

# MAFMA Final Report

Project Title: The Efficacy for Treating Grain with Ozone in Continuous Flow Systems

PI (s): Charles Woloshuk, Dirk Maier, Linda Mason

Academic Institution: Purdue University

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## 1. Objective Summary:

The goal of this project was to determine the parameters needed to treat food-grade grains with ozone in a continuous-flow system to control insects and reduce spoilage fungi. The objectives of this project were to determine the effects of various ozone concentrations in combination with various exposure times on 1) populations of fungi, 2) mortality of insects (adults, larva, and eggs), and 3) the resistance to ozone flow.

## 2. Objective Accomplishments:

In a continuous-flow system, the grain cannot move at a rate greater than the time needed to accomplish the desired treatment effect. For fungi located on the grain surface, a series of experiments were conducted to determine the minimum ozone concentration and treatment times that would lower the fungal population numbers. Grain with about  $1.3 \times 10^4$  colony-forming units per gram was treated with two concentrations (800 and 1600 ppm) of ozone for one and three hours. A reduction in the surface mold population of 28% and 15%, respectively, was observed after one hour of treatment and a reduction of 42% and 81% after three hours.

To determine whether high concentration/short treatment times are effective in controlling all life stages of two important post harvest pests, Indianmeal moth (*Plodia interpunctella* Hübner) egg, larvae and pupae and red flour beetle (*Tribolium castaneum* (Herbst) egg, larvae, pupae and adults were treated with various ozone time/concentration combinations. Indianmeal moth concentrations tested ranged from 50-1500 ppm ozone (50, 100, 500, 1000, 1500) with two time periods tested (30 and 60 min). Red flour beetle life stages were treated with ozone at 1800ppm for 30\_min, 60\_min, 90\_min, 120\_min, or 180\_min.

While no Indianmeal moth life stages reached 100% mortality, eggs achieved their highest mortality at 60 min/1500 ppm; larvae at 30 min/1500; and pupae at 60 min/150. One hundred percent mortality was achieved for all life stages of red flour beetles, i.e., at 2 h for adults, 1.5 h for larvae, and 3 h for eggs and pupae. Results indicate that eggs (and pupae) are more resistant to ozone than larvae, which was not unexpected based on past research. If retention times can be extended to at least 3 hours and high doses of ozone can be accomplished, control of these two important stored product pests may be realized, and continuous-flow ozonation treatment may thus be a viable treatment option.

In a continuous-flow system, the depth of the treatment zone is dependent on the ability of the ozone to effectively flow through the grain. Previous experiments have indicated that during the initial treatment of grain, ozone is rapidly degraded due to reactive sites on the grain surface. As a result the apparent ozone concentration remains low until these reactive sites are oxidized. In this study, we were able to make a preliminary evaluation of the flow characteristic (Objective 3). With an ozone concentration of 1600 ppm at the inlet to the treatment chamber and an ozone flow rate of 8.2 L/min, we measured changes in ozone concentration at the

chamber outlet. Under these conditions, movement of the ozone followed the equation  $y = 7.962x^{-0.6}$  ( $R^2 = 0.986$ ), where  $y$  = the difference between the ozone concentration at the inlet and outlet and  $x$  = time.

**3. Unexpected findings:** none

**4. Practical impacts of research efforts:**

**a. Short Term Impacts:**

The results from this study provide us with measures that indicate the magnitude of the ozone concentration and contact time that is needed to effectively reduce mold and insect populations in a continuous-flow system. Our industrial partner on this MAFMA project (O3Co, Inc.) will now try construct a generator that can delivery this level of ozone, which will be a challenge. Next month (June 2008) we will test their largest ozone generator under field conditions to determine what concentrations can be established in a counter-flow grain treatment system. In the fall of 2008, we will work with O3Co and a second partner (Lynntech) to test a screw-type transfer/treatment system. It is believed that the tumbling effect of the screw-type system may increase the exposure of grain to ozone, lowering the concentration or contact time needed for the treatment.

**b. Long Term Impacts:**

The work needed on a continuous-flow system for treating grain with ozone is not complete. However, the information generated thus far gives our partners and us a more realistic view of the challenges facing the commercialization of this technology.

**5. If you are also making reports to other funding agencies in the course of this research work, please include a copy of that report.**

**6. If any publications resulted from the research, a copy must be included:**

Three manuscripts for publication are forthcoming. A poster presentation on this work will be presented this summer at: 2008 International Grain Quality & Technology Conference, July 15-18<sup>th</sup>, 2008, Chicago, Illinois. EFFECT OF OZONE TREATMENT ON COMMON STORED GRAIN MOLDS & FUNGI. Author: J.D. McClurkin, D.E. Maier, and C.P. Woloshuk

Manuscript: Semi-Continuous Ozonation System for Pest Control in Stored Food Grain. C.A. Campabadal, J.D. McClurkin, D.E. Maier, L.J. Mason, C.P. Woloshuk. To be submitted to Journal of Stored Products Research.

Manuscript: The Influence of Short Treatment Times and High Ozone Dosages on Indianmeal Moth Immature Life Stages. M. McDonough, M.X. McDonough, and L.J. Mason. To be submitted to Journal of Stored Products Research.

Manuscript: Efficacy of High Ozone Concentrations on Red Flour Beetle Mortality. M.X. McDonough and L.J. Mason. To be submitted to Journal of Stored Products Research.

Oral Presentation: Is ozone effective in killing stored product insects when treatment times are reduced? L.J. Mason. GEAPS Regional Conference Grain Quality Workshop, Angola, IN. April 2008.