Processing (Post-Harvest) Water Basics

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Background

Effective water management is critical for ensuring food safety and preventing contamination in fruit and vegetable operations, regardless of whether the product will subsequently be frozen, further processed, or consumed as is. A lack of understanding of key food safety practices or mismanagement of post-harvest water can lead to foodborne illness outbreaks resulting from cross-contamination, even though antimicrobials only minimally reduce pathogens on the product.

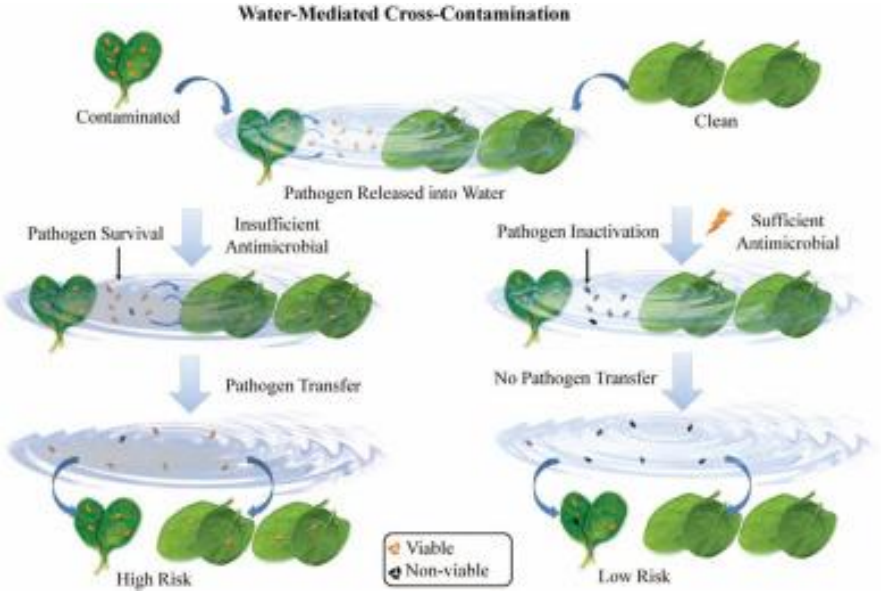
Despite post-harvest processing water often being called "wash water", it is not intended to serve as a "kill step" for the produce. Rather, water is used to remove soil (or other organic matter that a customer or consumer might find unacceptable), cool, or move produce (such as using flumes). **The primary goal of adding sanitizers to wash water is to minimize the possibility for cross-contamination to occur** (see Fig. 1). **Adding sanitizers to post-harvest water does not significantly prevent or minimize pathogens** on the fruits or vegetables. This is illustrated from Figure 1. Although this figure shows leafy greens, the principle applies to any fruit or vegetable.

Since washing produce cannot be relied upon as a microbial reduction step, other controls should be established at another stage of production (e.g., in the growing or production environment managed via a supply chain preventive control, through validated blanching, acidification, etc.). As an aside, pathogens that may be introduced through the process environment (e.g., post-process contamination with *Listeria)* should be controlled by your *cGMPs* and Sanitation Preventive Controls.

According to FDA guidance, a validated wash water system is one in which cross contamination via the water is prevented. Unlike thermal processing, validating antimicrobials in water does NOT evaluate the reduction of pathogens on the product itself.

Effective (validated) post-harvest water management must take into consideration several factors including the identification of an appropriate water source and distribution system, water treatment options, sanitation methods, and monitoring of key water quality parameters (pH, turbidity, temperature, sanitizer concentration, etc.). A summary of these key factors is described in this factsheet, along with regulatory considerations (See Appendix A) and industry guidance.

Figure 1. Illustration of microbial cross-contamination risk during washing of leafy vegetables. Figure by Y. Luo and B. Zhang from *Guidelines to Validate Control of Cross-Contamination during Washing of Fresh-Cut Leafy Vegetables*.



Water Treatment

Water treatment is an important component to managing the sanitary quality of process water. Although it is not a "kill step", for food facilities water treatment can be considered a process preventive control to minimize the likelihood of cross-contamination. Without it, the risk of cross

contamination is high so although it does not reduce pathogens, it does help control them. **The process control must use a treatment method validated for the specific application**. For sanitizers, this includes a target concentration level with minimum and maximums accompanied by descriptive SOPs to monitor, manage, and correct any deviations that occur. Water treatment may also include other methods such as ultraviolet light (UV), ozone, or filtration systems – also which need to be validated for the process control. *Note: rewashing is **not** considered an appropriate corrective action, because if cross-contamination has already occurred, rewashing will not remediate the issue.*

It is important to follow all label requirements for water treatments including sanitizers. The label is the law and should state specific commodities, uses, and concentrations. The Produce Safety Alliance maintains a sanitizer tool that can help in selecting an appropriate sanitizer and obtaining the documentation (product labels) needed. Note that FDA draft guidance for fresh-cut produce states that "any substance that is reasonably expected to become a component of food because of its intended use in wash water used during the production of fresh-cut produce (e.g., by migrating from the wash water into food) must be lawful under sections 402(a)(2)(C) and 409 of the FD&C Act". Although the language is specific to fresh-cut produce, it can reasonably be assumed to apply to frozen fruits and vegetables.

Validation & Verification of Process Water Treatments (process preventive control)

Validation of preventive controls involves demonstrating, through scientific evidence, that those controls will effectively control the identified hazards. The validation should be overseen by a Preventive Controls Qualified Individual (PCQI). For post-harvest water, validation should ensure that the water treatment method is achieving the goal of preventing cross-contamination. **It is not meant to validate a 5-log reduction or "kill step" which is not currently possible in a post-harvest water system for produce.** Validations can be based on relevant published literature or your own validation study.

To conduct a validation for process controls in post-harvest water systems, the following steps are described in FDA's draft guidance for fresh-cut fruits and vegetables in more detail (Pages 40-43):

1. Choose the commodity that you will use for validation purposes
2. Identify the target pathogen for the study (generally the one most resistant to the selected sanitizer).
3. Scientifically establish the minimum effective concentration of sanitizer in the water (using previous research studies as a guide).
4. Identify the process parameters for the validation study (e.g., sanitizer concentration, flow rates/contact time, water volumes, degree of agitation, temperature, turbidity, pH, etc. as previously discussed).
5. Conduct the validation study using the "worst case" conditions.

Table 1. Considerations for managing post-harvest water of safe and adequate sanitary quality.

EXAMPLE: Process Control Considerations – Post-harvest Water
Commodity: Strawberries
Water System: Single pass spray (initial) with peroxyacetic acid (PAA), followed by batch water dip with PAA
Target sanitizer concentration: >30ppm and <80ppm PAA in both spray and batch water
Contact time: 30 seconds spray bar, 90 seconds batch water
Pathogens of concern: *E. coli* O157:H7, *Salmonella, Listeria monocytogenes*
What to monitor: PAA concentration, pH and temperature of water
Frequency of monitoring: Continuous (automated system), plus twice per shift titration by QA technician
Corrective Actions: • Empty the processing line and discard the product back to the last time the monitored parameters were within the critical limits. • Clean and sanitize all affected post-wash food contact surfaces • PCQI takes steps to determining (if possible) what caused the PAA concentration to drop below the critical limit so that actions can be taken to prevent such occurrences from happening in the future • Replace non-functioning sensor(s) when applicable
Scientific literature to support validated method: Ortiz-Sola et al 2022 (used 40 ppm PAA, 2 min contact time, *Salmonella*) Pathogenic potential of surviving Salmonella Enteritidis on strawberries after disinfection treatments based on UV-C light and peracetic acid - PubMed

Once validated, verification activities are required to ensure that the preventive controls are consistently implemented and effective in minimizing hazards. Verification activities may include activities such as checking the accuracy of sensors used to monitor sanitizer concentrations and other parameters that must be measured to maintain an effective process (e.g., pH, turbidity, etc.), the PCQI reviewing process records documenting sensor readings, or verification of sanitizer levels using titration kits, just as a few examples. If the process changes (e.g., you increase the line speed), the validation will need to be re-done.

Process Water Best Practices

Water Source & System

- **Start with clean water:** What does clean mean? Water must be free of generic *E. coli* (also referred to as 'potable' water – though potability includes additional quality parameters).
- **Test water sources:** Water quality can be evaluated through testing. For municipal/public water supplies, annual system results or certificates of compliance should be kept on file. Some facilities will still test public water supplies at the point of use to ensure that no contamination is being introduced by the distribution system itself. For ground water sources (e.g., wells), initial testing should include 4 tests per year, and one every year thereafter (barring any abnormally high test results). Do not use untreated surface water for post-harvest activities that contact produce or food contact surfaces.
- **Evaluate the water application method:**
    - **Single pass water** (e.g., spray bar) – though the risk of cross-contamination is lower with single pass water, it is recommended that a sanitizer still be added to the water to reduce potential build-up of microorganisms on equipment and food contact surfaces.
    - **Batch water** (e.g., flumes, dump tanks) – treatment of any water that will contact multiple pieces of produce is crucial since cross-contamination is much more likely to occur in a batch water system (see Fig. 1 above). Typically, appropriate water quality is achieved through the addition of a sanitizer with specific monitoring steps and parameters for maintaining

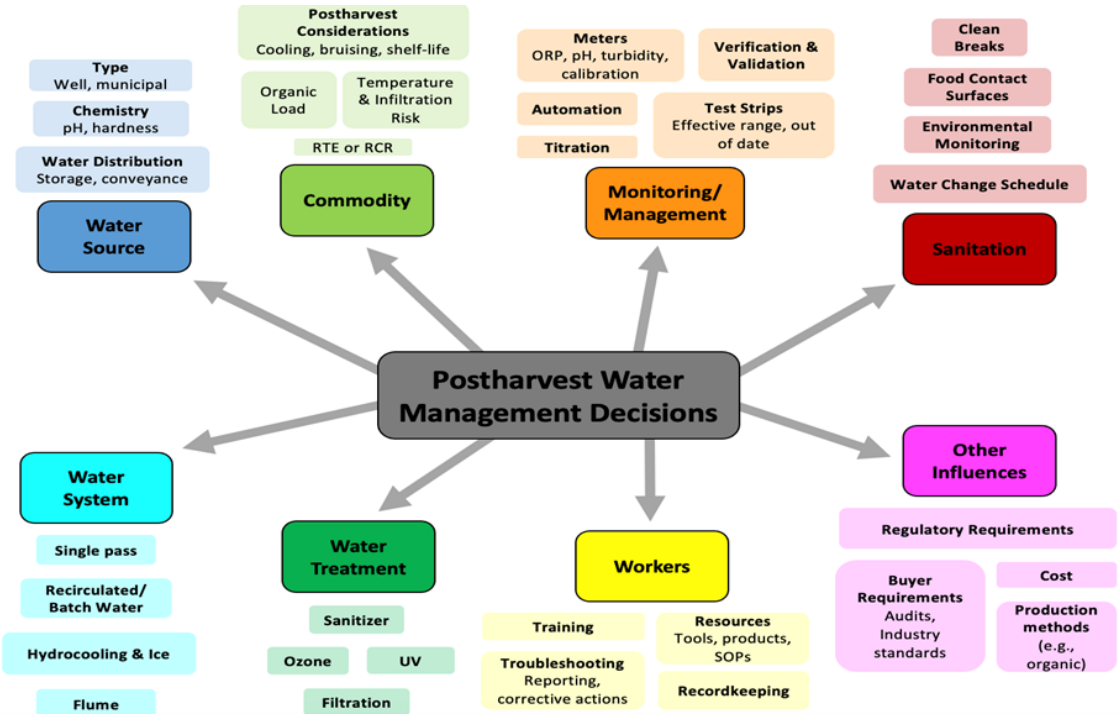
sanitizer concentration. Batch water can also be treated by other mechanisms, such as through UV or ozone. Regardless of the type of treatment, all methods should be validated for the specific equipment, system, and commodity.

- **Recirculated** (e.g., reused/recaptured) – some systems may recapture water used (such as through single pass spray) for efficiency and cost savings. It is important to treat this water like batch water since it also has a higher potential to cross-contaminate produce.

Water Quality Parameters

The following parameters must be evaluated and managed to ensure the safe and adequate sanitary quality of post-harvest water. Additional post-harvest water management decisions may be impacted by a variety of other factors (see Fig. 2).

Figure 2. Post-harvest water quality management decisions. Developed by G. Wall, L. Strawn, and K. Schneider for use in the Produce Safety Alliance Advanced Training.



- **Turbidity** – is a measure of clarity in the water and used to help determine when the water should be changed. With water that contacts produce repeatedly (such as batch or recirculated water), the sanitary quality of the water may be more difficult to maintain due to the build-up of organic matter (e.g., leaves, soil, plant exudates). Turbidity meters or established water change schedules are recommended.
- **pH** – can impact the efficacy of certain types of sanitizers. Be sure to read the label of any water treatment to ensure that the water pH is within the target range. pH can be adjusted in post-harvest water systems using food grade pH adjusters (such as citric acid or alkaline solutions). For example, chlorine is most effective in a pH range between 6.5-7.5.
- **Temperature** – can impact the potential for infiltration to occur in certain commodities (such as tomatoes, apples, melons, mangoes, avocadoes, and oranges). Infiltration occurs when the pulp temperature of the produce is warmer than the water. This can lead to compression of the air spaces inside susceptible produce commodities, creating a vacuum effect and drawing water inside. A 10°F (ten degree) difference is the typical benchmark, however the commodity and the wash system will also impact the likelihood for infiltration to occur, so 10°F (ten degrees) should not be used as a 'safe harbor' without further evaluation of the overall system and commodity considerations.

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Appendix A: Regulatory Requirements

Depending on the type of operation, two rules within the Food Safety Modernization Act (FSMA) may apply - ‘‘Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption’’ (Produce Safety Rule) and ‘‘Current Good Manufacturing Practice, Hazard Analysis, and Risk-Based Preventive Controls for Human Food’’ (Preventive Controls Rule for Human Food). The Produce Safety Rule applies primarily to raw agricultural commodities that are not further processed and may be eaten raw. The Preventive Controls Rule applies to facilities that cut, peel, or otherwise processed fruits and vegetables, but they may also be ready-to-eat.

Table 2. High level summary of regulatory requirements with application in produce packinghouses and food facilities related to post-harvest water management.

Produce Safety Rule	Preventive Controls Rule
Post-harvest water meets the definition of 'agricultural water' and therefore is subject to the requirements outlined in Subpart E	Identify hazards associated with post-harvest water system (both the water source and wash system) and implement preventive controls for the identified hazards.
Inspect agricultural water systems at least once per year and document	For **ground water sources** hazards might include: Bacterial pathogens (*Salmonella*, STECs, *Listeria*, human viruses, and parasites). Chemical contamination may also be a concern from heavy metals or agricultural chemicals used in the environment. For single pass or batch/tank wash water hazards might include: Bacterial pathogens (*Salmonella*, STECs, *Listeria*, human viruses, and parasites) either from cross-contamination within the system or from the original source.
Post-harvest water must be the quality standard of no detectable generic *E. coli* per 100 mL sample • If a public water supply is used, just the system results or certificate of compliance is required to demonstrate the water meets this water quality criterion • If untreated ground water (such as a well) is used, the water must be tested at least four times in the initial year of use, and once every year thereafter. • Untreated surface water cannot be used for these purposes.	Water used for washing, rinsing, and conveying food must be safe and of adequate sanitary quality. Water may be reused for washing, rinsing, or conveying food if it does not cause an increase in the level of contamination of the food.

If a test result shows presence of generic *E. coli* or you have other reason to believe the water is not safe, corrective measures can be implemented: • Reinspect the entire water system and take corrective actions to address contamination sources or issues • Treat the water • Confirm changes were effective to achieve no detectable generic E. coli in 100 mL	Establish Process Preventive Control(s) to significantly minimize the risks associated with post-harvest water. Options might include the use of an approved sanitizer at a specific concentration or another validated method such as UV or ozone treatment.

IMPORTANT NOTICE:

This document represents a user-friendly comprehensive guide designed to assist members of the American Frozen Food Institute (AFFI) with reviewing and understanding the basics of wash water (process water) used in post-harvest processing of fruits and vegetables in the frozen fruit and vegetable industry. Nonetheless, members are cautioned that this guidance does not purport to provide fail-safe solutions for all issues related to sanitation, sanitary design, environmental monitoring and process validation. While the guidance endeavors to present current industry food safety practices, it is not intended to be a substitute for careful review or analysis of the food safety risks as it relates to each member's own products and operations; nor does adherence to this guidance ensure compliance with applicable statutory and regulatory requirements. **THIS DOCUMENT PROVIDES GENERAL INFORMATION AND GUIDANCE BUT IS NEITHER INTENDED AS NOR DOES IT CONSTITUTE LEGAL ADVICE.** AFFI does not guarantee the accuracy, adequacy or completeness of any information provided in this guide and is not responsible for any errors or omissions or for any results obtained from the use of such information. AFFI gives no express or implied warranties, including but not limited to, any warranties of merchantability or fitness for a particular purpose or use. In no event shall AFFI be liable for any indirect, special or consequential damages in connection with any use of this guidance. **CONTACT: For questions about this guidance, please contact AFFI's Sr. Vice President of Scientific Affairs, Sanjay Gummalla (sgummalla@affi.com)**

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