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How is Chlorine Dioxide Gas Used to Process Foods?

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Background

Chlorine dioxide (ClO_2) is a chemical compound made up of chlorine and oxygen. Although "chlorine" is in its name, it is very different from what most people think of as chlorine (bleach). Currently, chlorine dioxide is used worldwide to disinfect drinking water, bleach wood pulp, and sterilize medical instruments. It can also be used as a food processing method to sanitize and extend the shelf-life of fruits and vegetables by destroying bacteria, viruses, yeasts, and molds.

Figure 1. This stainless steel chlorine dioxide gas generation system (Minidox-M system) on wheels is one example of a commercial chlorine dioxide gas generator that can disinfect large areas. (Photo courtesy of ClorDiSys Solutions Inc.)

How It Works

Chlorine dioxide gas is created by a reaction of an acid with sodium chlorite, a salt-based chemical frequently used as a disinfectant. It is typically prepared at a food processing facility before use. The gas can be applied either indirectly (absorbed in water, which is then used on the product being disinfected) or directly (through direct contact with a food). Chlorine dioxide gas can be added to dump tanks, which are large bins full of water to wash produce; applied directly as a gas to the surface of produce; used to sanitize food equipment; or dispersed in the air to reduce odors and/or microorganisms that spoil food. Chlorine dioxide kills bacteria by targeting the cell membrane — the envelope that protects bacteria against dangers outside the cell (Gómez-López et al. 2009). Chlorine dioxide also destroys viruses by damaging their genetic material (Kingsley et al. 2018).

Figure 2. Chlorine dioxide gas is generated by mixed media in the white bucket. Fumigation (disinfection with fumes) occurs via a large fan in the melon room. (Photo courtesy of Joel Tenney, ICA TriNova Corporation.)

Technology

Various types of equipment are used to generate chlorine dioxide gas. Some systems are sophisticated processes that use applicators or generators that can cover large areas (figure 1). Other systems are simpler where the components can be mixed and dispersed (figure 2).

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Efficacy

Chlorine dioxide may be a more effective disinfectant than bleach. Pathogens such as *E. coli* O157:H7, *Salmonella*, and *Listeria monocytogenes* can be considerably reduced when treated with chlorine dioxide. Efficacy depends on a number of critical factors, such as contact time (the length of time chlorine dioxide comes into contact with a food or surface); chemical concentration (amount of chlorine dioxide in a liquid or gas); the pathogen being targeted; and the food being treated. For example, exposing fruit to small amounts of chlorine dioxide gas (2 milligrams of chlorine dioxide gas per kilogram of product (i.e. the fruit) for two hours can reduce soft rot decay by 80%-90% (Mahovic, Tenney, and Bartz 2007). Chlorine dioxide also leaves little to no chemical residue on treated foods (Trinetta et al. 2011).

Figure 3. After three days of storage, Figure 3a depicts a container of moldy strawberries without treatment, while Figure 3b depicts fresh-looking strawberries having undergone (or post)--chlorine dioxide treatment. (Photos courtesy of Joel Tenney, ICA TriNova Corporation.)

Benefits

Compared with chlorine bleach, chlorine dioxide is effective over a wider range of pH (acidity) values. Chlorine dioxide is more versatile than chlorine because it can be applied in either gas or liquid form. Gas sanitizers are preferred over liquid because gas more effectively covers produce surfaces and can enter into wounds and stem scars — the point where produce is picked (figure 4). Wounds and stem scars on produce can be entryways for harmful pathogens. Chlorine dioxide is also effective against biofilms. Biofilms occur when microorganisms group and layer together. (Imagine biofilms as the dental plaque that collects on teeth overnight during sleep.) Within a biofilm, microorganisms become stronger against sanitizers.

Figure 4. A tomato's stem scar is the portion at the top of the tomato where the tomato is picked and the leaf-like sepal is removed. (Photo courtesy of Deborah Breen Whiting from Pixabay.)

Current Usage

The U.S. Food and Drug Administration (FDA) has approved chlorine dioxide gas for processed produce — produce that has been sliced, diced, cooked, or otherwise processed. As of fall 2019, the U.S. Environmental Protection Agency has approved chlorine dioxide gas for use on raw potatoes, tomatoes, and melons.

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