

Quantitative microbial risk assessments need to consider quality parameters to accurately predict produce food safety risks

Summary

Quality defects in fresh produce can lead to product rejection at various stages of the supply chain. While defects may primarily be considered a sensory issue, some defects can support pathogen growth and thus increase food safety risks. Hence, the aim of this project is to inform decision-making in industry about rejection of leafy greens due to mechanical damage and watersoak, using chopped romaine as a model. Using literature data, we developed a quantitative microbial risk assessment (QMRA) to estimate the recall risk of chopped romaine due to contamination with *Listeria monocytogenes* (LM) and *Escherichia coli* O157:H7 (ECO157), while accounting for impact of mechanical damage. We also experimentally characterized the dynamics of LM and ECO157 on watersoaked romaine; these experimental data will further inform the QMRA.

Objectives

1. Develop a QMRA to model food safety risks considering produce quality defects and their impact on pathogen survival and growth.
2. Perform inoculation studies on chopped romaine lettuce to collect input parameters to improve the QMRA.
3. Validate the QMRA model and its predictions through inoculation studies.
4. Run scenario analyses to model the impact of different “last mile” scenarios on produce food safety risks.

Methods

QMRA: The QMRA covers stages from product arrival at a processor through retail (Figure 1). Recall risk is calculated from the risk of a positive pathogen test at retail, assuming an annual production volume of 1,000 batches/processor and that each batch is tested. The QMRA was simulated assuming: (i) no mechanical damage (baseline scenario) and (ii) 0 - 15% mechanical damage (MD scenario). Partial rank correlation coefficient of QMRA inputs was calculated for sensitivity analysis.

Experiments: Chopped romaine was obtained from a collaborator. Watersoak was generated by freezing romaine at -20°C for 30 minutes followed by thawing at 4°C. Defect-free and watersoaked romaine were inoculated, separately, with two strains of LM and one strain of ECO157. Pathogen dynamics were assessed at 4°C, 12°C and 21°C.

Results to Date

QMRA: In the baseline scenario, the annual risk for one or more finished product positives (i.e. a recall) was 3.56% for LM and 0.03% for ECO157. Risks were comparable in the MD scenario, which had an annual risk of 3.62% for LM and 0.03% for ECO157. Sensitivity analysis demonstrated that mechanical damage, at levels up to 15%, does not greatly impact the QMRA's outcome (Figure 2).

Experiments: Pathogen concentration on watersoaked (Figure 3), compared to defect-free, leaves was significantly higher at: (i) all temperatures for LM and (ii) 12°C and 21°C for ECO157. For example, at 12°C, LM and ECO157 concentrations were approximately 1-log₁₀ higher on watersoaked, compared to defect-free, leaves. At 4°C, ECO157 concentration did not differ on defect-free or watersoaked leaves.

Benefits to the Industry

These data provide insight into the food safety risks associated with various quality defects in romaine. The current QMRA findings suggest that mechanical damage may present minimally higher risks of LM and ECO157, although further research is being conducted on the impact of mechanical damage on the prevalence of high-risk packages that have a high pathogen concentration. Our experimental data illustrates that watersoak can support pathogen growth on romaine. We will incorporate the experimental data on watersoak into the QMRA, along with estimates of the prevalence of watersoak in real-world supply chains, to evaluate the risks associated with this defect. Ultimately, the QMRA will be used to: (i) rank defects by safety risk, and (ii) evaluate control strategies for defects, including thresholds for product rejection.

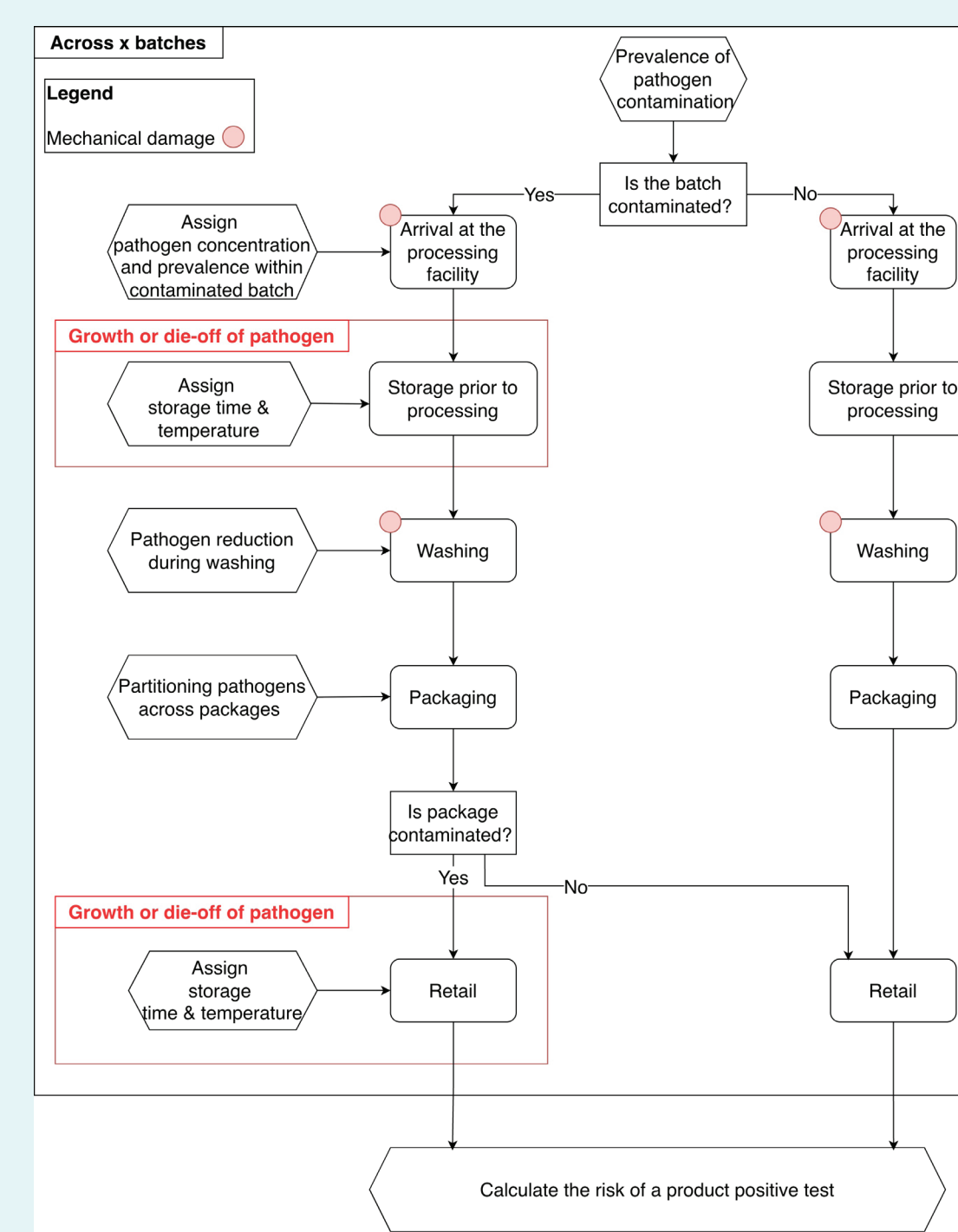


Figure 1:

The QMRA framework covers stages from product arrival at the processor until retail. Contamination of product with *L. monocytogenes* or *E. coli* O157:H7 is simulated in this supply chain, starting at product arrival at the processing facility. The red circles indicate the stages during which mechanical damage of the product was implemented.

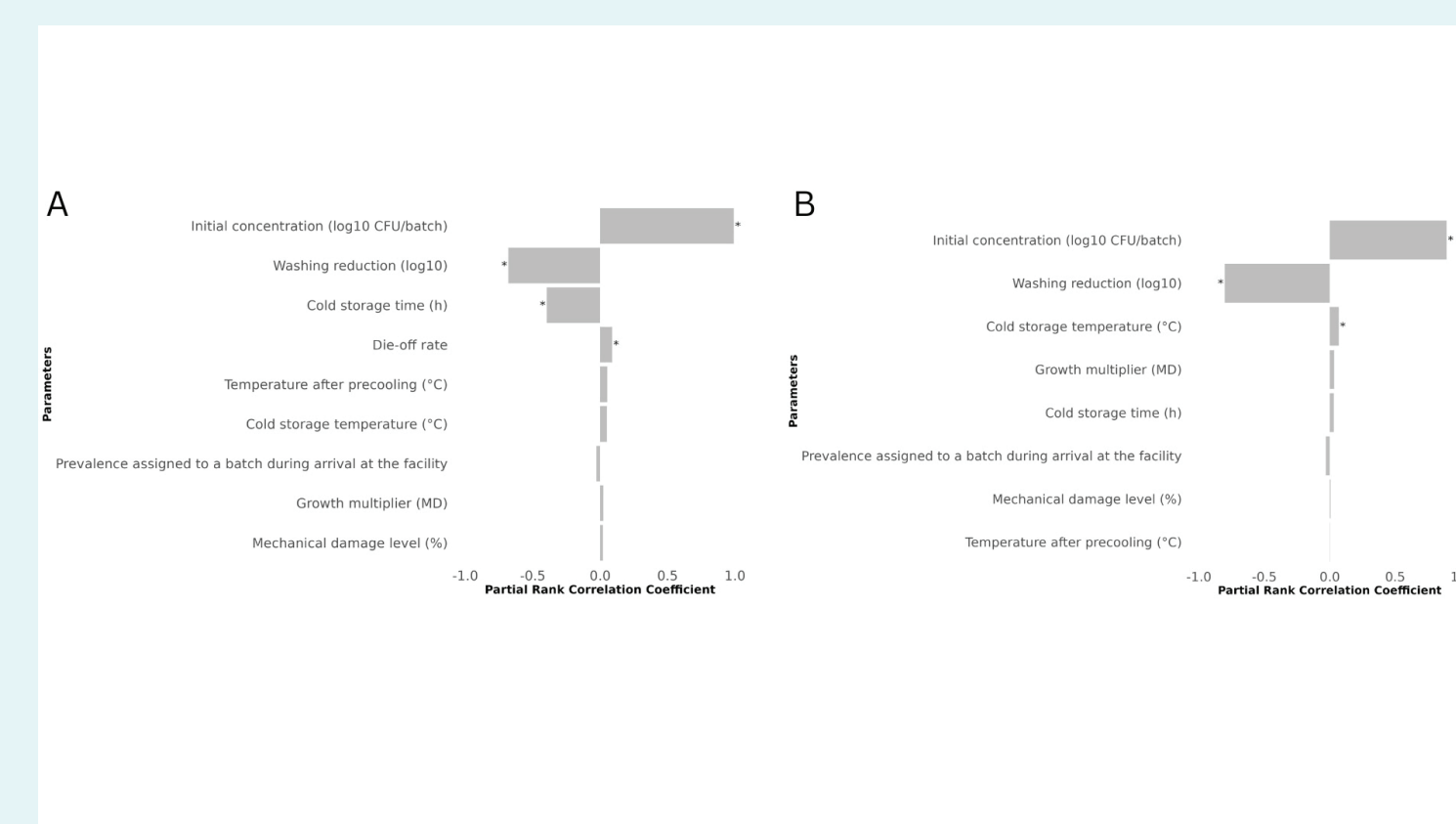


Figure 2:

Pearson Rank Coefficient Correlation (PRCC) sensitivity analysis for the mechanical damage scenario of the QMRA. Panels show PRCC results for batch-level detection probability under a 2-class, 5-unit sampling plan for: (i) *E. coli* O157:H7 (A) and (ii) *L. monocytogenes* (B). Analyses were restricted to contaminated batches. Bars represent PRCCs, where larger absolute values indicate stronger influence on the QMRA's output, positive values indicate a direct association, and negative values indicate an inverse association. Asterisks indicate statistically significant PRCC estimates after Bonferroni correction.

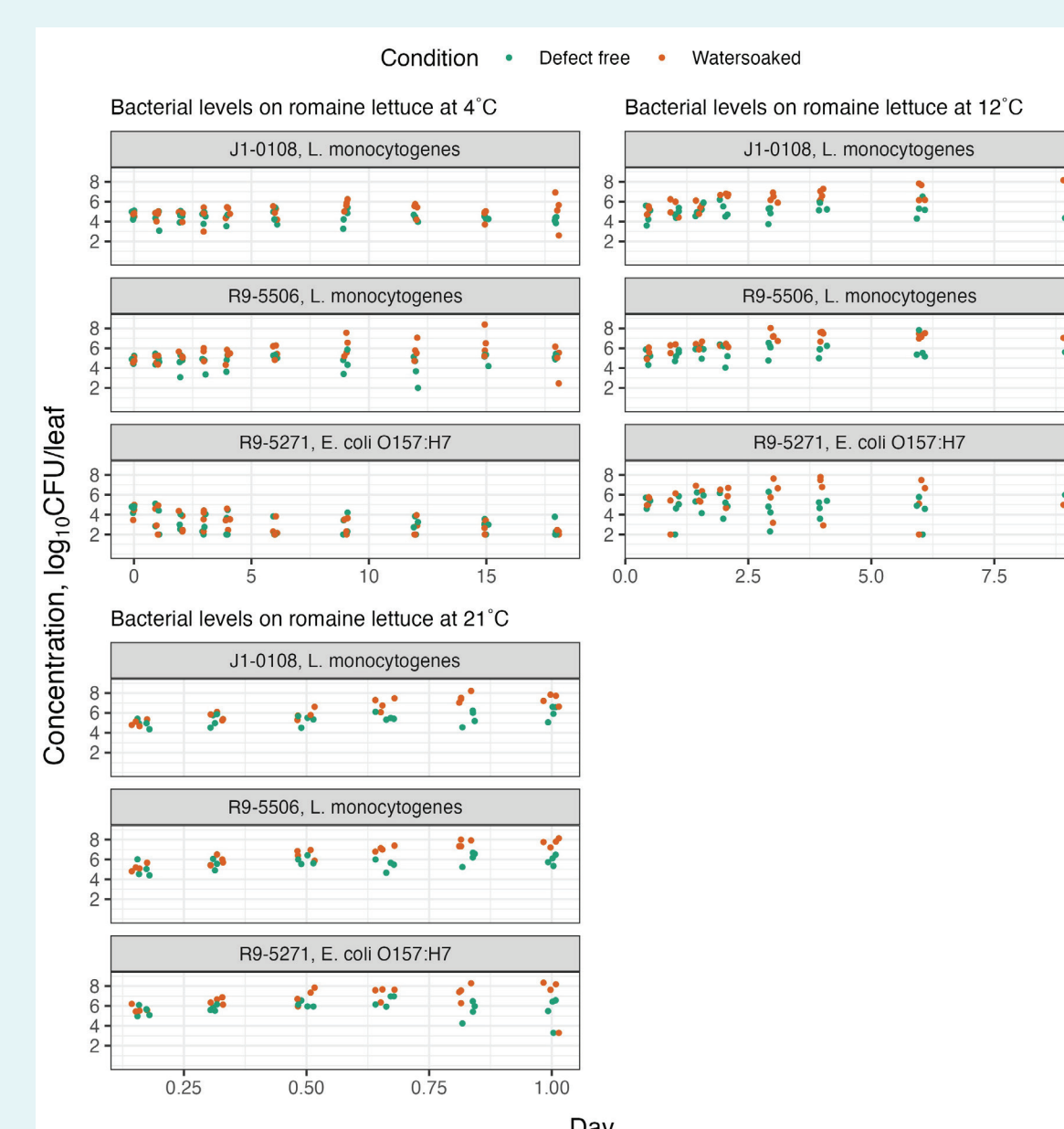
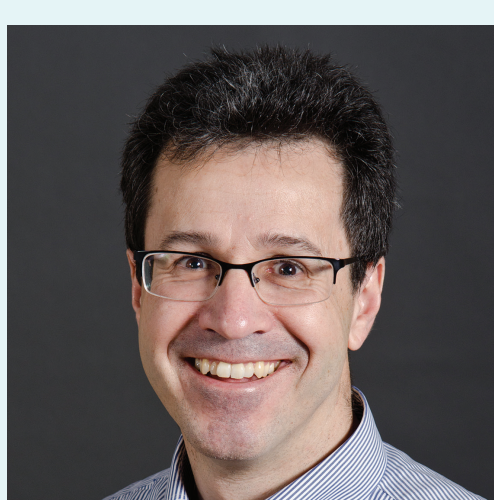


Figure 3:

Concentration of two strains of *L. monocytogenes* and *E. coli* O157:H7 on defect free and watersoaked romaine lettuce at 4°C, 12°C, and 21°C. Concentrations below the limit of detection by plating were substituted with 25% of the detection limit. Points represent the average of the concentration of microbes on two leaves of romaine from one trial; points were “jittered” to prevent overlap. Point color represents whether the romaine leaves were defect-free or watersoaked. As this figure represents data from four independent trials, there will be four points for each condition at each testing timepoint.



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