

Salmonella risk is enhanced by onion condition or defect

Summary

Onion recalls due to *Salmonella* have increased attention on pre- and post-harvest factors that may influence product safety risk. This study will evaluate the effect of various onion conditions and defects on *Salmonella* survival and growth. The impact of onion spoilage due to soft rot on *Salmonella* growth was quantified. In whole onions, co-inoculation with plant pathogens reduced early *Salmonella* growth, but concentrations increased to 6.72 ± 0.71 log CFU/g after visible spoilage onset. Additionally, the minimum temperature required for *Salmonella* growth in diced onions was determined. In diced onions, *Salmonella* growth occurred at 10°C from 3.02 to 4.26 log CFU/g over 14 days. Physico-chemical attributes (pH and Brix) were also measured. These findings help identify key post-harvest risk factors that may inform future mitigation strategies.

Objectives

1. Determine the effect of onion condition and defect on *Salmonella*.
2. Characterize the specific onion attributes that impact safety and quality.
3. Evaluate different post-harvest handling practices for their impact on *Salmonella*.

Methods

Onion Type, Culture Preparation, and Enumeration: All studies used yellow onions (*Allium cepa* L.). A three-strain *Salmonella enterica* cocktail was cultured in Brain Heart Infusion (BHI) broth at 37°C for 24 hours. Enumeration of *Salmonella* and background microflora was conducted.

- **Study 1:** Whole onions were co-inoculated with *Salmonella* and the spoilage bacterium, *Pantoea*, by injection or superficial nicking (0.5 cm \times 0.5 cm) on the surface, and then were stored at 20°C for 7 days. Spoilage signs were observed by cutting onions in half on each day.
- **Study 2:** Diced onions (100 g) were spot-inoculated with 30 μL of *Salmonella* (~ 4 log CFU/g). Samples were stored at 6 – 10°C for up to 14 days. Physico-chemical properties (pH and Brix) were measured during sampling.

Results to Date

Study 1: Spoilage impacted *Salmonella* growth dynamics. Spoilage appeared on Day 3 in co-inoculated onions (**Figure 1**). Prior to spoilage, *Salmonella* grew more rapidly in onions inoculated only with *Salmonella* (2.28 ± 0.43 to 4.46 ± 1.13 log CFU/g) compared to co-inoculated onions (2.14 ± 0.06 to 3.21 ± 1.05 log CFU/g). However, after spoilage onset, *Salmonella* increased to 6.72 ± 0.71 log CFU/g.

Study 2: *Salmonella* declined in diced onions stored at 6 – 8°C (**Figure 2**). *Salmonella* counts did not change in diced onions stored at 9°C . *Salmonella* counts increased at 10°C (3.02 to 4.26 log CFU/g) between Day 0 and 14. Minor differences in pH and Brix were observed under these same conditions (**Table 1**). Background microflora increased at all temperatures (**Figure 3**).

Benefits to the Industry

This research benefits the onion industry and those who buy or manufacture onion products by clarifying where food safety risks arise. Findings about how spoilage enhances food safety risk benefit growers, harvesters, packers, and processors of onions, including those handling both storage and non-storage varieties. Retailers, food service operators, and secondary processors who receive fresh-cut onions also benefit from research on growth in diced product. For example, these findings support risk-based decision making by helping the onion industry understand how different defects or conditions on onions may impact *Salmonella* fate. Together, these studies strengthen produce industry resiliency by improving food safety practices, reducing recall risks, and minimizing food waste.

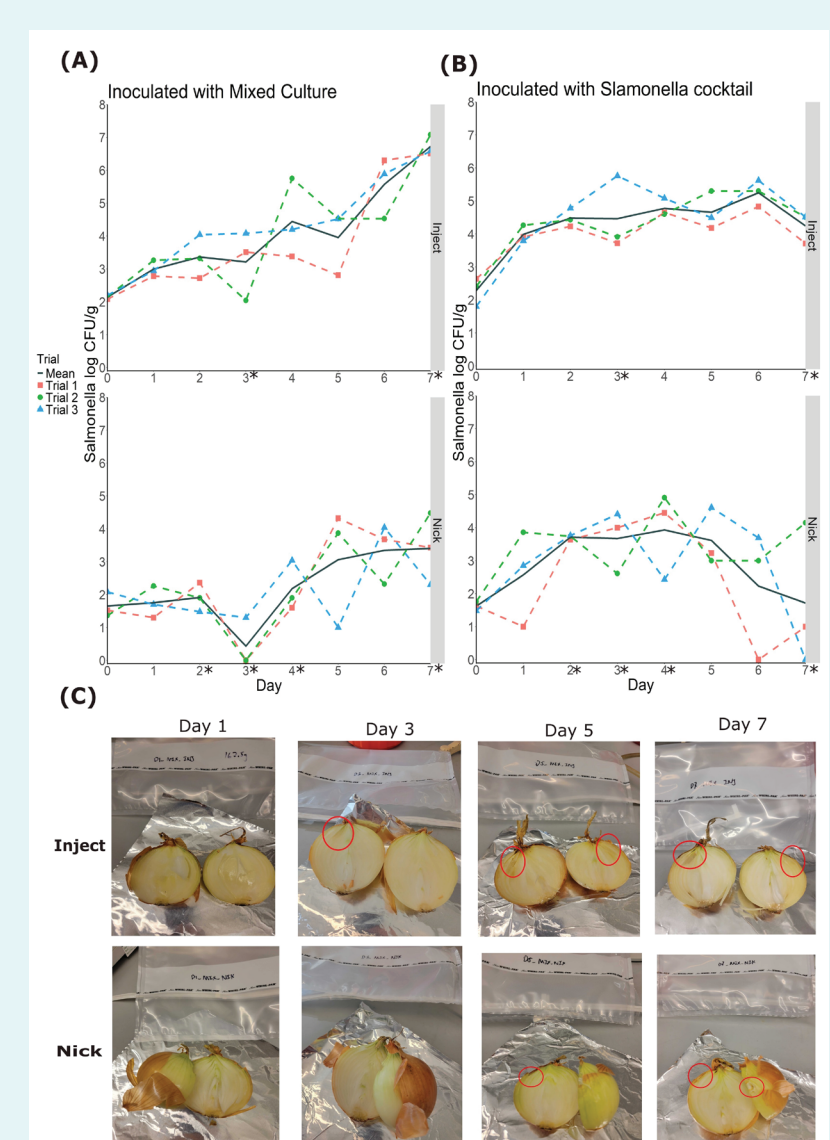


Figure 1: *Salmonella* concentration in long-day onions inoculated with either a mixed culture spoilage bacteria (*Pantoea ananatis*, *Pantoea agglomerans*) and pathogen (*Salmonella* cocktail) (A), or just pathogen (B). Two inoculation methods were used: injection (top) or a superficial nick of 0.5 cm \times 0.5 cm on the onion surface (bottom). The progression of onion rot is indicated in (C) with the red circle highlight. Onions were stored at 20°C for 7 days, and the concentration of *Salmonella* was monitored on each storage day. Asterisk (*) indicates a significant ($p < 0.05$) difference in *Salmonella* concentrations between onions inoculated with the mixed culture and onions inoculated with the *Salmonella* cocktail on the corresponding storage day.

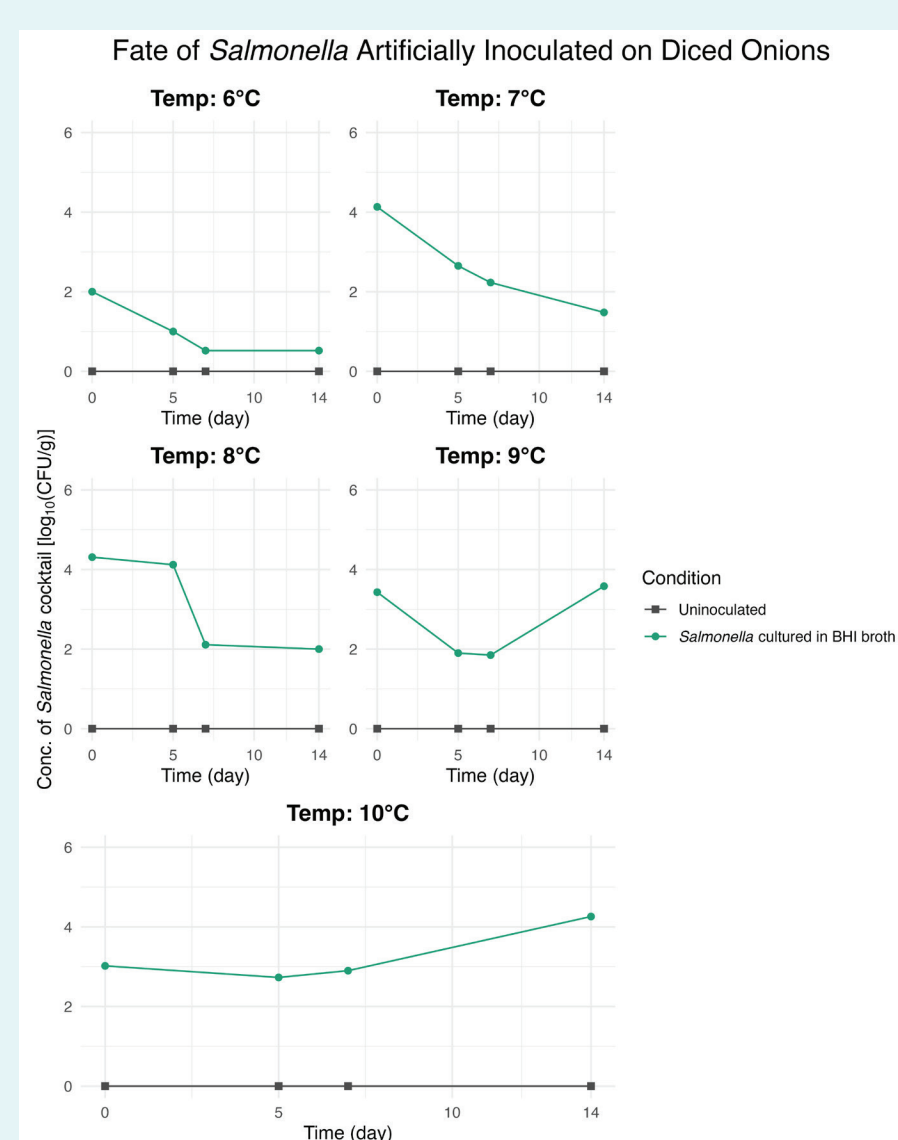


Figure 2: Fate of *Salmonella enterica* on diced long-day onions stored at 6, 7, 8, 9, and 10°C for 14 days. Concentrations of *Salmonella* were measured on XLD agar and are shown in $\log_{10}(\text{CFU}/\text{mL})$. Inoculum prepared from broth cultures is shown in green. Uninoculated controls, shown at 0 log for reference, yielded no detectable colonies on XLD. Sampling occurred on Days 0, 5, 7, and 14.

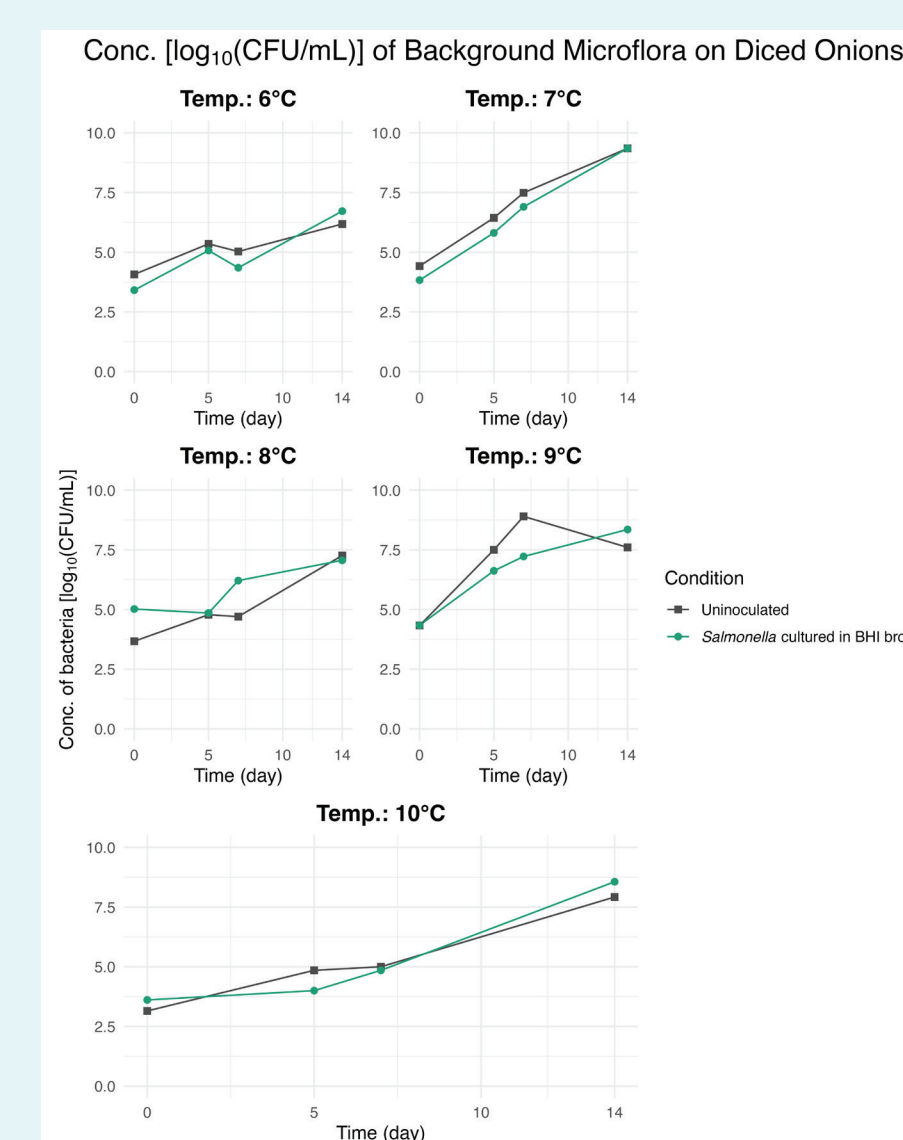


Figure 3: Total aerobic count of background microflora on diced long-day onions stored at 6, 7, 8, 9, and 10°C for 14 days. Bacterial concentrations were enumerated on SMA agar and are expressed in $\log_{10}(\text{CFU}/\text{mL})$. Green lines represent samples inoculated with *Salmonella* cultured in broth; orange lines represent samples inoculated with *Salmonella* cultured on BHI agar. Sampling was conducted on Days 0, 5, 7, and 14.

Day	pH					Brix (%)				
	6°C	7°C	8°C	9°C	10°C	6°C	7°C	8°C	9°C	10°C
0	5.60 \pm 0.01	5.60	5.77 \pm 0.02	5.79 \pm 0.01	5.79 \pm 0.00	7.05 \pm 0.07	7.20	8.00 \pm 0.00	8.30 \pm 0.10	8.30 \pm 0.00
5	5.79 \pm 0.01	5.72 \pm 0.02	6.16 \pm 0.01	5.48 \pm 0.01	5.86 \pm 0.01	6.40 \pm 0.00	6.80 \pm 0.00	6.90 \pm 0.00	7.20 \pm 0.00	6.70 \pm 0.00
7	5.72 \pm 0.01	5.26 \pm 0.05	6.11 \pm 0.01	5.69 \pm 0.00	5.81 \pm 0.01	6.35 \pm 0.07	5.60 \pm 0.00	7.10 \pm 0.00	7.27 \pm 0.06	7.00 \pm 0.00
14	5.18 \pm 0.00	5.70 \pm 0.03	5.82 \pm 0.01	5.27 \pm 0.01	5.84 \pm 0.01	6.13 \pm 0.12	4.50 \pm 0.00	6.00 \pm 0.00	5.90 \pm 0.00	6.70 \pm 0.00

Table 1: pH, water activity (a_w), and Brix (%) of uninoculated diced onions stored at 6 – 10°C for 14 days.



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