# Application of Ozone Technology in Enhancing Quality of Major Cereals

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## SUMMARY

Using ozone as a non-thermal food technique is both economical and environmentally friendly. It is extensively used in cereals to degrade mycotoxin and remove microbial contaminants. An overview of ozone's effectiveness in processing cereals for microbiological decontamination, insect control, and changes in grain quality is given in the current article. Discussions are held over several variables that affect the ozone treatment process, including grain bed thickness, temperature, moisture content, medium pH, and concentration. Since ozone treatment uses the oxidation principle, the finished product is guaranteed to be both microbiologically secure and shelf-stable. In order to preserve the quality of cereal and its products, ozone technology appears to be a promising one.

## INTRODUCTION

With the rise of world trade organization (WTO) and food safety standards awareness on the food safety has risen trade in agricultural products is subjected to slew of sanitary and phytosanitary measures. There were several reports of Indian food consignments getting rejected in European countries due to their strict adherence to food safety standards. On the other hand, ongoing Russia-Ukraine war has intimidated several European countries to look towards India for their foodgrain supply and opened new vistas for diversification of Indian grain exports. Moreover, adherence to food safety standards is vital for India to sustain demand of its grains in the world market. However, tropical and subtropical climate and humid weather of India pose great threat for the food contamination when the country has surplus production on one hand while inadequate storage structures for its surplus production. Conversely, contaminated food possess great challenge to the outcomes of global food and nutrition security. Therefore, adoption of robust food processing technologies to address such problems are vital for India to place it on the fulcrum of global food supply basket. Traditionally, India has relied on solarization of food grains before storage and sale to ensure the acceptability of its food products for consumption. However, with the advancement in the research and development, ozonation has emerged as a potential technology in the storage of cereal grains. In this article, we discuss about ozonation technology in details along with its application, advantages and challenges in its adaptation and its prospects in cereal processing.

The deterioration in the grain quality during storage is mostly influenced by three factors namely (i) attack by insects and rodents (ii) the growth of microbes like bacteria and moulds (iii) metabolic activities of the grain causing change in chemical composition of the grain. This damage can be looked after by carrying out curative action plans or preventive measures to maintain the optimum quality of grain. It is well known that there are various chemical disinfestation methods like fumigation, vaporization, application of insecticides etc. for protecting the grain from infestation. However, these methods involve toxic gas such as ethylene bromide, hydrogen cyanide which are lethal for insects and pests but leaves behind toxic residues harmful for both grains as well as human working in that environment. Besides, the nutritional quality of grains also gets affected. Therefore, its high time to move to nonchemical methods like microwave, infrared, ultraviolet and ozonation for grain disinfestation that can maintain the grain quality. Comparing all the methods, it was seen that ozonation technique could retain the nutritional quality with increased shelf life of the grains.

Ozone is used in gaseous or liquid form using spraying technique for the disinfecting various foodstuffs including both vegetarian and non-vegetarian, dairy, beverages and herbs too. Besides, undergoing this treatment enhances the qualitative shelf life of the products by providing microbiological safety.This owes to the fact that ozone readily gets decomposed into oxygen in air thereby leaving no residues on the products and does not require removal of gas from the products. These unique characteristics makes the ozone treatment as a safe and green technology in ensuring safe food in the retail store.It has also been designated as "Generally Recognized as Safe" (GRAS) and is recommended for disinfecting food matrix.

It is interesting to note that the functional properties of the cereals get altered with the application of ozone treatment. Seed treatment using ozone technique proves to be a potent proves to be a germination enhancer in cereals also enhances plant growth.Though ozone treatment has significant advantages over the other traditional techniques, nevertheless, it has not gained popularity because of its high cost.

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Feature Article

Commercially, ozone is generated using corona discharge technique which converts most of the input energy to heat and light, which is inadequate for treating the different food commodities (**Figure-1**). Research needs to be undertaken making this green technology more economically feasible and friendly for carrying out wide application in food industry.

## Application of ozone gas in cereal industry

In this section, we discuss the uses of ozone in the food industry for variety of purposes and (**Figure-2**) provides a brief idea of that.

### *(a) Decontamination of microbes and fungus in cereals*

As a potent microbial agent, ozone acts well against various microbes such as *Staphylococcus*, *Coliform bacteria, Aspergillus, Penicillium and Rhizopus*. The antimicrobial activity of ozone is greatly influenced by the factors like state of ozone (gaseous/aqueous phase), type or strain of microorganisms, state of cells, sample pH, temperature, humidity, and growth level. The process of inactivation of microbes includes two mechanisms. Firstly, oxidation of both the sulfhydryl and amino acid groups of protein and enzymes present in microbes whereas the later one oxidises PUFA which results in disintegration of the cell wall with leakage of cell matter and then cell lysis(**Figure-3**).

With respect to inactivation of fungal growth in rice grains, 100% efficiency was achieved against the lysis of *Aspergillus* spp. and *Penicillium* spp. at ozone

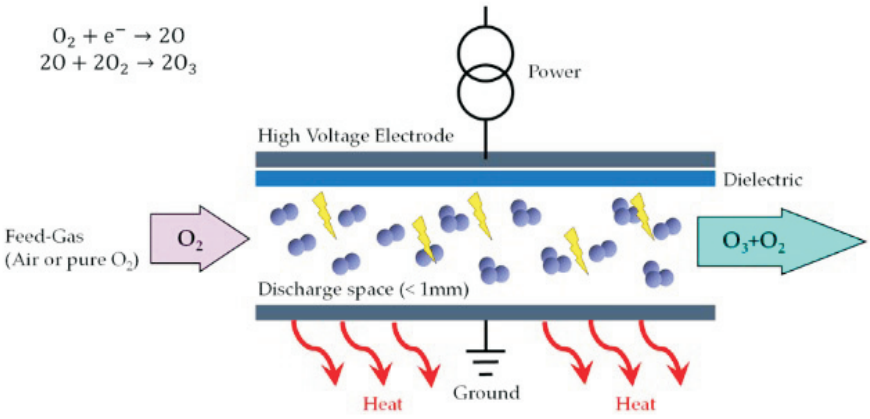


**FIGURE: 1** Ozone production from corona discharge.

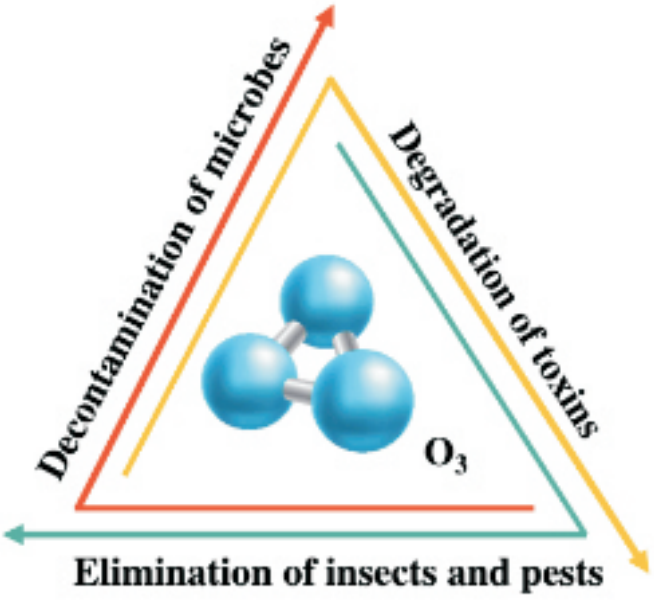


**FIGURE: 2** Application of ozone in food industry.

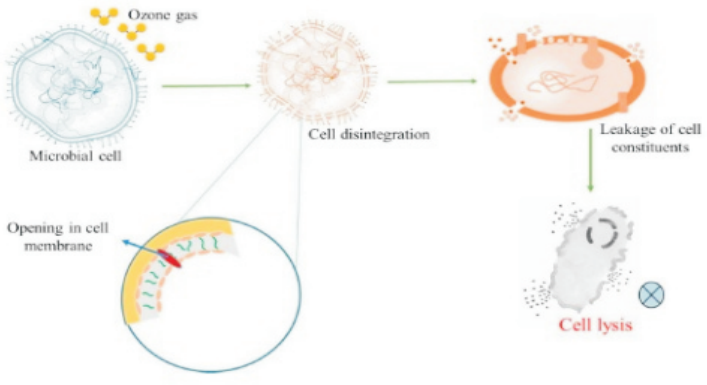


**FIGURE: 3** Schematic diagram of microbial inactivation by ozone treatment.

concentration of 10.13 mg/L for 60 h respectively. Most of the research studies have highlighted the same fact that the efficacy of ozone treatment is inversely proportional to the moisture content of rain. As we know ozone (2.14 kg/m$^3$) is denser than air (1.225 kg/m$^3$), its diffusion takes place in lateral direction rather than vertical which makes the maximum concentration at the bottom of the bin. Therefore, grain bed thickness is an important parameter to be considered for diffusion of ozone uniformly across the entire grain mass.

## Degradation of mycotoxins

Mycotoxins, known as secondary metabolites are mostly produced when fungi grow on foods such as cereals, pulses, spices under warm and humid conditions causing danger on consumption of infected foods. Ozone is found to be an effective against several mycotoxins like fungal spores and mycelia along with Aflatoxin and Deoxynivalenol (DON) in wheat, *fusarium* in barley, *Aspergillus parasiticus,* Zearalenone (ZEN) and ochratoxin A (OTA) in maize at different doses of ozone at different time interval. The inactivation involves a simple mechanism where the mycotoxin products reacts with ozone gas and forms low molecular weight end products which are less toxic. It is greatly affected by the exposure time, ozone concentration, pH and moisture content of the stored grains. In order to have a desired safe and quality product, there is a need to optimize the desired mycotoxin level in the grains when exposed to ozone treatment.

Feature Article

## Management of insects

Ozone is assumed to have strong insecticidal activity against various internal as well as external feeders in storage grains *Rhyzopertha dominica, Sitophilus granarius, S.zeamais, S. oryzae* and *Tribolium castaneum* with minimum residues. The toxic effect of ozone on the insects is influenced by its life stages. Eggs are least vulnerable because due to the outer layer providing mechanical barrier to ozone treatment. Therefore, the exposure time of ozone must be extended to the egg stage in order to obtain safe product.

## Effect of ozone treatment on quality of grains

For effective detoxification of grains against insects and pests, doses of ozone applied either in aqueous or gaseous phase may affect the quality parameters of grain positively or negatively.

### *(a) Starch modification*

Generally, native starch is modified by means of physical, chemical and enzymatic methods to enhance its functionality in terms of swelling capacity, viscosity, solubility and gelatinization widely applied in bakery industries for obtaining processed products of desired quality.

Ozonation technique oxidises the starch molecules based on two chemical reactions. The first step involves the conversion of the hydroxyl group to carboxyl and carbonyl groups by oxidation and then depolymerisation of the starch molecules by splitting the glycosidic linkages. Research study on exposure of wheat kernels as well as sorghum flour caused polymerization as well as degradation of starch. However, in case of waxy rice starch, thermal properties like gelatinization temperature, enthalpy etc. decreased which may be due to the presence of polyphenols, proteins, and non-starch polysaccharides, that prevented starch from oxidation when undergone ozone treatment.

### *(b) Effect on protein profile*

Unlike starch, protein is a vital component of grain whose properties highly influence the quality of end products such as bakery and fried products. It has been observed that the isolated proteins such as gluten, glutenin, gliadin etc. when treated with ozone (5g/h till 1h) caused a decrease in sulfhydrl group and also the gluten content.

### *( c) Other minor components*

On exposure to ozone treatment, lipid content of wheat kernels was unaffected which may be accrued to the fact that the pericarp of the kernel protected the matrix from trapping of ozone into it.On the other hand, ozone gas (5 g/h, up to 45 min) treatment caused oxidation of linoleic acid, thereby resulting an increase in palmitic acid content in wheat flour oil. The polyphenols, vitamins, phytates were observed to be least affected by ozone treatment because of the cohesive matrix of cell wall, starch, and protein that retarded the easy penetration of ozone into core.

### *(d) Color*

Due to the oxidation of the conjugated double bond in carotenoid pigments, ozonation caused a rise in the lightness value L* and a decrease in the yellowness b*. The oxidation of colourants like polyphenols and carotenoids in the grains by ozone may be the cause of flour's rising whiteness. Therefore, employing ozone as a bleaching agent instead of chemicals could be appealing. It provides consumer safety while lowering the dangers of chemical residue levels.

### *(e) Storage*

Ozone treatment could be advantageous for the long-term storage of cereals since it oxidises the free water when it interacts with the product. According to certain studies, noodles and bread prepared from ozonated wheat flour both had improved whitening, a longer shelf life, and a better specific loaf volume and internal structure.

## CONCLUSION

Across all the grain processing sector, there is a trending focus towards the safe storage of the various food grains that ensures good quality of grains fit for consumption Strict ban on chemical fumigants and the demand of consumers for “green” food has compelled the supply chain players to look for alternatives. Ozone is one such GRAS technology encompassing all qualities like antimicrobial, antifungal, insecticidal etc. Exposure of grains to ozone leaves behind negligible residues as well as least change in physicochemical properties of the end product. However, the processing cost of generating ozone makes hindrance for its wide spread acceptability. This requires a low-cost design to treat the cereal grains and its products commercially. Besides, ozone treatment may cope up with other strategies such as addition of other food additives or other greener technologies to obtain the desired product quality with enhanced shelf life.

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