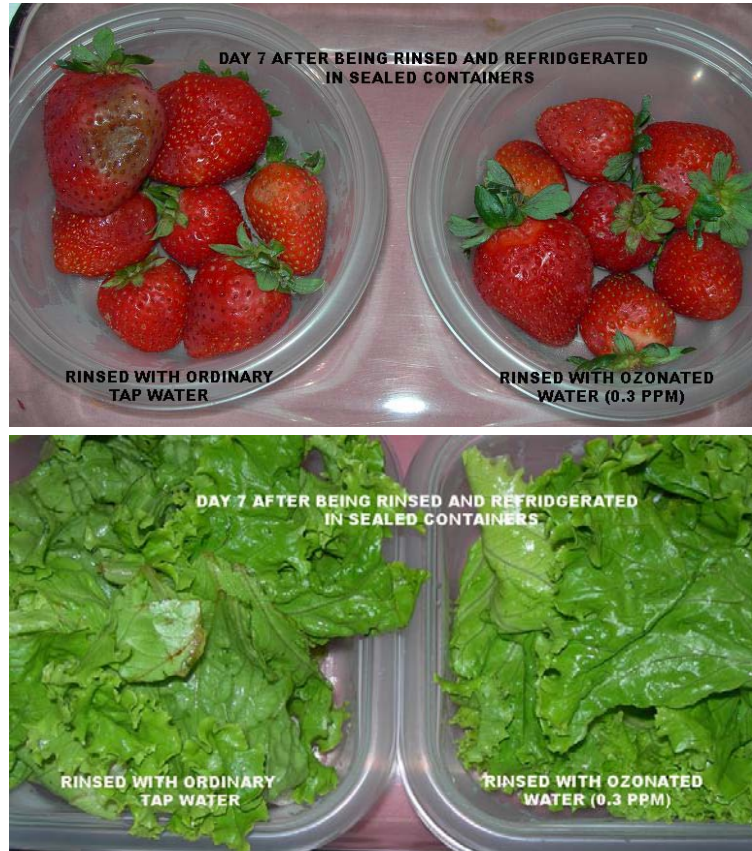


## POU Ozone Food Sanitation: A Viable Option for Consumers & the Food Service Industry

The United States Food and Drug Administration (FDA) gave final approval for the application of ozone for disinfecting and sanitizing food and food processing environments in September 2001. Whether applied in gaseous phase in the air for storage, or dissolved in water for microbial or chemical control on food surfaces, the FDA action permits a great leap forward in making the world's foods safer with ozone. As a side benefit, it generally makes most foods last longer, too.

The approval for ozone contact with foods accelerated what had been a simmering interest throughout the food-handling world. It would be an overstatement to say that interest in ozone treatment has come to a full boil among food processors, but as additional food/ozone related research findings come in, the industry is



**Shelf life extension:** Fresh cut lettuce and fresh strawberries on the right side of each photo were rinsed in a stream of PurePower ozonated water. The lettuce and strawberries on the left side in each were rinsed in regular tap water. The containers were sealed and refrigerated at 42 degrees F. for seven days.



becoming more receptive to what, for most, is still an unfamiliar technology.

At present, the majority of ozone applications in the food industry is at larger bulk operations which use relatively high doses of disinfectant. Previously, throughout the food handling chain, high doses

of chlorine - up to 200 parts per million (ppm) have been common. This raised concerns regarding by-product formation, such as trihalomethane (THM), a known carcinogen, formed as the chlorine reacts with organic materials on food surfaces.

In certain instances, i.e., at large growers and packers who are treating tons of produce per hour straight from the field, it may be necessary to apply ozone dosages as high as 2-10 ppm in the process water. Even though the actual amount of ozone necessary to disinfect foods is low, the huge ozone demand created by high organic loads from the farm environment means systems must be designed to counter those loads with enough ozone left over to control microbes and, in some instances, to chemically destroy pesticides.

That ozone is a powerful sanitizer that (even at low doses) is capable of remarkable microbiological control is undisputed. Water treatment professionals, in particular, have become knowledgeable in the technology. Many know what ozone does and how it does it, at least with regard to water treatment applications.

Now, with the approval of ozone for food, these ozone-experienced water treatment professionals have an entirely new market for what is, essentially, an entirely new product, the PurePower point of use (POU) ozone food sanitizing system. Dealers can offer

consumers and food service



**Events in the food distribution chain can impact food safety.**

operators alike the ability both to serve safer food *and* to save money by extending the shelf life of produce, fruits, meats and fish.

The potential for the emergence of the POU ozone food sanitizer first became evident when the Electrical Power Research Institute (EPRI) successfully petitioned the FDA in the mid-90s in support of ozone in food processing.



**Food safety at the home and restaurant level has become a national priority.**

That resulted in a GRAS (Generally Regarded As Safe) status for the technology. The further work by EPRI resulted in the final approval of ozone in food processing.

But testing results performed for the benefit of large food processors left a gap in validation of the process for POU customers, such as consumers and food service operators.

Soon after the original GRAS status award in 1997, the author began working with Dr. Joseph Montecalvo, Jr., professor and past chairman of the California Polytechnic University, Department of Food Science & Nutrition and a member of the Technical Advisory Panel of the USDA National Organic Standards Board. Our target was to develop protocols and execute testing of ozone food sanitizing systems for POU applications in the home and in the food service industry.

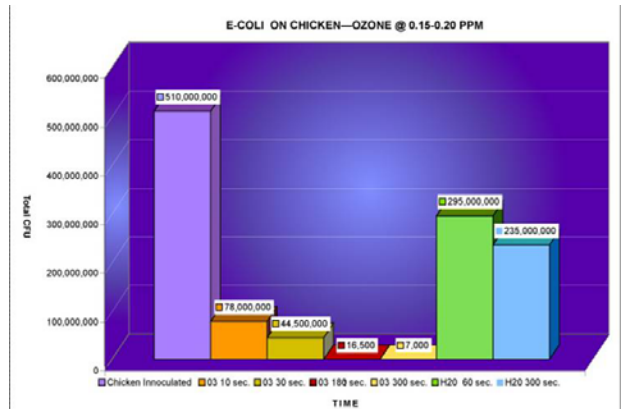


**Dr. Joseph Montecalvo, Jr.,  
California Polytechnic University**

The peer reviewed results of those tests have proven that small, properly designed POU ozone systems, applying dissolved ozone at very low levels and used in conjunction with safe food handling practices, can significantly reduce risk exposure to food borne pathogens.

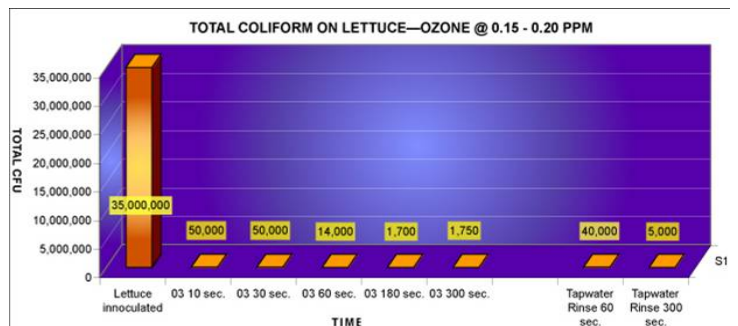
Research proved that a small ozone system used to rinse a variety

of foods was capable of two-to-four log reduction in food pathogens on the surface of food products.



Under the umbrella of a partnership among Dr. Montecalvo's research group, Primus Laboratories in Santa Maria, CA and the author, research was conducted both at Cal Poly and Primus Laboratories in order to determine the sanitizing functionality of ozonated wash waters using PurePower technology.

As background for the study, it was recognized that ozone itself is a highly reactive oxidizing agent with broad germicidal activity. It has been used both in Europe and in the US as an alternative to chlorine for disinfecting water. Chemically, ozone is 52 percent greater in oxidation potential than chlorine as well as 3,200 times faster. It acts



over a broader spectrum of microorganisms than does chlorine

research laboratory at a leading food safety research facility in California

under the direct control of a registered microbiologist.

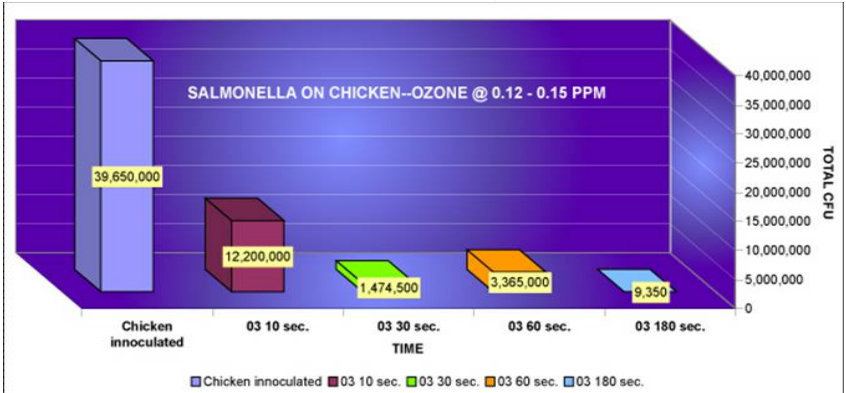
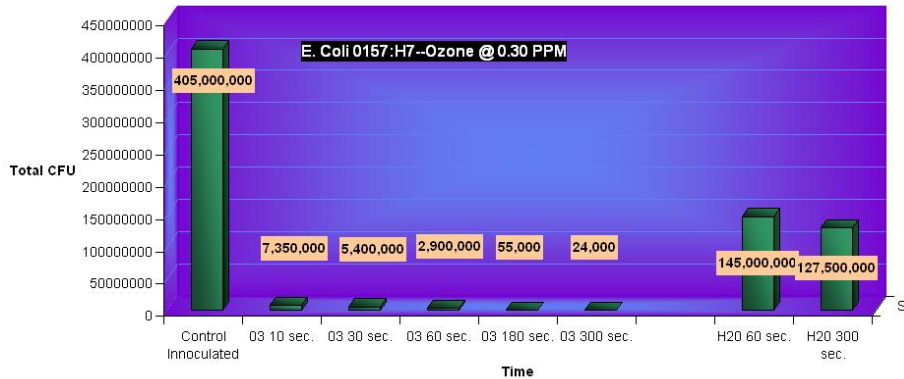
Experimental approaches

Pure cultures of *E. coli*, *E. coli*

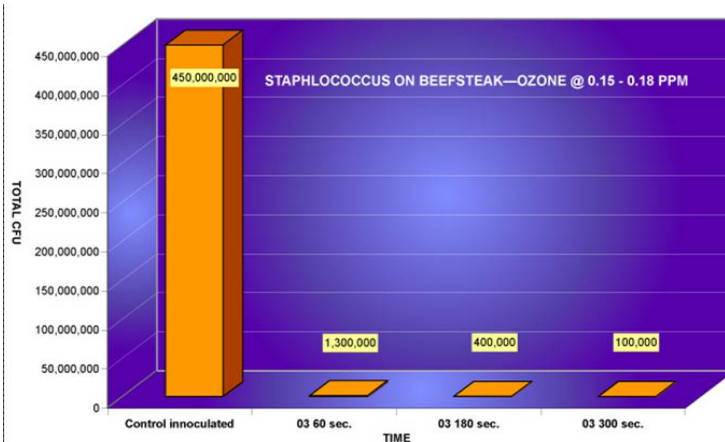
*0157:H7*, *Listeria monocytogenes*, *Staphylococcus aureus*, *Coliforms*, *Campylobacter jejuni*, *Shigella* and

and other commonly used sanitizing agents.

Next to fluorine, ozone is the most powerful oxidizing agent available. Because of its high oxidation capacity, the cell membrane of microorganisms is oxidized and ruptured, (lyced) thereby causing microbial cell destruction. This study focused upon determining the susceptibility of food pathogens to low levels of ozonated water (0.12 – 0.30 ppm) in an effort to determine the efficacy of ozonated water at those levels in food pathogen reduction. All microbiological food pathogen study was conducted at the microbiological



*Salmonella* were purchased from the American Culture Collection and grown in broth cultures and enumerated. Fresh samples of chicken, beef and lettuce were inoculated individually for each



microorganism creating two populations of sixteen food samples for each food pathogen tested. A one-hour equilibration period at room temperature prior to treatment with ozonated water was maintained for all food samples. Using the small ozone system, each freshly inoculated food product was

immersed in a continuously ozonated bath of municipal water (filtered through a one-micron absolute carbon filter, prior to ozonation). Dissolved ozone levels reached a maximum of 0.3 ppm, as measured by the indigo thiosulfonate spectrophotometric methodology. Food products were then immersed for different immersion times (i.e. 10, 30, 60, 180 and 300 seconds) in order to determine the optimum immersion time required for maximum microbial cell destruction.

For all experimental runs, controls were used which consisted of each inoculated food sample receiving a water wash only for the same immersion time. Following



**Laboratory studies of ozone rinsed foods proved pathogen reduction results.**

ozonation or water wash treatments, residual pathogen levels were determined by standard microbiological direct swab or Stomacher<sup>®</sup> sample preparation. Enumeration of bacterial numbers was conducted by using specific FDA-AOAC methods for each pathogen according to Bacteriological Analytical Manual (BAM), 8th edition published by AOAC

## Results

The results of this study show

that a four-log reduction (measured in colony forming units or cfu per gram of food tested) in *E. coli* on the surface of fresh chicken from  $5.1 \times 10^8$  cfu/gm to  $1.65 \times 10^4$  cfu/gm. For total coliforms, a four-log reduction (from  $3.5 \times 10^7$  to  $1.7 \times 10^3$ ) was observed on fresh romaine lettuce after 180 seconds of immersion in ozonated tap water. A two-to-three log reduction in *Listeria monocytogenes* (from  $8.5 \times 10$  cfu/gm to  $2.2 \times 10^5$  cfu/gm) was found after 180 seconds of immersion in ozonated water.

Little changes were observed in all cases for the control water wash, generally less than 0.5 log reduction.

A consistent three-log reduction in *Staphylococcus aureus* was observed on beef (sirloin steak) after 180 seconds of ozonated water immersion. A four-log reduction was found with *E. coli* 0157:H7 on romaine lettuce after 180 seconds of ozonated water immersion treatment. Additionally, a four-log reduction was observed for *Campylobacter jejuni* on chicken (i.e.,  $1 \times 10^8$  cfu/gm to  $1.25 \times 10^4$  cfu/gm). A slightly less than four-log reduction was found after 180 seconds of immersion for *Shigella* on romaine lettuce and a four-log reduction in *Salmonella* was observed ( $3.9 \times 10^7$  cfu/gm to  $4.1 \times 10^3$  cfu/gm).

The results show that at dissolved ozone levels of 0.3ppm and immersion times of 180 seconds, major reductions in surface food

pathogens were consistently observed.

## Conclusions

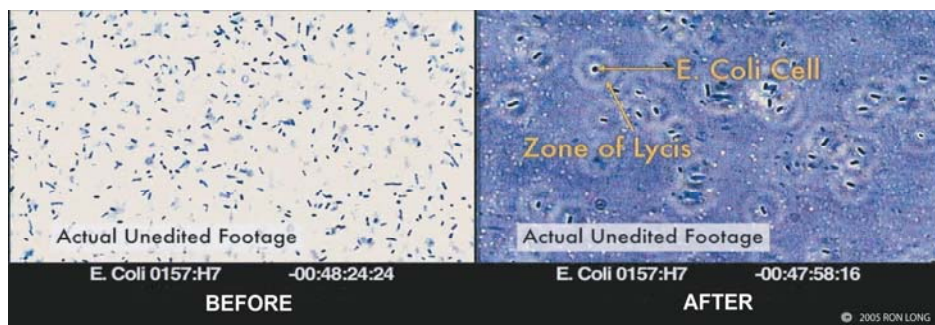
The results from this study allow for the following conclusions:

1. Use of the small POU system, as designed, confidently reduced food borne pathogens from the surfaces of fresh food products tested.
2. Overall, two-to-four log reductions were found for all eight food pathogens tested.
3. To achieve optimum results, the immersion time of the food product with hand massaging (vigorous rubbing of the food surface to assure contact) in the ozonated water was found to be three-to-five minutes for dissolved ozone levels of up to 0.3 ppm, even though ozone levels as low as 0.12 and immersion times as brief as 10 seconds produced significant results on some pathogen species.
4. The results further indicate that increasing the dissolved ozone levels results in greater reduction in bacterial numbers. Therefore, this may suggest that increasing the ozone levels above 0.3 ppm may reduce the contact time of

the food product in the ozonated water. Further studies will be conducted in order to prove this concept.

5. In all cases, water washing of the food products tested did not significantly contribute to food pathogen reduction. In nearly all cases, less than a one-log cycle reduction was observed.
6. Use of a properly designed small ozone system may offer both the consumer and the food service operator an effective means of reducing the risk of food born pathogen levels in foods when coupled with safe food handling and application of Good Manufacturing Practices.

## Ground-breaking real time video



Groundbreaking real time video shows ozone disrupting or lysing, the cellular wall of *E. coli* 0157:H7. The rings around the bacterium cells are the cytoplasm spilling out as the ozone breaks down the walls. The number of bacteria in the before shot are more than 100 million times the amount of cfu's encountered under "normal" contamination conditions.

In a recent second ground-breaking study, Dr. Montecalvo's team, together with the author, produced the first ever microscopic video capture of the real time destruction of the dangerous food-borne pathogen *E. coli* 0157:H7 utilizing POU ozone food sanitation technology. The new video shows

the actual instantaneous cellular disruption of the bacteria with the addition of low levels of ozone gas dissolved in water.

“Food safety at the home level and in restaurants has become a national priority,” Montecalvo stated. “That’s why visually proving the effects of ozone on pathogens that make people sick is so significant. To our knowledge it’s never been done before in real time.

“The numbers of *E. coli* colonies utilized in the research were nearly one hundred million times greater than would typically be found on contaminated foods,” Dr. Montecalvo stated. “The recently completed video documentation agrees directly with our previous studies which show greater than four-log (99.99 percent) inactivation of bacteria such as *E. coli* 0157:H7, *Salmonella*, *Listeria*, *Staphylococcus* and *Campylobacter* on surfaces of lettuce, meat and poultry with low level ozone technology.

As in the previous studies, the cellular disruption of the pathogen using 0.3 ppm low level ozone technology was accomplished.

## Conclusion

Testing of the process for controlling dangerous food-borne pathogens has confirmed that low-levels of ozone applied to food surfaces can significantly reduce the risk of illness caused by bacteria on produce, fruit, meats, fish and poultry.

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