

## Ozone — Another Layer of Food Safety

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Minimizing the occurrence of microorganisms in fruits, vegetables, meats and other foods is a primary food-safety concern. At the same time, sanitizers — such as the chlorine used both to wash produce as well as disinfect processing equipment — may potentially harm the environment. Some consumers also prefer these materials not be present as residue in the foods they eat. One way the food industry can address food safety and the negative perception of some sanitizing agents is through the use of ozone treatment.

### A bubble of safety

Ozone is a gas made up of oxygen. Unlike the more familiar diatomic form of oxygen, ozone has three oxygen atoms on its molecule and is formed from oxygen in the presence of heat and light. Lightning and ultra-violet rays both form naturally occurring ozone and the gas also makes up the familiar UV-shielding “ozone layer” in the Earth’s upper atmosphere.

Besides its function as planetary protector, ozone also is a strong oxidizer. This makes it effective in killing microorganisms because it oxidizes their cell membranes. In fact, ozone is more effective at killing a wider variety of potential pathogens than chlorine. Unlike many other sanitizing agents, ozone contributes no negative environmental impact because it quickly and easily degrades into diatomic oxygen.

Although its use is relatively recent in the United States, ozone and its oxidizing properties were first discovered as early as 1840. By the early 1900s, France was using ozone to disinfect drinking water, and this application soon spread to the rest of Europe. Ozone continues to be used in water treatment in both small and large applications. In 1997, the United States affirmed ozone as generally recognized as safe (GRAS) for treatment of bottled water and as a sanitizer in bottled water plants.

In Europe, ozonation in food processing began taking place shortly after it was first used for water treatment. Only with recent regulatory rulings has the stage been set for ozonation to make inroads into the U.S. food industry, where adoption of the technology has been slower.

### Reaching for the ozone

In addition to being effective over a broader spectrum of microorganisms, ozone is of particular interest to the food industry because it also is 52% stronger than chlorine. Unlike typical sanitizers, however, ozone’s short half-life means it cannot be delivered handled or stored in the usual way. After all, its environmentally friendly auto-decomposition characteristic gives it a half-life of only 20 minutes in room-temperature water.

Fortunately, ozone is easily generated with devices that create an electrical discharge across a

flow of either pure oxygen or air. Ozone generators are compact and can be installed right where they're needed on the processing line. This is particularly handy because ozone may, depending on the product, actually be applied in more than one way.

## Fruits and vegetables.

Ozone can be bubbled through water into which it will partially dissolve. This ozonated water then can be used for washing and/or in transfer flumes to reduce the microbial loads of berries and other fruits and vegetables. Controlled studies report that ozonated water may actually provide greater than 90% reduction of total bacterial counts for some vegetables. Such treatments also have been shown to reduce fungi populations and, subsequently, reduce fungal decay.

During such processes, ozone is consumed, so wash water must be ozonated continually. The environment for ozonation also should have at least a 50% humidity level, with optimum effectiveness on fruits and vegetables between 90% to 95% humidity. Below 50% humidity, ozone is less effective because microorganisms must be in a swelled state in order to be attacked. As humidity approaches 100% (or in the presence of steam), ozone's effectiveness also decreases somewhat.

Besides reducing microbial loads in wash water, ozone can extend the shelf life of produce in storage. During storage, fruits and vegetables ripen more quickly as they absorb respiration and decay gasses emitted by other fruits and vegetables. As more and more pieces ripen, this effect accelerates in a cascade effect.

Ozone in the storage environment can oxidize the metabolic products of decomposition and help to slow this cascade of accelerated ripening and decay. In some cases, ozone treatment in storage may nearly double the shelf life of fresh produce. For storage applications, the ozone is simply emitted periodically into the storage area. As with many oxidizing agents, exposure to high enough concentrations of ozone is harmful to humans. Ozonated storage areas should be enclosed and the ozone allowed to dissipate prior to workers entering the area. Fortunately, its short half-life makes this a manageable requirement.

Meat, fish and poultry. Typical poultry processing uses a great deal of water. Ozonating this water allows it to be reused, thus providing cost savings. In 1996, the [USDA](#) approved the use of ozonated water for washing poultry carcasses, but not for direct use. Other food processes also use significant amounts of water. Again, water recycling is a way to reduce consumption and, potentially, add microbial reduction properties.

Currently, researchers are looking into ozone's potential for directly cleaning the surface of animal carcasses. On fresh, raw meat, for example, levels as low as 0.04 ppm can retard and control microbial growth. Increasing the levels to approximately 0.10 ppm can help cure or age beef to make it more tender. If the meat starts with a low bacterial count, ozone storage may even

increase shelf life by up to 40%.

For fish, ozone has benefits that begin even closer to the source. By freezing ozonated water, for example, it can be stored on fishing boats and used at sea. The melted water can be used for washing and in processing, while the remaining frozen ice achieves atmospheric benefits in storage areas. Using such techniques, fishing boats can stay at sea for up to 14 days. Closer to consumers, ozonated ice in retail display cases may help extend the shelf life by one to three days.

### **Additional benefits surface**

Produce and muscle foods are not the only products that may benefit from gaseous ozone storage. In the 1980s, studies showed that cheese stored with periodic ozonation experienced no mold growth for four months while the control cheese began growing mold in as little as one month of storage.

Later in that same decade, ozone treatment was used to reduce airborne microorganisms in a confectionery processing facility. Not only did this reduce the incidence of airborne microorganisms over a year and a half, it actually extended the shelf life of the facility's products by seven days due to inhibited bacterial growth. In the 1990s, Japanese researchers discovered that exposing grains, flour and raw noodles to ozone yielded significant reductions in microbial growth.

Besides potentially reducing microbial loads on food itself, ozonated water also can be used to wash processing equipment. This reduces the number of microorganisms on surfaces and helps reduce cross-contamination onto the food. In some countries, ozonated water even is used to sanitize baby food jars.

In 2000, researchers at the [Department of Food Science and Technology at The Ohio State University](#), Columbus, studied the potential effectiveness of ozonated water in decontaminating the surfaces of both stainless steel and laminated aseptic food-packaging material. Researchers Mohammed Khadre and Ahmed Yousefi treated both types of surfaces and confirmed that sterility of naturally contaminated packaging material could be achieved when treated with ozone in water for as little as one minute. Dried films of spores could be eliminated by higher concentrations of ozone in water for both the packaging material and stainless steel. The researchers concluded that ozone is an effective sanitizer for both potential applications.

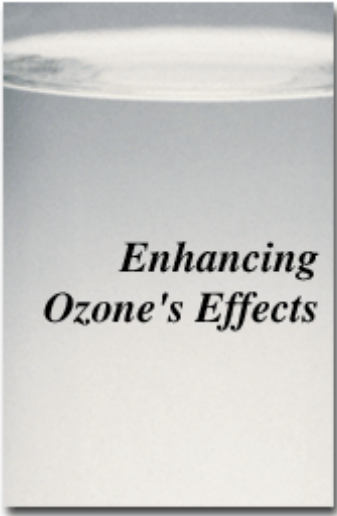
### **Regulatory catch-up**

Despite its food-processing use in other countries and water-treatment applications in the United States, the [FDA](#) did not approve ozone as a food additive for many years. Even after an independent panel gave ozone GRAS status in 1997, full approval for food-contact use still required filing a petition with the FDA. In hope of expanding ozone use, the Palo Alto, CA-based [Electric Power Research Institute](#) (EPRI) filed a broad petition to grant regulatory acceptance of ozone as a food additive.

On June 26, 2001, the FDA granted this petition and published its final rule in the Federal Register. The amendment to the food additive regulations (Title 21 of the Code of Federal Regulations, part 173) allows the use of ozone when used as a gas or dissolved in water as an antimicrobial agent on food, including meat and poultry.

In the regulations, ozone's uses include the reduction of microorganisms on raw agricultural commodities in the course of commercial processing. The regulations also state, however, that ozone's use may have the potential to fall under the guidelines of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), thus entering the jurisdiction of the [Environmental Protection Agency](#) (EPA). Food processors should check with ozone equipment suppliers and/or directly with the EPA to determine if a particular use of ozone will require a special pesticide registration under FIFRA.

Ozone offers the food industry another tool in the ongoing food-safety quest. At the same time, it does so in a more environmentally friendly way than many other sanitizing agents. With the new regulations in place, perhaps more U.S. processors will give ozonation a try.



***Enhancing  
Ozone's Effects***

While research has shown ozone to be an effective antimicrobial agent, at least one ozone system manufacturer claims to be able to more than double the gas' food-disinfecting capability. Utah-based Cyclopps Corp. has patented a process that incorporates a surfactant from the UK's Horsley Ltd. in addition to ozonated water.

Ozone is most effective at pathogen reduction in solution. But unless food is kept wet for a sufficient period of time, it may not maintain enough contact with the ozone for maximum effectiveness. The new process alters the wettability of the food surface, allowing the ozonated water to remain in contact with the food surface for a longer period.

In a test using sponges as a model, Cyclopps researchers exposed samples to both plain ozonated water and ozonated water enhanced with the surfactant. After two hours, they observed a three-fold reduction in microorganisms using ozonated water alone. With the surfactant, the ozonated water caused a seven-fold reduction of microorganisms.

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