Advanced Oxidation as a Food Preservative

By Ronald G. Fink, Christopher Willette and Walter Ellis

Bacteria, fungus and mold spores are the enemies of an effective food preservation program. The use of passive air ozonation, advanced oxidation washing processes, and photocatalytic oxidation has reduced bacteria counts up to 300%.

What is Ozone?

Ozone is a form of oxygen in which the molecule contains three atoms instead of two. Ozone is O_3, one more atom than oxygen (O_2).

How Ozone Purifies

One of the major benefits of ozone is its tremendous ability to oxidize substances. It is thousands of times faster than chlorine and disinfects three to four times more efficiently. Ozone's third atom, the loosely held or "unstable" atom, has a strong tendency to break away and attach itself to other substances. While the original ozone molecule reverts back to O_2, the loose molecule attaches itself to a new host substance and oxidizes it. Just as fire oxidizes organic matter and changes one substance to another substance, ozone will destroy a molecule through oxidation, and then revert back to oxygen leaving no chemical residue.

Advanced Oxidation

Oxidation is a chemical reaction in which an element or ion is increased in positive valence, losing electrons to an oxidizing agent. To oxidize is to change a substance by chemical reaction by combining it with oxygen, such as fire or rust.

CHEMICAL OXIDIZERS
(In order of Strength)

1. Fluoride
2. Hydroxyl Radical*
3. Ozone*
4. Hydrogen Peroxide
5. Permanganate
6. Chlorine
7. Bromine
8. Iodine
9. Oxygen*

* Elements of the RGF Advanced Oxidation Process. Friendly oxidizers do not use chemicals and revert back to oxygen and hydrogen.

Advanced Oxidation Process (AOP) refers to increasing the reactivity of ozone in water or air. This is performed by forcing ozone to

react via a free radical pathway (Hydroxyl Radical). There are two methods commonly used to create the Hydroxyl Radical:

1. Ozone and Hydrogen Peroxide-water treatment
2. Ozone and Ultraviolet Light-water or air treatment

Many molecules that are resistant to ozone alone are degraded by the Hydroxyl Radical process. AOP is used most often to control organics in water (taste, odor, color, THM precursors, micro pollutants and pesticides).

A Three-Process Approach

Utilizing the advanced oxidation technology, a series of experiments were run utilizing passive ozone and hydroxyl radical disinfection and photocatalytic oxidation as a method of prolonging food storage life. The concept was to increase the disinfection efficiency during processing and storage to eliminate molds, fungus, bacteria, and thereby increase the shelf life. A three-process approach was taken. The first was to expose the food to a photocatalytic process where ultraviolet light rays activate ozone gas to create a hydroxyl radical atmosphere. The second was to wash the food with water containing hydroxyl radicals and third was to treat the air with passive, low level ozone to reduce airborne bacteria levels in the processing and storage areas.

1. **Photocatalytic Oxidation Process**

The processed food is passed under a hooded system that utilizes ultraviolet light rays to activate ozone and form a hydroxyl radical. This process is performed just before final wrapping, thereby assuring the maximum sanitized condition. This process reduced surface bacteria by approximately 70%.

2. **Advanced Oxidation Food Wash**

The second series was run to determine the effect of washing food products with the Advanced Oxidation (water and hydroxyl radicals) Process to control decay. Test 1 was performed on processed chicken breasts (boneless, skinless), both preserved (marinated in Sodium Tri Poly Phosphate), and non-preserved (non-marinated). The control "A" was washed using typical chlorinated tap water; "B" was washed using Advanced Oxidation water.

Advanced oxidation process wash and rinse operation reduced bacteria levels by 80% over conventional washing methods.

A (marinated) **B (marinated)** **A (non-marinated)** **B (non-marinated)**

Results clearly indicate bacterial levels 80% lower with the use of the advanced oxidation method.

Test 2 was a shelf life longevity test performed on strawberries. This was a dual stage evaluation. The first step involved washing the strawberries with chlorinated water ("A") versus Advanced Oxidation Water ("B"). The second stage of this test was to examine the effects of storing the strawberries in a low level ozone environment (ozone 0.02 ppm). Here the

strawberries from the first stage were separated into two subgroups. One group was put in a non-ozonated (air) environment, and the other group was placed in a low level ozone environment (ozone 0.02 ppm).

A (air) B

Chlorinated water wash stored in air only for one week. Heavy mold growth

Ozone wash with Advanced OxidationProcess. One week storage in air 80% mold reduction

A (ozone 0.02 ppm) B

Chlorinated water wash stored in low-level ozone (0.02 ppm) one week. 50% mold growth reduction.75% shelf life increase.

Ozone wash with Advanced Oxidation Process. One week storage at .02 ppm No mold double shelf life

Again, the results indicate the Advanced Oxidation significantly increased the expected shelf life of the strawberries (by a factor of two). In addition, the low-level ozone atmosphere extended the shelf life even further.

3. **Passive Air Ozonation**

Tests were run to determine if low-level ozone (0.02 ppm) would actually reduce the airborne background count of mold, fungus and bacteria. Tests were conducted in an office, restaurants, kitchen, home, environmental laboratory, and chicken processing plant. All six tests produced an average of 96.6% reductions of airborne bacteria, mold and fungus.

Safe low level passive ozonation of food process work area reduces bacteria, mold, and fungi levels by 96.6%

Summary

The results of the three-process approach are important for six reasons:

- The passive ozonation of air significantly reduced airborne bacteria, mold and fungus an average of 96%.
- The advanced oxidation wash process reduced bacterial levels 80% over conventional washing.
- The photocatalytic oxidation process reduced surface bacterial levels over 70%.
- The levels of ozone air treatment used for the test were below OSHA's standard for occupied work areas. OSHA's standard is .04 ppm. The level used was .02 ppm, which means these levels of ozone can be maintained in worker areas.
- The food life was increased by twofold.
- The low level ozone used was made by a UV Ozone generator, which is low capital cost and very low maintenance (often no maintenance for the first year).

Conclusion

- Passive Ozonation Advanced Oxidation and Photocatalytic Oxidation have demonstrated superior bacterial killing power over traditional sanitizing methods.
- Passive Ozonation Advanced Oxidation and Photocatalytic Oxidation do not leave a residual of potential carcinogenics and taste distorting chemicals.
- Passive ozonation of the work areas will improve working conditions by reducing odors and providing cleaner air.
- The combination of all three processes has the ability to reduce food bacteria by 300%.
- The three-phase *RGF* Sanitation Program can be used in any food processing facility, food preparation, or restaurant.

RGF Environmental Group designs, engineers, and manufactures over 150 environmental products, including UV, corona discharge ozone products, advanced oxidation process, and photocatalytic oxidation process.

Ronald G. Fink
President, *RGF* Environmental Group. BSME, Numerous water treatment patents, authored over 40 published technical papers.

Christopher C. Willette
Engineer, *RGF* Environmental Group. BSME, BS Physics. Specialist in Ozone Systems Design.

Walter B. Ellis
Lab Manager, *RGF* Environmental Group. BS Degree in Biology & Marine Biology. Specialist in Ozone Testing and Monitoring.