

Survival of pathogens on work-in-process fresh-cut produce ingredients

Summary

The survival of *E. coli* O157:H7, *Salmonella enterica* and *Listeria monocytogenes* on work-in-process (WIP) red cabbage, yellow onions and carrots has been studied. Results showed that washing with chlorine or peracetic acid (PAA) had limited impact on pathogen populations, when compared with water washing. PAA was occasionally more effective than chlorine in reducing populations of pathogens on WIP ingredients, although it sometimes led to subsequent higher growth rates at 12°C. Carrots had innate antimicrobial activity, especially against *Listeria*. Temperature was the most important factor in delaying the growth of pathogens and microbiota. At 4°C, pathogens, in general, did not grow or decreased during 7 days, although microbiota populations often increased. Overall, the study highlights the importance of maintaining low temperature (4°C) during WIP storage.

Objectives

1. Evaluate the survival of *L. monocytogenes*, *E. coli* O157:H7, and *Salmonella* on the surface of work-in-process (WIP) ingredients during holding time, as affected by time, temperature, sanitization, pathogen populations, microbiota, and natural antimicrobials.
2. Study the transfer of pathogens from WIP ingredients to holding containers and the reusability of holding containers.
3. Model factors contributing to *L. monocytogenes*, *E. coli* O157:H7, and *Salmonella* survival and growth on WIP ingredients, as well as pathogen transfer between holding containers.

Methods

WIP red cabbage, yellow onions and carrots, prepared from whole produce items, were, respectively, inoculated with five-strain cocktails of *E. coli* O157:H7 (EC), *Salmonella enterica* (SE), and *Listeria monocytogenes* (LM), and then washed with water, 100–10 ppm chlorine, or 80 ppm peracetic acid (PAA) for 1 min. The WIP ingredients were then stored at 4, 8 and 12°C for 7 days. Populations of inoculated pathogens, mesophiles, psychrophiles, and yeast and molds were determined on days 0, 1, 4 and 7. Statistical analyses were conducted to evaluate the significant effects of each factor on pathogen and microbiota growth. Growth potentials were calculated.

Results to Date

PAA had similar or greater efficacy in reducing initial pathogen populations when compared to chlorine; however, during storage at 12°C, LM populations on cabbage, and EC on carrots, increased more rapidly on PAA-washed samples (**Figure 1**). WIP carrots had innate antimicrobial activity, especially against LM at all temperatures, and against EC and SE at 4 and 8°C. In general, pathogens did not grow over 7 days at 4°C. However, microbiota, such as psychrophiles and yeast and mold populations, increased, even at 4°C (**Figure 2**). Over 7 days at 12°C, SE populations increased by >1 log on all three WIP ingredients; all three pathogens increased by >0.5 log on cabbage; and SE and LM increased by >0.5 log on onions (**Table 1**).

Benefits to the Industry

This research provides a scientific basis for standardizing the handling and processing of WIP ingredients, including holding time, temperature, and sanitization of WIP fresh-cut produce for each individual common WIP ingredient. Temperature was found to be the most important factor in inhibiting pathogen growth on WIP. The influences of temperature, along with sanitization washes and storage time, is now predictable for each WIP ingredient. Based on these predicted conditions, the industry can apply selected sanitizer washes, and monitor and document the temperature and time during WIP storage, to prevent pathogen growth.

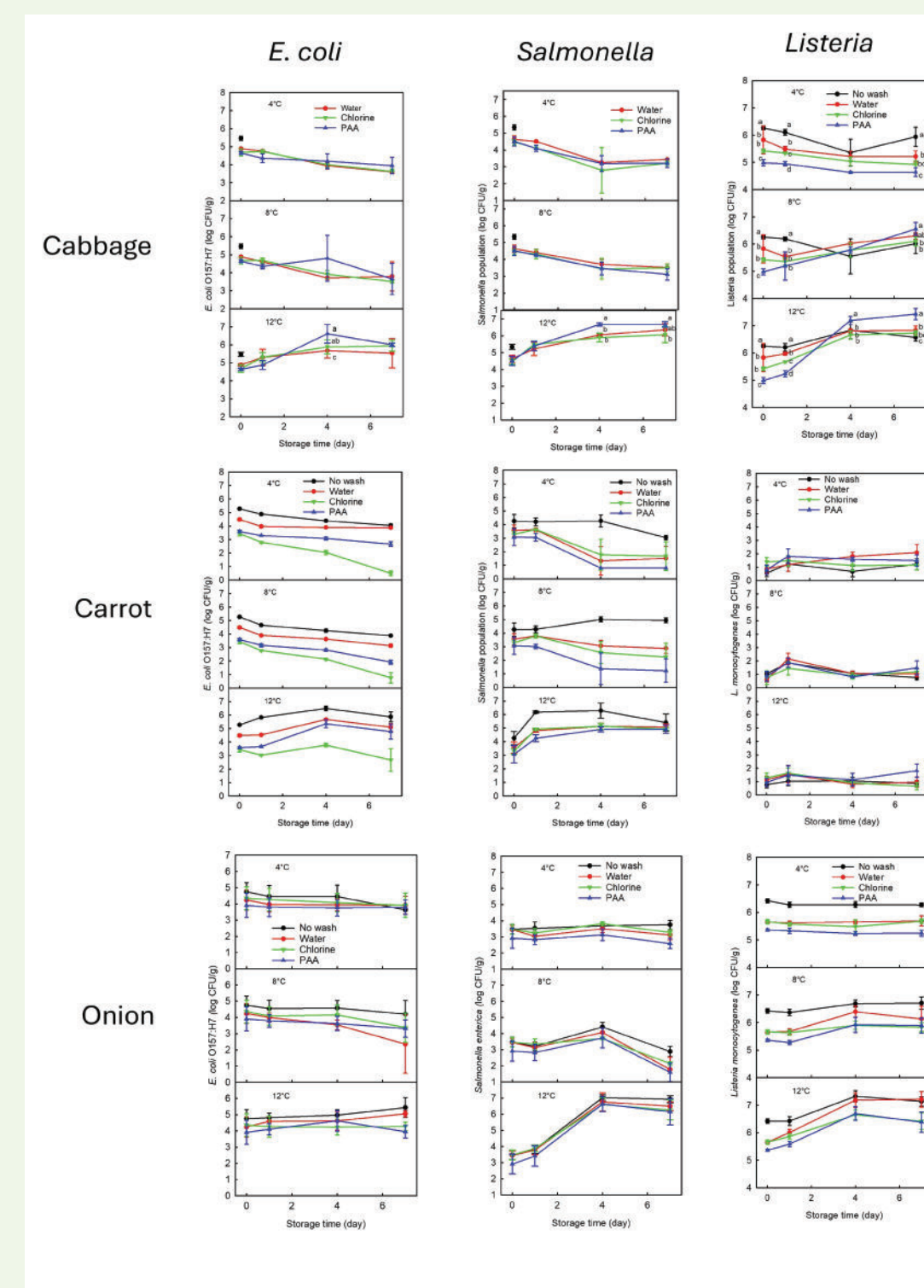


Figure 1: Changes in populations of *E. coli* O157:H7, *Salmonella enterica* and *Listeria monocytogenes* on WIP red cabbage, yellow onions and carrots during 7-day holding at 4, 8 and 12°C after washing with water, chlorine, or PAA. Vertical bars represent standard errors.

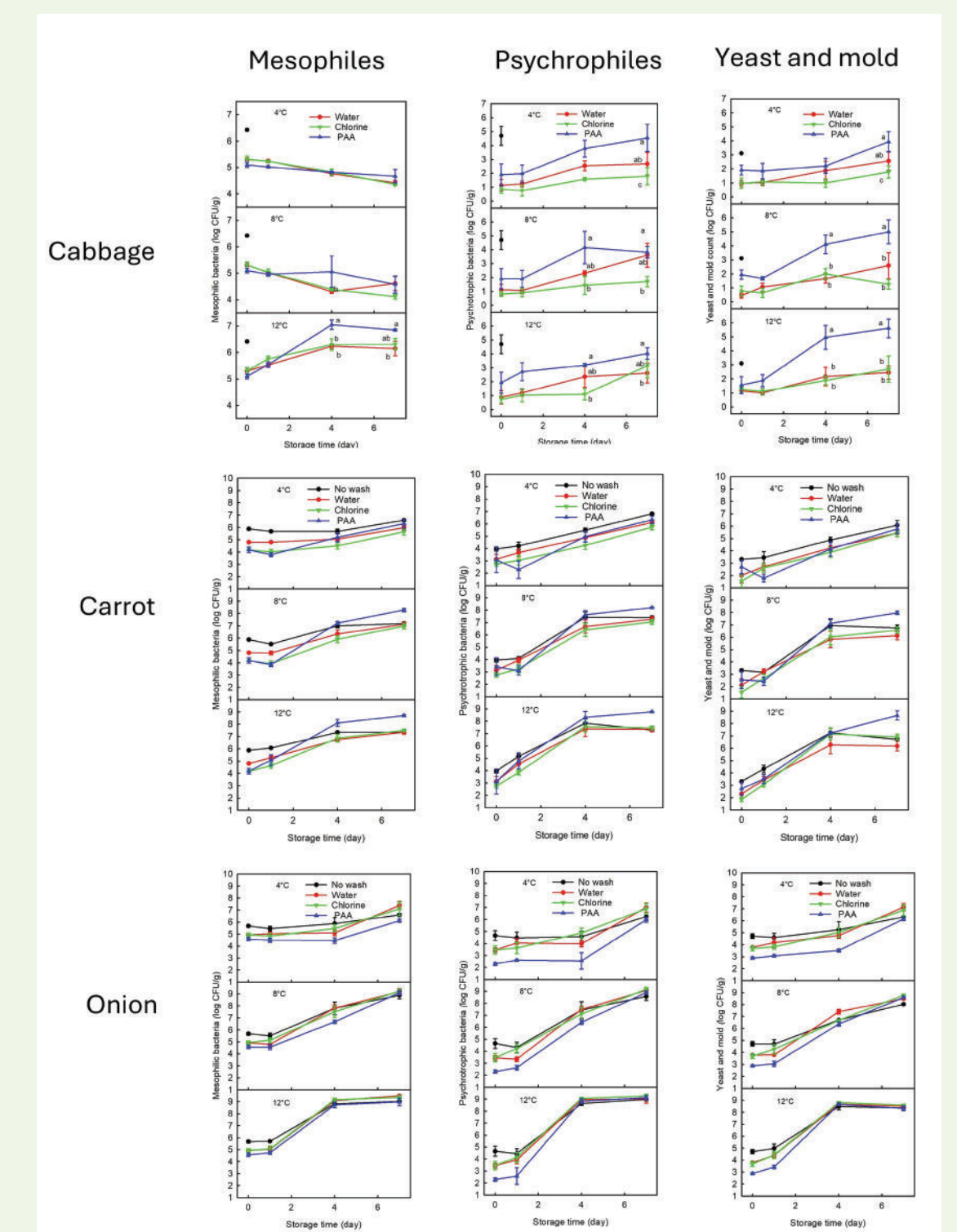


Figure 2: Changes in mesophilic, psychrophilic, and yeast and mold populations on WIP red cabbages, yellow onions and carrots during 7-days holding at 4, 8 and 12 °C after washing with water, chlorine and PAA. Vertical bars represent standard errors.

WIP item	Washes	<i>E. coli</i> O157:H7			<i>Salmonella enterica</i>			<i>L. monocytogenes</i>		
		4°C	8°C	12°C	4°C	8°C	12°C	4°C	8°C	12°C
Cabbage	Water	-1.29	-1.09	0.65	-1.19	-1.12	1.72	-0.61	0.47	1.01
Cabbage	Chlorine	-1.06	-1.17	1.26	-1.25	-0.97	1.60	-0.50	0.68	1.31
Cabbage	PAA	-0.69	-0.98	1.36	-1.29	-1.40	2.16	-0.35	1.57	2.44
Carrot	Water	-0.61	-1.35	0.62	-2.04	-0.68	1.51	1.22	0.42	-0.17
Carrot	Chlorine	-2.93	-2.67	-0.76	-1.61	-1.05	1.65	-0.24	0.44	-0.62
Carrot	PAA	-0.93	-1.67	1.19	<-2.27	-1.83	1.85	0.87	0.62	0.68
Onion	Water	-0.32	-2.11	0.81	-0.33	-1.67	3.05	0.04	0.48	1.56
Onion	Chlorine	-0.44	-0.98	-0.08	-0.19	-1.32	2.80	0.02	0.17	0.75
Onion	PAA	-0.12	-0.60	0.04	-0.33	-1.31	3.24	-0.11	0.53	1.02

Table 1: Growth potentials of *E. coli* O157:H7, *Salmonella enterica* and *Listeria monocytogenes* on WIP red cabbage, yellow onions and carrots during 7-day holding at 4, 8 and 12°C after washing with water, chlorine, or PAA. Growth potential = Population on day 7 minus Population on day 0. Numbers in red indicate the growth of pathogen populations (>0.5 logs); numbers in green indicate decline of pathogen populations (<-0.5 logs); numbers in black indicate minimal changes.



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