Effective use of Chlorine in Food Processing Environments

Shelly McKee
Auburn University Department of Poultry Science

Introduction

This fact sheet will provide information regarding the use of chlorine and chlorine-based compounds to achieve safety for food contact surfaces.

Chlorine is a widely distributed element that is not found in its free state, but exists primarily in combination with sodium, calcium, potassium, and magnesium. Commercially, sodium and calcium are generally combined with chlorine to produce hypochlorites which are more convenient to use than other forms of chlorine such as chlorine gas. Liquid bleach such as Clorox™ is sodium hypochlorite in water. Household chlorine bleaches in liquid form contain approximately 5.25% sodium hypochlorite.

What does a 5.25% solution mean?

A 5.25% solution would have 5.25 grams of sodium hypochlorite dissolved in 100 grams of water.

The chemical symbol for sodium is Na and the chemical symbol for chlorine is Cl or Cl_2 for chlorine gas. The chemical name for sodium hypoclorite is NaOCl (liquid bleach). This chemical name appears on the labels of compounds containing sodium hypochlorite. Some compounds may list $Ca(OCL)_2$ (calcium hypochlorite, usually granular or tablet) which is still chorine but it contains calcium instead of sodium.

Chlorine use as cleaning and sanitizing agent in food processing facilities

The terms chlorine and hypochlorite will be used interchangeably. Chlorine is often used as a cleaning and/or sanitizing agent for equipment, product contact surfaces, and hand wash stations in food processing facilities. Cleaning and sanitizing are two separate yet related processes. Cleaning removes visible soil and/or food particles from the equipment and physically reduces the microbial load. As a cleaning agent, chlorine is very effective in removing protein residues and to a lesser extent, carbohydrate residues from surfaces.

As a sanitizing agent, chlorine is also very effective and relatively inexpensive. Chlorine is an oxidizing agent, and it is through its ability to oxidize compounds that it is able to kill bacteria. Because it is an oxidizing agent, it can also be corrosive to some equipment. However, the effectiveness of chlorine as a sanitizing compound can be affected by residual food particles and the pH of the sanitizing solution (please refer to section below regarding a definition and explanation of pH*). According to the Code of Federal Regulations sanitizing has the following definition:

"21 CFR 110.3 (o) " Sanitize" means to adequately treat food-contact surfaces by a procedure that is effective in destroying vegetative cells of microorganisms of public health significance, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the product or its safety for the consumer."

Why should you clean before sanitizing?

Food product contact surfaces that have not been cleaned contain high organic loads that reduce the effectiveness of sanitizers such as chlorine. Therefore proper cleaning to remove residual protein, fat or other organic residues is essential for maintaining the effectiveness of the sanitizing step.

Steps to effectively clean and sanitize food product surfaces.

1) Before pre-rinsing, remove all food and residual particles that can be disposed of in the trash or container for inedible materials to prevent drains from being clogged and to reduce waste-water treatment costs.

2) Pre-rinsing food contact surfaces is necessary to further remove residual fat, protein and meat or food residues which can adhere to food contact surfaces. Clean, potable (approved for human consumption), warm water (100-110 degrees F) should be used for pre-rinsing. The temperature of the water is critical at this step because water that is too hot (above 115 degrees F) can "cook" meat and other food residues making them harder to remove. Also, pre-rinse water should not be re-circulated.

3) After thoroughly rinsing, equipment should be disassembled before applying chemical cleaning detergents.

4) During cleaning, organic loads are usually high and alkaline (high pH*) detergents are often used; therefore, chlorine compounds would function as a cleaning agent instead of a bacteria reducing compound. When applying any cleaning detergents, directions on the product label should be followed for diluting the solution to the final working concentration. Care should be taken to ensure the proper preparation of the cleaning detergent so it is not too concentrated nor too dilute. Water temperature may be recommended on the detergent label; otherwise, water temperatures of not exceeding 160-175 F are recommended. Proper cleaning is dependent upon chemical action and mechanical force. If necessary, water pressure can be adjusted to give the desired mechanical force, or brushes and other materials acceptable for cleaning the equipment surface can be used.

5) After cleaning with the detergent, warm water (100-105 F) should be used to remove residual cleaning chemicals and food particles. Depending on the process, the rinse step may include an acid to lower the pH*. Water having a pH value that is numerically lower than seven is "acidic", and chemicals that lower the pH of water are called "acids".

6) Once the equipment is cleaned and rinsed, the sanitizer is ready to be applied. As a sanitizer, chlorine has the ability to reduce pathogen levels on food contact surfaces. Chlorine activity is affected by the pH* of the solution, amount of residual organic material, the temperature of the water and the contact time (the time the sanitizer is allowed to stay in contact with the surface prior to rinsing). When chlorine is used as a sanitizer, the efficacy of chlorine as a bacteria-reducing agent decreases with increasing pH and increasing organic load. Therefore proper cleaning and sanitizer preparation is important. When sodium hypochlorite is used as sanitizer, USDA requires that chlorine concentrations in solution be no less than 50 ppm (One ppm is 1 part in 1,000,000 parts) and no greater than 200 ppm . Diluting bleach to achieve concentrations of 50, 100, and 200 ppm is described below. In addition, when using chlorine as a sanitizer it is important that the pH be 5-6 to improve its bacteria reducing properties. Therefore, the pH of the sanitizing solution should be measured to ensure that the pH is less than 6. pH should be carefully monitored because acidic pH solutions below 4 when using chlorine compounds can release chlorine gas which is toxic. Also, chlorine is a skin and eye irritant. Steps for determining solution pH and adjusting solution pH are also described below. Temperature of the water used to dilute and apply the chlorine as a sanitizer should be 105-120 F. Chlorine compounds can release chlorine gas at boiling temperatures; therefore proper water temperature is important to consider for the safe use of chlorine as a sanitizer. Once the sanitizer is applied, it is important for it to remain on the surface at least 1-5 minutes prior to rinsing. If chlorine concentration does not exceed 200 ppm, the equipment does not have to be rinsed. However, chlorine sanitizers can corrode equipment and should not be in contact with stainless steel surfaces for more than 30 minutes. Moreover, chlorine sanitizers should not be used on surfaces that are prone to rust. Also, the corrosive effect of chlorine increases with increasing water temperatures of chlorine solutions greater than 120 degrees F.

7) Rinse all food contact surfaces with clean, drinkable, warm water (100-105 F). Surfaces should air dry and not be dried with paper towels. Sanitized surfaces may be re-contaminated if dried with rags or paper towels.

Diluting bleach to achieve the desired chlorine concentration

It is important to use the proper concentrations when sanitizing equipment. Chlorine bleach in the amounts listed below should be added to water and stirred to achieve the desired concentrations.

Desired chlorine concentration	**Amount of chlorine bleach (5.25% sodium hypochlorite) needed**	**Amount of water**
50 ppm	¾ tsp	1 gallon of water
50 ppm	1 Tablespoon (½oz)	4 ½ gallons of water
50 ppm	2 ½ Tablespoon	10 gallons of water
100 ppm	1 ½ tsp	1 gallon of water
100 ppm	2 Tablespoons (1 oz)	4 ½ gallons of water
100 ppm	5 Tablespoons	10 gallons of water
200 ppm	3 tsp	1 gallon of water
200 ppm	4 Table spoons (2 oz)	4 ½ gallons of water
200 ppm	10 Tablespoons (5 oz)	10 gallons of water

To determine the amount of chlorine in a solution, chlorine test kits can be used. Chlorine test kits are available from pool supply shops, on-line and from chemical cleaning and sanitizer suppliers. These test kits usually involve a visible color change to give a measure of active chlorine present in solution. Some test kits involve strips of paper. With this system, test strips are dipped in the solution to be tested and after a determined period of time (seconds) a color change appears. Matching the color to the color chart provided in the test kit reveals the results.

What is pH, how does it affect chlorine, and how do you measure pH of water or a solution?

*pH of a solution means the degree to which it is acidic or alkaline (basic). The pH scale ranges from 0-14 with 0 being very acidic and 14 being very basic like lye. A pH of 7 is the midpoint or neutral pH, so less than pH 7 is acidic and a pH higher than 7 is basic. Normal food comparision inlcude soft drinks which are acidic (pH=~4), milk which is neutral (pH=~7.0) and lye which is alkaline or basic (pH=~11). Acidic means there are excess hydrogen ions (H+) and alkaline means there are more hydroxyl (OH-) groups in the solution. When chlorine is mixed with water having a pH of 4-6 then hypochlorous acid (HOCl) is formed:

$$Cl_2 + H_2O \text{ <---> } \underline{HOCl} + HCl$$

Hypoclorous acid is effective as a bacteria-reducing agent. pH can be measured with pH paper to determine the acidicity or alkalinity of a solution. pH paper is dipped into the solution and creates a color change based on the type of paper it is. pH paper can be purchased on-line or can be purchased from a pool supply store. Because high pH reduces the efficacy of chlorine, chlorine sanitizers should not be combined with alkaline compounds. In addition, surfaces should be rinsed thoroughly after using an alkaline detergent during washing so that residuals of the cleaning solution do not increase the pH of the sanitizing solution.

References

Code of Federal Regulations (21 CFR Part 178)
Code of Federal Regulations (21 CFR Part 110.3)

Supported by:
Non-Assistance Cooperative Agreement #FSIS-C-33-2003,
Development of a Virtual Library for Small and Very Small Meat and Poultry Processors
Auburn University ◆ College of Agriculture ◆ Department of Poultry Science
Poultry Products Safety and Quality Peak of Excellence Program