How Is Ozone Gas Used To Process Foods?

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Background

Ozone (O₃) is a chemical compound made up of three oxygen molecules. Since the late 1800s, ozone has historically been used to disinfect drinking water (Tiwari and Rice 2012). More recently, it has evolved to have new uses in the food industry as a food processing method. Ozone is a colorless gas commonly known as the thick layer covering Earth and protecting us from the sun’s rays. It is used to kill bacteria in various types of food (e.g., fruits, vegetables, spices, meats, seafood); to sanitize food equipment, food packaging, and contact surfaces; to reduce undesirable odors; and to extend a food’s shelf life (O’Donnell et al. 2012). Ozone can be applied either as a gas or dissolved in water as part of an aqueous solution.

Figure 1. Tomatoes being treated by ozone gas. (Photo courtesy of Wang et al., 2019.)

How It Works

Even though ozone is made up of oxygen, it is much less stable than the oxygen we breathe (O₂). In fact, ozone’s instability is what allows it to be a safe and effective food processing technology because it decreases contamination on food without leaving any harmful chemical residue. Ozone is made up of three oxygen molecules; however, oxygen prefers to be in pairs (two O molecules). Therefore, the third molecule easily separates from the pair into what is known as a free radical (a solo molecule). This free radical searches for a compatible pair. As a result, the free radical attaches to other molecules on biological surfaces and breaks the surface molecules apart, thereby destroying microorganisms (Brodowska, Nowak, and Smigielski 2018).

Technology

Because ozone degrades rapidly, it must be generated immediately before use. The two most common methods of generating ozone are by (1) corona discharge (CD) and/or (2) UV photochemical generation. Ozone is produced with CD technology by passing dry air — or an O₂-containing gas mixture — through a temperature-controlled high-energy electrical charge/field. Ozone is generated with UV photochemical generation by shining UV light (140-190 nm) on O₂ molecules. In both methods, O₂ molecules are split into individual oxygen (O) atoms that join with some other floating O₂ molecules to form ozone (O₃); (Brodowska, Nowak, and Smigielski 2018).

Once created, ozone can be applied directly as a gas or dissolved into water as part of an aqueous solution. Figures 2 and 3 show examples of ways that ozone is created in a laboratory setting. Ozone is more effective when applied as a gas than when dissolved in water. In water, ozone dissociates (breaks apart) quickly to become oxygen (Miller, Silva, and Brandão 2013).

Creating ozone using CD technology has advantages: a lot of ozone can be created, it can be used in water and many other applications, it removes odor compounds, and it is great for long-term equipment use. Creating ozone with UV technology, while cheaper, yields less ozone with limited applications (Brodowska, Nowak, and Smigielski 2018).
Efficacy

Ozone is 50% stronger than chlorine without using as high of a concentration. Leftover ozone quickly decomposes into oxygen, leaving no residue in foods. Ozone has been proven effective for enhancing microbial safety and extending the shelf life of spices, produce, meats and poultry, fish, dairy, and beverages. Its effectiveness against pathogens and spoilage microorganisms depends on a variety of factors (e.g., food product, microorganisms being targeted, contamination level, gas or aqueous, concentration used, contact time, humidity [as a gas application], ambient or product temperature, etc.; (O’Donnell et al. 2012). Ozonated water applied to blueberries can reduce pathogenic *E. coli* O157:H7 and *Salmonella* by approximately 99.999% (a 5-log reduction; Bialka and Demirici 2007). Exposing apples and pears to miniscule amounts of ozone gas can result in an extended shelf life (Brodowska, Nowak, and Smigielski 2018; Skog and Chu 2001).

Benefits

Ozone is effective against many types of food-related microorganisms (e.g., bacteria, fungi, mold, and yeast). Additionally, ozone does not negatively affect the qualities (appearance, texture, and nutrition) of the food products it treats. It is both cost-effective and eco-friendly; it is cheaper to purchase and maintain ozone systems than to continually purchase other disinfectants (Brodowska, Nowak, and Smigielski 2018). Ozone is also used as a replacement for insecticides due to increasing environmental problems and legislations that regulate or prohibit pesticide use (O’Donnell et al. 2012).

Current Usage

In 2001, the U.S. Food & Drug Administration (2001) approved ozone as an antimicrobial for direct contact with water and foods of all types. It is also used in the food industry to sanitize/decontaminate food surfaces, food equipment, packaging materials, water used in processing, and storage equipment.

References


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