

# Reassessing postharvest water management for pathogen infiltration/internalization

## Summary

Postharvest water management is a major control point for preventing pathogen infiltration during washing. Current industry guidelines require wash water to be warmer than produce to reduce bacterial internalization (e.g., *Salmonella* in tomatoes and *Listeria* in melons). However, maintaining temperature differentials is often difficult due to seasonal and operational variability. This project evaluates whether strict temperature differentials are necessary when alternative controls are applied. Specifically, the study examines whether maintaining effective residual antimicrobial concentrations and short immersion time (< 30 s) can prevent bacterial internalization despite temperature differentials. The study also evaluates commercial postharvest washing practices. These include spray-based systems that limit produce submersion. Results aim to support science-based, flexible water management strategies that reduce operational challenges while maintaining food safety.

## Objectives

1. Determine whether temperature differentials ( $\Delta T$ ) between tomatoes and wash water influence *Salmonella* internalization under controlled laboratory conditions and assess whether effective residual chlorine or peracetic acid (PAA) mitigates this risk without strict  $\Delta T$  control.
2. Evaluate the impact of immersion duration on *Salmonella* internalization, comparing short immersion times (<30 s) with longer exposure (2 min) across varying temperature differentials using commercial wash water.
3. Conduct field studies in commercial tomato and cantaloupe packinghouses to compare pathogen and indicator microorganism infiltration between immersion-based washing systems and spray-wash alternatives, supporting practical postharvest water management recommendations.

## Methods

**Tomato infiltration:** Trials were conducted using wash water without sanitizers obtained from a commercial cooperator (AMC GLOBAL). Four tomato temperatures (10, 20, 30, and 40°C) and four wash water temperature differentials ( $\Delta T$ : -10, -3.5, +3.5, and +10°C) were evaluated. Tomatoes were prepared by stem removal and inoculated by immersion in process water containing a low-level four-strain *Salmonella enterica* cocktail (1–100 CFU/mL) for 2 min (Objective 1) or 30 s (Objective 2). Fruits were externally disinfected with chlorine (2000 ppm, pH 6.5) for 10 s.

**Core extraction:** The blossom end was removed, cores were extracted from the blossom end toward the stem scar, and the stem scar was then removed.

***Salmonella* detection:** Extracted cores were enriched in Buffered Peptone Water, followed by Tetrathionate broth, and *Salmonella* was detected on Xylose Lysine Deoxycholate (XLD) agar.

Sixteen temperature combinations were tested, with five tomatoes per treatment and two independent trials.

## Results to Date

*Salmonella* infiltration occurred only when the calyx was deliberately removed immediately before washing. No infiltration was observed in retail stemless tomatoes.

Results for **Objective 1** demonstrated that washing tomatoes with **150–160 ppm free chlorine at pH 6.0–6.5** completely prevented *Salmonella* infiltration (**0/320; Fig. 2A**), regardless of temperature differential or immersion time. Subsequent experiments extending this objective showed the same outcome **at lower chlorine concentrations (12–20 ppm; 0/320; Fig. 2B)** and when **peracetic acid** was used (**80 ppm; 0/320; Fig. 2C**). In contrast, when no sanitizer was applied, *Salmonella* infiltration occurred consistently, **with 240/240 tomatoes testing positive (Fig. 2D)**, even at low contamination levels (1–100 CFU/mL).

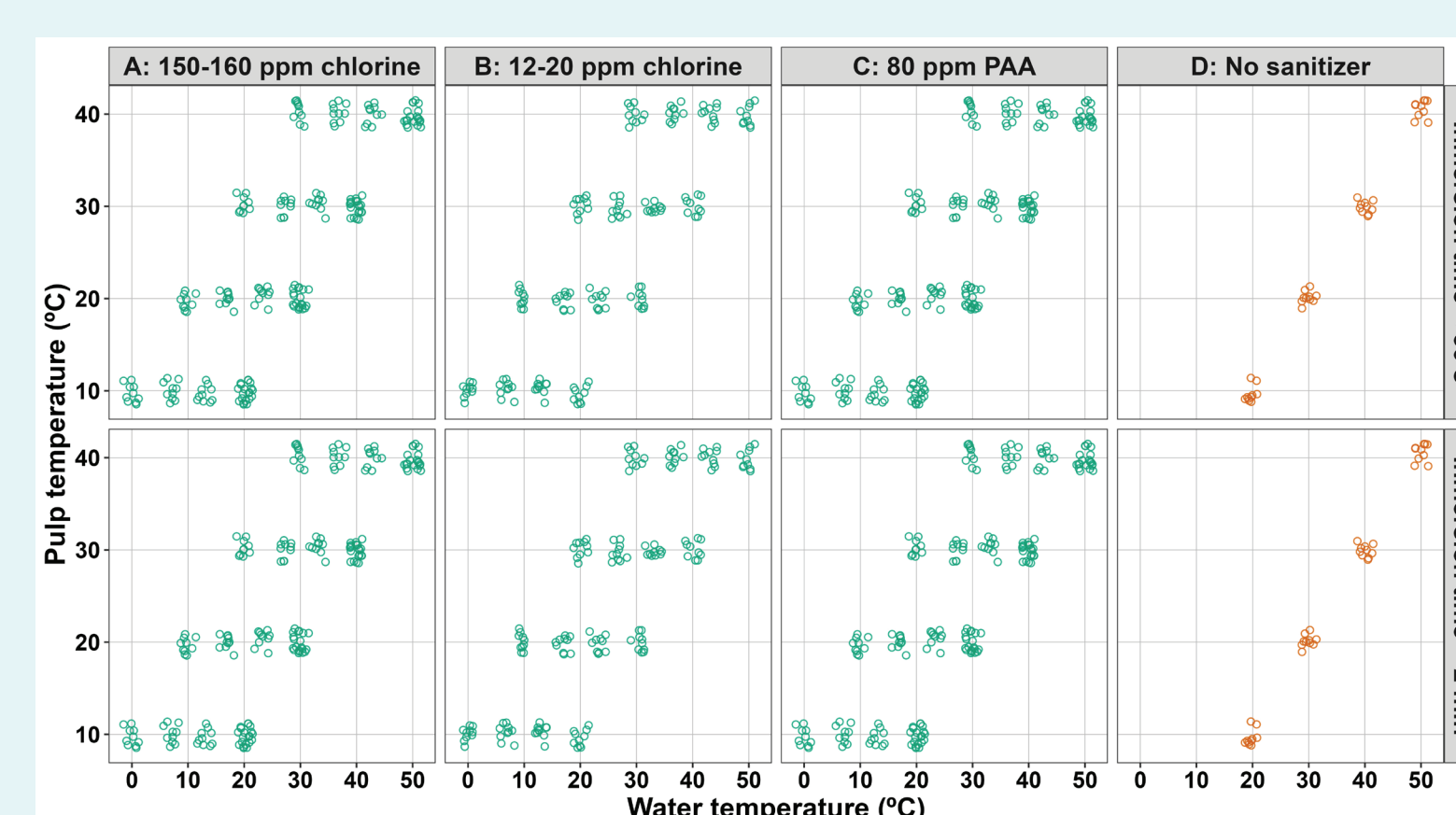
Infiltration occurred even when wash water was warmer and the immersion time was less than 30 seconds (**Objective 2**). Overall, these findings show that **sanitizer use is the most important factor in preventing *Salmonella* infiltration**.

## Benefits to the Industry

This project provides science-based guidance to improve postharvest water management in the fresh produce industry. Findings demonstrate that effective antimicrobial control is sufficient to prevent pathogen internalization, even in the absence of strict temperature differentials. Packers and processors benefit from clarified infiltration risk factors, evidence that temperature control is less critical than antimicrobial management, and validated sanitizer targets for chlorine, PAA, and immersion time. The project also supports spray-wash alternatives to immersion systems, reducing operational complexity while maintaining food safety. Results are broadly applicable across commodities, supporting harmonized best practices for water-based postharvest handling systems.



**Figure 1:** Flow chart illustrating the tomato infiltration and core extraction. Steps included: (1) stem removal, (2) inoculation by immersion, external chlorine disinfection, (3) blossom-end (bottom) removal, (4) core extraction from the bottom to the stem scar, and (5) stem scar removal.



**Figure 2:** Combined effects of sanitizers in process wash water at immersion times of < 30 s and 2 min. Treatment included: (A) 150–160 ppm free chlorine, (B) 12–20 ppm free chlorine, (C) 80 ppm peracetic acid (PAA), and (D) no sanitizer (control). Each dot represents one tomato; green indicates *Salmonella* not detected, and red indicates *Salmonella* detected.



## Contact

Mabel Gil  
CEBAS-CSIC,  
Murcia, Spain  
migil@cebas.csic.es

## Authors

Mabel Gil (PI), Natalia Hernández, Silvia Andújar,  
Diego Sabater, Juan Antonio Tudela (Co-PI),  
Pilar Truchado (Co-PI)

## Project funding dates

January 1, 2026 – December 31, 2026

## Acknowledgements

The team extends its gratitude for the support from the advisory committee members, including Trevor Suslow, Zoila Chevez, Kinsey Clishe, Susanne Klose, George Nikolich, Amy Parks, and Shane Sampels, as well as the industry collaborators (AMC Global, Grupo Paloma, Grupo Perichán).