Wash Water Chlorine Disinfection:

Best Practices to Ensure On-Farm Food Safety

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Washing fresh produce with potable water treated with a sanitizing agent can reduce microorganisms and pathogens that may be on the surface of the produce. Washing techniques and quality of water may affect the safety of the produce. Sanitizers must be used to minimize cross-contamination if the produce is washed together in a dump tank.

Potential problems include post-harvest rot and decay microorganisms, such as spoilage bacteria and yeast, Botrytis, penicillium and mucor as well as foodborne pathogens, such as *E.coli, Cyclospora, Listeria*, and *Salmonella*.

Chlorine can be used in wash water for apples, nectarines, plums, cherries, grapes (or muscadines), leafy greens, peppers, tomatoes, peas, melons, cabbage, green onions, cucumbers, zucchini squash and root vegetables, like carrots, sweet potatoes and others.

Do not wash or disinfect berries, such as strawberries, blueberries, blackberries or raspberries. While peaches and pears can be washed and sanitized, care must be taken because these fruits easily bruise and the washing process can damage the fruit and increase the chances of post-harvest decay.

How to wash and disinfect fresh produce with chlorine

In small- to medium-scale farms, produce can be washed using the immersion type of triple-wash system with circulating or non-circulating water. In either case, sanitizer is essential to reduce the risk of cross-contamination between produce during washing.

The triple-wash system of produce includes successively washing the produce in three dump tanks containing sanitizing solutions. Briefly, the produce is dumped in the first wash tank to remove the excess soil and debris from produce and then transferred to the second dump tank for further cleaning and then to the third dump tank for the final wash. When produce is dumped in the first tank, it should be in contact with the sanitizing solution for at least one minute. Depending on the type of produce it should be dipped, re-dipped, agitated or any suitable procedure necessary to remove soil from produce. The first two dump tanks should have higher chlorine concentrations (depending on the crop type) because organic matter, like soil, coming off the produce depletes the free chlorine rapidly. For final rinsing, potable water is generally used; however, adding a small amount of chlorine (target 5-10 parts per million free chlorine) in the final, i.e., third wash tank, will prevent buildup and cross-contamination of pathogens to produce.

General procedure of washing produce:

Step 1. Remove soil and other types of organic debris from the surface of the produce before treating the product. Soil and organic debris reduce the effectiveness of chlorine. Before treating the produce with chlorine, rinse with potable water.

Step 2. Measure the temperature of your wash water. Wash water should be cool but not cold. Chlorine is most effective when water temperatures are between 55 and 120 degrees Fahrenheit. The wash water should not be more than 10 degrees Fahrenheit cooler than produce. When washing tomatoes, peppers, melons or other produce with large stem scars, the water temperature should be at least 50 degrees Fahrenheit higher than interior temperature of the produce. If the water is colder than the produce, plant and human pathogens can be sucked into the fruit. Chlorine cannot kill pathogens that are inside the fruit. Holding produce with large stem scars for four to five hours before washing will allow the scars to heal and reduce the potential for pathogen intake.

Step 3. Measure and mix chlorine into potable water. The amount of chlorine you add to your water depends on the concentration you want to achieve, and the desired concentration is crop dependent. If you are using household chlorine bleach (5.25-6.25 percent hypochlorite), avoid the "splashless" or scented formulations. It is important to make sure that sanitizers to be used in wash water should be of food grade. Furthermore, sanitizers with EPA labels are encouraged for use. The following table provides the ranges of chlorine concentrations that should be used to disinfect different types of produce. A minimum contact time of one minute is recommended to ensure the pathogens are killed.

Produce type	Free chlorine strength (ppm)
Apples	100-150
Cabbage, leafy greens	100-150
Carrots	100-200
Celery	100-150
Cucumbers	100-150
Green onions	100-150
Lemons	40-75
Oranges	100-200
Peaches, nectarines, plums	75-150
Pears	200-300
Peas (pod type)	50-100
Peppers, tomatoes	200-350
Potatoes (red or brown)	200-300
Spinach	75-150
Sweet potatoes	100-150

Source: Suslow, T.V., 2000

Assuming a concentration of 5.25 percent hypochlorite in chlorine bleach, use the following volumes to achieve a concentration of 65-400 parts per million chlorine.

Amount of chlorine bleach/gallon	Free chlorine strength (ppm)
1 teaspoon (5 mL)	65
1 tablespoon (15 mL)	200
1 fluid ounce (30 mL)	400

Calculations:

$$\textit{volume of bleach} = \frac{(\textit{desired strength of free chlorine in wash water} \times \textit{volume of wash water})}{(\textit{concentration of bleach})}$$

To note, 1% = 100 ppm, 1 gal = 768 teaspoons

Example: If we want to make a 100 ppm sanitizing solution in 1 gallon of wash water using Clorox bleach with a concentration of 5.25% hypochlorite,

$$\textit{volume of bleach} = \frac{\left(\frac{100}{10{,}000}\right)\% \times 1 \text{ gallon}}{5.25\%}$$

$$\textit{volume of bleach} = 0.0019 \text{ gallon}$$

$$\textit{volume of bleach} = 0.0019 \times 768 \text{ teaspoons} \sim 1.5 \text{ teaspoons}$$

Verifying concentration using free chlorine test strips: The chlorine concentration can be verified using chlorine test strips or kits. The above calculation will result in a greater than 10 ppm (>10 ppm) concentration of free chlorine, which is beyond the range of some commonly available test kits. You may need to dilute a sample of your sanitizing solution to fall in that range. Kits can be purchased at most pool supply stores, online or at other stores that sell food-use sanitizers.

Step 4. Monitor the pH, ORP and sanitizer levels.

pH: Chlorine is most effective when the pH of water is maintained between 6 and 7.5. Always check the pH of your water before adding the chlorine. Add a dry acid such as sodium bisulfate to lower the pH. White vinegar also can be used to lower the pH. Add soda ash (sodium carbonate and/or washing soda) to increase the pH. Chlorine solutions with pH values lower than 5 will form toxic chlorine gas and are corrosive. Solutions with a pH greater than 8 quickly lose their effectiveness for microbial inhibition and also are corrosive.

Oxidative Reduction Potential, or ORP: Oxidative reduction potential is a measure of a sanitizer's ability to effectively kill or inhibit pathogens. Measuring the oxidative reduction potential after the sanitizer has been added provides a rapid assessment of the disinfection potential of the sanitizing solution. Sanitizing solutions with an ORP value of 650-750 mV will kill surface spoilage bacteria, E. coli and salmonella within a few seconds. Spoilage yeast, botrytis, penicillium, mucor and phytophthora are killed after one or two minutes. Devices to measure ORP (ORP meters) can be purchased at most pool supply stores, online or at other stores that sell food-use sanitizers.

Chlorine levels: Chlorine levels (measured in parts per million, or ppm) can be monitored using the test strips or kits described above. A free chlorine level of 2-7 ppm is important in the final wash water. The oxidative reduction potential, however, is a more informative measurement. It is important to note that a high level of chlorine, as measured by a test strip, does not necessarily indicate a high level of effectiveness.

Step 5. Rinse produce with clean potable water following the chlorine treatment. A small amount of chlorine can also be added to the wash water to avoid cross-contamination. However, care should be taken to prevent the produce from gaining a highly objectionable flavor and odor. After rinsing, air dry produce in a clean and closed area. If drying by hand, single-use paper towels should be used.

Step 6. Change the water frequently. The wash water should be changed when it becomes dirty and when a new crop is added. The free chlorine levels decrease, and turbidity increases as organic matter, such as soil, is released off produce. Thus, the free chlorine level and turbidity of wash solutions should be periodically checked, even more when the produce is heavily soiled. If free chlorine levels and turbidity are off limits, then replace the sanitizing solution. The wastewater can be poured down a drain or onto an area that does not contain edible crops. After the work is done, all wash containers and food contact surfaces should be cleaned and sanitized.

Step 7. Record all your practices. Maintain a log sheet with the date, time, chlorine concentration (ppm), pH, ORP (mV), water temperature and contact times (amount of time produce was exposed to the chlorine solution). All records must be kept on the farm and be readily available within 24 hours of a formal request by an auditor or inspector.

Root crops harvested from farm

Root crops being washed in a triple wash system with sanitizer

Cautions:

1. Always read and follow label instructions.
2. Always measure and mix chlorine or other sanitizers in a well-ventilated area.
3. Keep chlorine and other sanitizers away from children and pets.
4. Keep chlorine or other sanitizers in tightly closed and labeled containers. Do not expose sanitizers to heat or direct sunlight.

Other sanitizers for use on fresh produce: The common wash water sanitizer used is sodium/calcium hypochlorite, which is commonly known as Clorox Additional products are registered for fresh produce sanitation, including chlorine dioxide gas or activated solution, hydrogen peroxide or dioxide, hydrogen peroxide plus peroxyacetic acid or peroxyacetic acid. Always make sure to read the label of sanitizers to see its concentration and if it is food grade.

Additional information on the various types of Produce Safety Alliance-labeled sanitizers for produce is available at: https://producesafetyalliance.cornell.edu/sites/producesafetyalliance.cornell.edu/files/shared/documents/PSA-Labeled-Sanitizers-for-Produce.xlsx.

For more information on these sanitizers and instructions on how to use them for produce sanitation, consult the Southeastern U.S. Vegetable Crop Handbook (https://pubs.ext.vt.edu/AREC/AREC-66/AREC-66.html).

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