



# How to Use and Monitor Chlorine (Sodium/Calcium Hypochlorite) in Fruit and Vegetable Washwater and on Equipment and Food Contact Surfaces

Faith Critzer, Associate Professor and UT Extension Food Safety Specialist, Department of Food Science, University of Tennessee

Annette Wszelaki, Associate Professor and UT Extension Vegetable Specialist, Department of Plant Sciences, University of Tennessee

Diane Ducharme, Former Produce Specialist, Department of Horticultural Science, North Carolina State University

## Introduction

Chlorine is one of the most widely used sanitizers in food production due to its low cost and ease of application. Sanitizers are used commonly in postharvest handling of fruits and vegetables in two applications: 1) in washing systems to prevent cross-contamination and 2) as a sanitizer after cleaning of equipment, tools and the packing area. We will discuss both in this fact sheet.

## What exactly is a sanitizer?

While we hear the term sanitizer daily, we may not realize exactly what that term means. Sanitize has been defined by the FDA as, “to adequately treat cleaned surfaces by a process that is effective in destroying vegetative cells of pathogens, and in substantially reducing the number of other undesirable microorganisms, but without adversely affecting the product or its safety for the consumer” (21CFR part 117.3). Sanitizing is used as a step to reduce the number of disease-causing bacteria and viruses — also known as pathogens — to a safe

level and to prevent transfer of these pathogens from one object to another and the formation of biofilms (layers of bacteria that are difficult, if not impossible to remove). The EPA has stringent standards that a compound must meet to be considered a sanitizer for food contact surfaces. The compound has to cause a 99.999 percent reduction of a specific set of bacteria within 30 seconds to be considered a sanitizer. These compounds must be registered with the EPA and are considered antimicrobial pesticides. We will discuss this in a little more detail in a moment.

## Chlorine basics

Chlorine comes in three forms: 1) calcium hypochlorite ( $\text{CaCl}_2\text{O}_2$ ) that is a powder or tablet, 2) sodium hypochlorite ( $\text{NaOCl}$ ) that is a liquid and what we commonly call bleach, and 3) chlorine gas ( $\text{Cl}_2$ ). Calcium hypochlorite and sodium hypochlorite are most commonly used by small to medium growers.

When these compounds are dissolved in water they can form hypochlorous acid, which can kill our target microorganisms. However, as shown in Figure 1, when the pH increases above 7.0, the negatively charged hypochlorite ion predominates, which does not rapidly kill microorganisms.

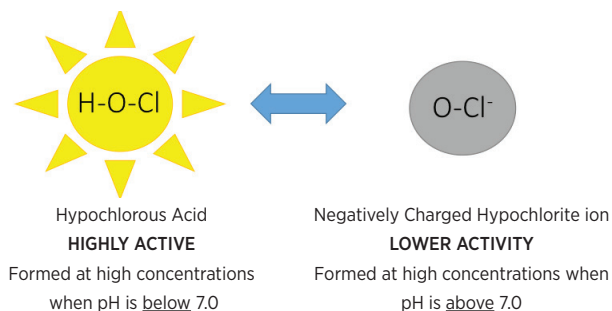


Figure 1. Transition of hypochlorous acid to hypochlorite ion in different pH conditions.

There are several terms associated with chlorine use that you should be familiar with:

- **Free or available chlorine** is used to describe the amount of chlorine in the form of chlorine gas, hypochlorous acid or hypochlorite ion. The rate at which bacteria are inactivated is proportional to the concentration of available chlorine.
- **Combined chlorine** is the quantity of chlorine that has reacted with nitrogen-containing compounds in the water such as ammonia to form chloramines that do not work well in a sanitizing capacity.
- **Total chlorine** is the sum of free (available) and combined chlorine.

Several factors impact chlorine's activity as a sanitizer, and it is important for you to be aware of these for your sanitizing program.

## pH

The effectiveness of chlorine can largely be influenced by the pH of the solution. The pH indicates the acidity or alkalinity of a solution or water. The pH scale ranges from 0-14; 7 indicates the neutral point. The normal pH range of drinking water is 6-8.5. Minerals found naturally underground — including calcium, magnesium and iron, among others — affect the pH of water. Also, the more chlorine that is added to the water, the more alkaline the water will become. For these reasons, we typically need to adjust the pH of the water to make sure hypochlorous acid predominates.

The pH of a solution can be lowered by using an acid (<7) or raised by using a base (>7). If any chemicals are used to alter or buffer the pH of a sanitizing solution, these also must be "food grade." Adding compounds such as lime (calcium hydroxide) or lye will raise the pH, while organic or inorganic acids such as hydrochloric, sulfuric or citric acid lower the pH. For a sanitizing solution, a pH between 6-7 is ideal. Checking the pH of the water regularly (before and after adjustments to pH and/or chlorine concentrations), will help ensure that you get the most effectiveness out of your chlorine sanitizer. If the pH is not within the acceptable range, it can become highly corrosive to equipment (pH <6), form chlorine gas (pH <5) that releases irritating fumes and irritates the skin, or lose effectiveness as sanitizer (pH >8).



## Temperature

Water temperature can play a role in postharvest quality as well as produce safety. In general, the rapid removal of field heat can reduce spoilage and loss of freshness and quality of produce. It is important, however, to be aware of the temperature of the inside of the produce, or pulp temperature, in relation to the temperature of water used for immersion applications. The water temperature should be within 10 F of the fruit pulp temperature. This is because warm produce can create a vacuum and pull water, and any contaminants in that water such as foodborne pathogens, inside the fruit. Heating of chlorinated water can increase the ability to "off-gas" and should be done with caution. The drop of water temperatures can also affect the required contact time of the sanitizer. Temperature should be kept below 110 F.

## Contact time

The length of time the produce is actually in contact with the chlorinated water affects the ability of the active chlorine,

hypochlorous acid, to inactivate pathogens. Generally, a 1- to 2-minute exposure is sufficient, but be sure to follow the EPA label for your specific sanitizer.

## Organic matter

Organic matter from soil, leaves and other debris can quickly use up all the chlorine. Organic matter in the water can appear as cloudiness, or turbidity, and indicates poor water quality needing attention. Prewashing produce with potable water can reduce the organic matter going into your wash water. The frequency with which you change the water should be gauged from the look of the water, as well as using chlorine test strips that measure the free chlorine.

## Implementing chlorine on the farm

Only food grade, EPA-registered chlorine sanitizers should be used during produce washing or equipment sanitizing. During the registration process, the EPA reviews the compound's activity, toxicology and proposed label before it receives approval. Always make sure you are only using sanitizers that have an EPA approval number. Some commercially available household chlorine bleaches contain fragrances and/or other additives not labeled for food use. The EPA label will clearly indicate intended uses, concentrations, methods of use and contact times as well as any additional steps, such as following with a potable water rinse after application.

## Before sanitizing packing utensils, equipment and facilities

Thorough cleaning of surfaces with a food-grade labeled detergent with potable water must be done prior to sanitizing. Detergents are used to reduce the surface tension and dirt. Removal of organic matter, like soil or plant debris, before sanitizing is essential, as sanitizers can bind with organic matter thus reducing their effectiveness. Detergent residue is alkaline (pH >7), which can alter the overall pH of the sanitizer solution thus also reducing the effectiveness of the sanitizer. Rinsing thoroughly with potable water to remove both organic matter and residues is recommended.

- » **Remember, an unclean surface cannot be sanitized.**
- » **Only potable water should be used in all postharvest water applications, i.e., rinsing surfaces, making sanitizing solutions, washing and cooling produce, icing, etc.**



## From label to implementation

Concentration refers to the percent active ingredient of the labeled product. Many liquid bleach solutions have concentrations from 8.3 to 12.75 percent sodium hypochlorite. Knowing the concentration of your starting material is essential in order to not make your sanitizing solution too weak or too strong. Determining what concentration of chlorine to use can be done by looking at the label under the “intended use” section of the EPA label. Remember, the EPA label for the sanitizer will set forth the specific concentrations for food contact surfaces, equipment, porous and nonporous surfaces, as well as use in vegetable washing.

As an example, an excerpt of an EPA approved label for a 12.5 percent sodium hypochlorite solution is shown in Figure 2. This is simply meant to be an example; other EPA-approved labels for sodium hypochlorite sanitizers may have different instructions for safe use of the product.

Remember, the label is the law that governs that product's use. Most labels will indicate to drain and air dry the surface adequately before contact with food. For direct contact with raw fruit/vegetable surfaces, usually the produce must be rinsed with potable water following the dump tank. Remember to look for all of these specifications on the label before you start using it.

By knowing the targeted final concentration for the sanitizer (from EPA label) and using the initial concentration of the sanitizer plus the final water volume, the correct concentration of your sanitizer, in parts per million, can be calculated using the formula highlighted on page 5.

FRUIT & VEGETABLE WASHING: Thoroughly clean all fruit and vegetables in a wash tank. Thoroughly mix 5 oz. of this product in 200 gallons of water to make a sanitizing solution of 25 ppm available chlorine. After draining the tank, submerge fruit or vegetables for 2 minutes in a second wash tank containing the recirculating sanitizing solution. Spray rinse vegetables with the sanitizing solution prior to packaging. Rinse fruit with potable water only prior to packaging.

Commodity	ppm Available Chlorine
Apple	150-200
Artichoke	100-150

Figure 2. Excerpt of an EPA approved label for a 12.5 percent sodium hypochlorite solution.

### Verifying your concentration

Once the chlorine concentration has been determined and an appropriate amount added to the dump tank, a determination or validation of the ppm should be done. Use chlorine test strips that measure the free chlorine to assess the accuracy of the concentration being used.

### Checklist for sanitizing with chlorine solution:

- Start with potable water.
- Determine the amount of food grade chlorine to use by checking the percent active ingredient on the label and using the formula to calculate the ppm you are targeting.
- Measure and add chlorine to potable water to make your solution.
- Check free chlorine concentration (ppm) with free chlorine test strips. This should be what is allowable on the label for fruits and vegetables. Record on log — example on page 6.
- Check pH of solution with pH test strips. Use food grade buffers to adjust as necessary. Record on log.
- Check turbidity of wash solutions. Change water when turbidity is high (e.g., brown with little transparency); also check free chlorine concentration (ppm) to ensure still at target level. Record time and ppm on log.

### Conclusion

Chlorine has been widely used for both washing produce as well as sanitizing equipment, tools and surfaces in the packinghouse. You should carefully consider your operation to determine if chlorine is a good fit as a sanitizer based upon the factors we have discussed.

## Determining Amount of Sanitizer to Achieve Desired ppm

Let's say you would like to prepare 5 gallons of a 200 ppm solution from a 12.5 percent sodium hypochlorite (NaOCl) solution. We'll use the equation:

$$C_i \times V_i = C_f \times V_f ; \text{ where,}$$

$C_i$  = initial concentration of hypochlorite

- 1) 12.5%
- 2) we will need to convert from % to number  $12.5/100=0.125$
- 3) next we will convert to parts per million by multiplying by a million  
 $0.125 \times 1,000,000 = 125,000 \text{ ppm}$

$C_f$  = final hypochlorite concentration desired (e.g., 200 ppm)

$V_i$  = initial volume of hypochlorite to add to water. This is what we will determine.

$V_f$  = final solution volume in milliliters

- 1) convert gallons to liters  
 $5 \text{ gal} \times 3.785411784 = 18.93 \text{ L}$
- 2) convert liters to milliliters  
 $18.93 \text{ L} \times 1,000 = 18,930 \text{ ml}$

### Calculations for $C_i \times V_i = C_f \times V_f$ :

- 1)  $125,000\text{ppm} \times V_i = 200 \text{ ppm} \times 18930 \text{ ml}$
- 2)  $125,000\text{ppm} \times V_i = 3,786,000 \text{ ppm} \times \text{ml}$
- 3)  $V_i = 3,786,000 \text{ ppm} \times \text{ml}/125,000 \text{ ppm}$
- 4)  $V_i = 30.29 \text{ ml}$
- 5) Round to unit you can accurately measure = 30 ml

Adding 30 ml of 12.5 percent sodium hypochlorite solution to a 5-gallon bucket of potable water will get you to the required 200 ppm concentration for your solution.

## References:

McGlynn, William. Guidelines for the Use of Chlorine Bleach as a Sanitizer in Food Processing Operations. [ucfoodsafety.ucdavis.edu/files/26437.pdf](https://ucfoodsafety.ucdavis.edu/files/26437.pdf)

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Date and Time	Sample Description	Temp (F)	Measured pH	Corrective Action (Acid to lower pH Base to raise pH)	Measured Free Chlorine	Corrective Action	Results/Comments	Initials





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