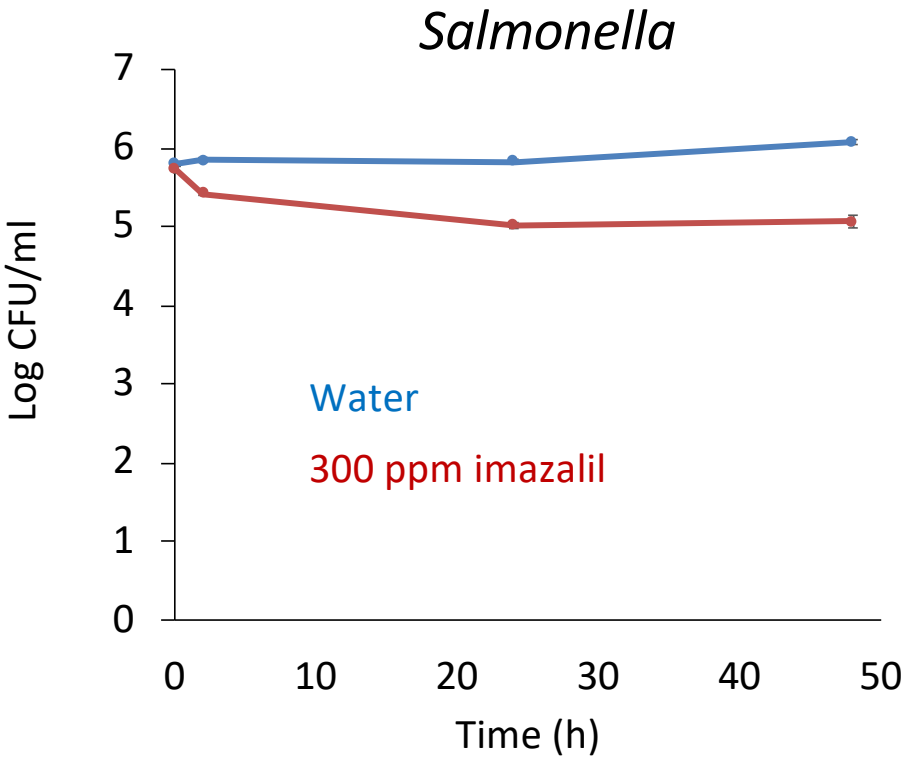
Fresh → Used (7 days)

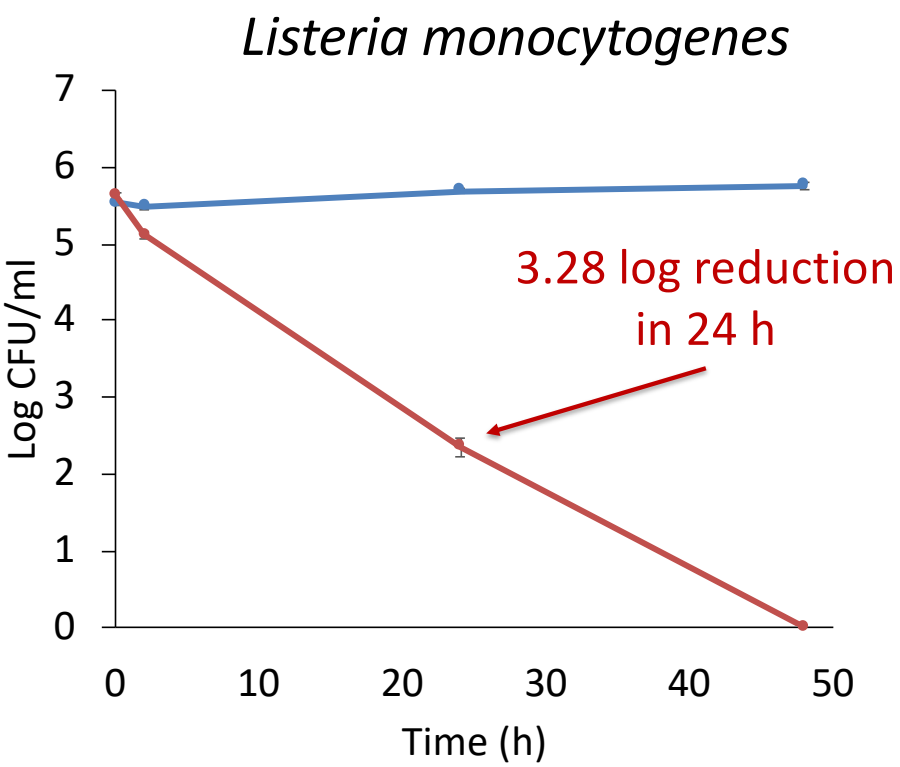
Key Outcomes

- Soda ash
  - Cross contamination is possible under normal simulated use
  - Current practice of nightly heating soda ash
    - Rapidly reduces populations of *L. monocytogenes*
  - No significant difference in impact on *L. monocytogenes* with extended use material

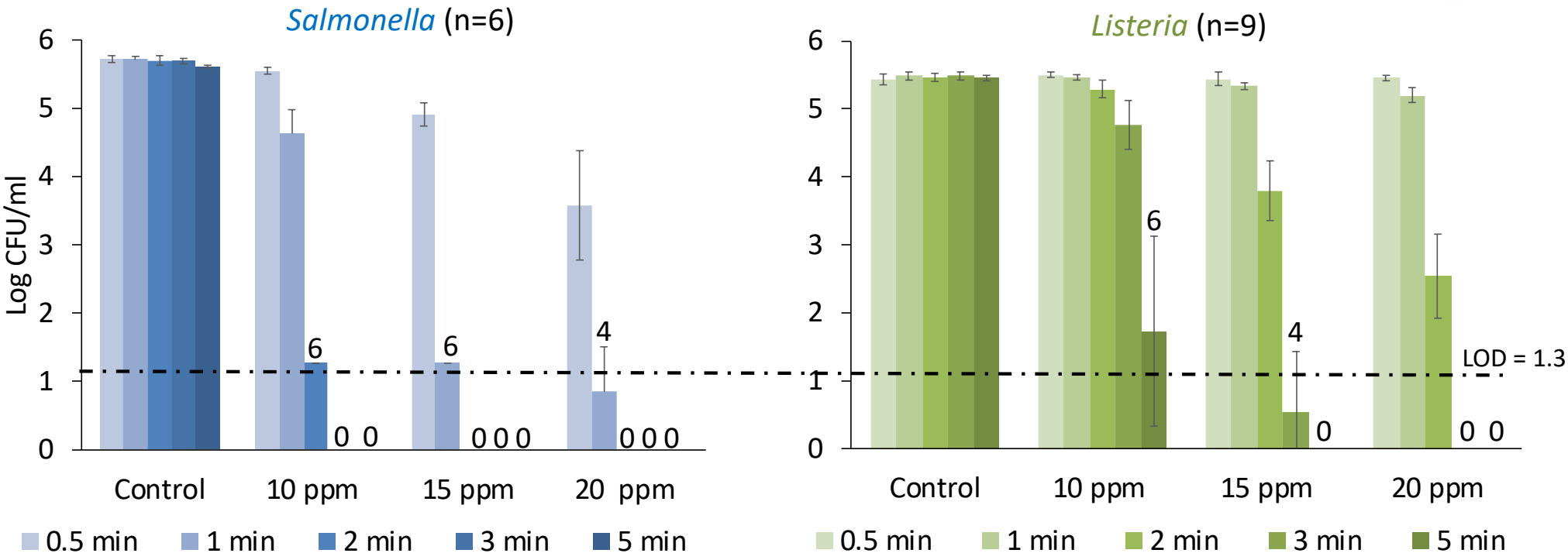
Imazalil with Peroxyacetic Acid (PAA)

Survival in 300 ppm imazalil at 16°C (60°F)





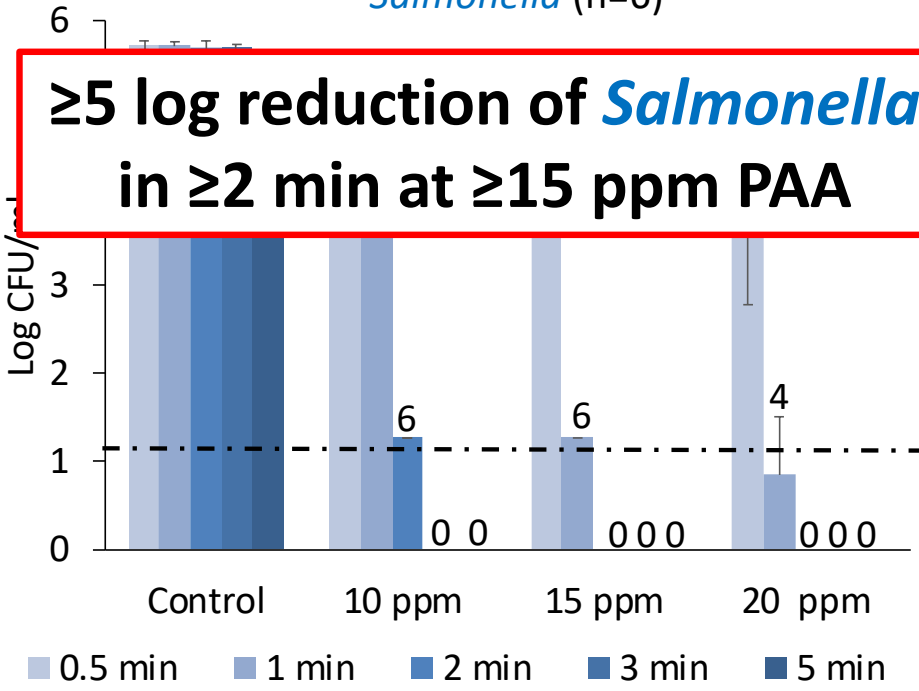
Inactivation of *Salmonella* and *Listeria* in 300 ppm imazalil with PAA at 16°C (60°F)



Inactivation of *Salmonella* and *Listeria* in 300 ppm imazalil with PAA at 16°C (60°F)

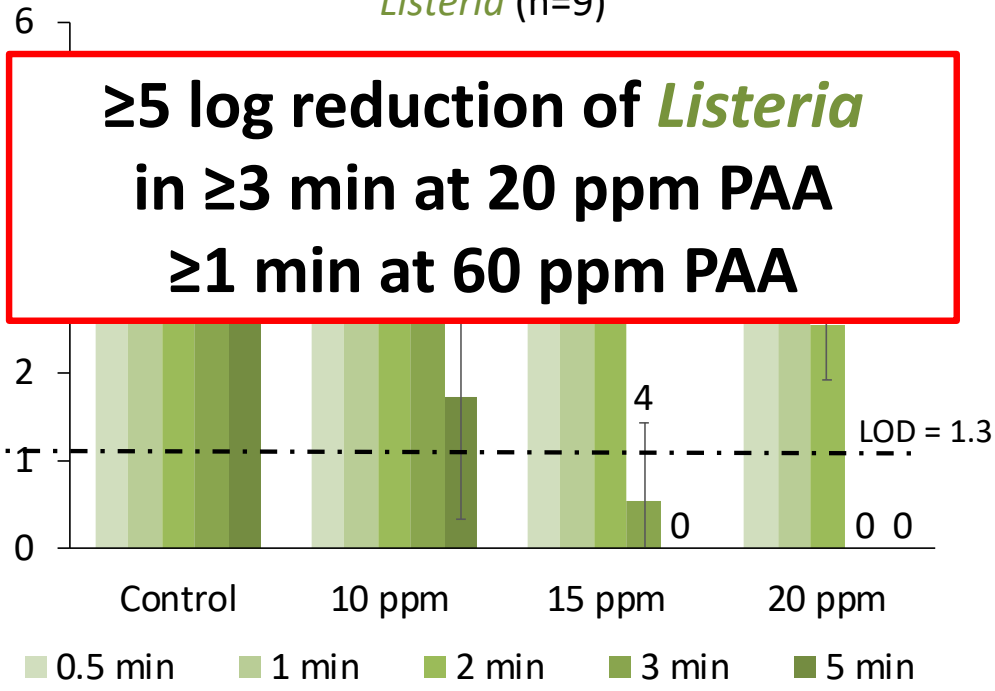
Salmonella (n=6)

≥5 log reduction of *Salmonella* in ≥2 min at ≥15 ppm PAA



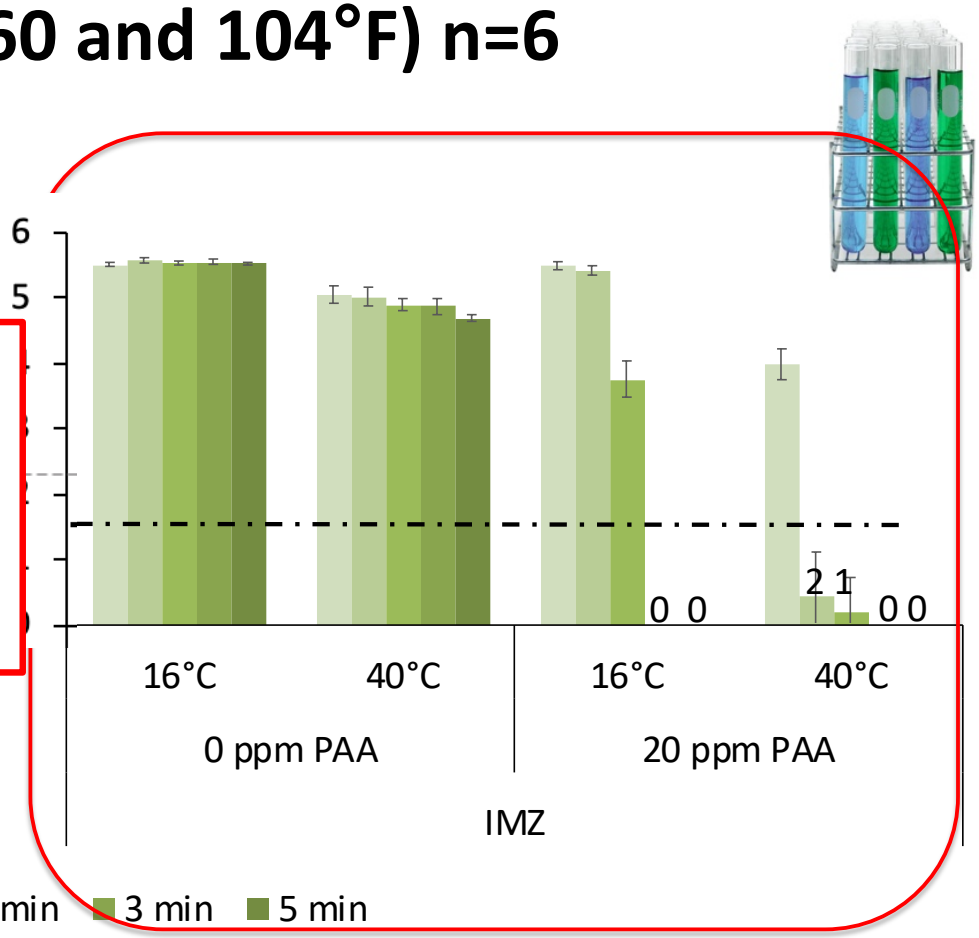
Listeria (n=9)

≥5 log reduction of *Listeria* in ≥3 min at 20 ppm PAA ≥1 min at 60 ppm PAA

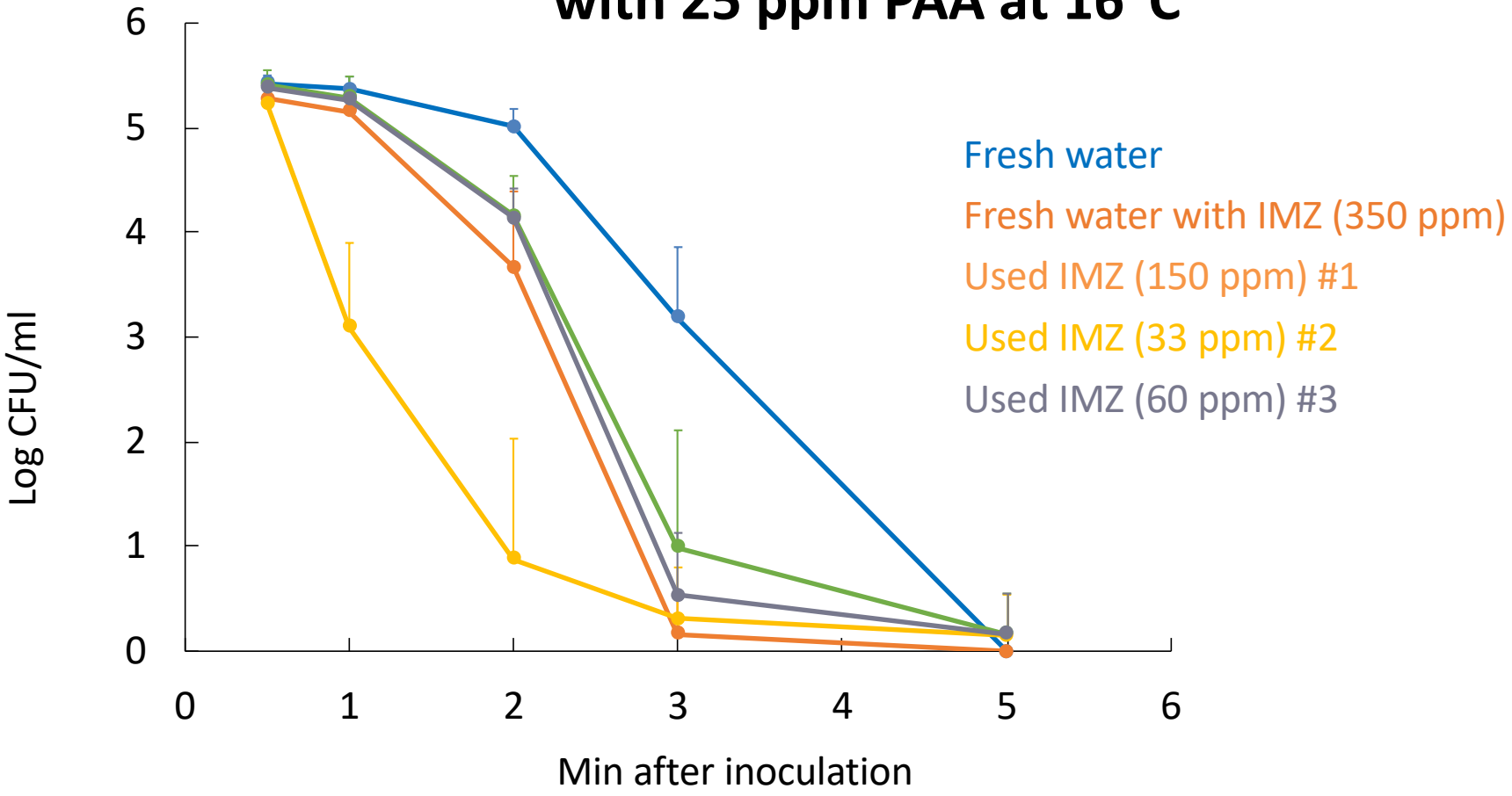


Inactivation of *Listeria* in 300 ppm imazalil with PAA at 16 and 40°C (60 and 104°F) n=6

≥5 log reduction of *Listeria*
in IMZ at 20 ppm PAA
≥3 min at 16°C
≥1 min at 40°C



Survival of *Listeria* in fresh and used imazalil with 25 ppm PAA at 16°C



Key Outcomes

- Imazalil with ≥20 ppm PAA
  - Significantly reduces
    - Both *Listeria monocytogenes* and *Salmonella*
    - Across temperatures of use
    - In fresh and end-of-use material

Dump tanks and recirculating systems

- ≥5 log reduction of *Listeria* in 3% soda ash:
  - ≥ 1 min at 60°C
- ≥5 log reduction of *Listeria* in imazalil
  - 20 ppm PAA: ≥3 min at 16°C or ≥1 min at 40°C
- >5 log reduction of *Listeria* in 3% SBC (not shown)
  - 18 ppm free chlorine: ≥ 20 s at pH 8.0 and 9.5

“Typical” Pre-Storage Lemon Packline

Receipt

- Chlorinated dump tank
- Sizer
- Pregrade

3% soda ash tank (sodium carbonate)

- Potable water
  - Spray
  - Brush rollers

Imazalil + PAA Recirculating

Storage wax

- Storage
  - 52°F (11°C);
  - 24 h-120 days

Pre-Storage Line

Receive Lemons

↓

Bin Dump-chlorinated water

↓

Pony Sizer-remove small fruits

P

Soak Ta

Washing

Fungici
ove

Storage
fungicide sprayed over rotating brushes

↓

Color Sorting/Box Fill

↓

Storage; 52°F (11°C); 24 h-120 days

Packing Line

Box Dump Rinse

↓

Rot Removal-by hand on PVC rollers

↓

Washing-SBC+chlorine (recirculating flood)

PVC rolls

nges

IMZ+PAA
es

ng brushes

↓

Packing

↓

Storage/Cooling; 40-42°F

↓

Shipping

What is the impact of all of these steps?

What is the impact?

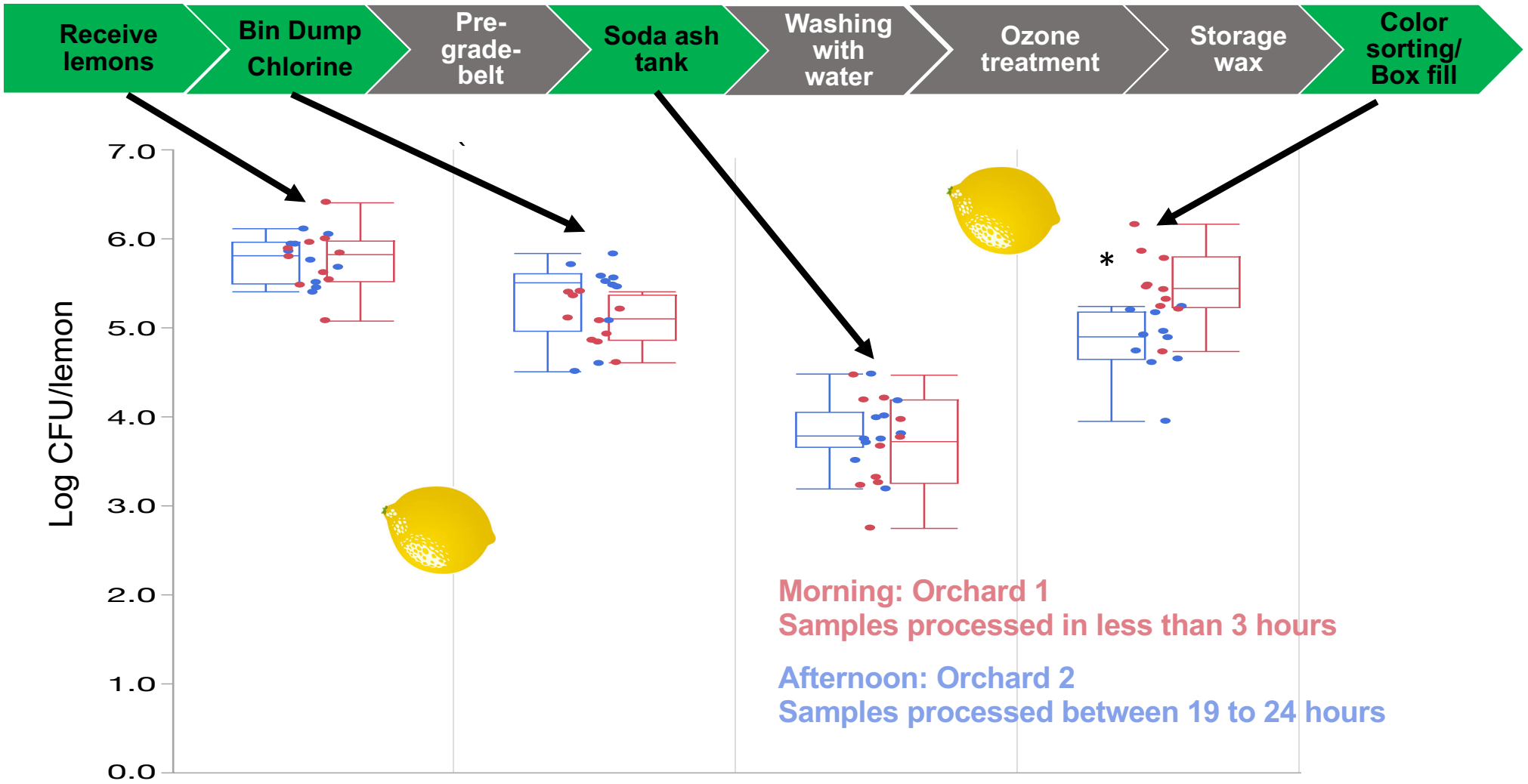
What are you harvesting?
- Multiple Products

What time of year?
- Long Season

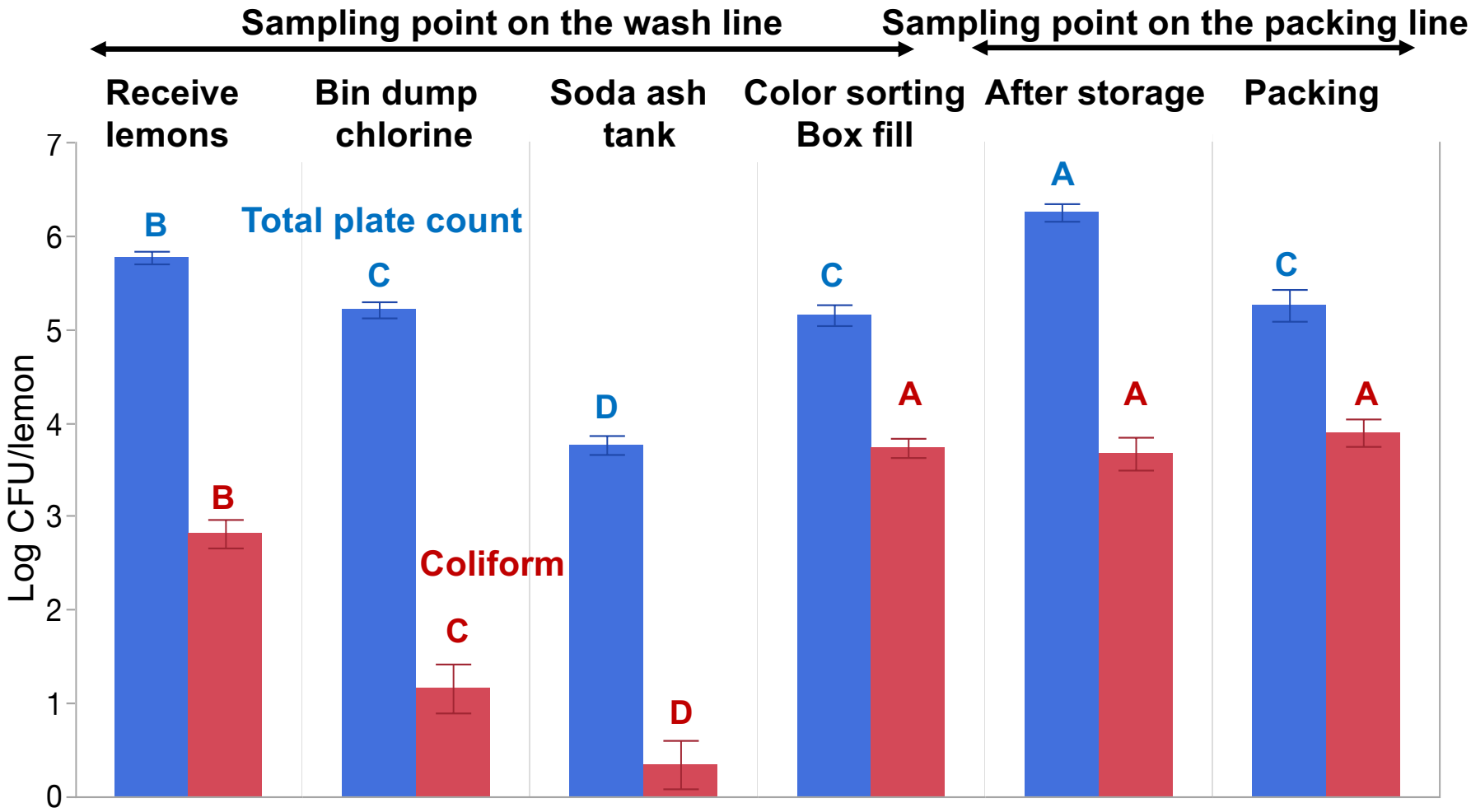
What is the weather?

Packinghouse layout?
- Varying practices
- Different age and size
- Production volume

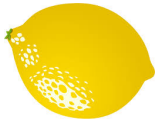
Change in lemon microbial populations in the wash line (preliminary data)

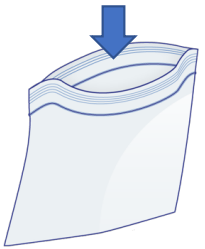


Variation in lemon microbial population in the wash and packing lines



Sequencing analysis of citrus native microflora

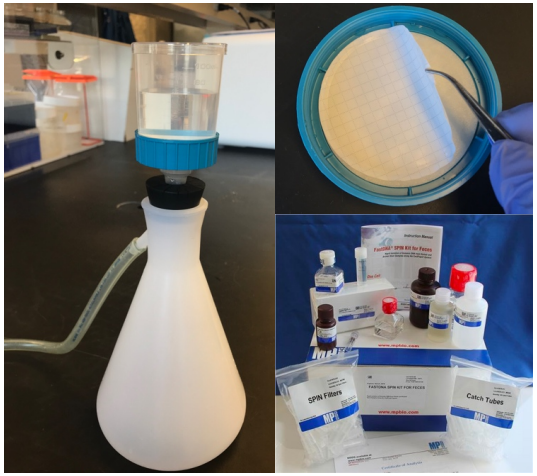




20 ml PBS + 0.05%
Tween 20, pH7.4

30s shaking
60s rubbing
30s shaking

Lemon Processing



FastDNA Spin Kit for feces

Filtration
DNA extraction

16S Amplicon PCR Forward Primer = 5'
TCGTCGGCAGCGTCAGATGTGTATAAGAGACAGCCTACGGGNGGCWGCAG
16S Amplicon PCR Reverse Primer = 5'
GTCTCGTGGGCTCGGAGATGTGTATAAGAGACAGGACTACHVGGGTATCTAATCC

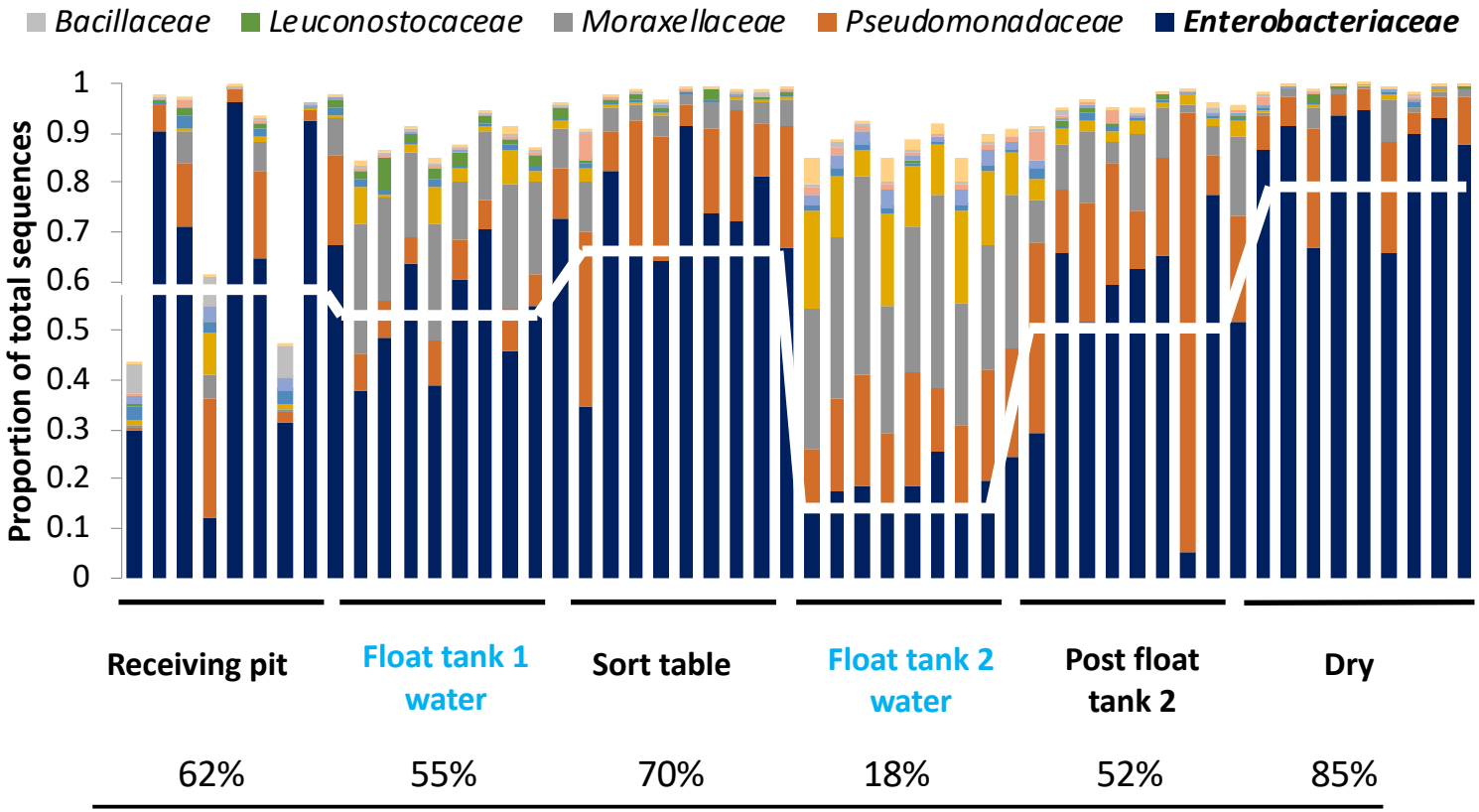
Library
Preparation

Illumina MiSeq

Sequencing

Sheng and Wang

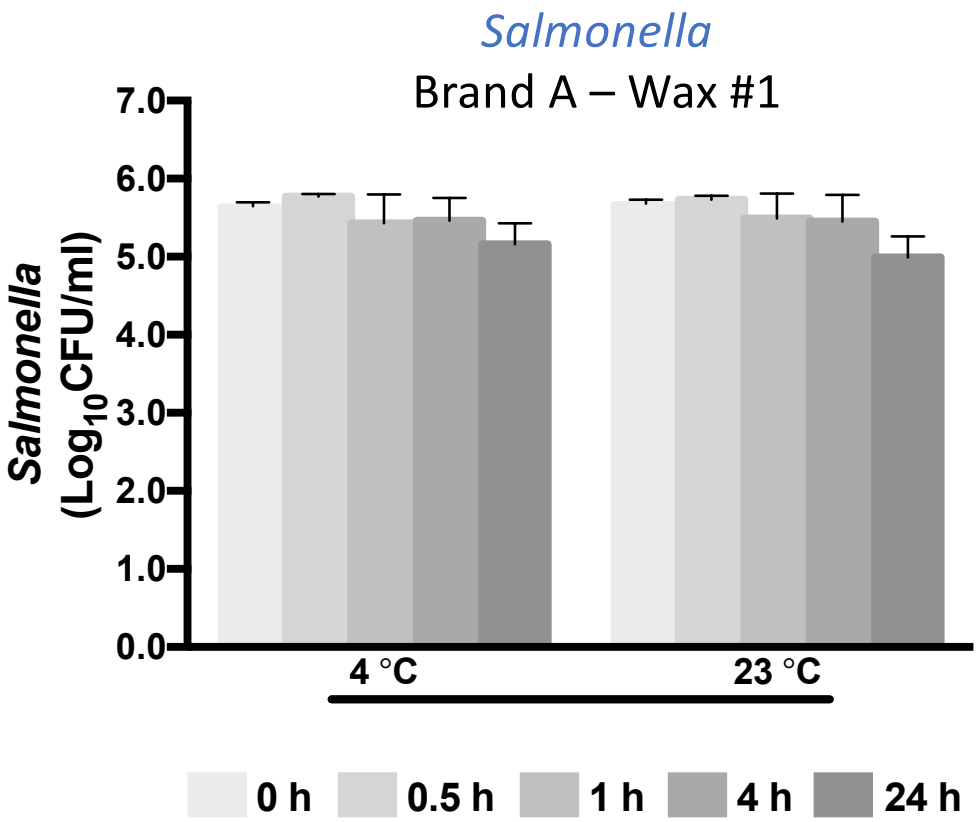
Anticipated Data Outcome
E.g. shown for WALNUTS

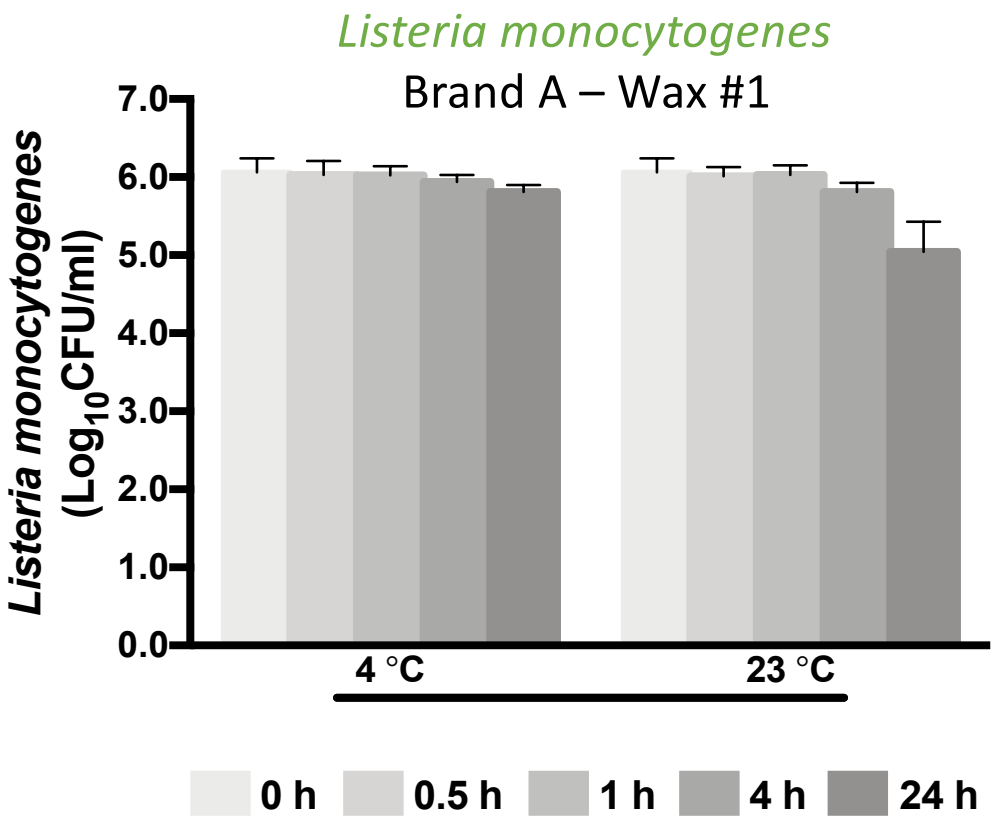


Davidson and Harris, unpublished

Survival in Lemon Storage Wax

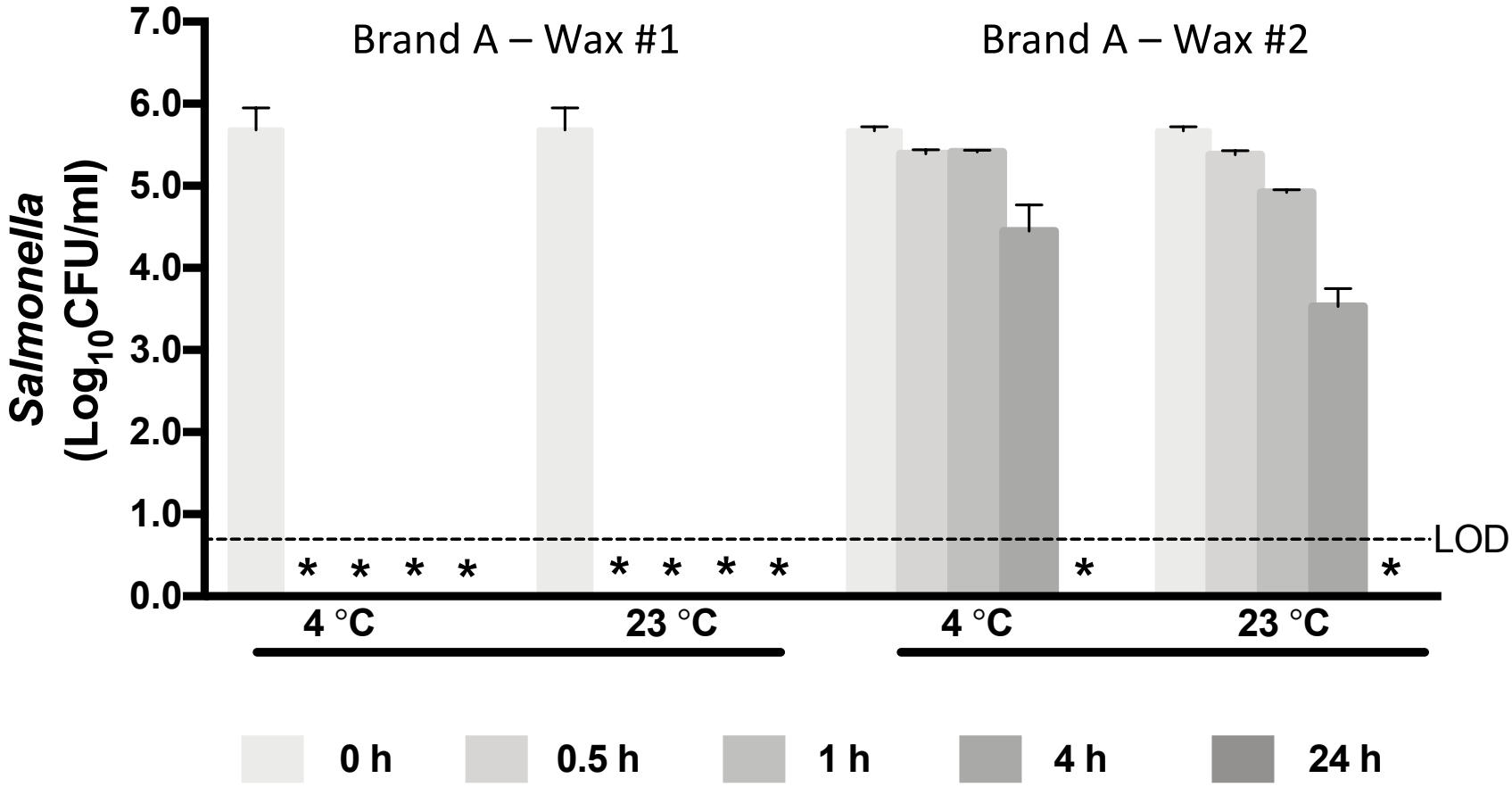
Sheng and Wang





Survival of *Salmonella* in Citrus Finishing Wax

Sheng and Wang



Citrus Food Safety Plans

- Each packinghouse and pack line
  - Engagement
- Foundational programs
  - GMPs/Sanitation/Monitoring/Adjusting
- Water quality – dump tanks and recirculation
  - What are the controls to prevent cross contamination?
  - How are they measured?
  - Validate/verify measurements.
  - Corrective actions?