Ozone may provide environmentally safe protection for grains

THE EFFECTS OF OZONE AND NEGATIVE AIR IONS ON MICROORGANISMS

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Abstract:
The control of microorganisms on fresh produce is very important to the food industry in order to maintain quality and ensure safety. *Pseudomonas fluorescens* and *Erwinia carotovora* pv. *carotovora* are plant pathogens that cause decay of many fresh fruits and vegetables during storage. Strains of *Escherichia coli* are pathogenic to humans and have been found on contaminated produce. In this study, dilute cell suspensions of *P. fluorescens, E. carotovora* pv. *carotovora*, and *E. coli* were inoculated onto potato dextrose agar (PDA) and subsequently exposed to 100 ± 5 nl·L^{-1} ozone and/or 10^6 negative air ions (NAI)·ml^{-1} to determine the effect of these treatments on cell viability. Treatment with NAI alone had no killing effect on any of the bacterial cells of all three species. However, ozone was effective in killing all three species and the addition of NAI enhanced this killing effect. *P. fluorescens* was most susceptible to the combined treatment; viability was reduced to 0.7% after 6 h, while 76% of the cells remained viable when exposed to ozone alone. Viability of *E. carotovora* pv. *carotovora* was reduced to 4% after 6 h in the combined treatment compared with 69% when exposed to ozone alone. *E. coli* was more resistant to the combined treatment; viability was reduced to only 40% after 11 h compared with 70% in the ozone alone treatment. Other factors, including the culture media used, influenced the effectiveness of ozone and NAI to kill bacteria and requires further study. The synergism of NAI with ozone may provide an effective method to reduce microbial contamination resulting in produce with less decay and risk of food borne disease.

WEST LAFAYETTE, Ind. – Taking a clue from air purification systems used in surgical suites, Purdue University researchers have discovered that ozone can eliminate insects in grain storage facilities without harming food quality or the environment.

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Ironically, the gas is being touted as a fumigant alternative in response to an international treaty banning the use of ozone-layer harming chemicals currently used to rid food storage facilities of insects. When ozone is used for killing grain insects, it lasts for a very short period of time without damaging the environment or the grain, the Purdue scientists report in the January issue *Journal of Stored Products Research*.

"Ozone has a very short half-life and we're using relatively low dosages, but enough to kill an insect," said Linda Mason, Purdue entomology associate professor and co-author of the study. "The chemicals currently used can kill everything in and around the grain bin, including people. With ozone, we're not generating ozone at deadly concentrations, and we have better control over it when it's present."

Purdue's Post Harvest Grain Quality Research team began its studies in response to the 1987 Montreal Protocol, an international agreement to prohibit substances deemed dangerous to the Earth's ozone layer. One such substance is methyl bromide, commonly used against crop pests in the soil and in grain storage facilities. Beginning in 2005, it no longer will be available.

A replacement for chemical fumigants is imperative because insects not only eat the grain, they defecate on it causing development of fungi, primarily *Fusarium* and *Aspergillus.*These fungi can release potentially deadly mycotoxins that can cause illness in most livestock and have been linked to some forms of human cancer. In humans, approximately 76 million cases of food-borne disease occur annually in the United States, according to the Centers for Disease Control and Prevention.

Experts estimate that 5 percent to 10 percent of the world's food production is lost each year because of insects, and in some countries that figure is believed to be as high as 50 percent.

In the latest study, Purdue researchers used ozone to treat rice, popcorn, soft red winter wheat, hard red winter wheat, soybeans and corn. They used five-gallon plastic pails and 50-gallon steel drums, storage bins filled with grain, and buried mesh bags all filled with grain and a known number of grain-eating bugs to test ozone's killing efficacy. The team's previous studies on ozone flow and effectiveness in eliminating insects were done either in similar storage containers or in 500-bushel bins built for pilot studies at the Purdue Agronomy Farm.

The ozone treatment of grain included two applications of ozone. In the first, the ozone moves through the grain slowly because the gas reacts, or bonds, with matter on the grain surface. This first treatment allows ozone to react with most of the grain surface and degrades the ozone, Mason said. With the second ozone application, the gas moves through the grain more quickly because it isn't slowed by reactions with the grain. This allows the ozone to kill the insects by reacting with them rather than the grain.

Testing different grains allowed the scientists to answer two important questions. One was whether ozone flowed differently through grains that were less porous or of a different kernel size than corn, such as wheat. The second was how exposure to ozone affects the quality of food products made from the treated grain.

Dirk Maier, a Purdue agricultural and biological engineering professor, studied how to make the ozone flow efficiently and effectively through grain storage bins. Charles Woloshuk, a botany and plant pathology professor, studied ozone effects on molds and mycotoxins. Fidel Mendez, a botany master's degree student, studied the final products produced from the treated grain to determine if they were the same quality as those made from untreated grain.

"We wanted to determine if the grain looked any different; if it milled the same way; if it made flour the same way. Does bread taste the same when made from ozonated wheat?" Mason said. "Essentially, there were no differences. The food industry can take grain that's been treated with ozone and know it won't affect their ability to come up with the same products in the end."

The team also checked how ozone treatments affected amounts of important amino acids and essential fatty acids, fats not produced by the body. The treatments caused no significant difference in any of the nutritional and metabolic values of these substances in any of the grains studied, Mason said.

The scientists began their study after a company that uses ozone air purification systems in hospitals noticed that air vents were cockroach free. Absence of cockroaches in a large building is unusual, so the researchers tested various ozone doses on different insects and found the gas was fatal to bugs.

"All the species we tested seemed affected," Mason said. "The only ones we don't have control over are immature weevils since they are hidden within the kernels. Ozone, unlike chemical fumigants, doesn't penetrate into the kernel enough to kill immature insects."

Currently, the researchers are studying ways to use ozone as a preventative treatment by possibly sealing of grain storage facilities with layers of ozone, much the way a jelly jar is capped with wax.

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