Validation of sanitizer disinfection of wash water in dump tank operation of apple packing lines

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Summary

During commercial processing, fresh apples are first handled by employing a dump tank and flume water system. Effective disinfection of the source water in the dump tank will be critically important to reduce the likelihood of *Listeria monocytogenes* and other foodborne pathogen contamination on apples. Despite disinfectants, such as chlorine or peroxyacetic acid (PAA), being extensively used in dump tank water, the practical antimicrobial efficacy of these sanitizers used in dump tanks has not been directly assessed. The overall goal of this study is to comparatively assess and validate critical operating parameters for commercially used sanitizers against *L. monocytogenes* in dump tank water and to further seek effective intervention methods and verify their efficacies on multiple apple packing lines.

Objectives

1. Assess efficacies of selected sanitizers to eliminate *L. monocytogenes* in wash water and cross-contamination in a simulated dump tank system.
2. Verify the selected sanitizer disinfections in representative commercial apple packing lines.

Methods

Simulated dump tank water (SDTW) was formulated using exudates from nicked fresh apples, decayed apples, and soil from an apple orchard; the level of organic matter in SDTW was adjusted to 1,000 ppm chemical oxygen demand to represent the medium organic load experienced in apple dump tank water.

Apples were inoculated with *L. monocytogenes* and held at ~22°C for 48 h before interventions. To test antimicrobial efficacy against *L. monocytogenes* on apples or assess apple-to-apple and apple-to-water cross-contamination, the inoculated apples were introduced (alone or with uninoculated apples) to sanitizer-treated SDTW. To test water-to-apple cross-contamination, the uncontaminated apples were introduced to sanitizer-treated *L. monocytogenes*-inoculated SDTW. Apples and water were sampled for survival enumeration after 2–5 min exposure.

Results to Date

Anti-*Listeria* efficacies of chlorine with initial free chlorine (FC) of 25–100 ppm were significantly impacted by the presence of organic matter, especially for the initial 25 ppm FC (**Figure 1**). At 2 min, 25 ppm and 50–100 ppm FC treatment reduced *L. monocytogenes* on apples by 0.3 and 0.9 $\log_{10}$ CFU/apple in SDTW, respectively (**Figure 1A**).

The efficacies of PAA against *L. monocytogenes* on apples at the tested concentrations, except 10 ppm, were minimally impacted by organic matter (**Figure 2**). A 2-min contact at 20–80 ppm PAA resulted in 1.2–1.7 $\log_{10}$ CFU/apple reductions (**Figure 2A**).

Sanitizer application, regardless of the type and initial concentration, reduced but could not eliminate *L. monocytogenes* transfer from contaminated water to apples (**Table 1**), or from contaminated apples to uncontaminated apples and SDTW (**Table 2**).

Benefits to the Industry

This project is expected to develop information for apple producers about the practical efficacy of antimicrobial interventions under commercial dump tank practices. The outcomes of this project will provide a foundation for validated process controls, verification of standard operating procedures, and monitoring protocols that will be accessible to the apple industry to support compliance with FSMA Preventive Controls requirements.

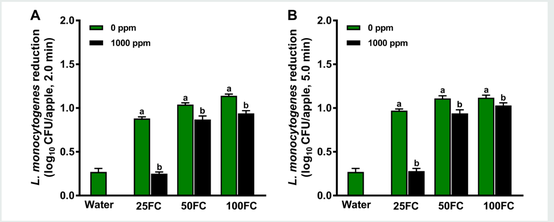

Figure 1. Efficacies of chlorine against *Listeria monocytogenes* on apples in simulated dump tank water after **A**) 2-min exposure, and **B**) 5-min exposure. Initial bacterial population was 6.46 ± 0.05 $\log_{10}$ CFU/apple. 25FC – 100FC: 25 ppm – 100 ppm free chlorine. Mean ± SEM, $n = 30$. Within each treatment, histogram bars with different superscript letters differed significantly ($P \leq 0.05$).

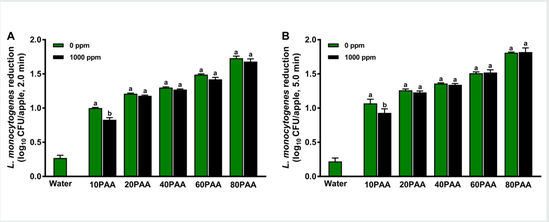

Figure 2. Efficacies of peroxyacetic acid (PAA) against *Listeria monocytogenes* on apples in simulated dump tank water after **A**) 2-min exposure, and **B**) 5-min exposure. Initial bacterial population was 6.46 ± 0.05 $\log_{10}$ CFU/apple. 10PAA – 80PAA: 10 ppm – 80 ppm PAA. Mean ± SEM, $n = 30$. Within each treatment, histogram bars with different superscript letters differed significantly ($P \leq 0.05$).

Treatments (Initial conc.)	Recovery on apples ($\log_{10}$CFU/apple)	Survivors in SDTW ($\log_{10}$CFU/ml)
SDTW	6.29 ± 0.03^{a}	6.91 ± 0.09^{a}
25 ppm FC	4.12 ± 0.03^{b}	5.45 ± 0.00^{b}
50 ppm FC	3.27 ± 0.07^{c}	2.48 ± 0.03^{c}
100 ppm FC	2.87 ± 0.06^{de}	1.83 ± 0.10^{d}
20 ppm PAA	3.17 ± 0.07^{c}	2.65 ± 0.14^{c}
40 ppm PAA	3.01 ± 0.11^{cd}	1.92 ± 0.05^{d}
60 ppm PAA	2.70 ± 0.02^{de}	1.54 ± 0.14^{de}
80 ppm PAA	2.63 ± 0.05^{e}	1.39 ± 0.01^{e}

Table 1. Transfer of *L. monocytogenes* from sanitizer-treated simulated dump tank water (SDTW) to apples after 2-min contact. Mean ± SEM, averaged from three independent studies (12 apples and 4 wash solution samples per treatment per independent study). Within columns, means with different superscript letters are significantly different ($P \leq 0.05$).

Treatments (Initial conc.)	Inoculated apple	Uninoculated apple		Washing solution		
	Reduction ($\log_{10}$CFU/apple)	Plating ($\log_{10}$CFU/apple)	Enrichment (+/total)	Plating ($\log_{10}$CFU/ml)	MF ($\log_{10}$CFU/100ml)	Enrichment (+/total)
SDTW	0.17 ± 0.01^{a}	3.62 ± 0.03^{a}	36/36	3.48 ± 0.04^{a}	/	12/12
25 ppm FC	0.25 ± 0.04^{a}	2.46 ± 0.09^{b}	36/36	1.42 ± 0.05^{b}	/	12/12
50 ppm FC	0.75 ± 0.02^{b}	1.65 ± 0.14^{c}	30/36	1.01 ± 0.09^{c}	/	12/12
100 ppm FC	1.01 ± 0.06^{c}	0.56 ± 0.14^{e}	12/36	0.40 ± 0.08^{d}	/	9/12
20 ppm PAA	1.22 ± 0.02^{c}	1.61 ± 0.16^{c}	28/36	1.35 ± 0.05^{b}	/	12/12
40 ppm PAA	1.35 ± 0.03^{d}	1.44 ± 0.15^{c}	27/36	< LOD	1.07 ± 0.12^{a}	11/12
60 ppm PAA	1.48 ± 0.02^{e}	1.00 ± 0.16^{d}	20/36	< LOD	0.89 ± 0.13^{a}	10/12
80 ppm PAA	1.70 ± 0.05^{f}	0.86 ± 0.15^{de}	18/36	< LOD	0.73 ± 0.14^{a}	9/12

Table 2. Transfer of *L. monocytogenes* from inoculated apples to uninoculated apples and process water after 2-min contact. LOD: limit of detection. MF: membrane filtration. Mean ± SEM, averaged from three independent studies (12 uninoculated apples, 3 inoculated apples, and 4 wash solution samples per treatment per independent study). Within columns, means with different superscript letters are significantly different ($P \leq 0.05$).