# Tech Update: Contamination Killers

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*Food products and the plants that process them aren't meant to be sterile, but a number of disinfecting and sanitizing technologies can reduce contaminants significantly.*

*A technician at Silver Spring Mineral Water Co. in Folkestone, UK, inspects the stainless-steel treatment chamber in the plant's UV system. Destruction of waterborne yeasts and other microorganisms without impacting pH and chemical composition was UV's appeal. Source Aquionics Inc.*

Don't tell a microbiologist anything in a food plant is sterile, up to and including the food itself. From a microbiological point of view, sterility doesn't exist, except in the medical arena or perhaps in a semiconductor clean room. Disinfection, not sterilization, is the operative term, the microbiologist says, and manageable risk is the objective.

While clean and sanitary are relative terms, sterile implies an absolute condition where microorganisms—bacteria, viruses, mold, spores—do not exist. Reasonable people can agree that something is sterile while acknowledging the inability to detect any life forms doesn't preclude their presence. Severe processes such as retorting achieve commercial sterility, though, even in that case, scientists hedge their bets with sodium and other preservatives.

*Professor Mark Morgan stands next to a lab-scale chamber designed to deliver the sterilant chlorine dioxide to fruits and vegetables. Source: Tom Campbell, Purdue University.*

Multiple hurdles in both the process and the operating environment are essential to controlling risk and delivering consumables that not only are safe to eat but also survive transport in a supply chain that is stretching around the globe.

"When we're dealing with food," emphasizes Adel Makdesi, corporate senior microbiologist at Zep Inc., "we're just trying to reduce the microbials to a safe level, which is all you can do."

"There is no such thing as a kill step in food safety interventions," agrees Dave Cope, a biochemist and CEO of Purfresh Inc. "Food safety is about risk management."

Risk management is about math, and the math of multiple disinfectants, sanitizers and other tools adds up to an effective strategy. At the same time, standbys like chlorine are falling out of favor. Residual chemicals on foods imported into the UK have been outlawed, according to Cope, creating another opportunity for new antimicrobial technologies.

Regulatory pressures also are entering the mix, though not from the usual agencies. In November 2007, the US Department of Homeland Security (DHS) issued a final rule on "chemicals of interest" stored at industrial sites, including food plants. Major meat and poultry processors have been advised by DHS that large tanks of chlorine gas used to treat wastewater could be targeted by terrorists and therefore require special precautions, according to Marc Scanlon, national industrial sales manager at Erlanger, KY-based Aquionics Inc. His firm provides ultraviolet (UV) systems that are gaining traction in wastewater treatment as an alternative to "the green cloud of death" that could wipe out a community if a 150-ton chlorine gas cylinder ruptured.

Chlorine dioxide (CD) is another potentially dangerous gas that may come under the DHS radar. Five years ago, Purdue University researchers demonstrated the efficacy of CD in destroying pathogenic bacteria and spoilage organisms in strawberries inoculated with huge plate counts. The gas did not adversely affect the fruit. Those results encouraged food engineers to build a pilot scale machine, which demonstrated the practicality of CD treatment. The project now is under the auspices of the USDA Specialty Crops Research Initiative, which is carrying it to commercial testing.

*The coils on a large air-conditioning unit take on a blue hue from UV lights that operate at a lethal frequency for microbes. Bacteria build-up on coils reduces cooling efficiency and can be a source of airborne contaminants in food plants. Source: Steril-Aire Inc.*

Before manufacturers can use it, the Environmental Protection Agency (EPA) needs to give its blessings for direct contact with food, explains Mark Morgan, an engineer and food science professor at Purdue. But he discounts security concerns: “since chlorine dioxide gas is generated on site, at the time of use, there are no storage requirements,” he writes. “If chlorine gas is used to generate the CD gas, it is ... not concentrated enough to cause a concern.”

Another new technology waiting in the wings is silver dihydrogen citrate (SDC), a nontoxic, stable compound that delivers both immediate and residual kills of a wide variety of microorganisms (see Engineering R&D, “Nanoscale silver on deck” on pages 95-96). It could become the first pesticide approved for direct food contact in more than 30 years, though controversy surrounding other products containing nanoparticle silver could delay final EPA approval.

### Natural born killers

While waiting for new antimicrobials to hit the market, manufacturers have plenty of disinfectants and sanitizers to deploy now. The cost and effectiveness of chlorine when alternated with quaternary ammonia has made it the chemical of choice for years, but its days are numbered. A new generation of chemical killers is emerging.

*Ozone is the disinfectant in this apple washing system. Rapid dissipation eliminates concerns of product residue and waste stream contamination, though off gassing must be strictly controlled. Source: Purfresh Inc.*

Peroxyacetic acid (PAA) is a powerful oxidizer that outperforms chlorine in many food applications. Atlanta-based Zep recently introduced three PAA formulations for direct contact with food and as a surface sanitizer. Concentrations range from 5.6% to 15.5%, with the amount of hydrogen peroxide in each formulation decreasing as the PAA increases. While chlorine is diminished by organic loads and is effective only at about 6.5 pH, PAA keeps rupturing cell membranes regardless of dirt load, according to Zep’s Makdesi. “It breaks down to water and carbon dioxide,” he adds, unlike the carcinogenic residue left by chlorine.

Zep also has introduced the first EPA approved treatment for destroying biofilms in drains, a particularly vulnerable point of entry for listeria, Makdesi points out. Positively charged quaternary chlorine and negatively charged hydrogen peroxide give the treatment “very unique cleaning and sanitizing abilities,” he adds. Although the compound is only approved for drains, the firm hopes to get regulatory approval for applying it to walls and other surfaces where biofilms can form.

Misunderstandings about the limitations of existing chemicals retard acceptance of new sanitizers. “A lot of food companies misunderstand basic facts about chemicals,” believing that adding chlorine to a detergent gives it antimicrobial properties, laments Makdesi. Likewise, combining multiple disinfectants “might be dangerous to human health” rather than provide a lethal microbial highball.

The second most powerful oxidizer (fluorine is number one) is ozone, which was approved by FDA for direct food contact in 2001. Initial enthusiasm has given way to concerns over out-gassing and the health risks from ozone gas to workers. Seal and gasket degradation also is a concern.

“A lot of charlatans were in the market in the early days,” complains Purfresh’s Cope. “There has to be a high degree of accuracy and efficacy for ozone systems to kill microbes and safeguard people. Unfortunately, some of the early suppliers basically put a spark plug in a box and said, ‘Spray it over your food.’”

Properly monitored and controlled, ozone systems won’t endanger human health while disinfecting food. Fruit and vegetable companies in particular have been receptive, using ozonated water as a HACCP step in their processes. The key is real-time monitoring and control technology to validate that the dose and delivery meet specifications. “Physics is nice because it’s always right,” Cope deadpans, and that applies to any disinfectant, chemical or otherwise. All work within given operating conditions, but those conditions can’t be assumed.

Purfresh recently installed a system at Auvil Fruit Co. in Fremont, CA. The firm wanted to eliminate chemical residues on its fruit and lower operating costs. Ozonated water sprayed on apples conveyed through a chamber provides a 3-log reduction. The water then is routed to dump tanks where incoming fruit receives a preliminary washing. By the time the water reaches the tank, the ozone has dissipated. There are no chemicals to filter out when the wastewater leaves the facility, and water consumption is down 6,000 gallons a day.

Just as an electrical charge from a generator creates ozone, an electrical charge in a salt-water solution creates electrolyzed oxidative water (EO). Researchers at Atlanta-based EAU Technologies Inc. developed a method to separate the positive and negative ions from an EO generator into two separate streams, creating low-pH hypochlorous acid in one and alkaline sodium hydroxide in the negative stream. The result is a one-two punch, with the alkaline solution exhibiting excellent cleaning properties and the acid delivering antimicrobial benefits.

Hypochlorous acid can’t match ozone as an oxidizer—“You can gargle it and it doesn’t hurt you,” reports Doug Kindred, EAU’s chief technology officer—and it is considerably more stable. If generated at 50 ppm, it can be stored in tanks and dispensed at 48 ppm several hours later, according to Kindred. Water temperature doesn’t affect performance, reducing the number of factors that must be monitored to gauge performance.

EAU’s biggest food-industry successes have come in the poultry segment, and seafood companies are expressing interest. Both protein sources are shipped in ice, and if EO is used to form the ice, hypochlorous acid is released as it melts, controlling microbial decay. Another potential application is clean-in-place systems: unlike chemical cleaners and sanitizers, which require a rinse cycle to prevent adverse reactions, EO’s alkaline solution can be immediately followed with the acid. “In CIP, 10% savings in water usage is not out of line,” Kindred says.

Ultraviolet disinfection is closer to mainstream acceptance. The soft drink and bottled water segments in particular are making use of UV as part of a multiple intervention strategy. UV chambers often are positioned after a carbon filter and before a reverse-osmosis unit to protect the R/O element from chlorine residues that can shorten filter life, Aquionics’ Scanlon says. “Anywhere they want to disinfect water, UV can play a role.”

More rigorous science is helping UV expand its foothold in food and beverage. Computational fluid dynamics modeling has taken the guesswork out of system sizing, allowing engineers to specify units that minimize energy costs and deliver the proper microbial-kill dose for targeted organisms. Quartz coating techniques push lamp life well past 12,000 hours, and light-emitting diodes could usher in replacement cycles above 100,000 hours. Costs are coming down, footprints are shrinking, and energy efficiency is up, making UV more attractive for industrial applications.

“The technology has not caught on to the extent it should,” demurs Bob Scheier, president of Burbank, CA-based Steril-Aire Inc. “We’re still bridging two disciplines: engineering and the biological side.” Similar to ozone, UV also suffers misunderstanding from vendors who treat this part of the electromagnetic spectrum as a commodity. Waves of 265 nanometers deliver optimum DNA destruction, and lamps that operate too far from that point can be ineffective. At 195 nm, oxygen molecules are cleaved, with the free molecule combining with $O_2$ to form ozone.

“This is another add-on” for antimicrobial systems, Scheier concludes, and in combination with other technologies, it can help render food as close to sterility as is practical. Just don’t call it sterilization: regulatory authorities wouldn’t like that.

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## Something in the air

When conducting food safety audits, Lou Cooperhouse sometimes shakes his head when eyeballing a facility’s air-treatment systems. The potential for post-process contamination from airborne pathogens or spoilage organisms can be great, yet manufacturers often give air disinfection short shrift.

Cooperhouse, who also is director of the Rutgers Food Innovation Center in Bridgeton, NJ, made sure HEPA filtration was part of the design when the center set up a clean room as part of a processing facility last year. When KesAir Technologies offered to augment HEPA with a UV system, he jumped at it. “UV is relatively rare when addressing air quality,” Cooperhouse allows, but as a comprehensive program to address environmental contaminants, it makes sense. “When you’re applying best practices,” he says, “it helps move you to great practices.”

The Rutgers system incorporates UV lamps inside a photocatalytic oxidizer. The UV excites titanium dioxide, which then mineralizes VOCs and microorganisms. A HEPA filter will eliminate 99.97% of particles 0.3 microns and larger; combining HEPA with UV results in air as close to sterile as most humans are likely to breathe.