Waxing of whole produce and its involvement in and impact on microbial food safety

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Summary

Many fresh fruits and vegetables are washed and waxed after harvest to prevent premature rotting and to extend shelf life. Over the past decade, the influence of commercially available waxes on fruit and vegetable quality has been investigated and reviewed, however, there is limited information about the impact of waxes on microbial food safety. This project aims to fill these knowledge gaps by conducting in-lab and pilot-plant studies using citrus as a model fruit. Results of this project will be used to support individual packinghouse food safety plans and facilitate auditor evaluations.

Objectives

1. Evaluate the microbial and chemical properties of currently available citrus waxes and determine the potential for foodborne pathogens to survive in these waxes under simulated packinghouse storage conditions.
2. Investigate the behavior of *Listeria monocytogenes (LM)* and *Salmonella* inoculated onto citrus fruit surfaces when storage waxes are subsequently applied and fruit is stored.
3. Characterize and evaluate the pathogen control efficacy of different finishing waxes, the heated drying steps, and subsequent storage by conducting in-lab and pilot-scale packinghouse trials.

Methods

- Commercially available citrus waxes were obtained from industry partners. Commercial waxes were inoculated with 5-strain cocktails of *LM* and *Salmonella* at 6 Log CFU/ml and their survival determined by during storage at 4 or 22°C (39 or 72°F).
- Lemons were spot inoculated with a 5-strain *LM cocktail* at 6 Log CFU/lemon, storage waxes were applied, and survival was determined during storage over 90 days at 12 to 14°C (54 to 57°F) and 90–95% RH.
- Finishing waxes were applied to *LM*- or *Salmonella*-inoculated lemons and dried at 22 or 60°C (72 or 140°F) for 4 min. Populations of *LM* or *Salmonella* were determined before and after finishing wax application and the drying step.

Results to Date

In general, populations of *LM* declined more slowly and to a lesser degree than populations of *Salmonella* in the full-strength waxes regardless of storage temperatures (**Figure 1**).
The application of storage waxes caused the movement of *LM* from the inoculated midsection of the lemons (**Figure 2A**). Culturable *LM* decline during storage was impacted by wax type and the dilution (**Figure 2B**).
Small reductions of both *LM* and *Salmonella* occurred after the application of finishing waxes (**Figure 3A** & **3B**). The reductions of pathogens during the subsequent drying steps were influenced by drying temperature and wax type. Greater reductions were observed for *LM* than for *Salmonella* (**Figure 4A** & **4B**).

Benefits to the Industry

The Preventive Controls for Human Food Rule and the Produce Safety Rule mandate that the food industry implement efficient preventive controls against identified hazards (e.g., *LM* and *Salmonella* for tree fruit). There is limited information on the food safety risks associated with waxing, a common step widely used by packinghouses. Results from this project will address this critical need by providing data to facilitate risk assessments and thereby strengthen food safety plans.

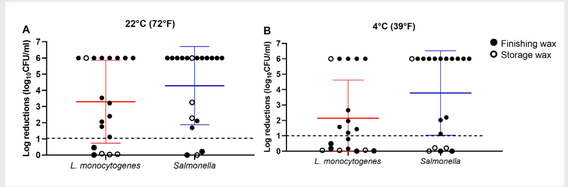

Figure 1. Log reductions of *L. monocytogenes* and *Salmonella* in inoculated full-strength storage and finishing waxes when stored at 22°C (72°F) (**A**) and 4°C (39°F) (**B**) for 24 h. The red and blue lines represent the mean with SD. The dashed lines separate waxes that resulted in <1-log reduction of pathogens after 24 h of storage from those that resulted in a >1-log reduction of pathogens after 24 h of storage.

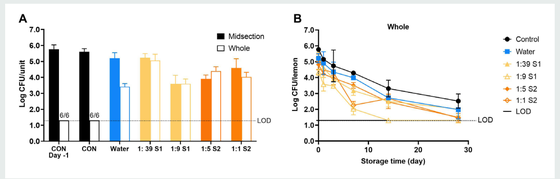

Figure 2. The impact of wax application on the movement of *L. monocytogenes* on lemon surfaces (**A**), and the survival of *L. monocytogenes* during long-term storage at 12 to 14°C (54 to 57°F) with 90–95% RH (**B**). Storage waxes S1 and S2 were diluted according to the manufacturer's instructions. LOD: limit of detection by plating, 1.0 log CFU/circle or 1.3 log CFU/lemon; #/# in the figure represents the number of samples that were positive after enrichment vs. the total number of samples tested; #:# in the figure legend represents the dilution factor (volume of wax: volume of water).

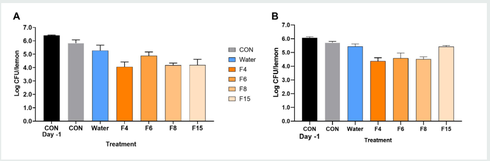

Figure 3. Reduction of *L. monocytogenes* (**A**) and *Salmonella* (**B**) on lemon surfaces after the application of finishing waxes. Control lemons were unwaxed (CON) or sprayed with water (Water).

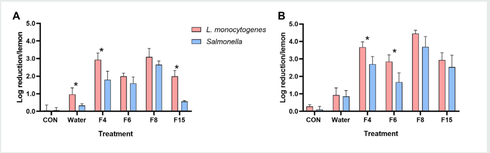

Figure 4. Reduction of *L. monocytogenes* and *Salmonella* on lemon surfaces after the application of finishing waxes, followed by the drying step at 22°C (72°F, **A**) and 60°C (140°F, **B**). Control lemons were unwaxed (CON) or sprayed with water (Water).