



Analysis of a combined Potassium Monopersulfate (PMS) and Ozonated Water treatment system for cereal decontamination.

1. Executive Summary

This document details the conceptual design and technical feasibility of an advanced oxidation process utilizing a combination of Potassium Monopersulfate (PMS) and Ozonated Water for treating cereals. The primary focus is on its high efficacy against enveloped viruses, specifically African Swine Fever Virus (ASFV). The system operates on the principle of synergistic oxidation, generating powerful hydroxyl radicals that destroy microbial contaminants, degrade mycotoxins and pesticides, and effectively inactivate viruses. The residual substances from this process (sulfates and potassium) are recognized as safe. The main challenges for implementation are process optimization to preserve cereal quality and obtaining regulatory approvals for its use in the food and feed chain.

2. Existence of a Commercial PMS and Ozonated Water Combination

Question: Does a commercial product exist that contains a combination of potassium monopersulfate (PMS) and ozonated water?

Answer: Yes, combinations of Potassium Monopersulfate (PMS) and Ozonated Water are used commercially, but not as a single pre-mixed product. Instead, they are deployed as integrated "water treatment systems" primarily for swimming pool and spa disinfection.

How the Combination Works:

* Potassium Monopersulfate (PMS): Acts as a powerful non-chlorine oxidizer. It eliminates organic contaminants (oils, urea, sweat) and, crucially, catalyzes the decomposition of ozone to generate highly reactive *hydroxyl radicals ($\cdot\text{OH}$)*.

* Ozonated Water (Ozone - O_3): A potent disinfectant and oxidant gas dissolved in water. It rapidly destroys bacteria, viruses, and algae but has a very short lifespan in water.

Commercial Application:

These are sold as "integrated systems" that include:

1. An ozone generator installed on the water return line.
2. An automated doser that adds PMS (often sold as "active oxygen").
3. A controller that manages the synergy between the two components for optimal efficiency.

Companies selling ozone generators often recommend and sell complementary PMS products to maximize system performance, marketing it as an "advanced oxidation" or "chlorine-free" system.

3. Application to Cereal Treatment and Residual Substances

Question: Can a system for treating cereals based on this mixture be conceived? What residual substances could result from this process?

Answer: Yes, a treatment system for cereals based on the PMS and Ozone combination is not only conceivable but also highly promising. It forms an Advanced Oxidation Process (AOP) highly effective for microbial inactivation, mycotoxin degradation, and pesticide removal.

Proposed Treatment Process:

1. Pre-wetting: Cereals are lightly moistened with ozonated water.
2. Oxidant Application: A solution of PMS is finely sprayed onto the cereals in a closed reactor while ozone gas is simultaneously injected.
3. Reaction Time: The cereals are mixed continuously for a predetermined time (e.g., 1-5 minutes) to allow oxidative reactions to occur.
4. Rinsing & Drying: Cereals may be rinsed with clean water to remove soluble residues, followed by a crucial rapid drying step to reduce moisture to a safe storage level.

Expected Residual Substances:

The residual substances from this process are primarily harmless:

- 1. Sulfates (SO₄²⁻):The main residue from PMS. Sulfate is Generally Recognized As Safe (GRAS) by the FDA and a natural constituent of many foods and water.
- 2. Potassium (K⁺): An essential nutrient and harmless in the quantities resulting from treatment.
- 3. Oxygen (O₂): Both PMS and ozone ultimately decompose into oxygen and water.
- 4. Degradation Products: Microorganisms are oxidized to CO₂ and H₂O. Mycotoxins and pesticides are broken down into smaller, more polar, and water-soluble compounds (e.g., carboxylic acids), which can be rinsed away. These specific degradation products must be studied to ensure they are less toxic than the original compound.

Key Challenges:

Quality Impact: Must evaluate the effect on nutritional quality (oxidation-sensitive vitamins), baking quality, and sensory properties (color, odor, taste).

Regulatory Approval: The biggest hurdle. Using PMS as a direct food/feed additive requires strict approval from food safety authorities (EFSA, FDA), involving extensive toxicological studies.

4. Efficacy Against ASFV: Concentrations, Doses, and Reaction Time

Efficacy of such a cereal treatment against the African Swine Fever virus, including concentrations, doses, and reaction time.

The PMS/Ozonated water system would be extremely effective at inactivating ASFV on cereals.

Efficacy Against ASFV: Scientific Reason: ASFV is an enveloped virus. Its lipid envelope is highly vulnerable to powerful oxidizing agents like ozone and the hydroxyl radicals generated by the PMS/O₃ synergy. Mechanism of Action: Oxidants attack and destroy:

- 1. The viral envelope.
- 2. The protein capsid.
- 3. The viral genetic material (DNA).

Supporting Evidence: Numerous scientific studies have proven ozone's high efficacy in inactivating ASFV in water and on surfaces. PMS is a powerful oxidizing biocide widely used in the swine and poultry industry for disinfecting surfaces and drinking water against a broad spectrum of viruses, including enveloped ones.

Recommended Process Parameters (Estimated):

Parameter	Recommended Range	Rationale and Notes
PMS Concentration	0.5% - 1.5%(5 - 15 g per liter of water)	Lower concentrations (0.5-1%) may be sufficient with optimal ozone synergy. Higher concentrations (1-1.5%) provide a safety buffer for heavily contaminated loads
Ozone Concentration in Water	2.0 - 4.0 ppm (mg/L)	A concentration easily achieved with a commercial generator and highly effective against viruses. Must be mixed efficiently
Solution/Cereal Ratio	1 - 2 L per 100 kg of cereal	This provides light moistening (1-2% moisture addition) for uniform coverage without requiring excessive subsequent drying
Reaction/Contact Time	10 - 20 minutes (Studies show that even 1 minute is enough)	Time required for oxidants to penetrate and inactivate the virus. Continuous mixing in a reactor is essential
Temperature	Ambient (15-25°C)	The process works well at room temperature
Solution pH	Neutral (6.5 - 7.5)	A compromise that ensures good stability for PMS and controlled reactivity for ozone

Process Flow:

- 1. Solution Prep: A stable PMS solution is prepared. Ozonated water is generated on-site in a separate tank.
- 2. Mixing & Application: The two solutions are mixed immediately before being applied as a “fine mist” onto cereals on a conveyor belt or in a mixer.
- 3. Reaction: The moistened cereals enter a retention reactor/silo where they are mixed slowly for 10-20 minutes for the inactivation to occur.
- 4. Drying (CRITICAL STEP): Cereals pass through a rapid dryer (e.g., hot air dryer) to reduce moisture content back to the original safe level (e.g., below 14%) to prevent molding.
- 5. Cooling & Storage: Cereals are cooled to ambient temperature and stored or packaged safely.

Residuals and Safety for Animals:

The amount of sulfates and potassium added per ton of cereal is minimal and poses no risk to animals. Proper drying is the key to preventing any post-treatment quality issues.

The list of benefits of such a system is large and with a single treatment a multitude of problems are solved.

Below is a table with the problems that this system solves, but it is only about applications to pig farms, but it can be extended to all farm animals.

Problem	Mechanism of Action (Ozone + PMS)	Practical Benefit
Viruses (ASFV, PRRSV, Circovirus, Rotavirus)	Oxidation of lipids in the viral envelope and structural proteins → rapid inactivation	Eliminates the risk of feed being a disease vehicle; increases biosecurity
Pathogenic Bacteria (Salmonella, E. coli, Listeria, Clostridium)	OH^- and $\text{SO}_4^{\bullet-}$ radicals attack cell membranes and bacterial DNA	Reduces the risk of food poisoning, post-weaning diarrhea, mortality
Molds (Aspergillus, Fusarium, Penicillium)	Ozone + PMS destroy fungal hyphae and spores	Inhibits mold development in silos, extends storage period
Mycotoxins (Aflatoxins, DON, Zearalenone, Fumonisin, Ochratoxins)	Ozone cleaves conjugated double bonds, PMS produces radicals that attack functional groups → partial degradation	Lower mycotoxin levels → liver and reproductive protection, better growth
Insect Eggs/Larvae (Storage Pests)	Gaseous ozone has an insecticidal effect on certain life stages	Reduces secondary infestations, storage losses
Biofilm on Equipment	Ozone/PMS destroy the polysaccharide matrix of the biofilm	Better hygiene in feeders, hoppers, pipes; reduced risk of cross-contamination
Unpleasant Odors (Aldehydes, Ketones, Volatile Compounds)	Ozone oxidizes odorant molecules	Feed with a neutral odor, better accepted by animals
Lipid Oxidation (Rancidity)	Reduction of microbial load reduces lipolytic enzymes	Longer shelf life, without organoleptic alterations
Contaminated Process Water	PMS + ozone sterilize water used for mixing or cleaning	Ensures water does not introduce germs into the process flow
General Biosecurity	Multi-point chemical and physical barrier	Reduces the risk of indirect transmission of ASF and other diseases