



United States Department of Agriculture

Preventing Pathogen Cross-contamination during Fresh-cut Produce Wash Operation

- Micro-fluidic device as a research tool for pathogen inactivation studies.
- Commercial fresh-cut operation data supporting FSMA implementation.

Yaguang (Sunny) Luo, Ph.D.



Produce Safety – State of the Science

- Scientific dream (ultimate goal) - **5 log** reduction during fresh-cut produce wash.
- Reality – No technology available today that can kill 5 log of pathogens without killing the produce! Worse yet, inappropriate post-harvest handling can cause pathogen cross-contamination.

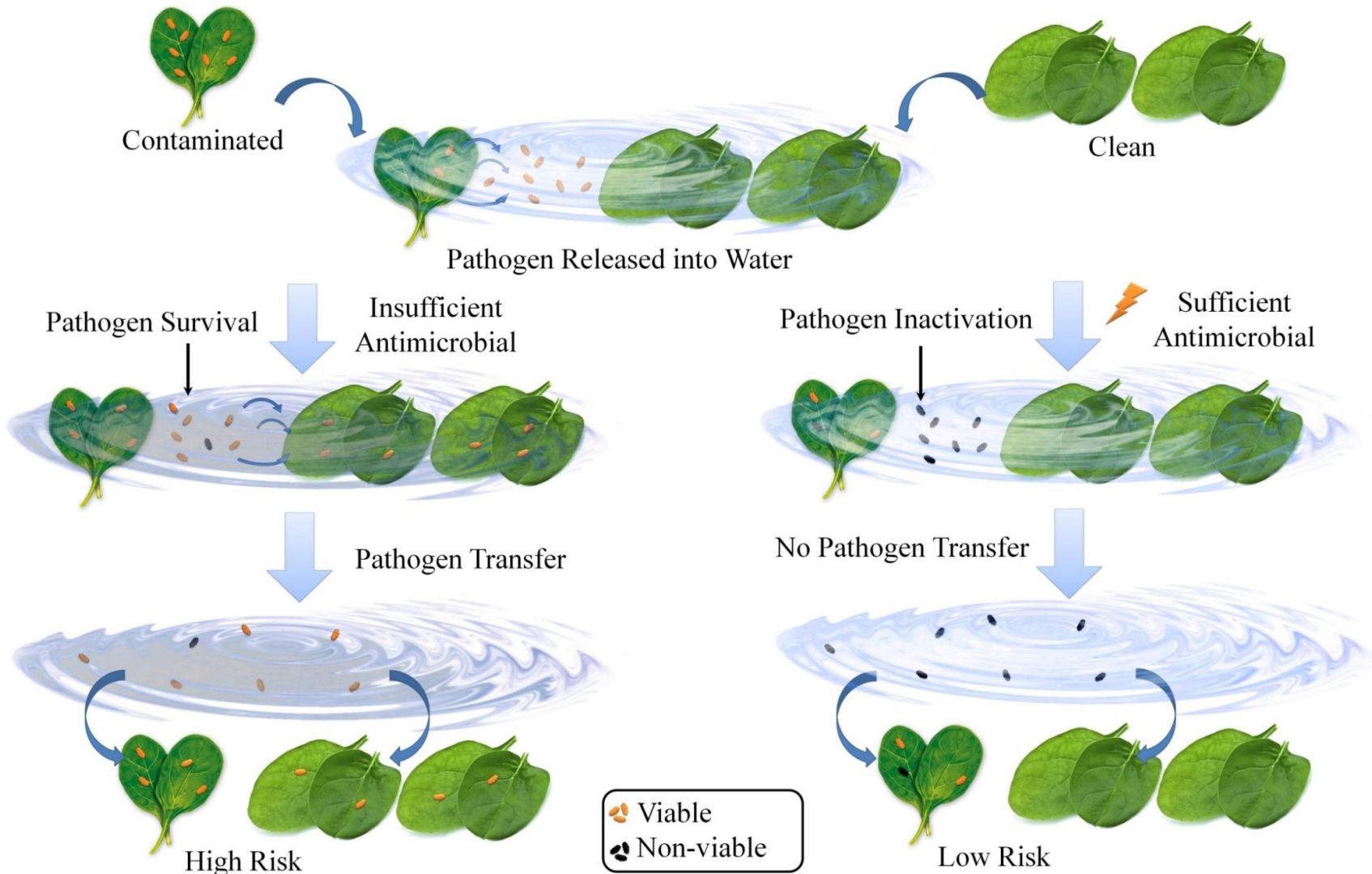


Goal:

While developing novel technology is still critical, Preventing Pathogen Cross-contamination will have immediate impact on food safety.

The Role of Sanitizer on Pathogen Survival

Water-Mediated Cross-Contamination



Improving Practices

Traditionally-

Critical Control Point: Chlorine;

Control Limit: 1 ppm free chlorine

Corrective Action: Rewash

Determining the minimal free chlorine concentration required to prevent pathogen cross-contamination

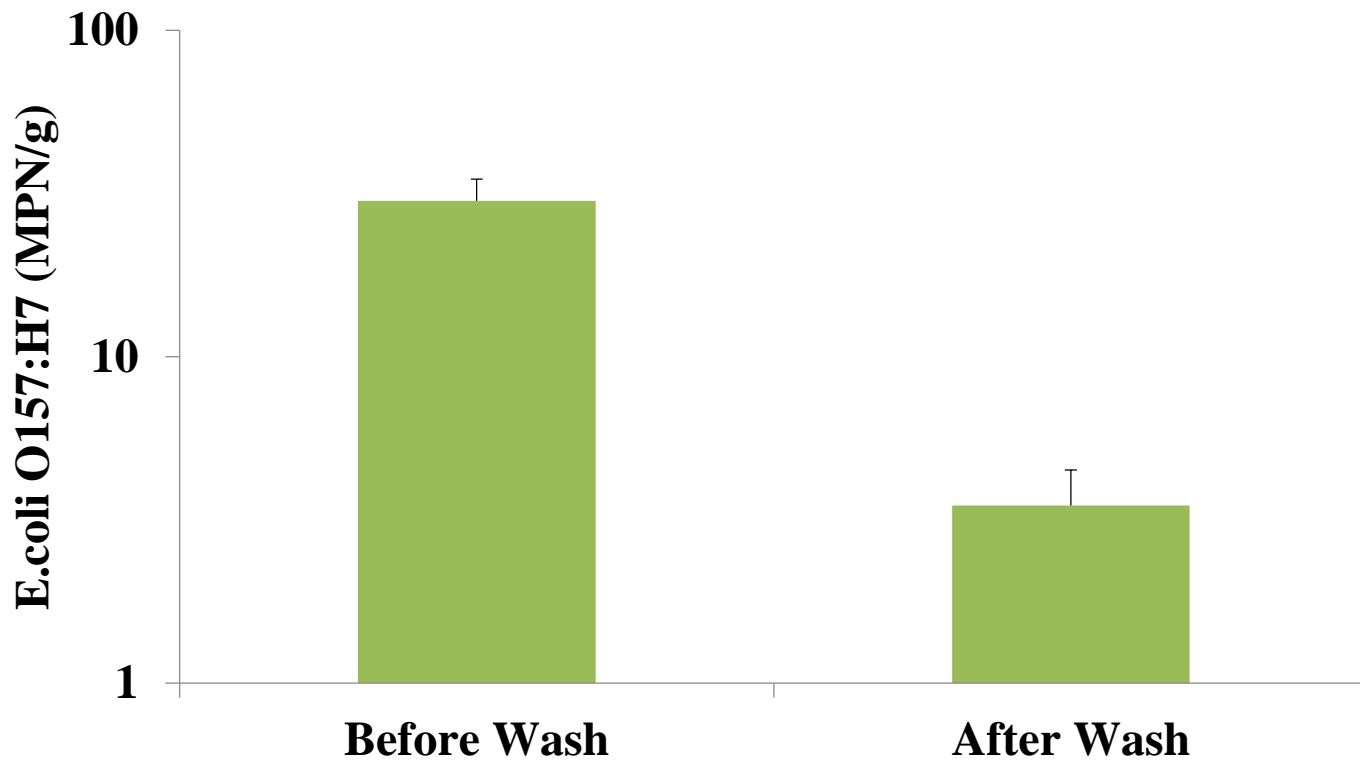
- A research study initiated as per the industry stakeholder request.



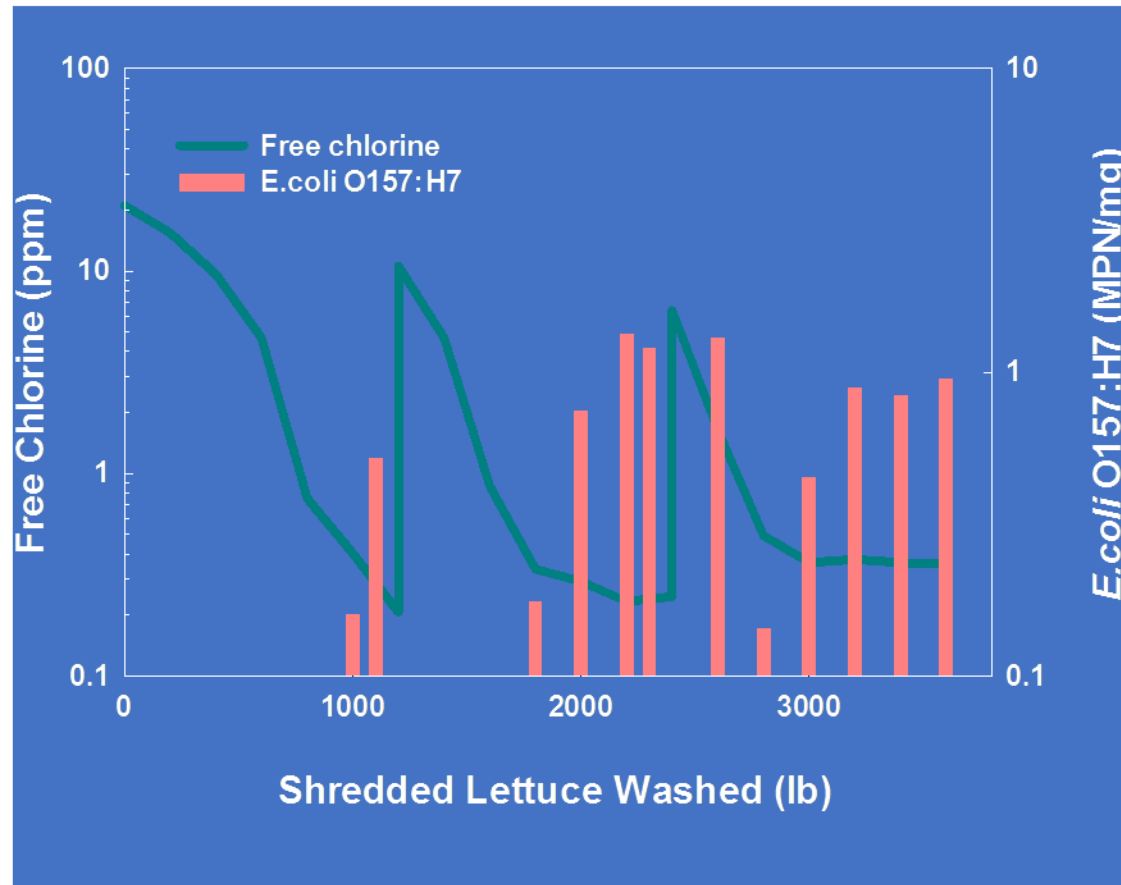
Studies shown that 1 ppm FC is insufficient to prevent pathogen cross-contamination

| | Rep | Free Chlorine Concentration (mg/L) | | | | | | |
|------------------------------|------------|------------------------------------|------|-------|------|-----------|----|----|
| | | 0 | 1 | 2 | 5 | 10 | 15 | 25 |
| Solution | V | 8.2 | 1.4 | 0.4 | ND | ND | | |
| | VI | 6.0 | 1.15 | 0.65 | ND | | | |
| | VII | 18.5 | 1.65 | 1.145 | ND | | | |
| Un-inoculated Lettuce | V | 18.5 | 2.1 | 2.3 | 0.65 | | | |
| | VI | 11.9 | 2.1 | 1.75 | ND | | | |
| | VII | 24.5 | 3.1 | 1.95 | 0.60 | | | |

While re-washing freshly contaminated produce can reduce *E. coli* O157:H7 populations, re-washing is not a reliable “Corrective Action” to rectify process failure



Additional pilot plant studies with the industry also proved the importance of maintaining sufficient sanitizer for preventing cross-contamination





United States Department of Agriculture

Impacts: Changes in Industry Practices

- Feedback received from the industry:
 - Your article “Determination ...” very clearly outlined the risk... we have updated our HACCP program requirement based on these learnings.”
- Research publication won the 2016 First Place John Sofas Publication Award from IAFP as the most cited JFP articles for the past five years.



FSMA

- The Preventive Controls for Human Food Rule require processors to **evaluate hazards** that can affect food production, processing, packing, transportation, and storage; identify and implement **preventive controls** to significantly minimize or prevent occurrence of such hazards; and **monitor performance** of such controls.

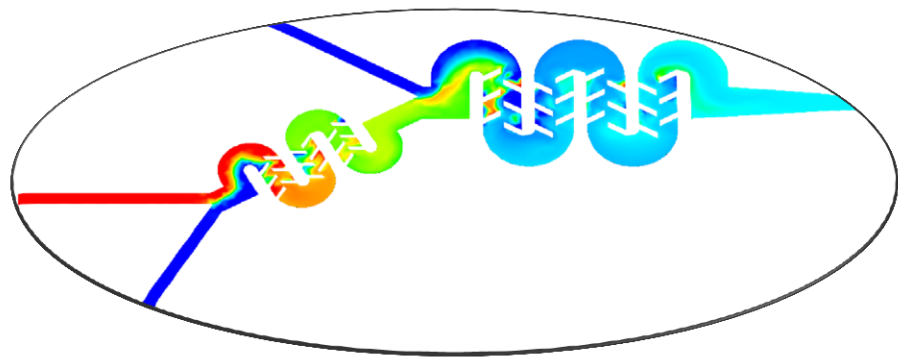


Pathogen Inactivation Kinetics

- Chlorine dose-time response on pathogen inactivation.

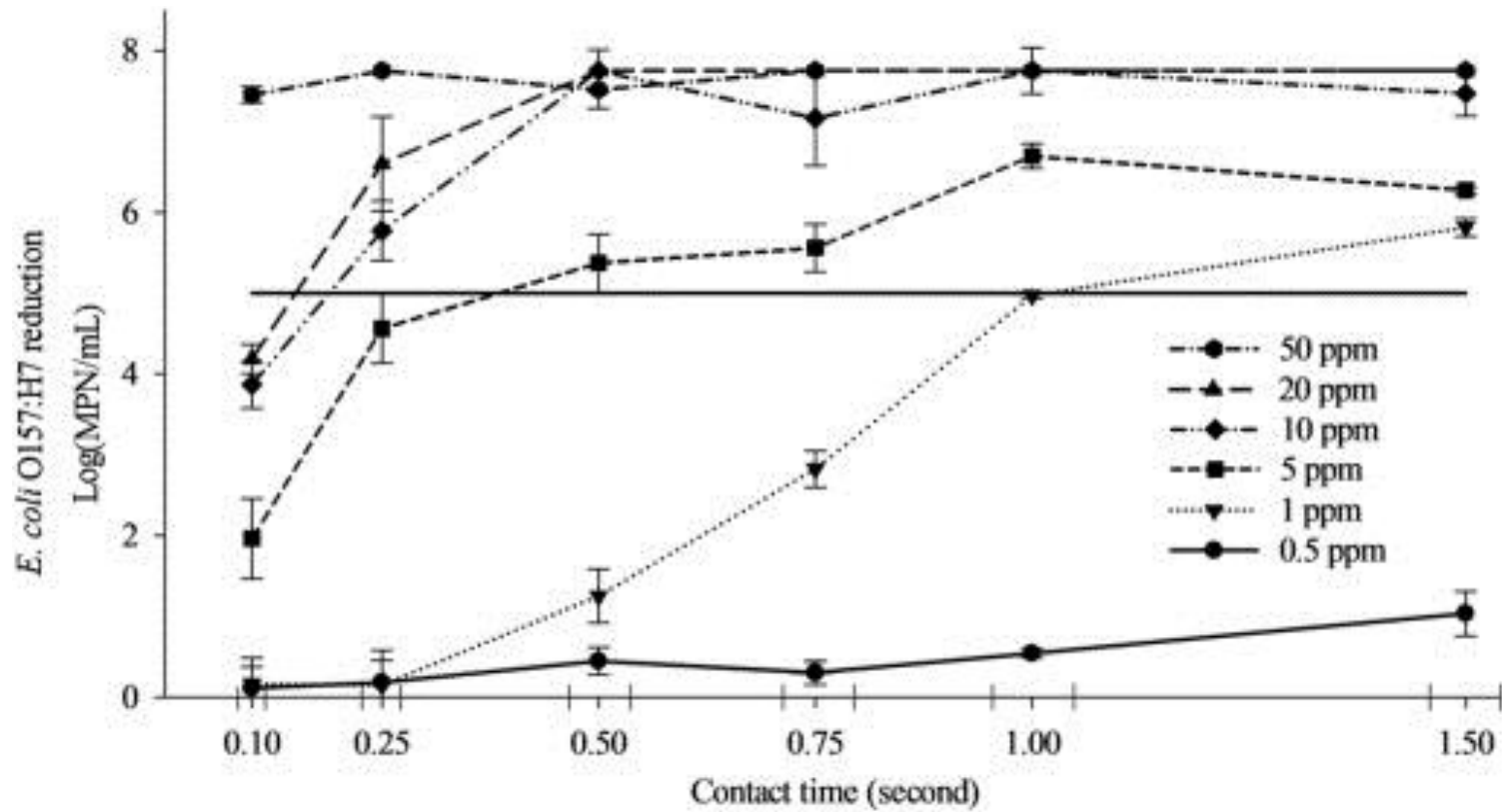
Challenge: Lack of technologies to determining sanitizer dose-time response on pathogen inactivation in a **sub-second** scale.

Solution: Developed a patent-pending **microfluidic device** (patent-pending) for evaluating chlorine dose-time response on pathogen inactivation is less than 1 second.



<https://www.youtube.com/watch?v=MbQbZ7DO8Rg>

Kinetics of Chlorine on Pathogen Inactivation





United States Department of Agriculture

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

- Gombas, D., Luo, Y., Brennan, j., Shergill, g., Petran, R., Walsh, C., Khurana, K., Zomorodi, B., Rosen, J., Varley, R., and Deng, K.

Additional Contributors: Joe Holt (Earthbound Farms), James Gorny (Produce Marketing Association), Steven Lange (Ecolab), Tony Banegas (Ready Pac), John Gurrisi and Courtney Parker (Chiquita Brands), Loys Larpin (Aqua Pulse Systems), Felice Arboisiere (Yum Brands), Robert Brackett (Illinois Institute of Technology), Trevor Suslow (UC Davis), Keith Warriner (Univ. Guelph), Keith Schneider (Univ. Florida), Vincent Hill (CDC), Tong-Jen Fu, Crystal McKenna, David Ingram, John Larkin, Mickey Parish, and Mary Lou Tortorello (FDA). **Reviewers:** Devon Zagory (Zagory and Associates), Glenn Black (FDA), Ginger Povenmire and Micah Fuson (Apio), Ronald Wesley and James Zeigler (Ready Pac).

International Collaborators: Sam Van Haute and Imca Sampers (Univ. Gent) and Ana Allende and Mabel Gil (CEBAS-CSIC).

Sponsors: Center for Produce Safety, Illinois Institute of Technology Institute for Food Safety and Health, and the United Fresh Produce Association.

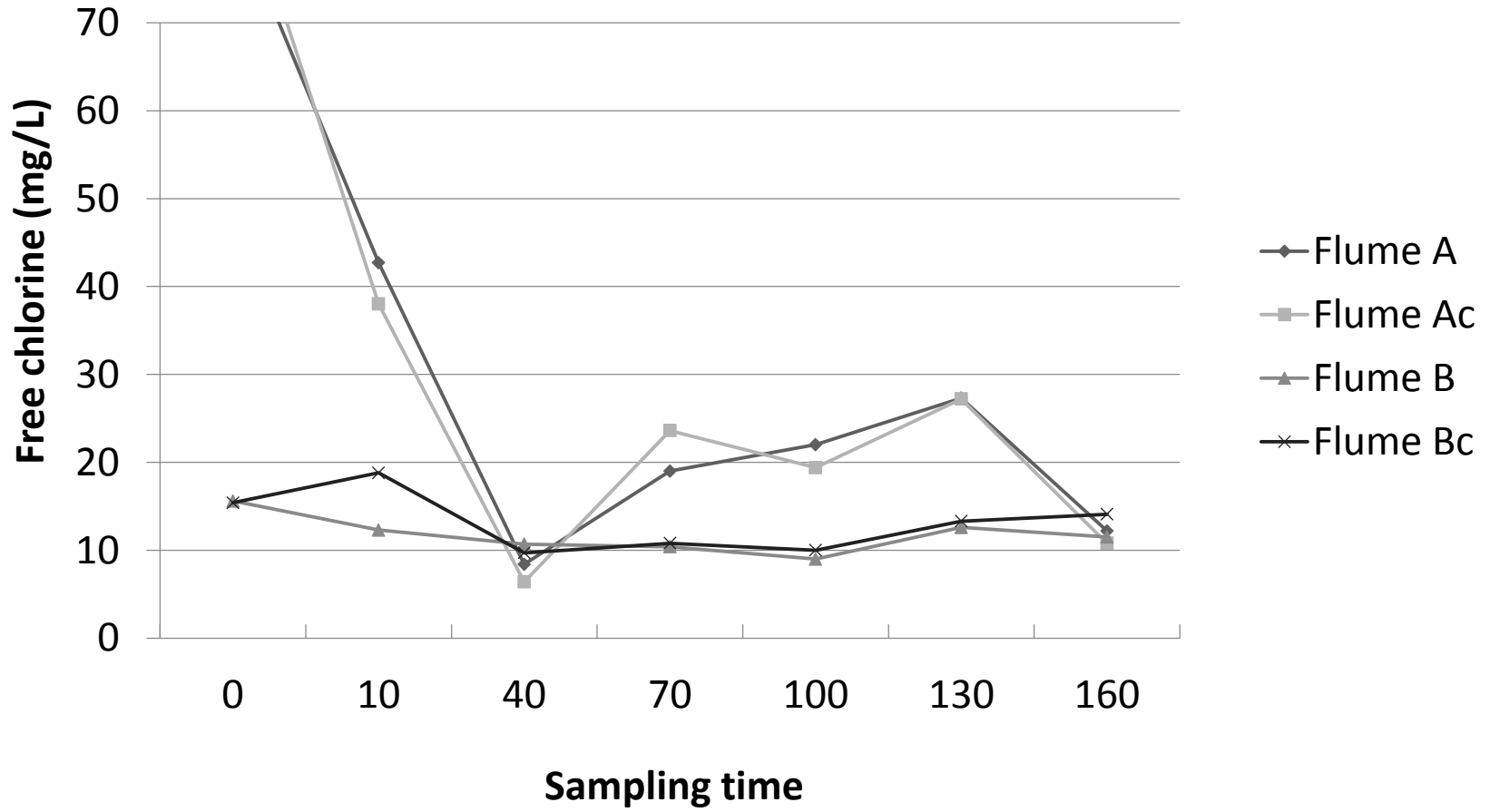
Additional Considerations

- Process capability
- Cost
- Chlorine disinfection byproducts
- Performance during commercial operation

Knowing that we can never use pathogens, or even their non-pathogenic surrogates during food processing, information regarding the survival of indigenous bacteria in relation to free chlorine becomes valuable.



Free Chlorine in Water from Cabbage Flume

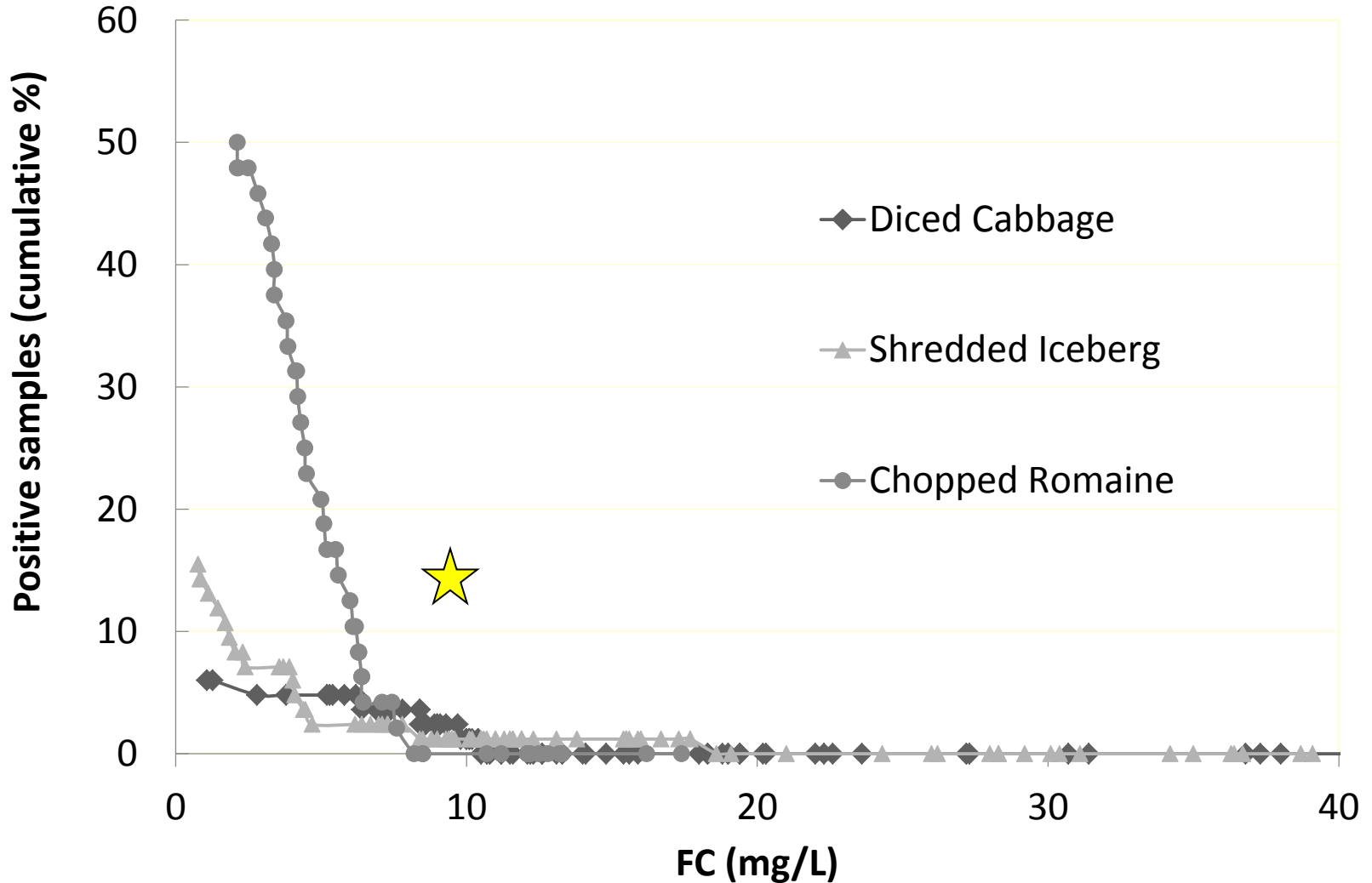


August 24-Cabbage



United States Department of Agriculture

Accumulative Percentage of APC Positive Samples





United States Department of Agriculture

Acknowledgement

Dr. Patricia D. Millner

Dr. Xiangwu Nou

Dr. Bin Zhou

Dr. Boce Zhang

Ms. Ellen Turner

Taylor Farms

McEntire Produce