Section 9: Postharvest Sanitation

Appropriate sanitation throughout harvest and postharvest activities is a vital component of a good postharvest management plan. As food safety regulations become increasingly important to the sales of crops in direct, wholesale, and retail markets, the establishment of proper measures to minimize the potential of contamination by foodborne pathogens is essential. In addition, proper sanitation during postharvest handling can also minimize the occurrence of postharvest disease and decay, ensuring the maintenance of produce quality throughout the entire period that it is stored.

Although often used interchangeably, the terms 'disinfectant' and 'sanitizer' differ in their official definitions (see sidebar). According to the United States Environmental Protection Agency (EPA), a disinfectant destroys or irreversibly inactivates fungi and bacteria, but not necessarily their spores[1]. Sanitizers reduce, but do not necessarily eliminate, microorganisms to levels considered safe as determined by public health codes or regulations.

Sanitizers and cleaners can be used on both food and equipment surfaces. A food contact surface can be defined as a surface that comes directly or indirectly into contact with food (i.e., preparation tables, spinners, containers, belts, washers, etc.) Although some overlap does exist, some products and active ingredients are specific for the sanitizing of equipment while others can be used for both food surfaces and equipment surfaces. It is important to check the label to be sure the product is used correctly and in accordance with the appropriate regulations.

Sanitizing is a multistep process that involves cleaning, rinsing, product application, and sometimes further rinsing. The initial step of sanitizing produce involves the removal of surface dirt and debris present at harvest.

Cleaners, Sanitizers, and Disinfectants

Although the terms are often used interchangeably, the words "cleaner", "sanitizer", and "disinfectant" describe products that differ in their specific characteristics and uses, and they should not be used interchangeably.

Cleaners or detergents assist in the physical removal of soil, debris, dust, organic matter, and microorganisms, such as bacteria, viruses, and fungi. Rinsing is an essential step in cleaning – the main purpose of a cleaner is to help rinsing be more effective.

Sanitizers reduce the amount of microorganisms on surfaces (both produce and equipment surfaces) to levels that are considered safe for human health, but do not completely eliminate them. The FDA and EPA define a sanitizer as a compound that is capable of killing 99.999% or a 5-log reduction of infectious organisms in a bacterial population within 30 seconds.

Disinfectants completely destroy all specific test organisms in 10 minutes under conditions of the AOAC Use Dilution Test.

The same compounds may function as either a sanitizer or a disinfectant at different concentrations of the active ingredient and/or length of exposure times. In general, produce is sanitized, while food contact surfaces can be sanitized or disinfected.

Soil and organic matter can be gently wiped from the produce at picking, with a prewash rinse step performed in the field or packing shed if organic matter, dirt, and debris remain. Cleaning steps may vary depending on the amount of dirt and debris on the produce and the appropriate postharvest handling related to the tenderness and perishability of the crop.

Similarly, when sanitizing equipment or food handling surfaces, the first step will involve the removal of any accumulated dirt and debris. Surfaces should be rinsed to remove organic matter and other materials, physically cleaned as appropriate with a detergent, and then rinsed again to remove the detergent, which can inactivate many sanitizers. The application of an appropriate sanitizer occurs after these initial steps. When investing in the purchase of equipment, items with smooth surfaces such as stainless steel should be selected, as these surfaces can be more effectively cleaned and sanitized.

Specific Examples of Sanitizers

Peroxyacetic Acid

Peroxyacetic acid (PAA) is an increasingly popular sanitizer for use on produce, particularly for organic producers. As with chlorine-based sanitizers, Peroxyacetic acid's mode of microbe-killing action is through oxidation. Peroxyacetic acid sanitizers are a mixture of the peroxy compound, hydrogen peroxide and acetic acid. The ingredients decompose into acetic acid, water, and oxygen. In addition to safety, PAA has several other advantages, including:

- Low reactivity with organic matter and soils, assuring consistent dosage is available for microbial control.
- No pH control necessary, allowing for effective microbial control at acid to slightly alkaline pH.
- Broad applicability to all vegetables and fruits, both whole and cut.
- No rinse required.
- Single product, ready-to-feed liquid; requires no precursor chemicals or on-site generation equipment.
- Controls fruit and vegetable surface microbial activity so product spoilage is minimized and shelf life is enhanced.

PAA can be used to sanitize produce, wash water, and food contact surfaces. However, different formulations of PAA are used in particular situations. SaniDate 5.0 (www.biosafesystems.com) and Tsunami 100 (www.ecolab.com) are two popular brands of PAA, but growers and processors must be aware of the appropriate applications as directed by the product labels. Tsunami 100 is used for pathogen reduction in fruit and vegetable processing water and is appropriate for the sanitation of produce. It can be used in both batch and continuous operations. Tsunami 100 reduces 99.9% of the pathogens causing foodborne illness (including *Escherichia coli O157:H7*, *Listeria monocytogenes* and *Salmonella enterica*), and it controls spoilage and decay on the surface of produce. Tsunami 100 is not labeled for use to control microorganisms on hard surfaces such as tanks, lines, flume surfaces, or food processing equipment. Consult the label for appropriate rates and contact times. Test kits are available through Eco-lab to ensure the proper concentration of the active ingredients are achieved and maintained.

Alternatively, SaniDate 5.0 is a peroxyacetic acid-based sanitizer/disinfectant that can be used directly on produce as well as on pre-cleaned, hard, non-porous, food contact surfaces and equipment. Examples of such equipment include harvesting equipment, filters, floors, walkways, walls, tables, chairs, benches, countertops, cabinets, bathroom fixtures, sinks, shelves, racks, crates, carts, trailers, vehicles, conveyors, refrigerators, coolers, fan blades, drains, piping, process water, transfer and handling systems, filter housings, vats, tanks, pumps, valves and systems. SaniDate 5.0 is effective against fungus, mold, and bacteria such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Salmonella choleraesuis*, *Salmonella enteriditis*, *Salmonella typhimurium*, *Proteus vulgaris*, *Streptococcus pyogenes*, *Enterobacter aerogenes*, *Lactobacillus*

maefermentans, *Pediococcus damnosus*, *Listeria monocytogenes*, *Klebsiella pneumoniae*, and *Escherichia coli*.

SaniDate 5.0 can be injected directly into spray system water on process and packing lines to prevent bacterial and fungal diseases from causing spoilage and decay, and to prevent the spread of human pathogenic organisms on postharvest fruits and vegetables. Consult the product label for appropriate rates. Product concentrations must be maintained at the appropriate predetermined residual level (again, consult the label for specific instructions) by using metering equipment, coupled with ORP measuring probes.

Federal regulations (Title 21, Code of Federal Regulations Parts 173 and 178)[2] specify the conditions at which these compounds can be used. Follow the product label for appropriate allowed use.

Both Tsunami 100 and SaniDate 5.0 are OMRI-approved for organic producers.

Chlorine

Chlorine is a very common sanitizer used in postharvest and food production applications. These products have the benefit of a long history of use and low cost. Chlorine can be used to directly sanitize produce, as well as to sanitize food contact surfaces. Chlorine for disinfection is available as three products: solid (calcium hypochlorite $Ca(OCl)_2$), liquid (sodium hypochlorite NaOCl or common bleach), and gas (chlorine Cl_2).

Federal regulations (Title 21, Code of Federal Regulations Part 173) specify two conditions for the allowed use of hypochlorite solutions in washing produce:

- The concentration of sanitizer in the wash water must not exceed 0.2% (2,000 ppm) hypochlorite.
- The produce must be rinsed with potable water following the chlorine treatment.

Chlorine can also be used to sanitize equipment. Federal regulations (21 CFR Part 178) permit the use of sanitizing solutions containing sodium hypochlorite on food processing equipment and food contact articles with the following conditions:

- Solutions are used, followed by adequate draining, before contact with food.
- Solutions used for sanitizing equipment shall not exceed 200 parts per million (ppm) available chlorine.

Chlorine can exist in different forms depending on the pH of the water. To maximize the concentrations of the chlorine forms that are most effective and minimize the potential for equipment corrosion, the pH of the solution should be adjusted to a pH of 6.0-7.5 with organic (citric) or inorganic acids (muriatic or phosphoric) as appropriate. Acids used for pH adjustment must be food grade. Care must be taken to add the appropriate amount of acid or base as to not exceed this range in either direction.

Some important points about using chlorine:

- As with all postharvest washing, grading, and cooling operations, only potable water should be used.
- Produce should be clean (prewashed), and organic matter/debris should be removed from the water for effective sanitation; the presence of dirt and debris will decrease the efficacy of the product.
- Chlorine bleach for sanitizing solutions must be food grade – fragrances, thickeners, and other additives common to household bleach cannot be included.
- Any farmer discharging water, such as from a hydrocooler, must comply with the Safe Drinking Water Act. Chlorine concentrations at the discharge/effluent point may not exceed the Maximum Residual Disinfectant Limit (MRDL) of 4mg/L for chlorine and 0.8mg/L for chlorine dioxide.

To ensure correct use of chlorine as a sanitizer, it is important to understand that chlorine in solution can exist in multiple forms, depending on the amount of suspended particulates in the wash water. Free chlorine (also called reactive or available chlorine) describes the form of chlorine capable of disinfection. When produce is added to wash water, though, the free chlorine can combine with dirt, organic matter, and microbes in the water. These combined forms of chlorine are much less effective disinfectants. Total chlorine refers to both free chlorine and combined chlorine; measuring the amount of total chlorine in wash water will not provide an accurate assessment of the sanitizing capability of the water, particularly once washing and hydrocooling processes have begun. Because of the changes that occur in the forms of chlorine present in wash water as it is used (and hence the sanitizing power), monitoring chlorine concentrations appropriately throughout washing and hydrocooling is essential to optimize sanitation practices.

Monitoring chlorine levels in solution can be done with test paper strips, colorimetric kits, or electronic sensors. The frequency of monitoring required depends on how dirty the water is – the presence of a lot of dirt and suspended materials will necessitate more frequent monitoring. Be sure the kit specifically tests for available chlorine, which is responsible for sanitation. Dilution of the water might be necessary to obtain accurate test results; the specific instructions will provide the range at which the kit reads accurately.

Chlorine use in organic production

The United States Department of Agriculture National Organic Program (USDA-NOP) allows for the use of chlorine as a sanitizer as per 7 CFR 205.601(a)(2), 205.603(a)(7) and 205.605(b) of the National List of Allowed and Prohibited Substances:

"(Chlorine is) allowed for disinfecting and sanitizing food contact surfaces. Residual chlorine levels for wash water in direct crop or food contact in flush water from cleaning irrigation applied to crops or fields cannot exceed the maximum residual disinfectant limit (MRDL) in the Safe Drinking Water Act (currently 4 mg/L)."

Certified organic operations should check the approved materials list to ensure that any compound used for pH adjustment is allowed by the National Organic Program.

As with all steps in organic production, it is important to keep accurate records when using bleach as a sanitizer and/or disinfectant. Certified organic operations should monitor and keep records to document that the chlorine concentrations of water coming in direct contact with produce remains at levels permitted by the FDA and EPA for these purposes. Additionally, the chlorine concentrations at the point where the water last contacts the organic product must also be monitored and documented so that it does not exceed the maximum residual discharge level (MRDL) for chlorine (4 mg/L). Similarly, when chlorine materials are used to sanitize food contact surfaces, residual chlorine levels in the discharge water may not exceed the MRDL. Initial concentrations of chlorine used for sanitation, however, can exceed 4 mg/L.

Individual certification agencies may have more stringent regulations regarding the use of chlorine. Depending on your certifier, an additional rinse of the produce with potable water or dilution of the produce wash water may be required before discharge. Contact your certifier before chlorine is used as part of the organic system plan.

Quaternary Ammonium Compounds (Quats)

Quaternary Ammonium Compounds (Quats) are not approved for direct food contact, but can be use for the sanitation of walls, floors,

drainage, equipment, and other food contact surfaces in the packing shed or processing plant. Examples of these products include benzalkonium chloride, octyl decyl dimethyl ammonium chloride, and dioctyl dimethyl ammonium chloride. These compounds have several advantages over other sanitizers, including: stability at high temperatures; not corrosive to metals; effective against yeast and molds; relatively stable in the presence of organic matter; and effective across a wider pH range of 6-10. If concentrations above 200 ppm are used, a rinse step is recommended.

Quats are restricted in organic production due to their persistence and potential to contaminate produce. An organic producer wishing to use quats would need to demonstrate in their organic system plan that the quat compound would not leave residues that would get in or on processed products. A food contact surface sanitized with a quat must be washed with a detergent/high-pressure hot water rinse and/or a product purge must occur to effectively remove any residue; these procedures must be documented by the producer. Residue testing is required, with a result of 0 ppm. Contact your certifier for the specific protocols that they would require.

Monitoring Levels of Sanitizer in the Wash Water[3]

A critical element of a sound sanitation plan is the ongoing monitoring of sanitizer in wash water. Monitoring sanitizer concentrations in solution can be done with test paper strips, colorimetric kits, or electronic sensors. The frequency of monitoring required depends on the cleanliness of the incoming produce and amount of suspended particulates in the water – the presence of a lot of dirt and suspended materials will necessitate more frequent monitoring.

Chlorine concentrations should be checked both at the initial addition of chlorine to the wash water as well as at regular intervals throughout produce washing. The amount of chlorine recommended for the initial dosage (generally between 50-200 ppm) should be double-checked through the use of test strips for free chlorine. Be sure to monitor pH along with chlorine throughout the wash period. When monitoring chlorine throughout the wash period, it is necessary to measure the amount of free chlorine in the wash water. Maintenance of free chlorine at levels of 20-25 ppm is generally adequate for decreasing both postharvest and foodborne illness pathogens to satisfactory levels. Be sure to use test strips specific for free chorine for this purpose.

Peroxyacetic acid concentrations in the wash water are measured similarly as described for chlorine. Test strips are available to measure peroxyacetic acid concentrations. Typical concentrations of 40-80 ppm of *Peroxyacetic acid* should be present throughout the wash process. PAA is not as sensitive as chlorine to suspended solids in the wash water; however, concentrations should still be monitored on an hourly basis, or more frequently if wash water is particularly dirty. Monitoring intervals can be extending once experience and documentation regarding maintenance of steady PAA levels is obtained.

Keys to success in monitoring wash water (adapted from Suslow, 2012[4]):

1. Be sure to use test strips in the right range for the expected dose/result (may need to dilute your sample to ensure that the concentration of sanitizer is in the appropriate range of the test strips).
2. Verify that the strips have not expired – mark on the container when the strips were purchased and opened.
3. Use single-test (not multi-test strips) and be sure they are for the correct purpose (i.e., free chlorine vs. total chlorine).
4. Be sure to sample a representative and adequate volume of wash/hydrocooling water (about 100 ml, or 4 ounces, is a sufficient volume).

5. Be sure to test for the length of time specified on the package.
6. Wait a few minutes before taking the initial measurement.
7. Check the level of sanitizer (particularly chlorine) every 30 minutes to one hour during the wash period (test more frequently if produce/wash water is dirty) – with chlorine use, be sure to also continue to monitor pH levels.
8. Document when and how much sanitizer you add throughout the wash period – include the date and time of testing, the name of the person doing the test, test results and any action taken as a result of testing.

Other Cleaners and Sanitizers Allowed for Organic

The National Organic Program regulates the use of sanitizers in organic postharvest handling and processing. With the use of sanitizers that will directly contact food surfaces, all ingredients, including inerts (as listed at §205.605 - §205.606), must be used appropriately in accordance with the regulations. Examples of allowed active ingredients that can be used for direct contact with produce include chlorine, hydrogen peroxide, potassium carbonate, sodium bicarbonate, sodium hydroxide, ozone, and peroxyacetic acid (all inert ingredients must be reviewed and approved at §$205.605-205.606). In addition, any of the products listed for direct food or product contact can be used on equipment without rinsing.

Other products can be used in organic production on equipment with the inclusion of a rinsing or purging step (such as a hot water rinse) to ensure that the substance is not in contact with organic food (see 7 CFR §205.272). These active ingredients include alkali cleaners, trisodium phosphates, tetrapotassium diphosphate, sodium hydroxide, sodium carbonate, acidic cleaners, iodophors, 1-octanesulfonic acid, sodium salt, and octanoic acid.

If you are an organic producer including the use of a cleaner or sanitizer in your organic system plan, please consult with your certifying agency before use.