AN EXPLANATION OF OZONE AND ITS USES

COMPLETE WITH

SCIENTIFIC AND TECHNICAL REFERENCES

AND SELECTED BIBLIOGRAPHY

Note: This material is extracted from scientific and engineering data and is intended to educate the reader. NuTek does not guarantee the validity of data. Much of this data supports claims made for NuTek ozonators; however, some specific applications mentioned herein may not be suitable as described. Variables in environmental and ambient conditions affect the actual performance of ozone. In all cases NuTek, or its authorized factory distributor, should be consulted about a proposed use of ozone.

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HISTORY AND GENERAL STATEMENT

The first ozone installation was made by Siemens Company (Germany) in 1857. (Ref. 151. p 17) Complex molecules can be broken down by the powerful oxidation effect of ozone. Ozone can react with compounds which cannot be broken down by biological agents (bacteria) or otherwise integrated into the biological process for further processing. (Ref. 1)

EFFECTS ON BACTERIA AND VIRUSES

Effects on bacterial aerosols (Fine: Uniform)

Aerosols were produced by spraying bacterial suspensions at 20 lb/sq. in pressure and concentrations of bacteria were in the range of 50-500 viable organisms per liter of air. The killing effect of ozone was determined by comparing the curves for decay with, and without, ozone. Ozone concentrations ranged from 2.0 p.p.m.v. down to 0.025 p.p.m.v. Tests were performed on three organisms; Streptococcus salivarius, Streptococcus 'C' and Staphylococcus albus. The role of humidity in the action of ozone, particularly when the gas is at low concentration, was apparent. At humidities less than 45%, ozone, even in high concentrations, exerts no appreciable disinfecting action on bacteria. For humidities above 50%, however, ozone reduced the bacteria count. **In fact, ozone as low as 0.025 p.p.m.v. showed definite bactericidal action at 60 to 80% humidity.**

Bacteria that have settled on surfaces

Bacteria on surfaces constitute a potential infection danger as a source of infection through redispersal in the air or contact with skin or clothes. Tests were made to determine whether ozone has any disinfecting action on deposited bacteria. Bacteria were sprayed on various surfaces: agar in Petri dishes; Whatman filter paper; sterile glass Petri dishes and wool cloth. These were placed in known conditions of humidity (range 60-85%), temperature and ozone concentration. After being exposed. the bacteria were counted and compared with surfaces having bacteria not exposed to ozone. Ozone in a concentration of 0.02 p.p.m.v. in a moderately humid atmosphere exercises a very definite killing effect against bacteria on surfaces, but below this level it has little effect.

The kill depends on (a) the "depth" and type of surface; so moist agar. Whatman #1 filter paper and wool cloth are more favorable to survival than glass or #50 Whatman paper; (b) resistance to ozone of different types of bacteria: Staphylococcus albus resistance is greater than Streptococcus Salivarius, which in turn is greater than B.prodigiosus.

Discussion

Ozone, in concentrations up to 0.04 p.p.m.v. in humid atmospheres exerts a disinfecting action on certain bacteria; Streptococcus salivarius. Streptococcus 'C', Staphylococcus albus and B. prodigiosus. Tests on E. coli with up to 1 to 2 p.p.m.v. in relatively dry air failed to destroy any organisms. This confirms ozone is a poor disinfectant at low humidities. However, at humidities above 60% tests confirmed pathogens can be destroyed by minute amounts of ozone. (Ref. 158)

Increasing the moisture content of the environment favorably influences germicidal effect. This is brought about by swelling of microbes making them more susceptible to destruction. (Ref. I)

ODOR CONTROL

Ozone is unmatched as a deodorizer. Ozone has a strong characteristic odor even in very low concentrations. Its effect on the olfactory membrane makes it difficult or impossible to detect other odors when ozone is present. In low concentrations (0.01 to 0.02 p.p.m.v.) ozone acts as a masking agent on most odors. Tests have demonstrated that room odors were undetectable even when ozone concentrations were less than 0.01 p.p.m. (Ref. 158)

Some very delicate odors are destroyed even at these low concentrations. However, to totally eliminate "heavy" odors higher concentrations of ozone are required to react with gases in the air and odors trapped in materials. Time to deodorize is determined by the quantity of the substance producing odor and the quantity of ozone available to react with it. (Ref. 152. 172)

Ozone at a concentration of 0.1 p.p.m.v will destroy microorganisms and eliminate most odors within 48 hours. (Ref. 1)

Odoriferous substances are susceptible to oxidation, but the addition of oxygen to a substance (oxidation) does not always render it safe. For example, oxidation of allyl alcohol yields aldehyde acrolein, a very deadly gas. Safety considerations apply only to definite industrial odors and do not include animal wastes or putrefactive gases of animal or vegetable tissue. Putrefaction produces highly odorous substances such as amino, aromatic and fatty acids, indole, skatole, cresol, and also the alkaloid-like ptomaines, such as tetramethylene-diamine and pentamethylene- diamine, etc. The effect of ozone on these substances is that of combustion; i.e., the final products of the hydrocarbons being C02 and water and those containing nitrogen, nitrogen pentoxide.

Where putrefaction occurs - the air from sewers, etc.- while highly odoriferous, contains but traces of these substances. The odors are easily and completely destroyed by ozone. Ozone has been used in San Francisco to deodorize a sewage pumping station when the pump screens had to be cleaned. A rat died in a wall of an office building and the odor penetrated several offices. The application of ozone completely destroyed the odor. (Ref. 153)

Single atoms of oxygen from the decomposition of ozone immediately oxidize odors. The lower the temperature and the larger the odor molecules, the weaker the oxidizing effect. Humidity has no effect on this process, but does accelerate destruction of bacteria, viruses and fungi that may contribute to odor. (Ref. 1)

Portable, compact ozonators have been used successfully in the following areas:

Garbage Holding Areas.
Bus, Train, Aircraft, and Vehicle Interiors.
Employee Lounges.
Fish Stores. Fish odors will riot cling to clothing.
Hotels. Smoke odors. spilled beverage or food odors, urine and fecal odor, vomit, individual body odors.
Restaurants, Cocktail Lounges and Bars.
Kitchen and Food Preparation Areas.
Rest Rooms.
Health Clubs, Swimming Pools, Spa Rooms and sports locker rooms.
Heat Pump and Air Conditioning Intstallations. Eliminates "Dirty Sock Syndrome" (Odor).
Chlorine smell control.

ODOR CONTROL. cont'd

Restoration of Buildings, Drapes, Curtains, Furniture, Rugs and Clothing.
Veterinary Clinics, Zoos, Indoor Animal Farm Areas.
Hospitals, Nursing and retirement Homes.
Office Buildings.
Retail Stores.
New Construction and Restoration. Ozone eliminates paint, carpet, Furniture and panelling odors-toxic outgassing, principally Formaldehyde.
Funeral Homes. Body transport, storage and preperation: vehicles.

THE SMELL OF OZONE

Ozone at low coricentrations (0.01 to 0.04 p.p.m.v.) leaves a fresh and pleasant feeling to a room. At high ozone concentrations, a characteristic "electrical" odor is noticeable.

STERILIZING

Ozone at ambient temperatures is the only substance which can be used as a total sterilizing agent and a substitute for high temperature. (Ref. I) Pyrogens, byproducts of microbial growth that are toxic to humans, are not eliminated after normal autoclaving or dry heat sterilization. Pyrogens adhere firmly to surfaces of containers and are removed only after heating at very high temperatures for extended periods of time. Because pyrogenic material is a lipopolysaccharide, the unsaturated double bonds are easily oxidized by ozone. (Ref. 34. 40) Therefore, ozone has a distinct advantage over other depyrogenation methods. (Ref. 24)

BIOCLEAN ROOMS

Ozone can be used to decontaminate Bioclean Rooms. (Ref. 60)

USE IN AIR CONDITIONING

Molds in ducts, filters and other parts of ventilating equipment, in basements and other damp places produce objectionable odors. In low concentrations ozone masks odors, giving a freshness to the air noticeably absent in recirculated air. Also with time and the right humidity conditions, ozone destroys bacteria and mold. Where possible, ozone should be introduced in sufficient quantity to mix with all the air when the building is unoccupied. With recirculation, this will build up a concentration sufficient not only to deodorize the air but thoroughly disinfect and sterilize the entire building and HVAC equipment. This will result in the absolute elimination of molds, bacteria and decomposing organic material in the duct work and parts of the equipment that are inaccessible. This work should be completed and the ozone reduced to acceptable levels before the building is occupied again.

Controlled levels of ozone are used in Europe in air conditioning systems to deodorize and freshen air in theaters, shopping malls, offices, etc. Demand for make-up air is reduced as the recycle system furnishes air of sufficient purity. Body odors, cigarette smoke and various unpleasant smells are removed. These gases are mostly hydrocarbons, together with hydrogen sulfide, and are rapidly destroyed by ozone. (Ref. I)

USE IN AIR CONDITIONING. cont'd

Our body automatically controls respiration. When air contains even minute and practically imperceptible quantities of disagreeable odors we involuntarily shorten our breathing. Even though rate of respiration may increase under such conditions, the total volume of oxygen taken into our lungs is reduced. This results in a mild form of autointoxication as wastes increase in the blood, and we feel lethargic and tired. (Ref. 153)

In 1919, the first ozone machine was installed in the air duct of the O'FaIIon School (St. Louis). The effects were so positive that ozonators were installed in thirteen old schools and three new ones. Teachers and administrators noted an improvement in the health of the children and a reduction in the number of colds.

The St. Louis Hygiene Department kept a record of all absences on account of illness, the nature of the disease and time lost. Two tests were conducted, one in the morning without ozone and one in the afternoon with ozone. Physicians from the Hygiene Department exposed agar dishes and delivered them to the City Bacteriologist for incubation and count. The afternoon test with ozone averaged half the bacteria count of the morning test when no ozone was used Another test was conducted with 65% recirculated air. Recirculated air with ozone gave 36 percent less bacteria than 100% fresh air without ozone. Odors were entirely absent in the recirculated air test.

EFFECTS ON BACTERIA AND VIRUSES

Bacteria are microscopically small, single-cell creatures having a primitive structure. They take up foodstuffs and release metabolic products, and multiply by division. The bacteria body is sealed by a relatively solid-cell membrane. Their vital processes are controlled by a complex enzymatic system. Ozone interferes with the metabolism of bacterium-cells, most likely through inhibiting and blocking the operation of the enzymatic control system. A sufficient amount of ozone breaks through the cell membrane, and this leads to the destruction of the bacteria. (Ref. 1.24)

Viruses are small, independent particles, built of crystals and macromolecules. Unlike bacteria, they multiply only within the host cell. They transform the protein of the host cell into proteins of their own. Ozone destroys viruses by diffusing through the protein coat into the nucleic acid core, resulting in damage of the viral RNA. At higher concentrations, ozone destroys the capsid, or exterior protein shell by oxidation so DNA (deoxyribonucleic acid) or RNA (ribonucleic acid) structures of the microorganism are affected. In fact, DNA and RNA breakdown products could be identified in this case. (Ref. 1, 24)

EFFECTS ON SPECIFIC BACTERIA. VIRUSES AND MOLDS

Aspergillus Niger (Black Mouni). Destroyed by 1.5 to 2 mg/l.
Bacillus Bacteria. Destroyed by 0.2 mg/l within 30 seconds. (Ref. 26, 27, 33)
Bacillus Anthracis. Causes anthrax in sheep, cattle, and pigsd Also a human pathogen. Ozone susceptable.
Candida Bacteria. Ozone susceptable. (Ref.24)
Clostridium Bacteria. Ozone susceptable (Ref. 24)

ClostridiumBondinum spores. Its toxin paralyses the central nervous system, being a poison multiplying in food and meals. 0.4 to 0.5 mg/l ozone threshold value.

EFFECTS ON BACTERIA AND VIRUSES. cont'd

Coxsackie Virus. Destroyed to zero level in less than 30 seconmds by 0.1 0.8 mg/l. (Ref. (30,31,34, 36, 37,38)

Diptheria Pathogen. Destroyed by 1.5 to 2 mg/l.

Eberth Bacillus (Typhus abdominalis), Spreads typically by aqueous infection and caused typhoid. Destroyed by 1.5 to 2 mg/l.

Echo Virus 29: The virus most sensitive to ozone. After contact time of one minute at 1.0 mg/l of ozone, 99.9995 % killed. (Ref. 151,P 17)

Escherichius Coil Bacteria (from feces) Destroyed by 0.2 mg/l within 30 seconds. (Ref.26,27, 33)

Encephalomyacarditis Virus. Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. (Ref. 30, 31,34, 36, 37, 38)

Endamoebic Cysts Bacteria Ozone susceptable. (Ref. 24)

Enterovirus Virus. Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. (Ref. 30, 31,34, 36, 37, 38)

GDVII Virus. Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. (Ref. 30,31, 34, 36, 37, 38)

Herpes Virus. Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. (Ref. 30. 31. 34. 36. 37. 38)

Influenza Virus. 0.4 to 0.5 mg/l threshold value.

Klebs-Loffler Bacillus. Destroyed by 1.5 to 2.0 mg/l.

Luminescent Basidiomycetes (species having no melanin pigmet). Destroyed in 10 mins at 100 ppm.

Penicillium Bacteria. Ozone susceptible. (Ref. 24)

Poliomyelitis Virus. Kill of 99.99% with .3 to .4 mg/l in 3 to 4 minutes.

Proteus Bacteria. Very susceptible. (Ref. 24)

Pseudomonas Bacteria. Very susceptible. (Ref. 24)

Rhabdovirus Virus. Destroyed to zero level in less than 30 secs with .1 to .8 mg/l. (Ref. 30, 31, 34, 36, 37, 38)

Salmonella Bacteria. Very susceptible. (Ret. 24)

Schistosoma Bacteria. Very susceptible. (Ref. 24)

Shigella Bacteria. Very susceptible. (Ref. 24)

Staphylococci. Causing general inflammation. Destroyed by 1.5 to 2 mg/l.

Stomatitis Virus. Destroyed to zero level in less than 30 secs with .1 to .8 mg/l. (Ref. 30, 31, 34, 36, 37, 38)

Streptococcus Bacteria. Destroyed by .2 mg/l within 30 secs. (Ref. 26, 27, 33)

Vesicular Virus. Destroyed to zero level in less than 30 secs with .1 to .8 mg/l. (Ref. 30, 31, 34, 36, 37, 38)

Vibrio Cholera Bacteria. Very susceptible. (Ref. 24);

Vicia Faba progeny. Ozone causes chromosome aberration and its effect is twice that observed by the action of X-rays.

EFFECTS ON BACTERIA AND VIRUSES. cont'd

The effect of ozone below a certain critical concentration value is small or zero. Above this level all pathogens are eventually destroyed. This effect is called all-or-none response and the critical level the "threshold value". (Ref. 24.25,27,28,29.52)

There is a two-step process of inactivation of viruses. Period one lasts less than 10 seconds. during which lime a kill rate of shout 99% is achieved. Period two runs for several minutes to complete destruction. This phenomenon is independent of changes in ozone concentration between 0.07 and 2.5 mg/l. (Ref. 1)

HEALTH AND MEDICINE

Effects on influenza

"EXPOSURE TO OZONE REDUCES INFLUENZA DISEASE SEVERITY AND ALTERS DISTRIBUTION OF INFLUENZA VIRAL ANTIGENS IN MURINE LUNGS."

This study was undertaken to assess the effects of exposure to ozone on the course of influenza virus infection. Mice were exposed to ozone or filtered air, or both, with aerosolized infection by influenza virus.

It was found that animals exposed to ozone during infection showed a reduced severity of disease measured by decreased mortality and delayed time of death. (Ref. 156)

Ozone reduces harmful ammonia and hydrogen sulfide

Ammonia, and to some degree hydrogen sulfide, affect pig performance directly (by altering metabolic reactions) and indirectly (by influencing pig health). Atmospheric ammonia was particularly damaging to young pigs infected with Ascaris suum. (Ref. 173, 174 and 175) Ozone converts ammonia (NH_3) to harmless nitrogen and water vapor. Hydrogen sulfide (H_2S) is broken down into water and sulphur dioxide. also a powerful disinfectant.

pH DEPENDENCY

Ozone does not react with water; therefore. the free electric charge of bacteria or virus cells does not reduce the sterilizing effect. This fact constitutes one of the major advantages of ozone over other disinfectants. (Ref. I)

OXIDATION POTENTIAL

Ozone owes its excellent bactericidal, virucidal, and sporicidal activities to its powerful oxidizing properties. Ozone has an oxidation potential of +2.07 volts as compared to HOCL (the active form chlorine in aqueous solution) which is + 1.49 volts. It is reported to be 3000 times as germicidal as chlorine. It retains this strong oxidizing capability in aqueous solution, a property crucial for water disinfection and sterilization, as well as in high humidity air applications. (Ref. 24)

<u>HALF LIFE</u>

As soon as ozone is formed, it starts to decay to oxygen. The half life is 2.5 to 7 minutes in most applications, depending on the ambient conditions. In cool, sterile environment the half-life can extend to 60 minutes.

<u>OZONE COMPARED TO OTHER GASEOUS DISINFECTANTS</u>

Gaseous disinfectants in common use are sulphur dioxide, formaldehyde, and in certain applications, hydrocyanic acid. It has been clearly demonstrated that ozone in equivalent concentrations exerts a much stronger bactericidal effect than any of the foregoing disinfectants. To obtain the same bactericidal effect a concentration of 160 times the amount is required for sulphur dioxide, 37 times the amount for formaldehyde, and 1.7 times the amount for hydrocyanic acid gas. (Ref. 152)

<u>SOME SPECIFIC COMPOUNDS OXIDIZED BY OZONE</u>

<u>WARNING: Care should be exercised if gas or vapor concentrations in air are suspected to be in the explosive range as ozone is a VERY aggressive oxidizer. Also, some products, even as oxides, may become or remain toxic. Consult NuTek regarding specific compounds to be oxidized.</u>

Amnonia

Phenolics

Detrergents

Natural rubber: Thin sections of natural rubber, such as sergical gloves, are very rapidly oxidized by ozone. Thicker sections of filled rubber(tires, door seals, etc.) and synthetic rubber (Buna N) are unaffected except by extremely high concentrations over very long periods of time. Silocone rubber is unaffected.

Fulvic Acid

Tannic Acids (plant-originated acids).

Sulfides

Cyanides

Spores of molds (very effective)

Amoeae (very effective)

Cigarette Smoke: A puff of cigarette smoke containes 4 billion particles and more than 1500 compounds, ranging from light, reactive gasses (deadly carbon monoxide is one), suspended chemical particles and tars. Ozone destroyes most of these products and even "burns" the lighter tars in the air and converts them to harmless carbon.

2.4D

Arsenic

Chlorine and its derivatives

DDT

SOME SPECIFIC COMPOUNDS OXIDIZED BY OZONE. cont'd

Dioxin

Haloforms Strongly reduced by ozone. Large amounts of Aldehydes and Keytones are produced as a byproduct. With a reaction time of 10 to 1440 minutes the concentration of the Aldehydes will be 8.5 times larger at a dosage of 5 mg/l and 30.6 times larger at a dosage of 5 mg/l. (Ref. 12)

Halogen compounds. 1.0 mg/l reduces by 31% and 5.0 mg/l reduces by 77% during a very long reaction time.

Nitrates

Perchlorate Biphenyis. With simultaneous ultraviolet irradiation it is even possible to subject

PCB's, the notorious successor of DDT, to oxidative decomposition. (Ref. 151, p. 15)

Phenol (Ref. 12)

Trihalomethanes (toxoc product of a chlorine, algae reduction)

Tricholorphenol. 1.0 mg/l reduces 500 microgram Tricholorphenol and 5.0 mg/lreduces 2500 Tricholorphenol. (Ref 12)

USE IN PRODUCT STORAGE

Ozone has been used in food preservation since 1909. Storage places, warehouses and refrigerated lockers can be disinfected. High humidity in the environment favorably influences germicidal effect. Ozone decomposition is accelerated due to high moisture content, the walls of the storage room, the packaging materials, the absorption effect of the stored goods, and also the oxidation reactions taking place. The ozone generator must have sufficient capacity to maintain ozone at the required level. A strong air movement is required to assure optimum distribution of ozone. The storage space need not be airtight as long as the capacity of the ozone generator is sufficient to replenish the ozone lost through air exchange. (Ref. I)

The prerequisite in the control of microorganisms is the maintenance of clean environment. The microbial population of the product and the storage environment determine the storage life of the product. When a food product is exposed to contamination during preparation, handling or storage, large numbers of microorganisms are introduced into the product. In food, microorganisms find a favorable habitat for growth and each new generation of bacteria means a doubling of the population. The result is a breakdown of the food product evidenced by objectionable physical appearance, taste and odor.

There is no compound that can be applied to a dirty surface to destroy all microorganisms. To demonstrate, a good sanitizer was applied liberally to a dirty wall in a food handling plant. This wall had a bacterial population of 28,000,000 organisms on a two-inch square. Five minutes after treatment the wall still had a bacteria count of 11,000,000. Although the contamination had been reduced. the wall was still heavily contaminated. A food product entering this storage room had a relatively low surface bacteria count, but in 48 hours the product had a count of 150,000 in a two-inch square. Air examination showed an extremely high bacteria count. Even though multiplication of bacteria might be slowed by low temperature, the product was acquiring a high count that would reduce its shelf-life after it left the storage room. If kept for a longer period in storage, its storage life would be considerably shorter than if stored in a room relatively free of contamination. (Ref. 161)

USE IN PRODUCT STORAGE. cont'd

Fish storage

Freshly caught fish can be stored longer if washed in water containing ozone. If it is packed in ice made from water containing ozone, freshness can be extended. (Ref. 176)

Control of surface microflora

In a refrigerated atmosphere with ozone, the growth of the surface microflora (pseudomonas families, spores, Salmonellae and staphylococci) is eliminated or retarded. (Ref. 1)

Forequarters of beef with relatively equal bacteria counts were tested. one in the ozone-treated refrigerator at a concentration of approximately 0.1 p.p.m.v. of ozone and 60^{o} F and the other under similar conditions except for the lack of ozone. At the end of the test period, the ozone-treated beef had about the same count as at the start, but the untreated beef showed an increase of 600 percent. (Ref. 161)

Ozone used in beef storage is most efficient if the meat surface has around 60% moisture content. (Ref. 1)

Beef stored in a cooler under an ozone concentration of 0.04 p.p.m at 2^{o} C, experiences 0.9 to 1.0 percent less shrinkage in three days and 17 percent less in 7 days. Trim loss is reduced by 2.6 to 5.5 percent. This is less shrinkage and trim loss than meat stored under identical conditions but without ozone usage. (Ref. 2)

The storage life of beef in a refrigerated state can be increased by 30 to 40 percent if the beef is kept in an atmosphere of 7.7 to 15 p.p.m. and the microbial saturation of its surface is not greater than 1000 bacteria per square em. (Ref. I)

Maintenance of cooling coils

Ozone eliminates or reduces mold build-up on cooling coils. Dirt and dust build-up is reduced,. drastically reducing the number of times coils need cleaning and increasing energy efficiency.

Produce storage

Ozone maintains produce quality by inactivation of metabolic products and destruction of odors and microorganisms. These properties makes ozone an excellent means of increasing the storage life of perishable foods in refrigeration. At the same time its use is economical as the investment and operating costs of the equipment are on an acceptable level in relation to the size of refrigerated rooms. Its application eliminates the risk of leaving the unpleasant odor or other traces of antiseptic used for preservation of produce.

Ozone's effect on produce

Ozone only affects the surface of the fruit, which contains compounds difficult to oxidize in most cases. Ozone has no detrimental effect on fruit itself. Although ozone is a very powerful oxidizing agent, it can not penetrate deeply into most fruits because of the lack of permeability of most fruit skins. (Ref. 14)

USE IN PRODUCT STORAGE. cont'd

Ethylene removal

During storage the process of respiration of fruit is speeded up and so is ripening. Ethylene is produced which affects other fruit and so initiates even more intensive ripening. The external signs of this process are browning of the skin, the softening of the flesh of the fruit and, finally, decay. This process is controlled by the presence of ozone because it oxidizes the metabolic products. (Ref. I)

Ozone destroys ethylene as it emerges from the fruit. The gas is readily oxidized by ozone. (Ref. 22.23)

It also promotes the healing of wounds and enhances resistance to further infection.

Mold elimination

The primary action of ozone on molds is to suppress their growth, and then destruction of the cultures already formed. Ozone prevents the formation of various mold colonies on the walls of the storage room, on packaging materials and wooden crates; these molds, even if doing no harm to the produce, readily impart a stale odor to it. In the environment of refrigerated storage, Blue Mold multiplies readily and its growth is not retarded even by temperatures as low as 32^{o} F. (Ref. 1)

Effects on specific produce

The following produce has been tested and positive results have been obtained in extending storage life.

APPLES	BANANAS	CELERY	CRANBERRIES
CURRANTS	GRAPES	LEMONS	LIMES
ORANGES	PEARS	PEACHES	POTATOES
RASPBERRIES	SQUASH	STRAWBERRIES	TOMATOES

Ozone can also extend the storage life of cheese and eggs.

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