CPS CENTER for PRODUCE SAFETY

2013 CPS Symposium: 10 Key Learnings

Dr. Bob Whitaker, Chief Science & Technology Officer, PMA, Past-Chair, CPS Technical Committee
Dr. Jim Gorny, Vice President Food Safety & Technology, PMA and Chair, CPS Technical Committee

The Center for Produce Safety (CPS) held its fourth annual Produce Research Symposium in Rochester, New York at the Wegmans Conference Center on June 25-26, 2013. The symposium featured sixteen CPS-funded research programs and discussions on what the research means to the produce industry. While the full technical reports for these research programs can be found on the CPS website at cps.ucdavis.edu, we have endeavored to identify ten key lessons learned from the symposium:

1. **Seek and destroy**. The 2013 CPS Symposium included a workshop focused on *Listeria* biology and lessons learned on *L. monocytogenes* control from the meat and produce industries. There are many basic differences between *L. monocytogenes* and other human pathogens like *Salmonella* and *E. coli* O157:H7. One of them is that *L. monocytogenes* can become a resident and persistent problem if it is permitted to establish itself in a produce processing or packing operation. The processed deli meat industry faced similar issues with *L. monocytogenes* ten years ago and adopted a "seek and destroy" strategy, i.e. a robust search for niches where *Listeria* might become established and implementation of aggressive sanitation programs to prevent Listeria from "moving in" and becoming resident. Key elements of a preventative program are: comprehensive Good Agricultural Practices (GAP) program at the field level to keep the incidence of *Listeria* introduction into the packing or processing environment low, work flow patterns within the facility that reduce cross-contamination potential, equipment design that reduces potential *Listeria* harborage areas and facilitates thorough cleaning and sanitation and a risk-based environmental testing program. On this last point, it is critical that operators develop a comprehensive plan for environmental testing and be committed to conducting root cause analysis when positive results are obtain to ensure that the reasons for the positive tests are understood and corrective measures put in place to prevent a reoccurrence.

2. ***Salmonella* is one tough bug**. A re-current theme across several research presentations dealt with the hardiness of *Salmonella* in the soil, on soil amendments and on plant tissues. Dr. Xiuping Jiang's (Clemson University) program on *Salmonella* in heat processed chicken pellets demonstrated that the production of finished heat treated chicken pellets has to be thought of as a manufacturing process with critical measures like moisture level and temperature fastidiously controlled to insure the pathogen is eliminated otherwise it can build a resistance to heat treatments. Similarly, Dr. Trevor Suslow (UC-Davis) shared data that pointed to the resilience of *Salmonella* in inoculated fresh cilantro under field conditions. Steve Koike (UC Davis Cooperative Extension) reported that attenuated *Salmonella* survived much better under commercial production conditions in the Salinas Valley than attenuated *E. coli* O157:H7 when inoculated on romaine leaves which were chopped and turned into the soil. Dr. Jitendra Patel (USDA-Beltsville) demonstrated that *Salmonella* serovars were much more resistant to the antimicrobial effects of natural isothiocyanates from broccoli versus *E. coli* O157:H7 strains. Lastly, Dr. Linda Harris (UC Davis) presented data that indicated that if *Salmonella* becomes desiccated, its ability to survive can be increased. If *Salmonella* are grown in liquid broth they are much less hardy than *Salmonella* grown on agar plates. This observation has important ramifications for researchers and the design of experiments testing survivability of *Salmonella* in

produce environments such as pack houses and fields. It also reminds produce industry operators that the environment in which produce is handled or processed (wet to dry transitions, rapid temperature changes, sanitizer concentrations, etc.) can affect the survivability of *Salmonella* and the potential for cross contamination hazards.

3. **Know your compost supplier**. The use of various composts is a common and necessary practice in the produce industry to improve and restore soil fertility. However, the safe production and application of composts must be viewed as the result of a well-controlled manufacturing process that is monitored and verified. Dr. Xiuping Jiang (Clemson University) demonstrated that the manufacture of heat treated chicken pellets requires precise control of temperature, time and moisture levels to achieve a ten million-fold reduction of *Salmonella*. Dr. Jiang has previously reported that several variables impact the efficacy of composting operations to reduce human pathogens and prevent cross contamination including: heat up times, temperature, time, moisture, turns, C:N ratios, particle size, microbial populations and finished compost storage practices. Dr. Manan Sharma (USDA-Beltsville) spoke about the importance of compost verification testing specifically pointing out that sample size is critical when testing to verify that a compost process has been conducted effectively. It is important for growers purchasing composts for use in fields that they know their supplier and that the supplier can demonstrate that the compost was produced according to a validated process and further they can verify that the specific lot(s) being purchased were produced within the parameters of that validated process. If the grower is producing composts for use on their farm, they must understand the variables of the composting process and verify that the process they used has effectively reduced human pathogen populations.

4. **Pathogen contaminated fields can be re-planted**. At earlier CPS Symposia, Steven Koike (UC Cooperative Extension) reported that attenuated *E. coli* O157:H7 and *Salmonella* strains inoculated onto spinach or romaine leaves could survive for over 90 days in the field when the vegetative materials were turned under the soil. This observation raised questions from growers as typical industry practice is to cut or mow residual plant materials postharvest and leave it on the surface for several days prior to turning it into the soil and preparing for the next crop. Follow on experiments were performed under commercial conditions using purposely inoculated spinach. Koike reported that when inoculated spinach was chopped or mowed and permitted to remain on the surface and dry out prior to incorporation into the soil, no *E. coil* O157:H7 was found on the second crop 27 days after planting and no *Salmonella* was detected 35 days post planting. It is thought that leaving the crop residue on top of the soil permits exposure to the sun and loss of moisture that enhances pathogen die off and prevents further growth. These data point out that pathogens can survive and contaminate subsequent plantings unless sufficient time (27-35 days) is permitted so choice of the next crop should be considered carefully; i.e. a crop that comes to maturity in less than 27 days may not be a wise choice even if the previous contaminated crop residue was permitted to dry out prior to incorporation. It is important to establish time intervals for specific environments, crops and soil types as variability in pathogen survival should be expected.

5. **Put your data to work**. Large segments of the produce industry currently perform some type of irrigation water testing. Generally, generic *E. coli* is used as an indicator for fecal contamination in irrigation water tests. Dr. Channah Rock (University of Arizona) pointed out that growers need to be sure that the tests used to measure generic *E. coli* have the proper sensitivity. While several tests are available, it is important that the detection level of the kit is matched to the

standard. For example, if the target is the EPA recreational water standard of less than 126 MPN E. coli/100 mls, then a test sensitivity of 200 MPN *E. coli*/100 mls would be inappropriate. Dr. Rock also demonstrated the value of quantitative microbial risk assessment or QMRA. Using irrigation water test data and a series of assumptions around time to consumption, serving sizes and irrigation practices, data was presented that showed sub-surface drip irrigation with water containing 126 MPN generic *E. coli*/100 mls could result in 9 illness/100,000,000 consumers compared to 1.1 illnesses/1,000,000 consumers if furrow irrigation were used and 1.1 illnesses/1,000 consumers if sprinkler irrigation were used. The data clearly show that public health risk is a function of source water quality and irrigation delivery system used. We were also reminded by Dr. George Vellidis (University of Georgia) in his presentation that our irrigation water sources each represent different contamination risk factors that must be evaluated and managed, e.g. water source, animal intrusion, potential for run-off, etc. Similarly, Dr. Max Teplitski presented data that suggests the genetic and physiological status of the crop may render it more or less susceptible to infection from compromised irrigation water adding another dimension for consideration. In the case of tomatoes, season, fruit maturity and cultivar were all important factors in susceptibility to *Salmonella* infection from irrigation water. Dr. Rock's QMRA analysis also reflects the approach taken by FDA in the proposed produce rule where exposure of the edible portion of the crop to irrigation water is a key public health risk driver. As in all models, the model is only as useful as the quality of the data and the assumptions made to build it. While the expected illness frequencies here are compelling, one of the assumptions used was that the lettuce would be consumed one day after harvest which is unlikely for the vast majority of lettuce grown in the US and therefore one would expect to get additional die-off and the expected illnesses would decline. However, the QMRA model is very useful in helping growers prioritize and manage potential contamination risks. It is imperative that instead of guarding our data, we take the appropriate steps to protect sources and use the data to quantify risks to help ourselves understand priorities and leverage our resources more effectively.

6. **Wash water: do no harm**. Many different products are washed, cooled or transported using water. Therefore it is important that the water is treated and maintained properly so that it does not become a source of cross contamination for human pathogens, should they be present. In other words, understanding your process for water disinfection and validating its efficacy is critical for the safety of the product. It is equally important to remember that simply washing products is not an effective mechanism for removing contamination, i.e. it cannot remove or kill pathogens that have had the opportunity to naturally seek out hidden surfaces on products and adhere to them. Therefore our focus is to manage contamination risks throughout production (e.g. GAPs, inspections, hygiene, equipment sanitation, training programs, etc.) and control wash, cooling and transport processes using water so that we do not create cross contamination scenarios. Dr. Keith Warriner (University of Guelph) stressed that it is important to understand the variables of your wash water system and control them properly to insure that disinfectants can control microbial populations in the water. Some of these variables include: temperature, pH, turbidity, sanitizer concentration, product load per wash volume, contact time and source water quality. Each type of system can have different characteristics and physical design so operators must characterize their specific system and validate that their disinfection process or preventive controls are effective and verify that they are operating the system within the validated limits during production run. This is the basis for FDA's proposed hazard analysis risk preventive controls (HARPC) proposal in the preventive controls rule. Improper control over

wash, cooling or water-based transport systems can do harm, i.e. resulting in large-scale cross contaminations. Dr. Trevor Suslow vividly demonstrated this assertion using an inoculated cilantro load and washing it with un-inoculated parsley on a commercial wash system. The improperly controlled wash system permitted cross contamination onto the parsley demonstrating the potential for cross contamination.

7. **Clean and sanitize surfaces that contact products**. Produce handling results in contact between the product and various surfaces that can become contaminated with pathogens. The CPS symposium featured three presentations dealing with the potential for transference of pathogens from contaminated gloves (Dr. Jennifer Cannon, University of Georgia), cloths (Dr. Michele Danyluk, University of Florida) and harvest buckets (Dr. Lynn McLandsborough, University of Massachusetts). The use of gloves has been debated within the produce industry for several years. Data presented by both Drs. Cannon and McLandsborough suggest that hand wash prior to use of any kind of glove is very important and that the gloves need to be sanitized as they are used. Nitrile gloves do not facilitate cross contamination as well as latex gloves, however both types will transfer pathogens if not cleaned and sanitized regularly with a sanitizer like sodium hypochlorite (>50 ppm) with proper pH control (6.5 to 7.0). Another frequent point of contention in the industry is the potential for pathogen transference owing to the use of cloths to wipe fruit that is field packed. Dr. Danyluk presented data that shows that pathogens can be transferred from fresh tomatoes to cloths and from cloths to subsequently handled tomatoes. While there are many factors at play, moist cloths facilitate transference more readily than dry cloths and dirty cloths seemingly are less efficient at transference than cleaner cloths, although both can facilitate transference if pathogens are present. As one panelists suggested, the use of cloths to wipe tomatoes in the field is analogous to "playing *Salmonella* lotto"; it has transference risks that are best avoided if possible. Lastly, Dr. McLandsborough examined the age and condition of tomato harvest buckets to determine their potential as transference vehicles. Surprisingly, older, scratched and worn plastic buckets were less effective in transferring *Salmonella* than newer buckets. Once again, new and old buckets could affect transference if the pathogen were present and the presence of soil on the buckets decreased *Salmonella* die-off. This emphasizes the importance of regularly cleaning and sanitizing harvest containers to prevent transference of pathogens to harvested products.

8. **Pathogens can be transferred by wind**. Growers have been encouraged to perform hazard assessments of production blocks prior to planting as part of their GAP programs. One of the key elements of the hazard analysis has been to evaluate the potential for contamination from concentrated animal feedlots should one be situated near the production block. Dr. Elaine Berry (USDA ARS) developed a study to examine the potential for wind-borne transference of *E. coli* O157:H7 from a herd of cattle known to be infected, to plots of leafy greens planted at varying distances from the cattle feedlot. The data demonstrate that *E. coli* O157:H7 can be transferred via bioaerosols and dust particles to crops at least out to 600 feet (the farthest distance tested). As distance increases away from the cattle feedlot, the frequency and level of contamination diminishes. However, bioaerosol and dust particle transference is not a simple matter of distance. The density of the cattle, wind intensity, moisture and activities within the feedlot; i.e. movement of cattle in or out, cleaning, etc., all impact formation of bioaerosols and dust particles containing pathogens. These factors must be considered in any hazard assessment and the development of management practices.

9. **"Risky" crops?** The FDA has confirmed the presence of *Salmonella* and shiga-toxin producing *E. coli* in over 30 fresh market cilantro samples since 2004 and issued a guidance letter to cilantro producers in 2011 expressing their concerns. Dr. Trevor Suslow (UC-Davis) conducted a study to determine the survivability of attenuated strains of *Salmonella enterica* and *E. coli* O157:H7 on cilantro during pre-harvest field conditions. The results demonstrate that Salmonella is much more vigorous in the production environment compared to *E. coli* O157:H7. Indeed, *Salmonella* was not only shown to persist on cilantro in the production environment for up to 12 days, but also survive a chlorinated postharvest wash treatment. As already indicated earlier, this observation highlights the fact that wash systems cannot eliminate pathogens present on crops and the importance of defining appropriate disinfection measures in wash systems to prevent cross contamination events that magnify the extent of the contamination. As cilantro can be harvested multiple times over a season, Dr. Suslow also looked at pathogen survival on re-grown cilantro. Detection of *E. coli* O157:H7 or *Salmonella* appears to be dependent on the timing of the contamination relative to subsequent harvests with decreased survivability over time, though *Salmonella* is hardier than *E. coli* O157:H7. Growth of pathogens during postharvest holding prior to cooling was not observed up to two hours (the last time measured). The importance of "cut to cool" times should not be overlooked however. As harvested crops heat up due to exposure to the sun or from metabolic activity postharvest, moisture levels can also increase creating an ideal environment for pathogen growth, i.e. what may have been a very low contamination level can be increased to a level that may cause an elevated public health risk. These preliminary studies by Dr. Suslow point out the importance of performing a hazard assessment for every crop production system; seed through finished product. It is not just the crop that presents a food safety risk, but the method of production, agricultural inputs, harvest practices and postharvest handling that need to be considered together and appropriate management practices designed.

10. **Animal intrusion: the road ahead?** For the last several years, the produce industry has struggled to understand wildlife transmission of pathogens to crops and the role of riparian areas may play. Dr. Martin Wiedmann (Cornell University) is studying 24 produce field areas in New York State by examining landscape features, land use in adjacent areas, animal movement patterns and prevalence of genetic strains of *E. coli* in soil, animal and water samples to create models that might be used to forecast contamination events. While this work is still in the early stages, Dr. Wiedmann has shown that the prevalence of *E. coli* in environmental samples differs between landscapes and different cover types. It also appears that forests that border production fields might be acting as a source of *E. coli* that can be transmitted to the fields since a forest habitat harbors increased genetic diversity and can support higher levels of bacteria than the field environment. It's too soon to tell what this will all mean and how we can use this information to better understand the complex interactions between our production environments and food safety risk factors. However, this study marks an important departure in industry thinking relative to animal intrusion. Previous CPS-funded research has shown that there are no "risky" animal species, only animals that exist in environments where pathogens may be present and that they can be vectors for transferring those pathogens to crops. Dr. Wiedmann's work is one of the first real examples of how data might be used to build predictive models of how pathogens move through production environments. With this understanding, it may be possible to design crop production practices that find balance in environmental and food safety management.