Cross-contamination in dry environments

Contact

Nitin Nitin, PhD
University of California, Davis
nnitin@ucdavis.edu

Authors

Yucen Xie, Xiaonuo Long, Yoonbin Kim, Nitin Nitin (PI) & Linda J. Harris (Co-PI)

Project funding dates

January 1, 2022 – December 31, 2023

Acknowledgements

We appreciate Harris Ranch and Gills Onions for providing site visits in 2022. This project is partly funded by the Center of Produce Safety Award No. 2022CPS06.

Summary

The risk of cross-contamination of fresh produce with foodborne pathogens during harvest and postharvest handling is a significant food safety concern. Cross-contamination can result from contact between contaminated food contact surfaces and fresh produce. However, there is a lack of knowledge about factors influencing cross-contamination in dry environments. This research aims to understand cross-contamination risk factors during fresh produce dry handling and processing, using onions as a model commodity. The results will provide an understanding of the risk of bacterial survival on surfaces and factors influencing bacterial transfer in dry conditions (**Figure 1**) and enable the development of a risk model for diverse conditions in dry packing facilities.

Objectives

1. Quantify survival of target pathogens in simulated dry environments, assess transfer coefficients of bacteria from inoculated dry food contact surfaces, including various plastics and stainless-steel surfaces, to model fresh produce (e.g., onions and stone fruits) and develop a quantitative risk model for cross-contamination.

Methods

Survival of bacteria (rifampin-resistant *Enterococcus faecium* and *Salmonella* cocktail) on food contact surfaces: Bacterial strains associated with outbreaks in produce or reported to have enhanced desiccation tolerance were selected. Polyurethane (PU) and stainless steel (SS), two common materials for conveyor belts and equipment surfaces, were selected to study bacterial survival with and without onion extract.

Transfer of bacteria in a simulated onion postharvest handling: For precise evaluation of physical parameters influencing the transfer of bacteria, the contact force, time of contact, and the number of repeated contacts were controlled using a texture analyzer. Bacterial transfer experiments were conducted to investigate the influence of bacterial species, inoculation levels, inoculum carriers, and transfer direction (onion-to-surface and surface-to-onion).

Results to Date

- Decline of *E. faecium* was limited to 1~2 log on PU and SS at three inoculation levels after 12 weeks of storage at 21°C (34% relative humidity). *Salmonella* declined >2 log over 6 weeks for the low inoculation level and was undetectable by enrichment after 12 weeks (**Figure 2A**).
- Bacteria survival was significantly improved on surfaces over 12 weeks when inoculated with onion extract compared to samples inoculated in peptone (**Figure 2B**).
- Bacterial cells formed aggregates on the inoculated surfaces and were embedded with the onion extract on both PU and SS surfaces (**Figure 3**).
- Bacterial species, inoculum carrier, and transfer direction significantly influenced the bacterial transfer between onion and contact surfaces (**Figure 4**). Transfer rates for *Salmonella* were influenced by the inoculation levels (**Figure 4B**).

Benefits to the Industry

The results of this study will aid in developing effective cleaning and sanitizing practices to mitigate cross-contamination risks in dry produce handling. The outcomes of this project will also provide a foundation for developing a quantitative model for cross-contamination in dry fresh produce environments. This project also illustrates that bacterial species, inoculum carrier, and transfer direction influence bacterial transfer rates and, thus, the risk of cross-contamination during dry onion handling.

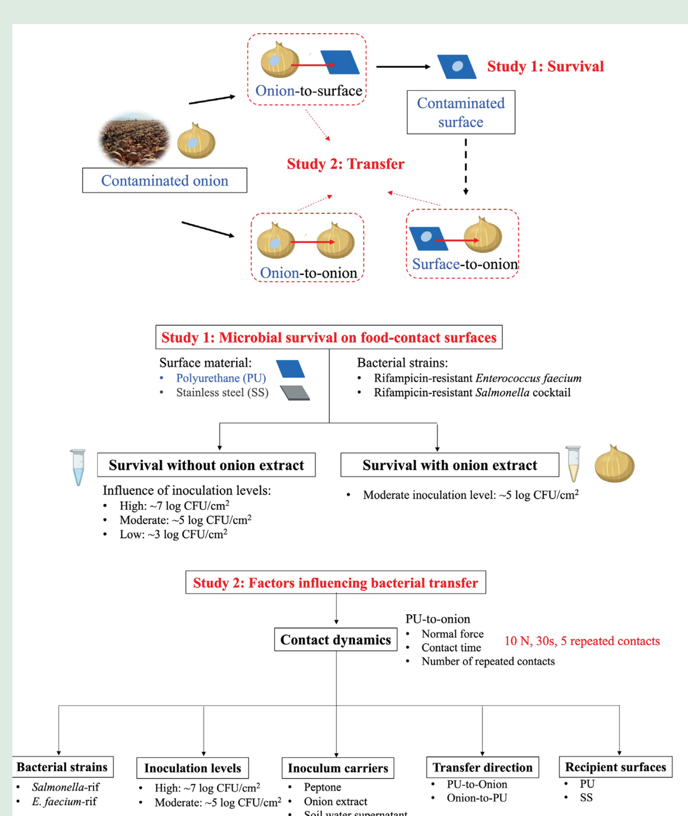

Figure 1. Schematic diagram of the overall goals and experimental design.

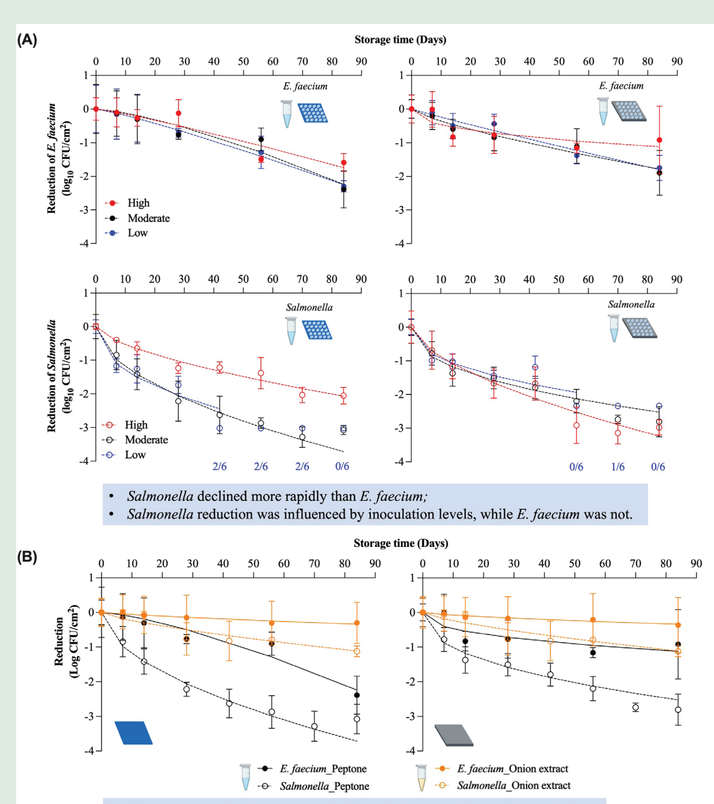

Figure 2. Survival of rifampin-resistant *E. faecium* and *Salmonella* cocktail on PU and SS in dry conditions: (**A**) Reduction of *E. faecium* (upper row) and *Salmonella* (lower row) on PU (left) and SS (right) under high (~7 log CFU/cm²), moderate (~5 log CFU/cm²) and low (~ 3 log CFU/cm²) inoculation levels over 12-weeks storage; dashed curves represent data fitted using Weibull model. (**B**) Influence of onion extract as an inoculum carrier on the reduction of *E. faecium* and *Salmonella* on PU (left) and SS (right) at moderate inoculation level.

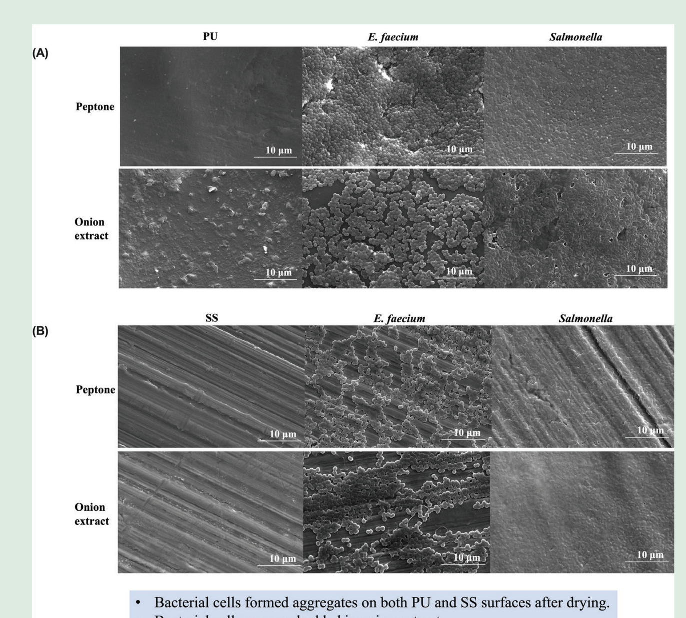

Figure 3. Images of the distribution of inoculated and dried bacterial cells (rifampin-resistant *E. faecium* and *Salmonella* cocktail) on (**A**) PU and (**B**) SS. Bacterial cells were inoculated using peptone (upper row) and onion extract (lower row) as the inoculum carriers.

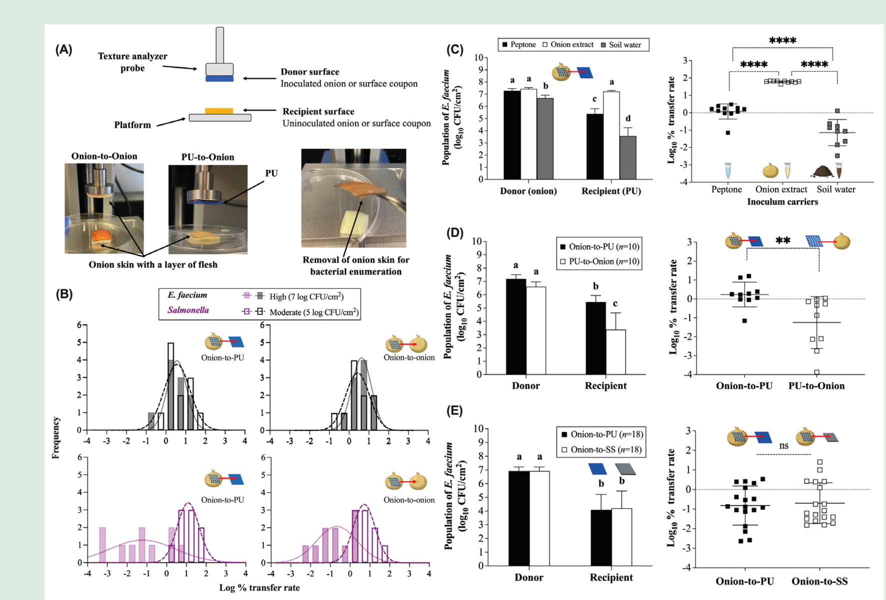

Figure 4. Transfer of rifampin-resistant *E. faecium* and *Salmonella* cocktail in simulated onion postharvest handling: (**A**) Schematic of bacterial transfer experiments using a texture analyzer. (**B**) Distribution of log percent transfer rates of *E. faecium* (dark, upper row) and *Salmonella* (purple, lower row) from inoculated onion to uninoculated PU (left) or to uninoculated onion (right) at high and moderate inoculation levels; (**C**-**D**) Influence of inoculum carriers (peptone, onion extract, and soil water) and transfer direction, respectively on the transfer of *E. faecium* from onion to PU; (**E**) Influence of recipient surface material (PU versus SS) on the transfer of *E. faecium* from inoculated onions.