CPS Research Symposium 2017

Hyatt Regency Denver Tech Center
Denver, Colorado
June 20-21, 2017

CPS CENTER *for* PRODUCE SAFETY

www.centerforproducesafety.org

Welcome

Dear Friends,

Welcome to Denver! Each of us play an important role in minimizing produce safety risks, and we are honored to be the host state for the 8th annual CPS Research Symposium. On behalf of Colorado's fruit and vegetable growers, thanks to CPS for the work that is funded and to the research community for providing us with science-based tools we can use as we continually strive to improve our operations. I look forward to engaging conversations and hope you all enjoy your time in Colorado.

Photo credit Matt Nager

Sincerely,

Robert Sakata
President
Sakata Farms

On behalf of the members of the Center for Produce Safety, I'd like to welcome you all to the 2017 Research Symposium. CPS was honored to have received an invitation from the Colorado fresh produce growers in 2014 to hold our annual event in this beautiful location. It took us a few years to get here and now we are looking forward to an excellent symposium. We are pleased to enjoy a very high level of interest from attendees, which we attribute to the talented scientists and esteemed moderators and panelists being featured this year. We are so grateful they have decided to dedicate so much time to creating an informative and compelling symposium. I also want to thank our generous sponsors for their support in helping us with our mission to enhance produce safety for everyone.

Your input and questions about CPS research are welcome. Please share your ideas with the CPS Board of Directors, members of the CPS Technical Committee or contact me directly. Thank you for spending time with us.

Sincerely,

Bonnie Fernandez-Fenaroli
Executive Director
Center for Produce Safety

CENTER *for* PRODUCE SAFETY

About Center for Produce Safety (CPS)

The Center for Produce Safety (CPS) is a 501(c)(3), U.S. tax-exempt, charitable organization focused exclusively on providing the produce industry and government with open access to the actionable information needed to continually enhance the safety of produce.

Chairman's Welcome

Ten years go by fast. Ten years ago, through the generosity of the Produce Marketing Association, California Department of Food and Agriculture, and Taylor Farms, the Center for Produce Safety was founded to address knowledge gaps in produce safety.

Since 2007, CPS has funded 124 projects at 35 institutions and in five countries. What a remarkable accomplishment! The diversity of our research reflects the diverse parts of the industry engaged with CPS – from the Board of Directors, the Technical Committee, other volunteers, and industry leaders.

Funding the research is just the beginning and thus the reason for this symposium. Translating research insights into action and improved industry practices is the next step. At this symposium, as we have at the previous seven symposia, you'll hear how those insights can be applied in your business to enhance produce safety – the investment of your time in Denver is well justified.

Our capital campaign has generated $11.3 million dollars from 70 companies and associations. Is your company one of them? You'll find a full listing of donors on the inside back cover of the program, and if you have yet to participate we hope you will consider supporting CPS.

There are countless people who make the CPS Research Symposium so valuable, and I'd like to first thank our sponsors – their generosity helps keep attendance fees low and supports the mission of CPS.

There are dozens of men and women on the Board of Directors and Technical Committee whose tireless efforts bring you this content-rich program. Researchers, technical experts, students, volunteers – to all of you, thank you for your contributions! And finally, my appreciation to *you* that you made the time to attend this symposium and expand your understanding of produce safety.

The Center for Produce Safety is more than just two days in June – there is ample information on our website at www.centerforproducesafety.org and we hope you'll use this resource as well.

Timothy York
Chair
Markon Cooperative

Agenda at a Glance

Tuesday, June 20, 2017

7:00 am – 8:00 am

Registration, Continental Breakfast, Poster Session

8:00 am – 8:05 am

Opening Comments

Tim York, Chair, CPS Board of Directors

8:05 am – 9:35 am

Agricultural Water

The safety of agricultural water has been an industry priority for over a decade. This session will focus on four CPS funded research programs to help stakeholders better understand the factors involved in sourcing, sampling, testing and treating specific types of agricultural water.

- Identification of novel indicator organisms to determine the risks of fecal contamination of irrigation waters. **Kelly Bright**, University of Arizona
- Microbial food safety risks of reusing tail water for leafy greens production. **Michael Cahn**, University of California, Cooperative Extension
- Demonstration of practical, effective and environmentally sustainable agricultural water treatments to achieve compliance with microbiological criteria. **Ana Allende**, CEBAS-CSIC, Spain
- Improved sampling and analytical methods for testing agricultural water for pathogens, surrogates and source tracking indicators. **Vincent Hill**, Centers for Disease Control and Prevention

Moderator: **James Gorny**, Produce Marketing Association

Panelists: **Samir Assar**, U.S. Food and Drug Administration
DeAnn Davis, Earthbound Farm
Walter Ram, Giumarra Companies

9:35 am – 9:50 am

Welcome to Colorado

The Honorable John Hickenlooper, Governor of the State of Colorado

9:50 am – 10:20 am

Break

10:20 am – 11:05 am

Stakeholder Value Session – Growers

Moderators: **Drew McDonald**, Taylor Farms
Bob Whitaker, Produce Marketing Association

Panelists: **Samir Assar**, U.S. Food and Drug Administration
Sharan Lanini, Pacific International Marketing
Robert Sakata, Sakata Farms

Agenda at a Glance

11:05 am – 11:50 am

FSMA Methods for Testing Agricultural Water – a CPS Colloquium

The Produce Safety Rule requires a water testing method that has not been traditionally used by the fresh produce industry or their laboratories for testing agricultural water. This session will report on the findings of a panel of regulators, public scientists and industry representatives convened by CPS in a recent Colloquium designed to offer recommendations to both FDA and industry that would address concerns with the FDA prescribed method.

Moderators: **Hank Giclas**, Western Growers
Trevor Suslow, University of California, Davis

11:50 am – 12:20 pm

Lightning Sessions

A view of things to come: these lightning sessions will explore exciting new pathogen testing technologies, an emerging class of pathogen indicators, and touch on the phenomena of viable but nonculturable bacteria and why they may or may not be an important food safety consideration.

- Significance of the dormant state in the persistence, interaction with growing plants and virulence of Shiga toxin-producing *Escherichia coli*. **Keith Warriner**, University of Guelph
- Detection, validation, and assessment of risks implied by the viable but nonculturable (VNBC) state of enteric bacterial pathogens in fresh produce. **Xiaonan Lu**, University of British Columbia
- Enteric viruses as new indicators of human and cattle fecal contamination of irrigation waters. **Kelly Bright**, University of Arizona
- Rapid bacterial testing for on-farm sampling. **Sam Nugen**, Cornell University
- Developing cross-assembly phage as a viral indicator for irrigation waters. **Kyle Bibby**, University of Pittsburgh

Moderator: **Jill Dunlop**, Florida Fruit and Vegetable Association

12:20 pm – 1:35 pm

Lunch

1:35 pm – 3:05 pm

Packinghouse/Supply Chain Food Safety

The ongoing debate on the application of food safety regulations to packinghouses has simultaneously fueled the need to expand our knowledge base on pathogen transference and wash water control in these environments. This session will focus on these areas and highlight key findings in supply chain-wide management of contamination risks.

- Factors that influence the introduction, fate and mitigation of foodborne pathogens on mangoes throughout the production chain. **Michelle Danyluk**, University of Florida
- Impact of wash water disinfectants on *Salmonella enterica* transfer and

Agenda at a Glance

survival in mango packing facility water tank operations. **Mary Anne Amalaradjou**, University of Connecticut

- Control of cross-contamination during field-pack and retail handling of cantaloupe. **Laura Strawn**, Virginia Tech
- Validation of chlorine level in sanitation systems to avoid cross-contamination. **Qin Wang**, University of Maryland

Moderator: **Joan Rosen**, JC Rosen Resources

Panelists: **Bill Gerlach**, Melissa's Produce
Manuel Michel, National Mango Board
Max Teplitski, National Institute of Food and Agriculture, USDA

3:05 pm – 3:35 pm

Break

3:35 pm – 4:20 pm

Stakeholder Value Session – Packing

Moderators: **Drew McDonald**, Taylor Farms
Bob Whitaker, Produce Marketing Association

Panelists: **Tony DiMare**, DiMare Fresh
Steve Kenfield, HMC Farms
Robert Kershaw, Domex Superfresh Growers

4:20 pm – 4:40 pm

Lightning Round – CPS Funded Research Projects

- Characterization and mitigation of bacteriological risks associated with packing fresh-market citrus. **Linda Harris**, University of California, Davis
- Evaluation of sanitizing treatments for sizer carriers in stone fruit packinghouses. **Steven Pao**, California State University, Fresno
- Control of *Listeria monocytogenes* on apple through spray manifold–applied antimicrobial intervention. **Meijun Zhu**, Washington State University
- *Listeria monocytogenes* growth and survival on peaches and nectarines as influenced by stone fruit packinghouse operation, storage and transportation conditions. **Mary Anne Amalaradjou**, University of Connecticut

Moderator: **Stacy Stoltenberg**, Hygiena

4:40 pm – 5:00 pm

Closing Comments, Day 1

Bonnie Fernandez-Fenaroli, Center for Produce Safety

5:00 pm – 6:30 pm

Official Symposium Reception

Agenda at a Glance

Wednesday, June 21, 2017

7:00 am – 8:00 am

Registration, Continental Breakfast, Poster Session

8:00 am – 8:20 am

Welcome Back

Michael Hirakata, Hirakata Farms
Robert Sakata, Sakata Farms

8:20 am – 9:50 am

Validation

One of the hallmarks of the final FSMA regulations is the need to validate key processes or practices employed to manage food safety hazards. Effective validation requires basic knowledge regarding the survivability and persistence of human pathogens and likely the use of surrogates that permit evaluations under actual industry conditions. This session will help stakeholders develop insight into the development of surrogate strains and how they can be used across the production spectrum.

- Comparative genomics analysis and physiological assessment of the avirulent *Salmonella* surrogate relevant to food safety. **Julie Meyer**, University of Florida
- Establishing die-off rates of surrogate and virulent EHEC/STEC strains from strawberry and cilantro surfaces: time, inoculum dose and chemical intervention. **Eduardo Gutierrez-Rodriguez**, North Carolina State University
- Validating a physically heat-treated process for poultry litter in industry settings using the avirulent *Salmonella* surrogates or indicator microorganisms. **Xiuping Jiang**, Clemson University
- Improving pasteurization validation methods for pistachio processing. **Bradley Marks**, Michigan State University

Moderator: **James Brennan**, SmartWash Solutions

Panelists: **Kent Kise**, Ready Pac
Martha Roberts, Roberts Associates
Felice Arboisiere, Yum Brands

9:50 am – 10:10 am

Travel Grant Awards

Moderator: **Doug Grant**, The Oppenheimer Group

10:10 am – 10:40 am

Break

10:40 am – 11:25 am

Stakeholder Value Session – Processing

Moderators: **Drew McDonald**, Taylor Farms
Bob Whitaker, Produce Marketing Association

Panelists: **Suresh DeCosta**, Lipman Produce

Agenda at a Glance

Carter McEntire, McEntire Produce
Brian Zomorodi, Apio, Inc.

11:25 am – 11:45 am

Lightning Round

- *Cyclospora*: Potential reservoirs and occurrence in irrigation waters. **Gerardo Lopez**, University of Arizona
- Establishment of operating standards for produce wash systems through the identification of specific metrics and test methods. **Ana Allende**, CEBAS-CSIC, Spain
- Resolving postharvest harborage sites of *Listeria* protects zone 1 surfaces. **Trevor Suslow**, University of California, Davis
- Remotely-sensed and field-collected hydrological, landscape and weather data can predict the quality of surface water used for produce production. **Martin Wiedmann**, Cornell University

Moderator: **Mike Villaneva**, California Leafy Greens Marketing Program

11:45 am – 1:00 pm

Lunch

1:00 pm – 2:30 pm

Hot Topics

Understanding what a positive STEC result means, determining effective ways to control *Lm*, quantifying the importance of parasites as a produce safety issue, and gaining insights into the role the physiological state of a pathogen may play in conducting validation experiments are at the cutting edge of food safety challenges. The programs in this final session will provide emerging data on these topics and commentary on how the industry can best apply this information.

- Rapid tests to specifically differentiate clinically significant from environmental STEC towards reducing unnecessary crop destruction. **Trevor Suslow**, University of California, Davis
- Evaluation of the efficacy of antimicrobial agents to prevent the transfer of *Listeria monocytogenes* from existing biofilms to produce or processing surfaces. **Rolf Joerger**, University of Delaware
- Methods for detection of diverse parasites on packaged salads based on (viable) oocysts. **Stefan Wuertz**, University of California, Davis
- Pathogen physiological state has a greater effect on outcomes of challenge and validation studies than strain diversity. **Martin Wiedmann**, Cornell University

Moderator: **Tiffiani Miller**, Florida Department of Agriculture and Consumer Services

Agenda at a Glance

Panelists: **Jennifer McEntire**, United Fresh Produce Association
Suresh DeCosta, Lipman Produce
Max Teplitski, National Institute of Food and Agriculture, USDA

2:30 pm – 3:00 pm

Break

3:00 pm – 3:45 pm

Stakeholder Value Session – Buyers

Moderators: **Drew McDonald**, Taylor Farms
Bob Whitaker, Produce Marketing Association

Panelists: **Natalie Dyenson**, Dole Food Company, Inc.
Mark Mignogna, Sysco
Mike Spinazzola, DRS International

3:45 pm – 4:30 pm

Lasting Impressions

CPS Board Chair and President of Markon Cooperative **Tim York** will lead an interactive discussion with symposium participants about the key learnings presented over the two-day event, highlighting new information that will strengthen food safety programs.

4:30 pm – 4:45 pm

Closing Comments

4:45 pm – 6:00 pm

Reception

CPS Research Symposium 2016, Seattle

General Session

Asterisks denote Specialty Crop Block Grant support. Key on page 36.

AGRICULTURAL WATER

Project Title
Identification of novel indicator organisms to determine the risks of fecal contamination of irrigation waters

Principal Investigator
Kelly Bright, University of Arizona

Project Term
January 1, 2016 – December 31, 2017

Non-Technical Summary
The methods used to detect *E. coli* were developed for drinking water and are known to produce high levels of false-positive and false-negative results when used for irrigation waters. Therefore, growers are required to make decisions about water quality/safety based on inaccurate tests. Our project goal is to identify microorganisms which may be used as novel indicators of the presence of pathogens (not just fecal contamination) in irrigation waters to allow the produce industry to make more accurate risk-based assessments to determine when it is safe to irrigate crops. Our specific objectives are the following: 1) We will examine irrigation water to determine the levels of fecal indicator and pathogenic bacterial/viral species by existing cultural and/or molecular methods; 2) We will determine the composition (presence and relative abundance) of the entire bacterial, protozoan, and fungal communities found in irrigation water using "next-generation" sequencing; 3) We will identify groups or specific species whose presence correlate well (presence/absence and relative abundance) with the occurrence of foodborne pathogens in irrigation waters. The use of more meaningful indicator species will provide growers with more accurate information upon which to optimize their irrigation practices to minimize the risk of contamination of produce by foodborne pathogens.

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety**

Acknowledgements
Luisa Ikner, Walter Betancourt, Enue Sicairos, Patricia Gundy, Huruy Zerzghi, Sherif Abdel Maksoud, Monique Torres, Brianna Leija, Candace Garrett, Jennifer Pearce-Walker, Irma Perez, Christina Morrison

Contact
bright@email.arizona.edu

Project Title
Microbial food safety risks of reusing tail water for leafy greens production

Principal Investigator
Michael Cahn, University of California, Cooperative Extension

Project Term
January 1, 2016 – December 31, 2017

Non-Technical Summary
The use of sprinklers and furrow irrigation frequently results in significant volumes of run-off, also referred to as tail water. Although vegetable growers have made much progress in reducing irrigation run-off by using drip lines, overhead sprinklers are needed for germinating and establishing crops, and for watering high-density leafy greens such as spinach and baby greens. Also, a significant number of acres of lettuce and other vegetables are irrigated by furrow after crop establishment. Many Central Coast ranches have infrastructure for reusing tail water for irrigating crops, including sediment basins, reservoirs, and pumping systems. Currently growers are reluctant to irrigate crops with tail water due to a lack of information on microbial food safety risks. Several options exist for reusing run-off water, which may

minimize microbial food safety risks for produce. Tail water could be used for irrigation practices that do not result in direct contact with the crop, such as pre-irrigation and germination, as well as for dust control of unpaved roads. Tail water could be reused for crops on drip. Other options include treating run-off by chlorination or other means to kill microbial pathogens, and blending tail water with a clean water source so that microbial levels meet industry or regulatory target levels for surface water. The objectives of this project will be to: 1) monitor, characterize and quantify microbial populations in run-off water from Central Coast vegetable fields; 2) evaluate the risk of using this water source for the production of lettuce and other leafy green crops by quantifying survival of microorganisms during reuse applications; and 3) evaluate economically-feasible methods to treat tail water that would minimize microbial food safety risks for a range of reuse applications (e.g., pre-irrigation, dust control, irrigation).The food safety risk of reusing run-off water needs to be evaluated in commercial vegetable fields under conventional irrigation practices.
Our project would address this need, and develop information on the food safety risks associated with re-using run-off water for leafy green production

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety; CA Leafy Greens Research Board **

Acknowledgements
Co-PIs: Linda Harris, Department of Food and Science and Technology, University of California, Davis; Steven Koike, University of California, Cooperative Extension, Monterey County

Staff: Anne-Laure Moyne, Department of Food Science and Technology, University of California, Davis and Laura Murphy, University of California, Cooperative Extension, Monterey County

Contact
mdcahn@ucdavis.edu

Project Title
Demonstration of practical, effective and environmentally sustainable agricultural water treatments to achieve compliance with microbiological criteria

Principal Investigator
Ana Allende, CEBAS-CSIC, Spain

Project Term
January 1, 2015 – December 31, 2016

Non-Technical Summary
Growers should be assisted in determining the risk associated with agricultural water and the best mitigation option to remove pathogens if needed. Water disinfection is one of the most recommended intervention strategies for irrigation water. The main purpose of this project is to demonstrate a practical, effective, and environmentally sustainable water disinfection treatment. Within this regard, we propose the use of stabilized chlorine dioxide (ClO_2) as a suitable disinfection treatment. We will try to establish if stabilized ClO_2 could be a suitable disinfection treatment to ensure the compliance with the established microbial limits, particularly fecal indicator bacteria such as E. coli. First, agricultural waters from different water sources will be characterized by microbiological and physicochemical parameters. Optimal operational conditions for stabilized ClO_2 as a suitable disinfection treatment will be established first at a pilot scale. After that, demonstration of practical, effective and environmentally sustainable agricultural water disinfection treatment will be carried out at commercial fields, where the impact of stabilized ClO_2 on the environment will be also evaluated. We believe that the conclusions will be very valuable for growers who will be able to integrate this technology in their water management practices.

Funding
Center for Produce Safety

Acknowledgements
Mabel Gil, Senior Researcher CEBAS-CSIC and Co-PI of the project; Pilar Truchado and Francisco López-

General Session

Gálvez, Post-doc researchers at CEBAS-CSIC; Macarena Moreno, Silvia Andújar and Nathalie Hernandez, Technicians at CEBAS-CSIC; Trevor Suslow, Extension Research Specialist and Scientific Cooperator of the project; PRIMAFLOR SAT and STC S.L.U., Industry cooperators of the project

Contact
aallende@cebas.csic.es

Project Title
Improved sampling and analytical methods for testing agricultural water for pathogens, surrogates and source tracking indicators

Principal Investigator
Vincent Hill, Centers for Disease Control and Prevention

Project Term
January 1, 2015 – December 31, 2016

Non-Technical Summary
New rules proposed under the Food Safety Modernization Act (FSMA) establish monitoring frequencies and *Escherichia coli* (*E. coli*) concentrations for characterizing agricultural water quality. In addition to monitoring for *E. coli*, other strategies for collecting and testing irrigation water can provide farm operators with a better understanding of the quality of water used in crop production. These strategies include collecting source water samples during times of greater potential risk for contamination (e.g., after rain events) and testing for pathogens and alternative water quality surrogates. In this project, ultrafiltration will be used to collect large-volume irrigation water samples from three farms in Georgia to investigate the benefits of collecting such samples for microbial water quality testing. Baseline and precipitation-impacted samples will be collected to enhance the comparison of large- versus small-volume collection procedures. Samples will be tested for traditional indicators of fecal contamination (*E. coli* and enterococci), alternative surrogates of fecal contamination (F+ coliphages), pathogens (*Salmonella, Cryptosporidium* and *E. coli* O157:H7), and analytes that can be used to identify sources of fecal contamination affecting agricultural water quality. This study will result in development of sampling and testing procedures for analysis of large-volume irrigation water samples for alternative microbial water quality parameters.

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety *

Acknowledgements
Center for Produce Safety; Dr. Vincent Hill, CDC Dr. Karen Levy, Emory University; Dr. George Vellidis, University of Georgia; Dr. Moukaram Tertuliano, University of Georgia; Amy Kahler, CDC; Mia Mattioli, Emory Postdoctoral Fellow; Candace Miller, CDC

Contact
veh2@cdc.gov

PACKINGHOUSE/SUPPLY CHAIN FOOD SAFETY

Project Title
Factors that influence the introduction, fate and mitigation of foodborne pathogens on mangoes throughout the production chain

Principal Investigator
Michelle Danyluk, University of Florida

Project Term
January 1, 2016 – December 31, 2017

Non-Technical Summary
Understanding the persistence and mitigation of foodborne pathogens on the surface of mangoes is

essential to the establishment of Best Management Practices for the responsible handling, packing, distributing, and importing of mangoes, and is a fundamental management prerequisite to providing customers with safe mangoes. There is inadequate science-based data to establish management standards and criteria for mangoes to meet pending requirements of the Food Safety Modernization Act. The purpose of this research project is to evaluate the persistence of foodborne pathogens on the surfaces of whole and fresh-cut mangoes, assess potential mitigation strategies for control of pathogens on mango surfaces, and appraise the ability of *Salmonella* to infiltrate mangoes under standard packinghouse conditions and then to determine the fate of the internalized cells. The research results will specifically address data gaps the National Mango Board currently faces, and will provide research-based metrics to validate mitigation strategies.

Funding
Center for Produce Safety

Acknowledgements
National Mango Board; Lorrie Friedrich, Biological Scientist; Xinyue Wang, MS Student; Vijendra Sharma, Technician

Contact
mddanyluk@ufl.edu

Project Title
Impact of wash water disinfectants on *Salmonella enterica* transfer and survival in mango packing facility water tank operations

Principal Investigator
Mary Anne Amalaradjou, University of Connecticut

Project Term
January 1, 2015 – December 31, 2016

Non-Technical Summary
Foodborne outbreaks associated with consumption of raw mangoes have been traced back to the use of contaminated wash water. This highlights the critical role of wash water disinfection in mango processing, affecting its quality, and safety. While investigations on the efficacy of disinfectants to reduce pathogens on other fruits have been performed, no studies have been conducted on mangoes. Therefore, this study will investigate the efficacy of different disinfectants (chlorine, peracetic acid and FIT fruit and vegetable wash solutions) for killing *Salmonella* on mangoes and prevention of water-to-mango cross contamination. The study will be performed under conditions that simulate dump tank washing, hot water treatment and hydrocooling. Additionally, the study will investigate the efficacy of trans-cinnamaldehyde, a GRAS status antimicrobial for use as a natural, alternative disinfectant in mango wash water. It is expected that this study will provide insight into the efficacy of disinfectants to inactivate *Salmonella* in mango packing facility water operations. Furthermore, this proposal will help us understand the role of organic load in mango wash water on disinfectant efficacy. In conclusion, the proposed research is expected to help develop best practices regarding post-harvest washing and disinfection of mangoes to control *Salmonella* and other potentially pathogenic organisms.

Funding
National Mango Board; Center for Produce Safety

Acknowledgements
National Mango Board; Center for Produce Safety

Contact
mary_anne.amalaradjou@uconn.edu

Project Title
Control of cross-contamination during field-pack and retail handling of cantaloupe

Principal Investigator
Laura Strawn, Virginia Tech

Project Term
January 1, 2016 – December 31, 2017

General Session

Non-Technical Summary

Following recent melon-associated foodborne outbreaks, California cantaloupe growers voluntarily developed and implemented commodity-specific food safety guidelines for the safe handling of cantaloupes and other netted melons. While this document details best food safety practices to reduce the risk of contamination during production, packing, and distribution, science-based metrics describing transfer coefficients for pathogen contamination onto melons during field-packing operations are needed. Cross-contamination is a known food safety risk in many environments, and is dependent on many variables, including transfer surface, commodity surface, and contamination level. Cross-contamination was highlighted by the Food and Drug Administration as a critical factor contributing to recent cantaloupe-associated outbreaks. To date, no published literature evaluating the cross-contamination potential of whole melons has been established under typical field-packing conditions. Furthermore, there is a lack of data on handling practices related to cross-contamination risks for melons in the retail distribution supply chain, as well as guidance on the safe and uniform handling of melons throughout the retail environment. Through this proposed project, potential cross-contamination points likely to increase risk will be identified, and intervention strategies targeted to reduce the occurrence of pathogen transfer events during the handling of melons at harvest and retail will be developed.

Funding

California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety **

Acknowledgements

Michelle Danyluk, Co-PI, University of Florida; Lorrie Friedrich, Biological Scientist, University of Florida; Ben Chapman, Co-PI, North Carolina State University; Chris Rupert, MS Student, North Carolina State University; Rachel Pfuntner, Research Scientist, Virginia Tech; Laura Truitt, Research Scientist, Virginia Tech

Contact

lstrawn@vt.edu

Project Title

Validation of chlorine level in sanitation systems to avoid cross-contamination

Principal Investigator

Qin Wang, University of Maryland

Project Term

January 1, 2015 – December 31, 2016

Non-Technical Summary

Scientifically validated data are needed by regulators and commercial fresh-cut processors to determine the minimum chlorine concentration required to prevent pathogen cross-contamination in produce wash waters. This project will address this issue by development of a microfluidic mixer that simulates cross-contamination and pathogen survival scenarios in chlorinated produce wash water. The microfluidic mixer has the unique capability of manipulating solutions at a miniaturized scale within instantaneous response times. Thus, the mixer will provide a technological solution to the limitations encountered in macroscale testing. This project will investigate the relationship between contact time (0.1 second – 5 minutes) and chlorine level (0.125 to 50 ppm) to prevent cross-contamination in wash water. Minimal contact times for given chlorine levels will be determined for planktonic and biofilms of bacterial cells. Results will be further validated using industrial produce wash water to investigate the effects of operational variables (pH, temperature, organic load) on the contact time requirement at different chlorine levels. We anticipate the proposed study will provide insight on the relationship between minimal contact time and chlorine level, and therefore predict the processing requirement at given variables to effectively prevent cross-contamination in wash water.

Funding

Center for Produce Safety; University of Maryland

Acknowledgements

Dr. Yaguang (Sunny Luo), Research Food Technologist, USDA Agricultural Research Service; Dr. Patricia Millner, Research Microbiologist, USDA Agricultural Research Service; Dr. Boce Zhang, ORISE Fellow,

USDA Agricultural Research Service; Dr. Bin Zhou, Research Microbiologist, USDA Agricultural Research Service; Dr. Zi Teng, Post-doctoral Research Associate, University of Maryland, University of Maryland NanoCenter and Fabrication Lab

Contact
wangqin@umd.edu

VALIDATION

Project Title
Comparative genomics analysis and physiological assessment of the avirulent *Salmonella* surrogate relevant to food safety

Principal Investigator
Julie Meyer, University of Florida

Project Term
January 1, 2016 – December 31, 2017

Non-Technical Summary
Coliforms and generic *E. coli* are poor predictors of the behavior of human pathogens (like *Salmonella*, pathogenic *E. coli* and *Listeria)* in the crop production environment. Mounting evidence suggests that accurate models of *Salmonella* behavior in the production environment will have to be built based on the experiments conducted with *Salmonella*, and not based on data from distantly related surrogates like generic *E. coli*. This, however, necessitates availability and careful characterization of "disarmed" strains of *Salmonella* that could be used for on-site research. Upon completion of this study we will have developed robust tools for modeling behavior of these outbreak strains in the pre- and post-harvest production environments. The purpose of this project is to carry out comparative genomic and physiological characterization of the outbreak strains under production conditions and to compare them with the nonvirulent strain of *Salmonella* that we have developed. We will also have tested two key hypotheses aimed at understanding why only a dozen out of over 2,500 *Salmonella* serovars are associated with produce-linked outbreaks of illness. With previous CPS funding we engineered and verified the first nonvirulent, nontransgenic strain of *Salmonella* suitable for on-site studies as an indicator organism.

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety **

Acknowledgements
Dr. Max Teplitski, University of Florida and Dr. Marcos de Moraes, University of Florida

Contact
juliemeyer@ufl.edu

Project Title
Establishing die-off rates of surrogate and virulent EHEC/STEC strains from strawberry and cilantro surfaces: time, inoculum dose and chemical intervention

Principal Investigator
Eduardo Gutierrez-Rodriguez, North Carolina State University

Project Term
January 1, 2016 – December 31, 2016

Non-Technical Summary
The fresh produce industry is facing major changes in production practices due to the implementation of the FDA Food Safety Modernization Act (FSMA). Within the new rules the standards associated with water quality are among the most contested by

industry associations. Current guidelines require water that will be in direct contact with the crop, to meet specific microbiological thresholds based on the 2012-EPA recreational water standards. Alternative provisions to comply with these rules have also been allowed by FDA when water cannot meet these standards. One of these options considers a microbial die-off rate of 0.5 log per day that may occur naturally between irrigation and harvest events as a safe alternative practice. Despite this potentially useful provision, there needs to be science-based information supporting this option, especially on cilantro and strawberry for which few or no further disinfection steps are commercially available after harvest and where large volumes of surface or well water are used for frost protection (strawberry) and overhead irrigation (cilantro). This research focuses on optimizing the existing knowledge in microbial die-off of avirulent and pathogenic EHEC- STEC microorganisms to determine whether the proposed microbial die-off rate is a safe farm practice to follow when using water that cannot meet the EPA microbial standards.

Funding
Center for Produce Safety

Acknowledgements
Co-PIs: Chris Gunter, North Carolina State University; Sid Thakur, North Carolina State University; Carole Saravitz, North Carolina State University, Dr. Victoria Albarracin

Contact
egutier2@ncsu.edu

Project Title
Validating a physically heat-treated process for poultry litter in industry settings using the avirulent *Salmonella* surrogates or indicator microorganisms

Principal Investigator
Xiuping Jiang, Clemson University

Project Term
January 1, 2016 – December 31, 2017

Non-Technical Summary
Poultry litter is an excellent source of nutrients for the growth of agricultural crops. To reduce the microbiological risks associated with the use of raw poultry litter as a soil amendment or organic fertilizer, heat treatment is recommended to reduce or eliminate potential pathogenic microorganisms. Our recent studies have demonstrated that thermal resistance of *Salmonella* in chicken litter is increased significantly when cells are adapted to desiccation or when aged chicken litter with low moisture content is heat treated. By increasing the moisture level in chicken litter or applying a two-step heat treatment (wet heat followed by dry heat), *Salmonella* can be inactivated more rapidly. Our preliminary results indicate a good correlation in thermal inactivation rates between desiccation-adapted *Salmonella* and indigenous enterococci in chicken litter, suggesting enterococci as a potential indicator for heat process validation. We will collaborate with two large poultry litter processors to validate their heat-treatment processes in industrial settings by using *Salmonella* surrogate and indicator microorganisms identified in this study. Results from this research will provide some valid guidelines and tools for the fertilizer industry to produce *Salmonella*-free heat-treated poultry litter, thereby ensuring safe production of fresh produce.

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety **

Acknowledgements
Dr. Annel Greene (Co-PI), Maple Wang and Jack Chen (graduate students), and our industry collaborators

Contact
xiuping@clemson.edu

Project Title
Improving pasteurization validation methods for pistachio processing

Principal Investigator
Bradley Marks, Michigan State University

General Session

Project Term
January 1, 2015 – December 31, 2016

Non-Technical Summary
Microbial safety of low-moisture foods is a particularly difficult challenge, as reflected in recent outbreaks and/or recalls associated with *Salmonella*-contaminated nuts and other low-moisture products. Therefore, processing interventions are an emerging imperative to reduce the risk of *Salmonella* in low-moisture products, including pistachios. The Food Safety Modernization Act (FSMA) proposed Preventive Controls rule will mandate that the low-moisture food industry implement and validate interventions against identified hazards, such as *Salmonella*. Although a number of pathogen-reduction technologies are available to the pistachio industry (e.g., dry heat, steam, radio-frequency), there are several significant problems: (1) No single technology will be universally applicable, so that product-specific/scalable solutions are needed; (2) The cost of stand-alone pasteurization technologies is an impediment to small processors; and (3) Robust validation protocols have not been widely tested or disseminated. Therefore, the overall goal is to improve the methods for validating pathogen-reduction processes for pistachios, with particular attention to improving existing processes and enabling any processor to reliably validate those processes. The work plan includes laboratory- and pilot-scale experiments with *Salmonella*-inoculated pistachios, and a process validation demonstration at the commercial-scale. A key project outcome will be a guidelines document for methods to validate preventive control measures for pistachios.

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety *

Acknowledgements
Co-PIs: Linda J. Harris, University of California, Davis; Elliot T. Ryser, Michigan State University

Contact
marksbp@msu.edu

HOT TOPICS

Understanding what a positive STEC result means, determining effective ways to control Lm, quantifying the importance of parasites as a produce safety issue, and gaining insights into the role the physiological state of a pathogen may play in conducting validation experiments are at the cutting edge of food safety challenges. The programs in this final session will provide emerging data on these topics and commentary on how the industry can best apply this information.

Project Title
Rapid tests to specifically differentiate clinically significant from environmental STEC towards reducing unnecessary crop destruction

Principal Investigator
Trevor Suslow, University of California, Davis

Project Term
January 1, 2015 – December 31, 2016

Non-Technical Summary
Though exceptionally rare events, relative to the scale of production and consumption, there is ample evidence to know that produce samples sometimes contain pathogens of serious potential human health consequences. Shiga toxin-producing *E. coli* (STEC) from diverse fresh produce were recovered from multi-year sampling programs conducted by the UDSA, largely at wholesale distribution centers. Leafy greens, herbs, and specifically spinach were singled out for concern due to a STEC prevalence rate exceeding 50% of the total isolates recovered. Product testing is used by many but not all producers to pre-screen leafy greens for bacterial pathogens, including STEC. Unfortunately, not all testing platforms rapidly distinguish STEC likely

General Session

to cause human illness from those that lack the genetic traits necessary for infection. Due to the high perishability of these commodities, testing can lead to destruction of a field due to false association with dangerous STEC. The combined objectives of protecting consumers, reducing food waste, and improving sustainability can be enhanced by applying new advancements proposed in this research in specific detection of clinically relevant STEC to risk management decisions and better defining the role of wildlife as vectors of preharvest contamination.

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety *

Acknowledgements
UCD - Adrian Sbodio, Janneth Pinzon, Jeremy Roland, Lee Ann Richmond; WCFS - Michele Jay Russell, Nora Navarro Gonzalez, Peiman Aminabadi;
Roka BioScience; Cooperating Grower-Shipper-Processors

Contact
tvsuslow@ucdavis.edu

Project Title
Evaluation of the efficacy of antimicrobial agents to prevent the transfer of *Listeria monocytogenes* from existing biofilms to produce or processing surfaces

Principal Investigator
Rolf Joerger, University of Delaware

Project Term
January 1, 2016 – December 31, 2017

Non-Technical Summary
Listeria monocytogenes (Lm) is a foodborne pathogenic bacterium that can cause serious illness and even death in susceptible individuals. Outbreaks involving this pathogen have been associated with fruits, sprouts and vegetable row crops. Like most other bacteria, *Lm* can form biofilms or became part of biofilms with other bacteria on produce surfaces and surfaces in produce harvesting and processing environments. Once established in a biofilm, *Lm* has highly diminished susceptibility to antimicrobial agents and is difficult to eradicate. Cells surviving in such biofilms can detach and be carried to new surfaces where they can start the formation of a new biofilm or become part of an existing biofilm. It is therefore extremely important to prevent the transfer of cells from existing biofilms to previously uncontaminated surfaces on produce or processing equipment. The proposed study will examine the efficacy of antimicrobial agents to inactivate *Lm* released from existing biofilms and prevent the formation of new *Lm*-containing biofilms on produce and equipment surfaces.

Funding
Center for Produce Safety

Acknowledgements
Gordon C. Johnson, Department of Plant and Soil Sciences, University of Delaware; Arpeeta Ganguly, Visiting Scientist; Juliet Wachira, Graduate Student; Quincy Hardy, Graduate Student

Contact
rjoerger@udel.edu

Project Title
Methods for the detection of diverse parasites on packaged salads based on (viable) oocysts

Principal Investigator
Stefan Wuertz, University of California, Davis

Project Term
January 1, 2016 – May 30, 2017

Non-Technical Summary
This project will involve an approach for managing and monitoring produce safety to reduce the risk of foodborne illness from consumption of packaged salads: detecting human parasites on the surfaces of leafy greens in a rapid, accurate, and affordable manner. A novel test will simultaneously detect four key parasites that can be associated with produce-

borne disease. Applying the newly validated tests in parallel with previously established methods for testing packaged salads will provide a realistic evaluation for the suitability of the developed assays for routine screening by the produce industry. Additional methods will determine the viability of these parasites and whether they are likely to cause disease to produce consumers if they are detected.

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety **

Acknowledgements
Karen Shapiro, assistant research faculty; Minji Kim, postdoctoral scholar; Veronica Rajal, associate professor (National University of Salta, Argentina); Beatriz Aguilar, staff research associate (SRA); Andrea Packham, SRA; Brittany Dalley, laboratory assistant; Lezlie Rueda, undergraduate assistant; Patricia Conrad, professor

Contact
swuertz@ucdavis.edu

Project Title
Pathogen physiological state has a greater effect on outcomes of challenge and validation studies than strain diversity

Principal Investigator
Martin Wiedmann, Cornell University

Project Term
January 1, 2016 – December 31, 2017

Non-Technical Summary
Effective control of foodborne disease-causing microbes ("pathogens") requires science-based validation of interventions and control strategies. For example, it is important to show that a given antimicrobial treatment can reduce bacterial numbers with a certain target efficiency, regardless of the specific genetic type of organism and regardless of the conditions under which an organism was grown prior to treatment. This is important, as it has been shown that *Salmonella* exposed to dry environments can be >100 times more resistant to some treatment (e.g., heat) than *Salmonella* grown in the presence of high levels of water. This project will assemble a collection of diverse microbes that are appropriate for validation of pathogen interventions in the produce industry, and will evaluate these organisms to determine whether and how exposure to different environmental conditions will affect the ability of these organisms to survive stressful conditions and control strategies. The resulting data, along with the bacterial collection developed as part of this project, will facilitate more reliable identification of effective control strategies that can reduce the risk of foodborne illnesses and pathogen contamination.

Funding
California Department of Food and Agriculture Specialty Crop Block Grant; Center for Produce Safety ***

Acknowledgements
Center for Produce Safety. We also appreciate the contributions of the reviewers of our strain collection drafts and contributors to the strain collection (P. Gerner-Smidt, M. Danyluk, L. Harris, R. Worobo, K. Nightingale, M. de Moraes, M. Allard, P. Fratamico, T. Monson, K. Musser, P. Griffin, M. Parish, S. Assar, M. Sharma, E. Brown, R. Mandrell, B. Sauders, L. Gorski, E. Berry, R. Boyer, L. Beuchat, T. Suslow, J. Farber, F. Yiannas, J. Brennan, B. Whitaker, D. McDonald, K. Refsnider, T. Stoltenberg, G. Keller, J. Reed).

Contact
mw16@cornell.edu

CPS Research Symposium 2016, Seattle

Panelist Biographies

FELICE ARBOISIERE

Felice Arboisiere is the Corporate Microbiologist and Produce Manager for Taco Bell. Ms. Arboisiere joined Taco Bell in 2014 and is responsible for managing the Produce Category as well the microbiological work for all commodities. Prior to Taco Bell, Felice worked as a Sr. Microbiologist for Estee Lauder, where her work was focused on fermentative bacterial studies and overall oversight of the cosmetic microbiology program. Ms. Arboisiere has worked as a microbiologist for Food Safety Net Services as well as Celgene, a cancer research firm. Felice was born and raised in Nogales, AZ, where her family is deeply involved in produce and this is where her love of agriculture stems from.

SAMIR ASSAR, PH.D.

Dr. Assar is Director of the Produce Safety Staff in the Food and Drug Administration's (FDA) Center for Food Safety and Applied Nutrition. Since 2008, Dr. Assar has managed development of FDA's policy, regulation and guidance on produce safety, including those mandated by the 2011 Food Safety Modernization Act. Dr. Assar provides strategic leadership in developing plans for research, training, and compliance activities that target a safe and abundant produce supply. He is committed to enhancing partnerships with produce safety stakeholders, and has collaboratively forged initiatives and agreements aimed at protecting public health. Dr. Assar also serves as FDA's project leader for the Western Center for Food Safety at the University of California, Davis, the focus of which is on research, education and outreach on production agriculture and food safety issues. He received his M.S. and Ph.D. in Food Science from the University of Florida.

JIM BRENNAN

Mr. Brennan is currently President of SmartWash Solutions, LLC (SWS), a food safety company founded by Taylor Fresh Foods, the parent of the Taylor Farms family of companies. SWS was established to commercialize revolutionary wash aid technology to the fresh food segment of the food industry. Before joining SWS, Mr. Brennan started a technical consulting firm, The Alliance of Technical Professionals (ATP), the focus of which is on helping small- and medium-size companies develop new food business while navigating operational, food safety and regulatory issues. Prior to establishing ATP, he has held domestic and international management positions with Gallo Winery, Dole Food Company and PepsiCo. Mr. Brennan has over three decades of experience in new business development within the food industry, and has been intimately involved in launching product lines that today contribute over $3 billion in annual revenue to their respective companies. Many of these products established completely new categories such as 100% blended fruit juices, frozen fruit novelties and ready-to-eat salads.

DEANN DAVIS, PH.D., DABT

Dr. Davis joined Earthbound Farm, now part of the Danone Wave Companies, in December 2015. Most recently, she was the Chief Food Safety Officer at Kraft Foods Group, where she had responsibility for the scientific and technical basis for food safety and microbiological quality programs across all the Kraft Foods brands. At Kraft, Dr. Davis also served as co-lead for the industry FSMA working group for the Grocery Manufacturers' Association; the group developed industry comments and worked with FDA to shape the final FSMA regulations. Dr. Davis has over 20 years of experience in the consumer product goods industry, leading global product safety and compliance organizations for companies such as Alberto Culver, Kimberly Clark, The Dial Corporation and Procter & Gamble. Her experience spans diverse product categories, including cosmetics, paper and non-woven materials, medical devices and cleaning products, as well as scientific disciplines including quality assurance, toxicology, microbiology, regulatory affairs, and product and process development. Dr. Davis earned her B.A. in Biology and Chemistry from Point Loma College in San Diego, and her Ph.D. from Texas A&M University, College Station. She has been certified as a toxicologist by the American Board of Toxicology since 1996.

SURESH DECOSTA

Suresh DeCosta joined Lipman Family Farms as

Panelist Biographies

Director of Food Safety in April 2016. Suresh is a recognized subject matter expert with the ability to lead cross-functional groups of suppliers, customers and produce industry representatives. He has broad food science industry experience including product development, beverage formulation, food irradiation, coffee blend management, good agricultural practices and fresh cut processing. He leverages his holistic understanding of supply chain from farm to fork to mitigate food safety risk, with an awareness of the impact to commercialization, and he uses interpersonal skills to build consensus in technical and non-technical environments and drive industry change. Suresh currently serves as the chairman of United Fresh Produce Association Food Safety and Technology Council and also serves on UFPA board of directors. He has received multiple industry awards, including the UFPA technical award for his leadership in helping standardize agricultural food safety practices. Suresh received a M.S. in Food Science from Chapman University and a B.S. in Environmental Science from Slippery Rock University.

TONY DIMARE

Tony DiMare serves as vice president of The DiMare Company, an 88-year-old family produce business with growing, packing, and repacking operations, operating in Florida, South Carolina, California, Illinois, Massachusetts, Pennsylvania, and Texas. Mr. DiMare began working for the family business in 1983 and is among the third generation of DiMares' to do so. The DiMare Company believes strongly in industry organizations. Mr. DiMare is active in the industry and serves on several volunteer boards and committees. He is Chairman of the Florida Specialty Crop Foundation and is currently serving on the Board of Directors of the Florida Fruit & Vegetable Association, the Florida Tomato Committee, Florida Tomato Exchange, Florida Tomato Growers Exchange, Monsanto's Vegetable Advisory Committee, and Commissioner Adam Putnam's Florida Agricultural Promotional Advisory Committee. In 2002, he was appointed by the Secretary of Agriculture to the Inaugural USDA Fruit and Vegetable Industry Advisory Committee. Also that year, he served on the Florida Agriculture Trade Advisory Committee for Congressman Adam Putnam. In addition to serving the ag community, Mr. DiMare also co-chairs the YMCA's South Shore Leadership and Advisory Council, and is the co-founder and coordinator of the inaugural Florida Ag Expo.

JILL DUNLOP

Jill Dunlop is responsible for providing support to Florida Fruit & Vegetable Association members in developing and implementing food safety and sustainability programs. She also provides training for and assistance with third-party audits as well as coordinating and conducting food safety and sustainability education and outreach. Before joining FFVA, Jill Dunlop spent five years as food safety manager for FFVA producer member SunnyRidge Farm/Dole Berry Company in Winter Haven, responsible for the southeastern United States and Latin America. Before that she was a researcher at the University of Florida's Citrus Research and Education Center in Lake Alfred for nine years. She is a graduate of Elon College in North Carolina with a B.S. degree in Environmental Studies.

NATALIE DYENSON

Ms. Dyenson joined Dole as Vice President, Food Safety and Quality in October 2016. She has responsibility for food safety and quality programs globally for all divisions of Dole. Prior to Dole, she spent eight years in various senior director positions with Wal-Mart Stores, Inc., most recently leading food safety across 6,500 retail stores, 48 company owned manufacturing facilities and 220 fresh distribution centers in 26 countries for Walmart's international division. Prior to Walmart, Ms. Dyenson spent eight years with Walt Disney Parks and Resorts, based out of Orlando, Florida, where she held various roles in food safety and public health supporting Walt Disney World, Disney Regional Entertainment, Disney Cruise Line and the Parks and Resorts business globally. Ms. Dyenson holds a B.S. in Microbiology from the University of Iowa and a M.P.H. in Infectious Disease Epidemiology and Biostatistics from the University of South Florida.

Panelist Biographies

BILL GERLACH

Bill has served as the World Variety Produce Research and Development Director for Melissa's Produce since 1999 and is responsible for researching and sourcing exotic new tropical products. He is also responsible for government and regulatory affairs and university research liaisons. Bill has brought to Melissa's such new products as vacuum packed beets, Crimson Gold apples, cinnamon persimmons, watermelon radishes, dragon fruit, mangosteen, and Australian mangos. Previously, Bill served as Peace Corp Volunteer and Recruiter and later worked as the Commodity Director for the CA Farm Bureau, the University of California Patent Office and Doulos Marketing. Bill earned his B.S. in Economics from the University of Wisconsin and has an M.S. in Agricultural Economics from the University of California, Davis.

HANK GICLAS

Mr. Giclas serves as Senior Vice President of Strategic Planning, Science and Technology for Western Growers, a department he created and grew to help Western Growers become a leading trade association. This division now assists members with food safety, crop protection, environmental compliance, sustainability and a host of other areas where sound science and new technology must drive industry advancement, solutions and government policy. Mr. Giclas is also Executive Director for Western Growers' Center for Innovation & Technology, based in Salinas, Calif. Mr. Giclas serves on many industry advisory boards and technical committees including the Center for Produce Safety (CPS), Western Institute for Food Safety and Security, Coalition for Urban and Rural Environmental Stewardship, and the Specialty Crop Committee serving the National Agricultural Research Education, Extension and Economics Advisory Board. He received his B.S. from The University of Arizona in Agricultural Education, and was a vocational agriculture instructor before coming to Western Growers.

JAMES R. GORNY, PH.D.

Dr. Gorny is Vice President, Food Safety & Technology for Produce Marketing Association (PMA), where his primary responsibilities are to assist produce industry members with issues associated with food safety, product quality, biotechnology, agricultural innovation, process and packaging technology, and environmental sustainability. Dr. Gorny is also a past chair and current member of the Center for Produce Safety Technical Committee. Additionally, he is a member of the PMA "crisis" team, which provides assistance to members during foodborne illness outbreaks and/or recalls and assists in crisis communications. Prior to joining PMA, Dr. Gorny served as the Senior Advisor for Produce Safety at FDA's Center for Food Safety and Applied Nutrition; he also served as the first Executive Director of the Postharvest Technology Research and Information Center at the University of California, Davis. Dr. Gorny received his Ph.D. in Plant Biology from the University of California, Davis in 1995, and B.S. and M.S. degrees in Food Science from Louisiana State University.

DOUG GRANT

Doug joined The Oppenheimer Group in 1995 as director of information technology after spending 12 years in IT at the British Columbia Automobile Association. He was appointed as Oppy's chief information officer in 2003, and promoted to vice president and chief operations officer in 2006. While at Oppy, Doug has spearheaded the implementation of state-of-the-art IT systems, keeping the company at the digital forefront of the produce industry. He has since taken on executive responsibility for information technology, operations, quality control, facilities, manufacturing, transportation, supply chain management, grower relations, contracts, and food safety, while having oversight responsibility for Oppy's South American offices. Doug is co-chair of the PTI (Produce Traceability Initiative) Leadership and Executive Council and sits on the Center for Produce Safety Board of Directors. He has authored numerous white papers on key technology topics facing our industry. Doug is a past recipient of the Canadian Produce Marketing Association's "Produce Man of the Year" award, and was featured among the 2012 Packer 25 industry leaders.

Panelist Biographies

STEVE KENFIELD

In 1979, Steve joined Salinas lettuce shipper, Bruce Church, as export sales manager. He then became sales manager for the company's pre-cut lettuce operation, "Red Coach Foods", which later became Fresh Express. Steve moved to Seattle to run the produce operation for the broad line foodservice distributor, Miller Cascade, (now Food Service of America). He was later promoted to become the company's general sales manager. Through the acquisition of Pacific Gamble Robinson, Steve became president of the produce shipping operations, now known as AmeriFresh. Returning to California in 1990, he joined Corrin Produce and advanced the Company's focus on foodservice grapes and was involved in developing packaging of grapes and tree fruit, tailored for the emerging club stores. The introduction of Chilean Lunch Bunch grapes in 1991, lead the way to year-round supplies. In the mid-90s, in a short lived joint venture with Fresh Express, ready-to-eat grapes were tested. In 2003, Corrin Produce merged into HMC Farms, where a ready to eat, de-stemmed grape operation is being advanced. In addition to leading the value added and foodservice sales, Steve oversees HMC Farms food safety activities.

ROBERT KERSHAW

Robert Kershaw, who spent his summers as a teenager working in Domex's orchards, is the fifth generation of Kershaws to head the business that made Domex Superfresh Growers one of the world's largest growers and marketers of apples, pears and cherries. Domex is recognized worldwide for its produce expertise and pioneering work in freshness. Integral to the company's success is its transportation division, which now operates independently and serves the entire produce industry. Over the years, the Kershaw Companies have grown into a vertically integrated organization to include farming, warehousing, sales, marketing and logistic services. Robert earned his economics degree from the University of Colorado, Boulder.

KENT KISE

Kent Kise is Vice President, Corporate Food Safety and Quality at Ready Pac Foods, Inc., (now Bonduelle) the premier producer of convenience fresh foods, including fresh-cut produce. Kent joined Ready Pac Foods in 2015 and brings more than 20 years of global manufacturing operations, food safety/quality management systems and processing technology experience within the food and water industry. In his current role, Kent has end-to end responsibility for Food Safety, Quality and Regulatory from agricultural operations through to the customer providing strategic vision and leadership to drive operational processes, productivity and bottom line improvements. In addition, Kent partners closely with the Company's research and development team to ensure clear alignment with technical services and quality assurance. Previously Kent was a Director at Certified Laboratories, Inc., managing 17,025 certified food safety and quality testing operations including environmental, raw material, import and finished product testing. Prior to that role, Kent served as VP of Production, Quality and Technical Services at DS Waters of America, Inc. He also served in integral leadership positions at a number of CPG companies including Nestlé, Clorox, PepsiCo and Hanover Brands. Kent is a graduate of Delaware Valley College of Science and Agriculture, where he received a bachelor's degree in Biology.

SHARAN LANINI

Sharan Lanini is the Director of Food Safety at Pacific International and its affiliated companies. She is actively involved in all aspects of Food Safety Program and Regulatory affairs including development and management of food safety programs across all growing regions and commodities, facilitating food safety communications and issue management and proactively managing trends and continuous program and process improvement. Sharan Lanini also serves as the corporate Food Safety Regulatory Affairs and Compliance liaison for PIM with federal, state and regional regulators, certification bodies and NGOs. Sharan is actively involved in many industry boards and committees such as: PMA Science and Technology Committee, United Fresh Technology Council, LGMA Exec. Board and Technical Committee, Center for Produce Safety Ad Hoc Technical Committee

Panelist Biographies

and many others. Sharan Lanini is a proud third generation California farm family member and a graduate of UCD, and recipient of the prestigious UCD Award of Distinction from the College of Ag.

DREW MCDONALD

Drew is the Vice President Quality & Food Safety at Taylor Fresh Foods, Salinas CA. He has over 20 years' experience in Fresh Produce and Fresh Foods. He oversees the quality and food safety programs across the food service, retail, and deli operations. Drew works with an impressive team developing and managing appropriate and practical quality and food safety programs for fresh food and produce products. Over the course of his career he has worked with growers and processors of fresh produce items all over the world. He currently serves on numerous food safety-related technical committees and has participated in the authorship of many produce food safety guidelines. Drew received his education from Lawrence University in Wisconsin. He currently lives in the Monterey area with his wife Aimee and their three young girls. When he is not working he enjoys cycling, tennis, and playing guitar.

CARTER MCENTIRE

Carter McEntire is the current President and Chief Executive Officer of McEntire Produce, Inc. and brings more than 19 years of experience in the produce business. He has held positions in sales, purchasing, equipment acquisition, finance, computer network administration, and other management positions. His experience started with McEntire Produce, Inc. in 1993 when he computerized the company with a 24-workstation network. He assisted his father, Buddy McEntire, in automating processing lines and building sales in the foodservice category. In 1998 he left the company to work as a financial advisor at Smith Barney. Upon returning to the company in 2002 he took on the task of moving the business from its location of 55 years at the State Farmer's Market to a new 163,000 sq. ft. state of the art produce processing facility in Columbia, SC. Recently, Carter and a small team from McEntire Produce, Inc. have worked on and achieved a patent on the Simply Clean process and started Simply Clean Technologies, LLC. Carter is a native South Carolinian and achieved his bachelor's degree in Mathematical Economics from Hampden-Sydney College in Virginia. He earned his MBA from the Darla Moore School of Business at the University of South Carolina. He resides in Columbia, South Carolina, with his wife of 10 years and their three children.

JENNIFER MCENTIRE, PH.D.

Jennifer McEntire is VP Food Safety and Technology at United Fresh Produce Association. A food microbiologist by background, she has always worked in the Washington, DC area, bringing the scientific perspective to food safety regulatory issues. She was previously Vice President of Science Operations at the Grocery Manufacturers Association, overseeing the microbiology laboratory, process authority team, and claims laboratory. She has also had roles as VP and Chief Science Officer at The Acheson Group and as the Senior Staff Scientist and Director of Science & Technology Projects at the Institute of Food Technologists. Dr. McEntire earned a PhD from Rutgers University and received a Bachelor of Science with Distinction, magna cum laude, in food science from the University of Delaware. She serves as an advisory board member of the Global Food Traceability Center, is an ad-hoc reviewer with the Center for Produce Safety, is on the board of Phi Tau Sigma, the food science honorary society and is a member of the International Association for Food Protection.

MANUEL MICHEL

Manuel Michel joined the National Mango Board (NMB) in 2014 as the Executive Director. He is responsible for overseeing the NMB's research and promotion programs, and developing strategic goals, plans, and program initiatives that promote higher awareness and consumption of mangos in the U.S. Manuel joined the NMB with a background in agriculture and experience on issues affecting the produce industry. As a marketing order specialist for USDA's Marketing Order and Agreement Division, Manuel provided regulatory oversight on federal government commodity programs. Prior to this he was a managing

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associate attorney with the Whittenburg Law Firm in Texas. In addition to policy and management experience, Manuel developed his knowledge in food safety programs as a produce consultant with Davis Fresh Technologies, and later as a quality assurance manager at L&J Farms and Jackpot in the Salinas Valley of California. Manuel attended Oregon State University where he received dual bachelor's degrees in agricultural business management and international studies in agriculture, and a minor in crop science. Manuel also earned a Doctor of Jurisprudence from Texas Tech University School of Law, and he has been a member of the Texas State Bar since 2008.

MARK MIGNOGNA

Mark joined Sysco in 1988 as Senior Manager, Quality Assurance. Since then, Mark has progressed through positions of increasing responsibility until reaching his current position as Vice President of Food Safety and Quality Assurance for Sysco Corporation. Sysco is the global leader in selling, marketing and distributing food products to restaurants, healthcare and educational facilities, lodging establishments and other customers who prepare meals away from home. The company operates 198 distribution facilities serving approximately 425,000 customers. Mark earned his B.S. in Food Science from Rutgers University.

TIFFIANI MILLER, PH.D.

Dr. Miller is the Director of Food Safety for the Florida Department of Agriculture and Consumer Services. She oversees inspection bureaus for retail, manufacturing and dairy milking and processing facilities as well as laboratories that perform microbiological, molecular, chemical residue and antibiotic analyses on food. Dr. Miller's primary focus is always on protecting public health through the monitoring of food products and food processing practices, from production through retail. She also aims to ensure that food safety regulations are firmly based on science and research. Dr. Miller serves on many advisory boards including those of the Center for Produce Safety (CPS) and Florida's Food Safety and Defense Council. She also assists the FDA, the USDA's National Advisory Committee for Microbiological Criteria in Food (NACMCF), and other committees that make recommendations on food safety policy and its implementation. Dr. Miller joined the Florida Department of Agriculture in 2012 after leading the foodborne outbreak investigation team for the state. She holds a Ph.D. in Comparative Medicine and Integrative Biology from Michigan State University, an MS in Environmental Health Science from University of Georgia, and a BS in Chemistry from University of South Carolina.

WALTER RAM

Mr. Ram is Vice President of Food Safety at The Giumarra Companies and has been with Giumarra since 1995. He is responsible for food safety and regulatory affairs for Giumarra's 15 operating divisions, and is active in food safety and food defense work at the industry level. Giumarra is one of the world's largest table grape producers, and is a major supplier of over 60 fresh fruits and vegetables from a dozen countries. His current industry activities include: Center for Produce Safety's Technical Committee; Produce Marketing Association Food Safety, Science and Technology Committee; Fresh Produce Association of the Americas Board of Directors; and Canadian Produce Marketing Association Food Safety Committee. Previous industry activities have included: chairman of United Fresh Produce Association's Food Safety and Technology Council; contributor and editor of Commodity Specific Guidelines for the Fresh Tomato Supply Chain; contributor to Commodity Specific Guidelines for the Melons Supply Chain; member of the steering committee for the National Mango Board; and Strategic Partnership Program for Agroterrorism (a joint government/industry program).

MARTHA RHODES ROBERTS, PH.D., CFS

Dr. Roberts heads Roberts Associates, is a member of Food Foresight, a food trends analysis group, and is a Certified Food Scientist. She is a current member of the Center for Produce Safety's Executive Committee and formerly served on the CPS Technical Committee. She served as Florida's Assistant and Deputy Commissioner of Agriculture from 1984-2003, and was part time at the University of Florida, Institute of

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Food & Agricultural Sciences from 2003-2017, and currently serves as a consultant to various produce associations and the National Association of State Departments of Agriculture on FSMA implementation. Dr. Roberts is a member of the Florida Agricultural Hall of Fame, and has received multiple state, federal, and industry service awards, including Life Honorary member of the Farm Foundation. She is the former President of the Association of Food and Drug Officials' Conference for Food Protection, and previously served on FDA, USDA and IFT committees as well as the National Advisory Committee on Microbiological Criteria for Foods and the FDA Advisory Panel, and as a member of the National Academy of Sciences Institute of Medicine panel on FDA's role in ensuring food safety. Dr. Roberts holds a M.S. and Ph.D. in Microbiology from the University of Georgia and a public health postdoctoral.

JOAN ROSEN

Ms. Rosen is the founder of JC Rosen Resources, a consulting firm that provides services globally with expertise in food safety, quality systems, postharvest technology, and regulatory affairs for the fresh produce and food industries. Previously, Ms. Rosen was Director of Global Food Safety and Quality for Chiquita Brands International/ Fresh Express, where for over 22 years she had increasing responsibilities in key management leadership positions. She received her M.S. in Food Science and Postharvest Physiology from the University of California, Davis, and her B.S. in Food Science from Cornell University. Ms. Rosen is a recipient of the International Fresh-Cut Produce Association's Technical Excellence Award for her achievements in advancing the common good of the fresh-cut industry, enhancing food safety and quality initiatives and supporting innovative technological advancements. She serves on the Technical Committees for the Center for Produce Safety, Produce Marketing Association and United Fresh Produce Association. Ms. Rosen is a lead instructor for FSMA's Preventive Controls for Human Foods and a trainer for the Produce Rule. Previously, she led postharvest research programs at Campbell Soup Company, and also worked in flavor development and application at Florasynth Inc.

ROBERT SAKATA

Mr. Sakata is owner of Sakata Farms in Brighton, Colorado. He is founding President of the Board of Directors for the Colorado Fruit & Vegetable Growers Association, Treasurer of the New Brantner Ditch Board, and serves on the Board of Trustees for the National Onion Association. In addition, he sits on the Fulton Ditch and Colorado Water Congress Board of Directors, as well as the Colorado Agriculture Water Alliance Executive Committee. Mr. Sakata served the state of Colorado on the Water Quality Control Commission (WQCC) for 15 years, appointed to that position by three different state governors. The WQCC is charged with setting the water quality standards, protecting designated uses for the state's waters. While studying at the Molecular Cellular & Developmental Biology Department at University of Colorado, Mr. Sakata worked for AMGEN when they opened their research labs in Boulder. Currently, Sakata Farms grows fresh market sweet corn, dry bulb onions, winter wheat, grain corn, pinto beans and barley.

MIKE SPINAZZOLA

Mike began his career in 1981 working for Maggio Inc., before graduating from Arizona State University in 1985 with a BS in Agribusiness Marketing. In 1988, he began working for DRS, Inc., a foodservice consulting company, and is now President/CEO. In 1996, he helped develop IPC, the purchasing cooperative for SUBWAY North America. DRS then spearheaded the development of SUBWAY fresh produce procurement programs, which have grown to cover over 30,000 restaurants, and have expanded to include preserved produce as well. In addition to his team in San Diego, Mike heads an international procurement team sourcing olives, pickles, and peppers globally. Working very closely with the SUBWAY's corporate team, DRS partners with vendors to uphold strict food safety requirements without jeopardizing supply protection and quality. As he works to help protect a global brand, Mike is keenly aware of the importance of food safety, and as such, also serves on the CPS Board of Directors.

Panelist Biographies

STACY K. STOLTENBERG

Ms. Stoltenberg is a Western Territory Technical Sales Manager for Hygiena, a life sciences company which delivers rapid microbial detection, monitoring, and identification solutions to improve food safety. For the past 7 years, she has been dedicated to working with food companies and third-party laboratories to help make faster release decisions while testing their food products for harmful pathogens. Prior to her work with Hygiena and Qualicon Diagnostics, Ms. Stoltenberg worked in business development/sales and as the lead Microbiologist at PrimusLabs for nine years. Ms. Stoltenberg received her B.S. and M.S. from Kansas State University in Food Science and Microbiology.

TREVOR SUSLOW, PH.D.

Dr. Suslow is an Extension Research Specialist at the University of California, Davis, with statewide responsibilities in quality and safety of perishable horticultural commodities. Dr. Suslow's program spans preharvest to postharvest research and outreach education on diverse fresh and minimally-processed horticultural foods, from annual row crops to tree and vine commodities. He has served on the Center for Produce Safety Technical Committee since its creation in 2008. His research combines lab and on-farm/packing facility research on *E. coli, Salmonella*, and *Listeria* in conventional and organic production systems, for the purpose of identifying opportunities for optimal microbial reductions and delivery of safe food to the consumer. Dr. Suslow received his B.S. in Agricultural Sciences with high honors, and a Ph.D. in Plant Pathology from the University of California, Berkeley. Dr. Suslow helped found and worked at Advanced Genetic Sciences and DNA Plant Technology Corporation from 1981 to 1995 before joining UC Davis. Dr. Suslow took on the role of Director of the UC Postharvest Technology Center in 2016.

MAX TEPLITSKI, PH.D.

Dr. Max Teplitski is a National Program Leader in Food Safety and Microbiology at the USDA National Institute of Food and Agriculture (NIFA). Prior to joining USDA NIFA, Dr. Teplitski was a professor of microbial ecology and led an academic research, teaching and outreach program that focused on understanding *Salmonella* genetics and genomics, persistence of human pathogens in the environments, and defining the molecular basis of the interactions between human pathogens and produce. Dr. Teplitski was selected as a G.E. Burch Fellow in Theoretical Medicine at the Smithsonian Institution, where his research identified chemical signals exchanged by pathogenic and commensal bacteria within a polymicrobial disease consortium, microbiome shifts and metagenome transitions associated with disease progression. He has authored over 70 peer-reviewed publications. Dr. Teplitski is a Fulbright Specialist in Agriculture.

MIKE VILLANEVA

Mike Villaneva manages the LGMA's technical programs, including industry technical outreach, involvement with food safety research and data analysis. He comes to the organization with over 30 years' experience in the public and private agriculture sectors working with food safety training and regulatory programs. He was also responsible for creating LGMA's comprehensive LGMA Tech food safety training program for the leafy greens industry.

BOB WHITAKER, PH.D.

As Chief Science & Technology Officer for Produce Marketing Association (PMA), Dr. Bob Whitaker oversees PMA's food safety and technology efforts across the produce supply chain. This work focuses on delivering education content, and connecting members to technical solution providers. Before joining PMA, Dr. Whitaker held various scientific and senior management positions at DNA Plant Technology Corporation, and senior operation and technical functions at NewStar Fresh Foods. Dr. Whitaker served as Chairman of the Board of Directors for the International Fresh-Cut Processing Association (IFPA), and was a board member for the United Fresh Produce Association. Dr. Whitaker has received a number of industry awards for achievement, has served on the USDA National Advisory Board for Microbial Criteria in Foods, the National Academies of Sciences Genetic Engineering Review Panel and worked on a number of industry and government food safety

Panelist Biographies

and technology initiatives. He was named to the Executive Committee for the Center for Produce Safety (CPS) in 2007, and served as Chairman of the CPS Technical Committee 2008- 2013. Dr. Whitaker received his Ph.D. in Biology from State University of New York at Binghamton.

TIM YORK

Mr. York is President of Markon Cooperative, Inc. Markon is a purchasing, marketing and logistics cooperative serving North America's leading independent foodservice distributors. Based in Salinas, Calif., Markon distributes produce to over 75 facilities in the United States and Canada. Mr. York has 40 years' experience in the produce and foodservice industries. He began his career in 1977 at H. Hall & Company, a grower/shipper of strawberries and mixed vegetables. Mr. York joined Markon in 1985 as Purchasing Director. He was promoted to his current position of President in 1990. Mr. York has held numerous committee and task force positions, including Chairman of the Produce Marketing Association (PMA) (2002-2003) and Chairman of PMA's Foodservice Division (1994-1996); he is currently a member of the Canadian Produce Marketing Association Board of Directors.

BRIAN ZOMORODI

Brian Zomorodi, a 34-year veteran of the fresh-cut produce industry, joined Apio Inc., a leader in fresh-cut vegetables and salads in 2015. Brian started his career with Ready Pac in 1984. He developed and led their Research & Development, Quality Assurance and Food Safety Departments as Sr. Vice President for 31 years. He has been responsible for launching several successful fresh-cut product lines for the retail and food service industry and in developing many food safety and quality assurance systems. He has been actively involved in establishing standards and guidelines for fresh-cut produce and has many publications. Brian holds a MS degree in Food Science and is a recipient of many distinguished awards. He has actively served in a number of technical councils for trade organizations including PMA, UFPA, and global food service companies such as McDonald's and YUM! as a founding member.

2016 CPS Research Symposium, Seattle

Poster Session

Significance of the Dormant State in the Persistence, Interaction with Growing Plants and Virulence of Shiga Toxin Producing *Escherichia coli*

Contact
Keith Warriner, University of Guelph
(519) 824-4120, kwarrine@uoguelph.ca

Project Date
January 1, 2017 – December 31, 2017

Summary
Shiga toxin producing *Escherichia coli* (STEC) are potentially highly virulent and can cause illness at levels of 10 cells if ingested by a susceptible host. Manure is a significant source of STEC and consequently when applied to land there is an interval of 90 to 120 days before harvest to permit any pathogens to die off. In field trials, it has been demonstrated that STEC die off rapidly within the first weeks of being incorporated into soil but a sub-population persist and can be recovered beyond 120 days. This led to speculation that there is a persistent sub-population of STEC that have enhanced tolerance to stress encountered in the field and possibly post-harvest. In the proposed study the persistent (dormant) state will be studied in STEC. Specifically, the culture conditions that induce the dormant state will be elucidated along with potential genes implicated. Studies will then determine the extent to which dormancy contributes to persistence in soil and resistance to sanitizers. Finally, the virulence of STEC in the dormant state will be determined. The main benefit of the research relates to providing data for risk assessment and also to develop novel methods to make STEC more susceptible to pre- along with post-harvest interventions.

Poster Session

Detection, Validation, and Assessment of Risks Implied by the Viable but Non-culturable (VBNC) State of Enteric Bacterial Pathogens in Fresh Produce

Contact
Xiaonan Lu, University of British Columbia
(604) 822-2551, xiaonan.lu@ubc.ca

Project Date
January 1, 2017 – December 31, 2018

Summary
More fresh fruits and vegetables are grown, sold and eaten today than at any other time in history. Unfortunately, outbreaks of food poisoning caused by pathogenic bacteria in fresh produce are also more common than in the past. Products are routinely analyzed to ensure that they are free of such bacteria, but some are very difficult to find because they do not grow on media used by quality control laboratories. These are known as "viable but non-culturable" (VBNC) bacteria. We will develop a new, inexpensive and easy-to-use method based on the well-known PCR reaction to make it possible for quality control laboratories to detect two important pathogens in fresh produce, *Salmonella* and *E. coli*, even when they are in the difficult-to-find VBNC form. The performance of the new method will be checked through field trials and pilot-plant experiments with leaf lettuce. Information from these experiments will be used to reveal how likely fresh produce is to be contaminated with VBNC pathogens during production and after harvest. Therefore, this research will contribute to an important new laboratory method and key information to support on-going efforts by the industry to improve the safety of fresh fruits and vegetables.

Enteric Viruses as New Indicators of Human and Cattle Fecal Contamination of Irrigation Waters *

Contact
Kelly Bright, The University of Arizona
(520) 626-8094, bright@email.arizona.edu

Project Date
January 1, 2015 – December 31, 2016

Summary
The standards used by the produce industry to detect fecal contamination (by indirectly testing for indicator organisms) in irrigation waters are based on tests developed for drinking waters (rather than surface waters) and include risk threshold levels established by the Environmental Protection Agency for recreational (bathing) waters. This contamination threshold is set with little scientific evidence for risk to human health from potentially contaminated irrigation water for food crops. Thus, it may not be appropriate for determining if there is a "risk relevant" level of contamination for cops irrigated with waters tested in this manner. To improve these regulations, we will use novel viral targets that have shown to better correlate with the presence of fecal material and evaluate them for potential use as more sensitive and specific detection methods for evaluating the safety of irrigation waters. This work will evaluate the accuracy of these novel indicator viruses and optimized the methods required for field use. This information may allow the produce industry valuable exposure data on the presence/absence

and quantity of fecal contamination that may be present in irrigation waters and provide much needed improvements to the use of indicator organisms for evaluating irrigation water quality.

Rapid Bacterial Testing for On-Farm Sampling *

Contact
Sam Nugen, Cornell University
(607) 255-8195, snugen@cornell.edu

Project Date
January 1, 2015 – December 31, 2016

Summary
Due to the sensitive nature of fresh produce, bacteriological safety tests which requires days for results are not practical tools for food safety. In order for a testing plan to present a pragmatic solution, it must be low-cost, reliable, robust and deliver rapid results. Our labs have been developing diagnostics to be used in non-laboratory settings by utilizing bacteriophages. These viruses can attack specific bacteria, replicate within them and then lyse the host while releasing hundreds to thousands of additional viruses. We are proposing the development of a dipstick for the rapid detection of *Salmonella* spp. in agricultural samples. Following a sample pretreatment, the bacteriophages will be used to infect *Salmonella* spp. in the sample. Within 45 minutes, the increase in bacteriophage can be quantified with a simple lateral flow device resembling a pregnancy test. Preliminary results for our *E. coli* sensor suggest a very low limit of detection (<10 CFU/mL). This project will perform the additional development, optimization and validation steps needed and if successful will empower farmers to perform tests on-farm with rapid results and at low-cost. This ability will then enable more risk-based testing of agricultural waters following heavy rains or high flow.

Developing Cross-Assembly Phage as a Viral indicator for Irrigation Waters ****

Contact
Kyle Bibby, University of Pittsburgh
(412) 624-9207, BibbyKJ@Pitt.edu

Project Date
January 1, 2017 – December 31, 2018

Summary
Ensuring high-quality irrigation water is necessary to protect the public when consuming minimally processed produce. The highest risk from exposure to contaminated water is due to viruses; however, water quality is currently monitored using bacteria that are poor representatives of viruses. All previous viral indicators are limited by a low abundance (i.e. difficult to detect) in the environment. Recently, a bacteriophage (virus that infects bacteria) named 'cross-assembly phage' (crAssphage) was discovered that is more abundant than all other bacteriophages in the human gut combined. Investigations in the PI's research group have shown crAssphage to be highly abundant in sewage. As crAssphage is a virus, it will be a better representative of viral contamination in the environment. In this investigation, I propose to sample irrigation water samples and measure crAssphage, viruses, and indicators in these samples to demonstrate the correlation of crAssphage and pathogens. I also propose to determine how much sample volume is necessary to accurately measure crAssphage. The development of this viral monitoring tool, catalyzed by funding this project, will enable risk-

managers to have an accurate and abundant indicator of viral contamination. This will ultimately provide greater protection of public health and improve consumer confidence in produce consumption.

Characterization and Mitigation of Bacteriological Risks Associated with Packing Fresh-Market Citrus ***

Contact

Linda Harris, University of California, Davis
(530) 754-9485, ljharris@ucdavis.edu

Project Date

January 1, 2017 – December 31, 2018

Summary

After harvest, fresh oranges and lemons are sorted, washed and packed for further distribution and sale in packinghouses. Because green and blue molds result in significant losses of citrus fruit during storage and shipping, fungicides are often applied to during packing. Recirculating drench applications are common because they significantly increase fungicide efficacy but they also provide an opportunity for cross contamination or movement of microorganisms throughout the facility, which can be a food safety issue if not appropriately managed. The overall goal of this project is to provide data that the California fresh citrus packinghouse industry can use to support the controls that reduce or eliminate foodborne pathogen cross contamination where citrus fruits are comingled or where recirculating materials come into contact with the fruit. A laboratory component is included to determine, for the most common fungicides, minimum compatible sanitizer concentrations that are effective in eliminating *Salmonella* and *Listeria monocytogenes*. The laboratory data will be verified in a pilot scale citrus packing facility and the results of these studies will be used to prepare documents the industry can use to support the efficacy of their food safety practices.

Evaluation of Sanitizing Treatments for Sizer Carriers in Stone Fruit Packinghouses **

Contact

Steven Pao, California State University, Fresno
(559) 278-1624, spao@csufresno.edu

Project Date

January 1, 2016 – December 31, 2016

Summary

Ensuring the safety of fresh fruit is a top priority of fresh produce packinghouses. The aim of this one-year research project is to evaluate and improve sanitizing treatments for sizer carriers in stone fruit packinghouses. The project will not only describe the potential for sizer carriers to harbor pathogens and allow for their growth under different environmental conditions, but will also define a set of sanitizers and application methods that represent the greatest promise for evaluation at the commercial level. Environmental sampling will be performed in active commercial packinghouses to determine natural microbial loads on fruit contact surfaces of sizer carriers. Subsequently, laboratory inoculation studies will be performed to determine the growth potential of foodborne pathogens on fruit sizer carriers under varied humidity and temperature. Furthermore, the potential of Clean-in-Place (CIP) sanitization will be

evaluated by applying no-rinse sanitizers (steam and aerosol antimicrobial chemicals) to the sizer carriers. Results from this study potentially will be applicable to diverse fresh fruit packinghouses for preventing pathogen cross-contamination in produce packing operations. Findings and recommendations will be reported and/or disseminated through industry meetings and technical publications.

Control of *Listeria monocytogenes* on Apple through Spray Manifold-Applied Antimicrobial Intervention ***

Contact

Meijun Zhu, Washington State University
(509) 335-4016, Meijun.zhu@wsu.edu

Project Date

January 1, 2017 – December 31, 2018

Summary

Listeria monocytogenes is listed by the Food and Drug Administration as a 'pathogen of concern' and has been singled out on both ready-to-wash and ready-to-eat produce due to its nature as a true evironmental species. The Pacific region apple industry, led by Washington, suffered a significant loss of income following the *L. monocytogenes* outbreak that was traced back to a California packer. The final FDA Produce Rule and Preventive Controls Rule are challenging apple packers and handlers to develop specific efficacy data for their process controls. The apple industry has an immediate need to begin the process of science-based improvements in *Listeria* control during packing and subsequent storage. The overall goal of the proposed studies is to comparatively assess and validate critical operating parameters for registered, commercially practical, and legally allowed sanitizer(s) against *L. monocytogenes*, and to further seek to verify their efficacy on multiple apple packing lines. The proposed project will develop information for apple producers about the practical efficacy of antimicrobial interventions under commercial packing conditions, resulting in tested and proven methods for spray bar intervention in fresh apples, which will fill critical gaps in the knowledge. The results will be crucial for addressing *L. monocytogenes* safety in fresh apples.

Listeria monocytogenes Growth and Survival on Peaches and Nectarines as Influenced by Stone Fruit Packinghouse Operations, Storage and Transportation Conditions ***

Contact

Mary Anne Amalaradjou, University of Connecticut
(806) 486-6620, mary_anne.amalaradjou@uconn.edu

Project Date

January 1, 2017 – December 31, 2017

Summary

The recent multi-state *Listeria monocytogenes* outbreak associated with stone fruit consumption highlights the potential for stone fruits to serve as a vehicle in *Listeria* transmission. Further, the outbreak also demonstrates the pathogen's ability to persist and survive on stone fruits during handling, storage and transportation. While investigations on the persistence of Listeria have been performed on other

produce, there is a general lack of knowledge on the behavior of pathogens associated with stone fruits. Additionally, each produce type has unique compositional and physical characteristics that require produce-specific management practices. Therefore, to develop stone fruit-specific risk reduction knowledge and preventive controls, this study will investigate the survival and growth of *Listeria* on peaches and nectarines under packinghouse environment, storage and transportation conditions. The study will be performed under conditions simulating stone fruit unloading and staging, waxing and fungicide application, and storage and transportation from the packing facility. It is expected that results from this study will provide quantifiable data on the effect of current practices on *Listeria* survival on stone fruits. Furthermore, identification of food safety risks associated with different steps within the packinghouse continuum will help develop comprehensive preventive controls for foodborne pathogens including *Listeria monocytogenes*.

Cyclospora: Potential Reservoirs and Occurrence in Irrigation Waters ***

Contact

Gerardo Lopez, The University of Arizona
(520) 834-2795, lopezg3@email.arizona.edu

Project Date

January 1, 2017 – December 31, 2018

Summary

Cyclospora has recently been implicated in outbreaks associated with U.S. produce imported from Mexico. Outbreaks have also been linked to drinking water. Information on the sources and occurrence of this organism are very limited. Currently, only humans and possibly primates are believed to be infected by this parasite. Our goal is to determine if produce in the United States is at risk of contamination from irrigation waters contaminated with human sewage (e.g., from faulty/leaky septic systems or compromised sewer pipes) and treated wastewater effluents that could potentially be discharged into surface waters used for the irrigation of food crops. Our specific objectives are to: a) determine the occurrence of *C. cayetanensis* in irrigation waters in Arizona and Texas, which will allow a determination of any risk from *C. cayetanensis* and to identify areas of potential risk; and b) to determine the occurrence of *C. cayetanensis* in raw sewage and treated wastewater effluents in produce producing areas such as Yuma, AZ and El Paso, TX, which will allow for an assessment of the incidence of *C. cayetanensis* infection among these communities. In addition, treated wastewater effluents are sometimes released into watersheds and could potentially impact irrigation waters. This study will allow us to determine if any risks exist from *Cyclospora* in irrigation waters from these two regions.

Establishment of Operating Standards for Produce Wash Systems Through the Identification of Specific Metrics and Test Methods

Contact

Ana Allende, CEBAS-CSIC
+34 968 396377, aallende@cebas.csic.es

Project Date

January 1, 2017 – December 31, 2018

Summary
The main objective of this proposal is helping producers to maintain the quality of the process water in commercial washing systems through control of water quality variables and the selection of adequate test methods for monitoring the process. Water disinfection is one of the most critical processing steps in fruit and vegetable production aimed at preventing cross-contamination. In the packinghouses and processing facilities, it is difficult to treat and maintain properly the quality of the process water because of the variability in the demand of disinfectant, the lack of operational limits and test methods to monitor the process and the different commercial operations. This project will investigate the most common disinfection agents used in packinghouses and processing facilities. Four scenarios have been selected based on different water characteristics including fresh-cut onions (excessive cell exudates, very high organic matter and turbidity), chopped lettuce (high organic matter and low turbidity), baby leaves (low organic matter and low turbidity) and peppers and tomatoes (low organic matter and high turbidity). Operational limits will be established in commercial facilities and lab-scale experiments using inoculated foodborne pathogens. Results obtained should inform producers about the realistic expectations for controlling selected water quality variables in produce washing systems.

Resolving Postharvest Harborage Sites of *Listeria* Protects Zone 1 Surfaces ***

Contact
Trevor Suslow, University of California, Davis
(530) 754-8313, tvsuslow@ucdavis.edu

Project Date
January 1, 2017 – December 31, 2018

Summary
Fresh citrus is an important global commodity and a major specialty crop in California. The 2014-15 CA Agricultural Statistics Review places the combined value of oranges, lemons, and tangerines at over $ 2 billion dollars and all three are in the Top 15 Specialty Crops by value. Fresh whole citrus has not experienced an incident of recall, illness, or outbreak and CA citrus production practices and regions appear to significantly limit the environmental risk of preharvest contamination. However, recent serious incidents involving the bacterial pathogen *Listeria monocytogenes*, associated with CA apple, have prompted proactive measures to more carefully assess postharvest risks and develop validated interventions for citrus system-wide. Confidentially enrolled handlers will participate in a detailed survey for indicator *Listeria* and *L. monocytogenes*. The outcome will be the development of model Environmental Monitoring Program (EMP) and guidance in establishing an environmental-zone Master Sanitation Schedule linked to EMP-outcomes for California fresh citrus packinghouses. The anticipated outcomes are expected to include a general overview and report-card of the CA citrus packing environment and identification of potential sources of Listeria related to industry growing regions and harvest/postharvest practices. From this knowledge-gap closing effort, measureable improvements in reduced *L. monocytogenes* prevalence will result.

Poster Session

Remotely-sensed and Field-collected Hydrological, Landscape and Weather Data can Predict the Quality of Surface Water used for Produce Production ***

Contact
Martin Wiedmann, Cornell University
(607) 254-2838, mw16@cornell.edu

Project Date
January 1, 2017 – December 31, 2018

Summary
There is a clear need for the development of improved, science-based tools to help reduce pre- harvest introduction of microbial produce safety risks through surface water use. The purpose of this project is (i) to identify and prioritize spatial and temporal risk factors for microbial contamination of surface water, and (ii) to develop geospatial models that predict surface water microbial quality, which will be assessed by quantifying generic *E. coli* and testing for key pathogens (e.g., *Salmonella*). Spatial and temporal variation in water quality will be assessed by repeatedly testing multiple water sources over two years. Publicly available remotely-sensed data (e.g., predominant upstream land-use) will be used to identify factors that are associated with elevated *E. coli* levels, and an increased risk of pathogen detection. Data collection will be performed in two produce growing regions (AZ and NY) to assess the robustness of our models and their translatability to other regions. These data and models will allow growers to identify times and locations where surface water sources are more likely to be microbially contaminated. This will enable growers to better time water use, testing, and treatment to minimize produce safety risks associated with microbially contaminated surface water.

(*) 2014 RFP This project was supported by the Specialty Crop Block Grant Program at the U.S. Department of Agriculture (USDA) through Grant 14-SCBGP-CA-0006. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USDA.

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