Confronting Some Myths about Ozone and Food Safety

Deck: The purpose of this paper is to focus on basic criteria for more effective application of ozone in food processing.

The use of Ozone in Food Processing was affirmed GRAS in May 1997 (Graham 1997, EPRI 1997) and granted FDA approval as an Antimicrobial Agent for direct contact with all food types in June 2001 (Federal Register 2001). Subsequently, numerous processes have been developed and adopted (EPRI 2001, Sopher et.al. 2002). Risk of recalls due to microbial contamination drives Food Processors to search for and apply safer and more effective sanitizers. Known antimicrobials include heat, chemical additives, pressure, drying, gasses, radiation, UV light, and ultrasound. Each system has its own special requirements for contact time, temperature, pressure, treatment intensity, and method of application. Ozone properly applied has the unique ability to kill microorganisms, avoid creation of mutants, and leave no harmful residual chemicals. A clear understanding of the application dynamics is a key factor in the effective use of ozone.

Previous publications have detailed specific uses for ozone (Sopher 2012). In their quest for better systems, some ozone equipment vendors now offer systems producing much higher levels of ozone in water without emphasis on the actual application process. We note a trend toward the applications of ozone at levels of 8 to 25 PPM and at temperatures above 21°C in water applied at pressures above 25 psig. These practices and our observations of sporadic results from such "high ozone" treatment systems have led us to assume that there is a lack of application knowledge concerning the following questions:

1. What are the actual dissolved ozone levels of these systems and how were they measured (titration, ozone meter, other)?
2. How much ozone is degraded passing through high pressure nozzles producing small water droplets?
3. Is the ozone wash water temperature low enough to ensure appropriate levels of dissolved ozone in the water?
4. Is product pre-cleaning adequate to remove unnecessary ozone-demanding organics before ozone is applied?
5. Is the initial ozone demand of the fresh wash water known?
6. Is the potential for mold and other airborne microbial contaminants in the processing area considered?

The purpose of this paper is to focus on basic criteria for more effective application of ozone in food processing. Some accepted facts about ozone are:

1. Water containing ozone applied at pressures above 20 psi may perform similar to gaseous rather than aqueous ozone when sprayed on food product surfaces. Ozone's reactivity in aqueous solution is very high compared to its reactivity in ambient air. At 20°C the solubility of oxygen is 0.0439 g/L of fresh water (Handbook of Chemistry and Physics 1949); ozone is more soluble in water than oxygen by approximately 13 times, depending on pressure (Lenntech Webpage 2013); lower temperature increases solubility of oxygen and ozone in water.

2. Ozone in water under high pressure sprayed as small droplets reverts more quickly to oxygen and degasses from solution
3. At elevated temperature (21°C and above), gaseous ozone is less soluble in water and degrades increasingly rapidly to oxygen and other oxygen-containing species, thereby reducing possible benefits from increased oxidative reaction rate due to higher temperature
4. It is critical to ensure that dissolved ozone actually reaches the reaction site to obtain microbial kill. Water containing more than 4 or 5 PPM dissolved ozone also contains gaseous ozone, air and/or high purity oxygen which by mass action at the reaction site on a food product surface may interfere with dissolved ozone access to the target and actually decrease microbial kill (Lenntech Webpage 2013).

These basic facts indicate that process designs tested recently on food products would be expected to show very limited microbial lethality; typically the authors have observed about 1 log count reduction in poorly designed application systems. A high pressure water pre-wash followed by complete immersion of a food product for 2 or 3 minutes in cold water providing an applied dose of 3 to 5 PPM of dissolved ozone should have microbial lethality in the range of 3-4 log count reduction. For this reason, thorough pre-wash of soiled surfaces is strongly recommended. That will remove unnecessary organic load which has high ozone demand and impedes microbiological lethality of ozone.

Ozone lethality for microorganisms is measured as Ct value, which means PPM O_3 times minutes of contact time (Ct=PPM ozone x minutes of application) (O'Donnell et.al. 2012). Kim and Yousef (2000) reported Ct values for *Pseudomonas fluorescens, Escherichia. coli, Leuconostoc mesenteroides,* and *Listeria monocytogenes* are 2 or less for 5 log count reduction in clean water. In a food system, substances such as protein, fat, or sugar consume ozone and increase the required dose to provide required ozone levels after contact with food products. Thus it is important to rely on the level of ozone remaining in the stream after contact with food, i.e., applied dose versus absorbed dose.

Where these application principles are applied correctly, we have seen at least 3 to 4 log count reduction of *Salmonella heidelberg* in unpublished trials conducted recently by Graham and Stevens (2013) (Table 1).

Table 1. IMPACT OF SPRAY APPLICATION OF AQUEOUS OZONE TO CHICKEN PARTS SURFACE INNOCULATED WITH *SALMONELLA*

Date	PPM	psig	GPM	Minutes	Log Reduction	*Salmonella*
11/29/2012	36	25	0.3	12	1.0	PT30
1/30/2013	8	25	0.3	15	1.35	*heidelberg*
1/30/2013	8	25	0.3	135	0.73	(bleached white)
2/26/2013	<8	13	2.5	3	4.1	*12* hour count
2/26/2013	~8	13	2.5	3	3	*24* hour count

Untreated inoculated control samples measured 6.18 to 6.30 logs of *Salmonella*

The new Food Safety and Modernization Act (FSMA) requires prior verification of microbial lethality of process methods. The current regulatory trend is to specify demonstration of 5-log microbial count reduction for food processes. The scientific basis for this approach is valid in a test laboratory, but the practical interpretation is flawed. To demonstrate 5-log count reduction statistically, test product is inoculated with 6-log or higher. A food product with a microbial count of 6-log or higher is unacceptable for commercial processing, and use of inoculated packs for testing in food processing plants is not a safe practice. There is also the question of reliability of inoculated microbial cultures to simulate embedded naturally grown microorganisms.

The generally accepted hurdles of rigorous equipment sanitation, raw product microbial limits, clean handling practices, prewashing, refrigeration, prompt processing, and raw material inspection combine to ensure safe processing. Greater emphasis should be placed on microbial standards for product to be processed and residual counts after processing rather than exclusive focus on 5-log count reduction for process verification. Microbial limits on raw product for processing have been used effectively for dairy product safety for nearly a century. Air often is overlooked as a significant source of mold and other microbial contamination (EPRI 1992).

Hopefully these comments will be useful to leaders in food processing, process design and evaluation for food safety generally and specifically for effective use of ozone in food processing.

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