PRESENTATION ABSTRACTS (alphabetically by SPEAKER)

Christopher Amrhein, Ph.D.: Ozone as a Soil Fumigant - An Investigation into its Effects on Soil Physical and Chemical Properties

M. H. Strong, C. Amrhein

Christopher Amrhein is Professor of Soil Chemistry at the University of California, Riverside, where he has taught courses including Soil Chemistry, Principles and Theories Relating to Arid Zone Soils, Professional Development in Soil Science and Introduction to Environmental Sciences. Dr. Amrhein received his Ph.D. in Soil Chemistry (1984) from Utah State University, his M.S. in Water Science (1980) and B.S. with High Honors in Soil and Water Science (1977) from the University of California, Davis. His areas of specialization include trace element chemistry in soils, sediments, water, and brines; oxidation/reduction chemistry in wetlands and on metal surfaces; dissolution and precipitation kinetics of carbonate and silicate minerals; cation and anion adsorption reactions on phyllosilicate clays, metal oxides, and soils; reclamation of salt-affected soils and the maintenance of soil structure; and mechanism of boron toxicity in ants.

ABSTRACT: Methyl bromide, a popular soil fumigant, is being phased out due to environmental concerns. Ozone is currently being field tested as an alternative soil fumigant to replace methyl bromide. Concerns exist that ozone will oxidize soil organic matter, causing undesirable changes to physical and chemical soil properties. We conducted laboratory studies to determine the changes to physical and chemical properties of nine California agricultural soils where ozone was tested as a fumigant. We measured changes in clay dispersion, swelling, saturated hydraulic conductivity, and hardness as a function of repeated ozone treatment, and analyzed the chemical composition of the leachate from ozonated and air-treated soils. These studies showed that ozonation of the soil reduced the pH in all soils, and reduced hydraulic conductivity in soils with low clay content and increased the hydraulic conductivity in high clay soils. Organic matter was degraded, shown by increased dissolved organic carbon and decreased soil organic carbon content. Ozone also affects SOM-metal complexes in soil, shown by increased concentrations of Al, Fe, Mn, Na, Ca, Ba, Sr, Li, and K in leachates of ozonated soils. Ozonation increased chelation by SOM; concentrations of ammonia, nitrate, and phosphorus in leachates of ozonated soils; and cation exchange capacity. These studies suggest that under specific guidelines described in the presentation, ozone should be used to fumigate soil to treat pathogens and as preplant fertilizer.

Scot Appel: Improved Ozone Generation Through Oxygen Enrichment

Scot Appel is a Principal Chemical Engineer at SeQual Technologies in San Diego. He received a Bachelor's degree from Rensselaer in 1993, and Masters and Doctorate degrees from the University of Virginia in 1995 and 1998, respectively, all in Chemical Engineering. Prior to his current position, Scot worked as an Applications Development Engineer for the Activated Carbon Division of Westvaco. Scot's expertise is in the field of gas separations using pressure swing adsorption. At SeQual, he is developing adsorption cycles and separation equipment that will provide systems with improved energy and space efficiency.

ABSTRACT: Ozone can be an effective, environmentally-friendly means to disinfect food or treat water contaminated with organic pollutants which cause taste, color, odor, or sanitary problems, as well as certain inorganic pollutants. In many of these applications, the attainable ozone concentration is important since higher concentration translates to less required contact time. For this reason, corona discharge ozone generators are the preferred technique for concentration-dependent applications since they typically deliver higher concentration ozone compared with UV ozone generators. The achievable ozone concentration can be further increased by including oxygen enrichment with the air preparation requirements for a corona discharge ozone generator. With using either air or enriched oxygen, corona discharge systems require a feed stream with a dew point below about –60ºF in order to prevent the formation of nitric acid, which can corrode the unit.

Pressure Swing Adsorption (PSA) systems can be a reliable, convenient, and cost-effective means to provide either enriched oxygen or dry air feed to an ozone generator. PSA systems operate by passing a high-pressure fluid stream over an adsorbent bed to selectively remove, or adsorb, certain species. For air drying systems, water is adsorbed and the bulk of the air stream is delivered as moisture-free product. In oxygen enrichment systems, water, nitrogen, and carbon dioxide are removed from the feed stream to provide a moisture-free, enriched oxygen stream at over 90% purity. The adsorbent beds are periodically regenerated by passing low-pressure product gas (either dry air or enriched oxygen) over the adsorbent. Improved ozone generator performance using PSA usually entails higher capital and operating cost, but recent improvements to PSA system design are leading to smaller, more efficient systems. Additionally, PSA-produced enriched oxygen provides an advantage over compressed gas or liquid oxygen since a PSA system eliminates the need for frequent deliveries and oxygen is available whenever and wherever electricity is available.

Christine Boisrobert: U.S. Regulatory Review of Ozone Use in the Food Industry

Christine Boisrobert has 14 years experience working with the Food Industry. She has served as Applications Development Manager for Air Liquide America Corporation's Applied Technology Center in Countryside, Illinois since 1996. In this position, Christine has helped Air Liquide develop its modified atmosphere packaging and ozone surface sanitation technologies, both of which service the food industry. Prior to her current position, Christine worked as a food scientist at American Air Liquide, where she oversaw the company's food research and development.

ABSTRACT: Although the U.S. food supply remains among the safest in the world, an estimated 76 million Americans become ill from food borne infections each year, resulting in 325,000 hospitalizations and 5,200 deaths. After widely publicized food borne outbreaks and in response to consumers' concerns, the food industry and the Federal Government focused considerable efforts on reducing microbial contamination of foods to enhance food safety.

As part of this initiative, FDA reviewed a Food Additive Petition filed in August 2000 by the Electric Power Research Institute (EPRI) covering the use of ozone as an antimicrobial agent for the treatment, storage and processing of foods. On June 26, 2001, the FDA amended the food additive regulations to provide for the safe use of ozone in gaseous and aqueous phase as an antimicrobial agent on food, including meat and poultry. Following the FDA's final ruling, the use of ozone on meat and poultry products, including ready-to-eat products, just prior to packaging was deemed acceptable by the USDA's Food Safety and Inspection Service (FSIS) in December 2001.

In addition to direct food contact applications, ozone complements the sanitation technologies currently available to the food processing Industry. NSF registration, based upon meeting regulatory requirements for appropriate use, ingredient review and labeling verification, assures inspection officials and end-users that products are acceptable for use in a food plant environment. Some ozone suppliers have received NSF registration of their systems for sanitizing and disinfecting pre-cleaned surfaces in and around food processing areas, and are listed in the NSF *White Book™ of Proprietary Substances and Nonfood Compounds*; they can be considered by food processors as "USDA approved" for sanitation of food-contact and nonfood-contact surfaces. This is particularly critical for plants operating under the USDA poultry, meat, shell egg grading, and egg products inspection programs, or the US Department of Commerce (USDC), Fishery Products Inspection Program. This paper also reviews regulatory compliance with other federal agencies, namely the US Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA).

Nicolas Cantacuzene: Efficacy of Gaseous and Aqueous Ozone in Treating Oak Used in Winemaking for *Brettanomyces*

N. Cantacuzene, E.S. Dormedy, J.S. Smilanick, K.C. Fugelsang, R.L. Wample, D.F. Dormedy.

Nicolas Cantacuzene is a Master of Science Candidate at the California State University, Fresno in Food Science with an emphasis in Enology. Nicolas is a French citizen who started his degree in Pharmacy but decided to pursue studies in chemistry. Like his parents, he attended the University of Paris V. He completed his B.S. in Chemistry at Sonoma State University (2000). Nicolas has been working closely with Dr. Erin Dormedy and Dr. Joe Smilanick using ozone to control *Brettanomyces* in oak. He has worked in several wineries as a lab assistant and plans to become a winemaker one of these days.

ABSTRACT: This experiment evaluated the efficacy of ozone as a sanitizer in the treatment of *Brettanomyces* found in oak cubes. The wine industry uses oak barrels to enhance flavor, favor wine structure and promote slow incursion of oxygen into the wine. During storage of wine in barrels, sediments deposit and form a layer of nutrient that favors the growth of undesirable microorganisms. *Brettanomyces* can proliferate in the sediment layer and produces an unwanted compound, 4-ethyl phenol, which is associated with a "band-aid aroma." This yeast also possesses a ß-glycosidase capable of breaking down the hemi-cellulose found in wood. Thus, its population can be found on the surface and in the pores of the wood. We compared the efficiency of ozone with a commonly used sanitizer: hot water. Because hot water is energy demanding and has the potential to denature flavor compounds found in barrels, wineries have looked at alternatives for sanitation.

We used aqueous and gaseous ozone to treat oak cubes, which were used during this experiment due to the difficulty of determining *Brettanomyces* populations in oak barrels. An initial wine broth was spiked with a culture of *Brettanomyces* and oak cubes were introduced. Different concentrations of ozone and times of treatment were used. The efficacy of ozone was measured by determining the population of *Brettanomyces* in oak cubes before and after the treatments.

Gary B. Carman: The Use of Gaseous Ozone to Control Insect Pests and Pathogens in a Dynamic Flow Vacuum Chamber

Gary has been active in the food industry for the past 25 years, since graduating from the University of California, Davis. He has worked in quality assurance for General Mills, Contadina Foods, Tone Brothers, McCormick & Co., and Burns Philp Foods. He has developed several sterilization and fumigation systems and holds three patents in this area, including the PureOx Process. Gary has served on the Technical Advisory Board for ASTA, is a professional member of IFT, and is President of Tahoe Food Technology.

ABSTRACT: Traditional ozone-based sanitation systems have relied on water to transfer dissolved ozone to the reaction site. This works well in remediating waste water or sanitizing drinking water, but problems occur when one tries to sanitize food products that are not fully "wettable." This paper describes a dry process which utilizes ozone gas applied in a vacuum chamber. Its advantages include an increase in gas permeation, precise environmental controls and gas mixtures, and personnel safety.

In addition to providing microbiological control of human and plant pathogens, ozone has been demonstrated to be an effective fumigant when applied appropriately. Ozone used in conjunction with carbon dioxide allows relatively low concentrations of ozone to control target insect pests without discernable phytotoxic issues. In chamber tests various fruits have been successfully treated for both surface pathogens and insect pests. This paper discusses four specific tests to eliminate bean thrips, E. coli, Listeria, and coconut scale. The concentrations of ozone required varied and temperature in the working zone was carefully controlled.

The major advantage of gaseous ozone over many water-based systems is that the gas can be applied into all of the interstitial air spaces. Specific gas mixtures can also be utilized to help reduce phytotoxic issues, increase permeability, and accelerate insect respiration, with fumigation\sanitization treatment times comparable to current gas treatments. As methyl bromide (MB) is phased out in accordance with the Montreal Protocol and the EPA Clean Air Act, an MB replacement for food protection is direly needed. Ozone is environmentally responsible, produces no residues, is safe to handle, and is economically feasible. No other MB replacement to date can make those same claims.

JiaJia Chen: Survival of Escherichia (ATCC 25922) and Natural Microflora Populations on Avocado after Exposure to High Concentrations of Gaseous Ozone

JiaJia Chen, J. L. Smilanick, E. Dormedy.

JiaJia Chen is a microbiologist at ConAgra Foods and a Master of Science candidate at California State University, Fresno in Food and Nutritional Sciences. She is finishing her thesis involving ozone as a potential food disinfectant under the advisement of Dr. Erin Dormedy and Dr. Joe Smilanick at the USDA. JiaJia received a B.S. in Biochemistry from Beijing Union University, China in 1996. She came to America to advance her education and expects to complete her M.S. requirements by the end of 2002.

ABSTRACT: Ozone gas was applied to whole fresh avocado in a closed chamber. *E. coli* (ATCC 25922) was cultured on nutrient agar and applied to the surface of each avocado. After ozone treatment and shaking, the solution was plated and incubated for different periods to detect and quantify *E. coli,* natural populations of aerobic mesophilic bacteria, and natural yeast and mold populations. Ozone reduced *E. coli* populations to the minimum detection limit.

Natural microbe populations were low and more resistant to ozone; reductions in populations by ozone were one $\log_{10}$ or less. *E. coli* populations applied to the surface of the fruit were eliminated by ozone at relatively low doses, while natural microbe populations, particularly fungi, were much more resistant.

Lee Ditzler: Ozone – The Gas

Executive Vice-President and founder of NOVAZONE, Lee Ditzler received a B.S. in Industrial Technology and is a Registered Professional Engineer, California #1371. Mr. Ditzler directs design, development, manufacturing and installation of ozone systems. He assisted in validating ozone systems applied to pharmaceutical waters. His design responsibilities include implementing electrical and mechanical designs with emphasis on automatic control and monitoring. He has over 30 years engineering experience designing, manufacturing and installing equipment for the pharmaceutical and water related industries. He holds several patents in ozone equipment and applications. He was a founder of TriNeos and its division, TriOx, a leader in the field of ozone technology for industrial applications. Prior to the formation of TriNeos, Mr. Ditzler was founder and President of Universal Engineered Systems (UES) and of ETI, Inc. UES developed and manufactured measurement and control equipment installed in municipal fresh water and wastewater systems, hydroelectric power generation, and irrigation systems.

ABSTRACT: Ozone has been recognized as a powerful sanitizer and oxidizer in industries such as bottled water, pharmaceuticals, food processing, and municipal water. Many additional uses can benefit from ozone's high oxidizing potential. Understanding how ozone is created (ultraviolet or corona), and applying the appropriate equipment is very important for successful applications. Ozone created with ultraviolet light has limited uses, while corona discharge ozone generators provide a wider range of applications. Measuring the amount of ozone being produced and applied is required in some installations. Several technologies exist to make these measurements. All ozone generator manufacturers and users operate under State and Federal regulations. The FDA and USDA have approved the use of ozone as an antimicrobial agent for direct contact with all food products. The EPA registered ozone as a pesticide and provided a 100% exemption for all reporting and use. The Uniform Fire Code and a few air quality management districts have specific requirements for the operation of an ozone system.

Dr. Erin Dormedy: CSUF Ozone Research Program

Dr. Dormedy is an Assistant Professor in the College of Agricultural Sciences and Technology, California State University, Fresno. She has a 75% teaching appointment to the Department of Food Science and Nutrition where she teaches primarily Food Microbiology and Food Chemistry, and serves as the Food Science Program Coordinator. Dr. Dormedy has a 25% research appointment to the California Agricultural Research Institute (CATI). Her research interests include control of food-borne pathogens, use of ozone as a disinfectant in food processing applications, and HACCP. She is director of the CSUF Ozone Research Program. Dr. Dormedy received a B.S. (1990) in Food Science and Nutrition from Cal Poly, San Luis Obispo, and her M.S. (1997) and Ph.D. (1999) in Food Science and Technology from the University of Nebraska, Lincoln.

Joseph Eifert, Ph.D.: Inactivation of *Salmonella* on the Surface of Strawberries and Cut Cantaloupe by Gaseous Ozone

Joe is currently an Assistant Professor and Extension Specialist in the Department of Food Science and Technology of Virginia Tech. His research focuses on prevention and reduction of microbial pathogens in poultry, seafood and produce. His Extension program emphasizes microbiological safety and quality issues for poultry processors. Additionally, he teaches the graduate course *Food Regulatory Affairs*. Dr. Eifert received his M.S. (1991) and Ph.D. (1994) in food science and technology from Virginia Tech, and his B.S. (1980) in biology from Loyola Marymount University. His graduate studies focused on food safety, food microbiology, microbial modeling and further processing of aquacultured finfish. After graduate school, Joe worked as the Manager of the Microbiology Department of the Nestlé USA Quality Assurance Laboratory in Columbus, Ohio, and also provided technical services to numerous Nestlé factories throughout the U.S. and Canada. Prior to graduate school, Joe was employed by the U.S. Food and Drug Administration in Los Angeles, California. His primary responsibilities were for chemical and microbiological analysis and research of foods.

ABSTRACT: Raw or minimally processed fruits and vegetables are increasingly implicated as a source of microbial pathogens. Fruits and vegetables can become contaminated with pathogenic microorganisms while growing in fields or during harvesting, processing and distribution. Surface pathogens may penetrate to interior or edible portions through cutting or juicing, or may cross-contaminate food preparation areas and handlers. While the use of gaseous ozone for pathogen destruction on produce surfaces has not been well documented, treatment of raw produce with gaseous ozone could be advantageous where there are hard-to-reach or irregular food product surfaces.

This study demonstrated that a gaseous ozone treatment can effectively reduce the population of *Salmonella* sp. from the surface of raw produce. Further studies that explore gaseous ozone temperature, airflow, humidity, product moisture content and exposure time effects may demonstrate that greater reduction of pathogenic bacteria concentrations on produce surfaces can be achieved, and with lower gaseous ozone concentrations.

Charles F. Forney: The Effects of Ozone and Negative Air Ions on Microorganisms

L. Fan, C. F. Forney, P. D. Hildebrand, J. Song

Dr. Charles F. Forney holds degrees in Biology and Horticulture from the Pennsylvania State University and obtained an undergraduate degree from Oregon State University in 1984. He worked for the United States Department of Agriculture in Fresno, California as a research scientist in postharvest physiology from 1984 to 1991. For the past 11 years he has conducted research for Agriculture and Food Canada at the Atlantic Food and Horticulture Research Centre in Kentville, Nova Scotia and has served as Study Leader of the Postharvest Program. His research involves the development of technologies to maintain the quality of fresh fruits and vegetables throughout storage and marketing. Over the past 10 years he has conducted studies on a variety of fruits and vegetables including strawberries, blueberries, raspberries, cranberries, apples, carrots, onions, and broccoli.

ABSTRACT: Ozone effectively reduces surface microbial contamination of fresh fruits and vegetables, but killing concentrations of ozone may also damage the commodity being treated. Negative air ions (NAI) enhance the effectiveness of ozone, making it possible to use lower concentrations of ozone to kill microorganisms and thus avoid phytotoxic effects. The effectiveness of the combination of ozone and NAI to kill *Pseudomonas fluorescens*, *Erwinia carotovora* pv. carotovora , and *Escherichia coli* was compared to that of ozone and NAI alone. 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. Other factors, including the culture media used, influenced the effectiveness of ozone and NAI to kill bacteria and require further study. The synergism of NAI with ozone may provide an effective method to reduce microbial contamination on fresh produce while avoiding phytotoxic effects.

Tony Giletto, Ph. D.: Miniature Ozone Generation: Consumer Products and More

Tony Giletto received his B.S. in chemistry from Drexel University in 1987 and his doctorate in chemistry from Purdue University in 1993. He worked at Texas A&M University as a post-doc for two years and joined Lynntech as a Research Scientist in January 1996. Since then Dr. Giletto has been actively involved in the development of oxidation and decontamination technologies for a variety of applications. Recently his research has focused on the identification and development of novel applications for the electrochemical ozone generation technology

ABSTRACT: This paper describes electrochemical ozone generation and the use of this technology in point-of-use applications. Ozone is usually synthesized from molecular oxygen by the corona discharge process, using either air or an enriched oxygen stream. Contrary to this process, electrochemical ozone generation generates ozone from water using an ion-conducting fluoropolymer membrane as the electrolyte. This method generates high concentrations of ozone gas and is fully scalable allowing ozone to be used in a variety of miniature applications. The only requirements for electrochemical ozone generation are a power supply and water. This paper will discuss the strengths and limitations of electrochemical ozone generators and the use of these devices for surface decontamination, food sanitation, and household applications. The paper will also describe the development of a unique point-of-use water treatment application and novel test strips to determine the concentration of ozone in solution.

Dee M. Graham, Ph. D.: Successful Ozone Applications in Food Processing

Dr. Graham chaired an Expert Panel which evaluated and determined GRAS (Generally Recognized As Safe) status for ozone use in food processing in 1997. In 2000 he filed a Food Additive Petition with FDA seeking approval of ozone as an antimicrobial agent in all areas of food processing. Both USDA and FDA published their approval during the second half of 2001. Since 1997 Dr. Graham has assisted numerous firms evaluating and installing ozone for application to fruit and vegetable products, prepared salads, onions and garlic, various berries, pork, poultry, beef products, and non-food applications. After retiring as Director of Technical Services for Del Monte Corporation in 1990, he founded R and D Enterprises and has consulted since. He has been Professor and Department Chair, University of Missouri; Technical Director, Pet Inc.; Associate Professor, Clemson University; and Research Associate, Iowa State University. He served on National Academy of Sciences committees including Food Additive Usage, Nutrition and Microbiology; holds patents on Infant Feeding and Aseptic Processing; developed several nationally marketed products including SEGO®, Del Monte LITE® Fruit, and No-Salt Added Vegetables; and received the Calvert L. Willey Distinguished Service Award from the IFT. Dr. Graham has published more than 40 scientific papers, written chapters in books and encyclopedias, published 47 technical reports for the EPRI, made 11 court appearances as an expert witness, and published numerous trade papers.

ABSTRACT: The appearance during recent years of more virulent microbes, e.g., *E. coli* 0157:H7, *Listeria*, *Chryptosporidium*, and *Salmonella* has refocused the need for more effective antimicrobial agents in food processing. Ozone has emerged as a valuable new tool for such applications. An overview of the history of ozone will be presented, including the leadership of the Electric Power Research Institute in publishing an Expert Panel Report in 1997 related to the use of ozone in food processing. Regulatory constraints in the U. S., technical hurdles, and successful applications of ozone in food processing will be discussed, including critical factors observed in a variety of new ozone food installations. This information will help in evaluating, selecting and designing ozone systems for use in food processing. The need for definitive data on CT values for a variety of microorganisms of public health interest on many different food product systems will be emphasized.

Thomas Graham: Ozone, Greenhouses and the Moon – An Overview of Ozone Related Research at the University of Guelph's Controlled Environment Systems (CES) Facility

T. Graham, Y. Zheng, M. Dixon, L. Greenway,

Thomas Graham's current research areas include the use of ozone as a remediation technology for use in recirculating plant production systems, as well as system automation and protocol development for closed environment plant production (greenhouse production and advanced life-support).

ABSTRACT: The Controlled Environment Systems (CES) facility is a state-of-the-art research infrastructure located at the University of Guelph (Guelph, Ontario, Canada). Dedicated to the study of plant physiology and biophysics in closed and semi-closed environments, the CES complex consists of 14 closed gas analysis chambers, 2 canopy scale sealed growth chambers, 9 single plant hypobaric chambers and 5 canopy scale hypobaric chambers. These chambers are used, in conjunction with dedicated laboratory and greenhouse areas, to develop protocols and technologies to maintain crop quality in greenhouse production systems, while reducing environmental impacts. CES is also involved in developing plant-based advanced life support systems for extended space exploration. CES is working closely with Purification Research Technologies Incorporated (PRTI) to develop these technologies. Currently, management strategies are being developed to extend the service life of nutrient solutions under recirculating irrigation regimes. Ozone has been selected as a key treatment option for these studies, as it addresses both organic accumulation and pathogen proliferation, while having only minor impacts on the nutrient dynamics of the solution. Early results have been promising, but further development and research are required.

Dan Grasmick, P.E.: Applications Using Ozone for In-Situ Treatment of Contaminated Soils and Groundwater

Mr. Grasmick has 12 years experience in the fields of hazardous waste consulting, site assessment and cleanup, in-situ soil and groundwater remediation, project management, waste management unit closure under Federal and State programs, and site restoration and revegetation. He has directed remedial investigations, baseline risk assessments, and risk-based treatability and feasibility studies. Mr. Grasmick has managed design and implementation of remedial actions that have involved excavation and offsite disposal, as well as use of in-situ soil and groundwater treatment technologies. He has expertise in soil and groundwater assessment and remediation, in-situ soil and groundwater remediation, management of technical and financial aspects of projects, and waste management unit closure under RCRA and PBR programs.

ABSTRACT: Ozone is among a growing list of chemical agents that are being used for cleanup of soil and groundwater impacted by organic compounds. In-situ ozonation consists of the injection of ozone gas into the subsurface to chemically oxidize contaminants such as chlorinated and petroleum hydrocarbons in soil and groundwater. In-situ ozonation is especially useful where recalcitrant organic compounds are encountered, or current land uses rule out more disruptive site cleanup approaches. In-situ ozonation has been successfully combined with other remediation technologies to achieve a cost- and time-efficient site cleanup overall while maintaining compliance with performance goals. Recently implemented in-situ ozonation projects will be summarized to illustrate how the aforementioned issues of safety, ozone delivery, and treatment effectiveness were monitored.

Mirat Gurol, Ph.D.: THE EFFECT OF OZONE ON SHELF-LIFE OF CUT FLOWERS

M. D. Gurol, J. Smith

Since 1997, Mirat D. Gurol has been Blasker Chair Professor and Director of the Environmental Engineering Program at San Diego State University (SDSU). She served previously at Drexel University in Philadelphia for seventeen years as a faculty member in the Departments of Civil and Chemical Engineering, and the School of Environmental Science, Engineering and Policy. Dr. Gurol holds degrees in Environmental Engineering and Sciences from the University of North Carolina at Chapel Hill, and in Chemical Engineering from the Middle East Technical University in Turkey.

Dr. Gurol's academic interest focuses on treatment technologies of contaminated water, air and soil and of hazardous wastes, concentrating on ozonation, photochemical and catalytic oxidation processes for removal of environmental pollutants from contaminated water, air and soil. Her research has been funded by the Federal Government, Pennsylvania, California, several research foundations and private industry. She has published over 60 scientific articles, and supervised over 30 doctoral and masters students on their research projects as their principal advisor.

She received SDSU's Alumni Award for Outstanding Faculty, the "Best Ph.D Dissertation Award" of the Association of Environmental Engineering Professors, the "Research Scholar Award" of Drexel University, the "Best Research Paper Award" by the Journal of the American Water Works Association, and Tokten and Fulbright fellowships. Her students received numerous national and international awards for their doctoral dissertations and research papers.

ABSTRACT: This research was undertaken to investigate the effect on longevity of exposing cut flowers to ozonated water. Under controlled conditions, the flowers were subjected to various treatments including different concentrations of ozone, continuous versus intermittent exposure to ozone, exposure to glucose solution, and exposure to commercial biocide solutions. The flowers were observed visually, and by taking digital photographs of each treatment to observe the rate of decay of the flowers. Quantitative data were obtained in 1) percent change in initial weight and 2) water uptake rate as a function of time. The data indicate that the ozone treatment extended the life of the cut flowers considerably compared to all other treatments.

Beth Hamil: Ozone Technology Review and Application in Fresh Produce Processing

Beth Hamil is Vice President Sales/Agrifood Products for DEL Ozone. She has been strategically and scientifically involved in the research and development of ozone products and applications for over 22 years with DEL. She has been named in multiple ozone patents for DEL and has been instrumental in gaining several governmental approvals for ozone applications.

ABSTRACT: As an FDA approved direct food contact, anti-microbial agent, ozone can be dissolved into water and used for direct contact on fruits and vegetables, raw and ready-to-eat meat and poultry, fish and commercial eggs. The benefits of ozone-enriched water far outweigh those of chemical-enriched water traditionally used in the twentieth century. When used on fruits and vegetables, ozone offers several benefits over common chlorine use including extended shelf life, improved product color and appearance, improved taste, and reduced product spoilage.

In order to safely and effectively apply ozone in a direct contact scenario, several equipment and application guidelines must be followed. To protect operators from the potentially harmful effects of gaseous ozone, highly effective mixing, de-gas, and destruct systems should be used to insure the complete control and destruction of undissolved ozone gas.

In addition, ozone suppliers should offer complete system consultation and design. Ozone systems should include ozone generation, dissolution, and management. Regulatory approvals and registrations are a requirement, in addition to efficacy data, including dose rate consultation and review of customer variables. Variables that must be carefully reviewed include: commodity to be treated, existing facility and equipment, and the specific mode of application (spray, flume, or cascade, for example).

A packing plant in Arizona using a DEL ozone system has met or exceeded microbial reductions previously attained with chlorine or traditional antimicrobial chemicals, reduced spoilage, extended shelf-life, improved product quality and appearance, and maintained the highest level of employee safety. The client is using their new higher quality of produce as a marketing tool to successfully increase overall product sales.

Brian C. Hampson, Ph.D.: Who is Asking What About Ozone? The Need for Continuing Education

Dr. Brian Hampson received his Ph.D. in Food Microbiology from the University of Illinois and degrees in Biological Sciences (MS) and Genetics and Human Development (B.S.) from the University of Illinois, Champaign/Urbana. He worked as a graduate research assistant in the Department of Food Science, a graduate teaching assistant in the Department of Microbiology, and a staff research associate in the Department of Aquatic Microbiology. He has twelve years of retail experience with Jewel Food Stores. Upon completing college, Dr. Hampson worked for the USDA's Agriculture Research Service in Albany, CA, and then as a Scientist for McCormick Corporation in its Gilroy Foods Division. In 1991 he joined the faculty of the Food Science and Nutrition Department at California Polytechnic State University, San Luis Obispo, CA, and is now Professor of Food Science. Dr. Hampson has researched the application of ozone as a germicidal agent for use in food and agriculture, and as a professional member of several societies and organizations he has worked to teach and promote the safe and efficacious use of ozone for food and facility sanitation.

ABSTRACT: Despite the long history of ozone use, especially for municipal drinking water and bottled water, not enough is known about ozone's use in the food and agriculture industries. While technical, regulatory and economic hurdles have been largely overcome, there still exists a great need for education. The suppliers of ozone technology need to learn about the food and agriculture industries. And, the food and agriculture industries have had to sort through a plethora of information about ozone to determine whether this technology has an application in their operations. Occasionally, misunderstanding, misrepresentation and wrong decisions have hindered the introduction of ozone science, but inquiries about ozone are being made from all over the world, ranging from the simple "How do I measure ozone?" to the more complex issues of dosage requirements for a particular application. This presentation will review such inquiries and provide responses based on current knowledge.

Jenny K. Hansen: Application of Ozone as a Disinfectant for Commercially Processed Seafood

Jenny Hansen received her M.S. (2002) in Food Science and Technology from Oregon State University in coordination with FITC, Kodiak, AK and the University of Alaska at Fairbanks; and her B.S. (1998) in Biology from Pacific University, Forest Grove, Oregon. Her work has included positions as VP/Principal Consultant for Forever Wild-Alaska, Inc.; Operations Manager of Salty Fly Safaris; Seafood Consultant to Alaskan Salmon canneries; and Microbiology Laboratory Manager for Wards Cove Packing, Inc. in Ketchikan and Kodiak, AK.

Jenny carries out research and development in commercial seafood microbiology labs in Alaskan canneries, trains microbiology personnel, and designs and sets up laboratories. Previously, as Graduate Research Assistant (National Sea Grant Program) she researched and developed ozone treatment systems to study the effects of ozone as a disinfectant for commercially processed seafood. She also developed and organized the Caviar Microbiology Lab at Wards Cove Packing Co.; for the microbial monitoring of processing equipment, salmon, and salmon roe products; and the development of sanitation procedures and contamination control practices for the processing of seafood. She conducted a workshop on the Use of Aqueous Ozone in Seafood Processing and is a member of the Pacific Fisheries Technologists Association.

ABSTRACT:

(PLEASE SEE ADDENDUM)

Senol Ibanoglu, Ph.D.: Tempering Wheat with Ozonated Water (POSTER)

Dr. Ibanoglu received his B.S. in Food Engineering (METU, Turkey, 1987) and M.S. in Food Engineering (Gaziantep University, Turkey, 1992). His Ph.D. in Food Technology was awarded by The Manchester Metropolitan University, UK, in 1996. His current position is Associate Professor at Gaziantep University, Turkey teaching at undergraduate and postgraduate levels and conducting research in the following areas: ozone applications to cereals, extrusion of cereal-based fermented foods, mathematical modeling of extrusion processes using response surface methodology, baked products, extrusion of starch containing foods, high hydrostatic pressure applications on cereals, and stability of thermally treated wheat germ.

ABSTRACT: Wheat samples were tempered using ozonated water. Milling (rate of extraction), rheological (farinograph and extensograph characteristics), chemical (protein, falling number, sedimentation volume), colour (Hunter Lab values) and microbiological (total bacterial and yeast/moulds) properties of flours were evaluated. Results indicated that tempering with ozonated water did not significantly alter the chemical, physical and rheological properties of the flours. However, a statistically significant reduction in the total bacterial and yeast/mould counts was obtained after tempering with ozonated water. Results suggest that water ozonated up to 11.5 mg ozone/L can be successfully used in tempering of wheat without deteriorating the flour quality.

Lynn Johnson: Ozone Gas Use in Potato Storage

Lynn has over 45 years of professional experience, most of it in the potato industry, related to harvesting, handling, packing, sorting, and storing potatoes. He founded four successful companies: one that developed, manufactured and sold sod harvesting equipment; two that developed, manufactured and sold potato handling equipment; and presently O3Co., which has developed and is selling ozone generating and application equipment storage (patent applied for) to treat potatoes going into storage and maintain ozone in the storage. Lynn holds several patents generally related to potato handling. He spent several years conducting research related to mechanical damage of potatoes and published more than 30 papers covering this research. He has spent the last 8 years developing methods to use ozone and to determine its efficacy to control potato disease in storage and to disinfect fresh potatoes for shipment.

Lynn earned his B.S. in Agricultural Engineering (1953, University of Idaho, Moscow, Idaho); a Certificate of Competence in Meteorology (1954, University of California, Los Angeles, California); and his M.S. in Agricultural Engineering (1958, University of Idaho, Moscow, Idaho). In 1991 Lynn was awarded Agricultural Engineer of the Year by the Pacific Northwest Region of American Society of Agricultural Engineering.

ABSTRACT: For the past seven years, O3Co. has used ozone gas supplied through ventilation systems to help control pathogens in stored potatoes. Ozone in very high concentrations is applied for 15 seconds to a continuous stream (4 to 5 tons per minute) of potatoes going into storage. When the storage facility is full, a maintenance level of ozone is then applied through the ventilation system. In one test nearly 100% control of a resistant strain of phythophthora erythrosertica (pink rot) was achieved. No detrimental effects to the potatoes were observed. A system (patent applied for) that uses a high concentration of ozone to treat potatoes was developed and was used commercially for the 2001 potato harvest with very good results.

James (Jim) G. Leesch: The Use of Ozone as a Gaseous Fumigant for Stored-Product Insect Control

Since 1994 Dr. Leesch has been a Research Entomologist in the Agricultural Research Service of the U. S. Department of Agriculture working at the San Joaquin Valley Agricultural Sciences Center in Parlier, California. His major assignment is to investigate alternatives to replace the fumigant methyl bromide (MB), which is being phased out through the Montreal Protocol and the U.S. Clean Air Act. A recognized authority on the use of fumigation to disinfest postharvest commodities, he has worked on fumigations with postharvest commodities ranging from fresh and dried fruit, nuts, cereal grains and spices to processed commodities such as flour, corn meal and other durables. He has a B.A. in Chemistry (1965, Occidental College, Los Angeles, CA) and a Ph.D. in Entomology (Insect Toxicology) from the University of California, Riverside, CA and has published over two dozen articles.

Jim successfully developed a system that traps MB following chamber fumigations of commodities and transferred the technology to industry. He developed a quarantine fumigation schedule to allow fresh prunes into Japan. He also served on a USDA/USTR team that won a case against Japan at the WTO concerning the use of varietal testing of commodities as a trade barrier.

ABSTRACT: As the fumigant methyl bromide (MB) is phased out by the Montreal Protocol and the U.S. Clean Air Act, scientists are searching for alternatives which can be used to rid commodities of damaging insects.

Methyl bromide has been used for decades to kill insects in commodities for both control and quarantine purposes. We tested ozone as a toxicant to stored product insects in hopes of killing insects at low dosages in short periods of time. To achieve shorter exposure times in this challenging application, we combined the ozone with CO_2 and reduced pressure in a chamber built by our cooperating partner. The efficacy of ozone alone and with reduced pressure and/or carbon dioxide against a common stored product insect, the Indianmeal moth, will be reported.

James Leung: Ozone – The New Tool

Jim received his B.S. in Mechanical Engineering from Rutgers University. Prior to joining Novazone, Inc. as Regional Sales Manager, he was an Applications Engineer with Air Liquide, where he managed food industry accounts. He was the technical and marketing team leader for the food and industrial cryogenics business segment on the west coast. He placed emphasis on real-world, practical examples with field testing and hands-on experiments. Jim has also worked for Interquest Communications and Darwin Networks, where he specialized in providing high-speed, fixed wireless Internet access to small and medium-sized businesses.

ABSTRACT: As a replacement for chlorine and other chemicals ozone continues to gain major acceptance in the treatment of agricultural products and is used to sanitize products and equipment, to fumigate facilities and cold storage rooms, and to control odors. Determining the amount of ozone required to achieve the desired results is critical. The ozone system must be sized to take into account the product being treated, the length of time available for treatment, and the quantity of product, as well as the reason for the treatment.

As most processes cannot sustain any down time, the ozone generator must be designed for industrial use and be a complete system, with everything needed to make ozone, apply it, and control ozone levels. The supplier should be responsible for the generator, dry air/oxygen preparation, computer controls and the contacting systems. Choose a supplier with technical knowledge of ozone systems as well as applications experience. Long term maintenance requirements must be understood and considered when comparing equipment. Typical operating costs are electric power ($2-$10 per day) and maintenance parts. Ozone equipment should be installed in a cool, dust-free environment to increase reliability and durability of the equipment.

Ozone can significantly increase the shelf life of products and decrease losses due to spoilage, which translates into increased profits for the grower/distributor. Test results, documented by independent laboratories, illustrate ozone's effectiveness.

Matthew Lowe: Surface Sanitation with Ozone-Enriched Water, NSF Registration and Case Study Review

Matt Lowe is the Marketing Manager for DEL Ozone. He has been involved in the research and development of ozone applications for over 3 years. Previously, he worked in the environmental groundwater remediation industry. Matt holds a B.S. degree in Biochemistry and Cell Biology from the University of California San Diego.

ABSTRACT: Ozone is an unstable molecule of three oxygen atoms that readily oxidizes organic material. It breaks down microbial membranes and denatures metabolic enzymes. Ozone-enriched water kills microbes as effectively as chlorine, and has been proven to be effective against bio-film, bacteria, viruses, fungi, and protozoa, none of which can build up a resistive tolerance to ozone. It is generated on-site and eliminates the need for personnel to handle, mix and dispose of harsh chemicals for sanitation. Furthermore, ozone readily reverts to oxygen, an end-product that leaves no residue on contact surfaces. Ozone-enriched water can be sprayed directly on floors, drains, walls, wettable equipment, tanks (externally and internally), and clean rooms via mobile or centralized systems with hand-held or drop-down low pressure sprayers.

Ozone is an effective, scientifically proven, broad-spectrum antimicrobial agent. In USDA-inspected facilities, ozone equipment must be registered by NSF International and listed in the NSF International *White BookÔ of USDA Approved and NSF Registered Nonfood Compounds and Proprietary Substances*. DEL's surface sanitation systems are registered with NSF International, ensuring OSHA safety compliance and compliance with anti-microbial efficacy claims.

Facilities currently using DEL's ozone surface sanitation systems are realizing cost, time, and water savings as compared with the use of conventional chemical disinfectants. Other processors are introducing ozone surface sanitation to their HACCP plans as a final intervention or as an additional step.

Yaguang Li Luo, Ph.D.: Effect of Ozone and Negative Air Ions on Produce Quality and Microbial Growth during Storage

Y. Luo, J. Li, X. Wang, X. Shi

Dr. Luo is currently a Research Food Technologist with the USDA Produce Quality and Safety Lab, Beltsville, Maryland. She previously served as a Food Scientist and R&D Research Leader for fresh-cut produce industry leaders Dole Fresh Vegetables and Fresh Express. Today, she will discuss pioneering work on ozone accomplished in the 1980s which remains valuable and pertinent to current ozone research.

ABSTRACT: Pioneering studies on ozone and negative air ions were conducted from 1983 to 1987 in China, investigating the effects of ozone, negative air ions, positive air ions and their combinations on postharvest biology, product quality, and microbial growth on apples, oranges and tomatoes. The best results were obtained with the combination of ozone and negative air ions; their efficacy on postharvest biology and microbial growth was significantly affected by concentration, frequency, and duration of each treatment.

S. D. Marko: Oak Volatile Analysis after Ozone Sanitation

S.D. Marko, E.S. Dormedy, D.F. Dormedy, K.C. Fugelsang, R.L. Wample, B.H. Gump.

Steve Marko received his B.S. in Biochemistry from Cal Poly, San Luis Obispo (1995) and is currently completing his M.S. in Food & Nutritional Sciences at California State University, Fresno. His research emphasis has been in the use of ozone as a sanitization agent for oak wine barrels and its effects on aroma volatiles. He is a member of the American Society for Enology & Viticulture and has received scholarships from ASEV, American Wine Society, Temecula Valley Wine Society, and Scott Laboratories. He currently works as a senior food technologist for Fresh Express, Inc. in Salinas, Ca.

ABSTRACT: For many years, oak barrels have been used to store wine, to provide the complex aromas and flavors desired by wine consumers. Processing raw oak wood into toasted barrels generates volatile compounds extracted by the stored wines. Given the high cost of new barrels, wineries try to clean used barrels for reuse. We investigated sanitizing used oak barrels with ozone and the effect on oak aroma volatiles. Toasted French oak blocks were treated with ozone, then extracted in model wine solutions. Headspace extractions were then analyzed using gas chromatography and mass spectroscopy to determine the concentration of each volatile provided by the oak blocks. The results support the use of ozone as a sanitizing agent for oak wine barrels.

Bruce K. Marvin, P.E.: Subsurface Treatment of Soil and Groundwater with Ozone: Pesticides and Fuel Hydrocarbons

Bruce is the Operations Manager for the California office of Aquifer Solutions, Inc. He holds an M.S. in Civil and Environmental Engineering from Stanford University and a B.S. in Civil Engineering from Northeastern University. A licensed civil engineer in California, Mr. Marvin has over 10 years of experience in subsurface contaminant remediation and investigation. He has managed the investigation of numerous facilities and locations, designed and built over 15 full-scale remediation systems, and designed and implemented more than 30 field treatability studies. Mr. Marvin has worked throughout the United States and in Japan.

ABSTRACT: During the last ten years, subsurface injection of ozone (O_3) has gained attention for a variety of uses from improving crop production to destroying environmental pollutants ranging from chlorinated solvents to polychlorinated biphenyl (PCBs). In-situ ozonation is a fast, cost-effective means of treating pesticide and fuel-derived pollutants. Careful evaluation of potential by-products, subsurface geochemistry, soil mineral properties, and the geologic setting should be performed during site screening. A wide range of pesticides is susceptible to oxidation by ozone and radicals species that are produced in the subsurface, including atrazine, 2-4 D, DDT, DEET, isoproturon, lin/diuron, and mecoprop (MCPP).

Rapid and cost-effective destruction of petroleum compounds, such as MTBE, has also been achieved using ozone gas injection. Complete destruction of fuel contaminants was achieved in two recent short-term pilot tests in California. No accumulation of intermediate compounds such as tertiary butyl ether (TBA) was observed. Clean up and closure of contaminated properties is being performed rapidly and cost effectively using ozone.

Angelo Mazzei/Paul Overbeck: Effective Ozone Mass Transfer, Residual Ozone, and Ozone Off-Gas Control

Angelo Mazzei is President of Mazzei Injector Corporation (MIC), a Bakersfield, CA-based manufacturer of the venturi-type, patented Mazzei® Injector. Mr. Mazzei is also Chairman of the Board of GDT Corporation.

Paul Overbeck is President and Chief Executive Officer of GDT Water Process Corporation. Prior to joining GDT, Overbeck was Chief Operating Officer for Osmonics, Inc., Phoenix Operations, where he was responsible for marketing and operations for both Ozone Research and Equipment Corporation (OREC) and Lakewood Instruments subsidiaries. He has also held marketing and sales management positions with Mulligan International and Polymeric. Overbeck holds a B.S. in Chemistry from the University of Minnesota.

ABSTRACT: Ozone entered the U.S. agricultural market place in June 1997 with the affirmation to the US FDA by an Electric Power Research Institute (EPRI) assembled Expert Panel that, "the available information supports a GRAS classification for ozone as a disinfectant or sanitizer for foods when used in levels and by methods of application consistent with good manufacturing practices." The FDA released a final ruling in June 2001, in response to an EPRI food additive petition, amending previous regulations and granting regulatory acceptance of ozone as an anti-microbial food additive agent.

Ozone has been employed effectively internationally as a disinfectant and oxidant in over 3,000 municipal drinking water treatment plants and in well over 1,000 bottled water plants regulated by the FDA as the final treatment process to assure a microbial free and aesthetically preferred product

This presentation covers the application of ozone to water, dissolved ozone measurement and control and off-gas safety considerations in ozone contacting systems with emphasis on how ozone can be used safely and effectively in food processing applications. The rather complex requirements of engineered subsystems, e.g., interface with the ozone generator, gas/liquid contacting, and contactor off-gas destruction, will be discussed in detail.

John McClain: Use of Ozone in Winery Sanitation

John McClain has twenty eight years experience in environmental and sanitation management. He established and directed the Environmental Protection Agency's regional training center. As a consultant, he has developed and delivered environmental and sanitation programs to business and industry, government, municipalities and educational institutions. As President of McClain Ozone Inc., Mr. McClain pioneered the use of ozone in the wine and cork industry and has extensive experience utilizing ozone in food and agricultural applications.

ABSTRACT: The history of ozone sanitation in wineries is presented (i.e., process and equipment sanitation) including early experimentation and current applications, including recent innovations and successes. Standard sanitation procedures in the industry are presented and compared, and the advantages of using ozone are documented and discussed, along with ozone safety considerations. Future applications and trends in the use of ozone are addressed, along with education and training needs.

Joseph Mendez: Ozone 101 – Facts Without the Fluff and Lessons from the Field

Joseph Mendez has a Bachelor's of Engineering in Mechanical Engineering from Stevens Institute of Technology in Hoboken, NJ. He has a wide background ranging from electric generation, to electronics, to pharmaceuticals. He spent over twenty years in facilities management and construction before becoming a Director at Piper Environmental Group, Inc. seven years ago.

ABSTRACT: As confirmed successful uses of ozone become more numerous, ozone is becoming more readily accepted for a wide variety of industrial uses. The increasing number of operational systems is placing ozone gas under higher levels of scrutiny by building and fire officials, Corporate safety departments and individual employees. Regulatory requirements and restrictions are now being more strictly enforced.

This presentation will deal with safety in ozone applications, OSHA regulations, ICBO Uniform Fire Code requirements for ozone generators, and other common sense safety issues. The second portion of the presentation will deal with ozone uses that have been successful and those that have failed or proved indeterminate.

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Bill Nelson: Food Safety Benefits with Ozone

Since his start in the Alaskan fisheries during the early 1980's, Bill Nelson has become a well-known pioneer in the use of ozone in food processing. After more than a decade at the University of Washington College of Fisheries and Food Science, as a senior developmentalist, Bill received three consecutive grants from the Alaska Department of Commerce. He proved in his grant studies that, by using an ozonated rinse on fish, then storing them on ozonated ice, bacteria were removed, resulting in improved product quality and extended shelf life. Since then, Bill has developed methods and equipment to simplify the practical application of ozone for food safety, resulting in his patented "Vortex Mixing Chamber", which crushes ozone gas into microscopic bubbles. Since FDA's approval of ozone on food, Bill has worked in many areas of the food industry, including pork, beef, poultry and produce, and has traveled the world consulting and teaching his "dual system" method of using ozone to sanitize the product and then for plant wash-down. With today's built in ozone monitors, and the ability to maintain the correct amount of ozone residuals in both water and air, through the use of computer diagnostics, Bill has accomplished his goal of taking the work and worry out of using ozone.

ABSTRACT: Using data collected from his customers and from personal experience, Bill will discuss how to use ozone on product and equipment for cost-effectively sanitizing seafood, beef, pork, poultry and produce.

Bill pioneered use of ozonated water and ice on fish, in the United States, during the early 1980's. He will detail 15 ways to improve the quality of your fish and shellfish, including oysters, throughout the seafood process.

He will continue with the use of ozone on beef, pork, and poultry, and will diagram total plant sanitation with the use of ozone, and will explain the "Dual System" for sanitation. For produce processing and sanitizing, he will cover several specific tests on various fruits and vegetables, ending with the difference between ozone and chorine for bacteria kill.

Bill will conclude with how time, temperature, and proper ozone treatment extends shelf life and makes food safe, will explain how to maintain an ozone safe environment, and will discuss the bottom line, dollars and cents.

Shaun Porter: Case Study: - Ozone System to Provide Sterile Rinse Water

S. Porter, P. Vervalle

Shaun Porter is the Sales Manager for ClearWater Tech, LLC. of San Luis Obispo, CA. Previously, he spent two years as a factory Account Executive for the company, working with ozone applications for commercial and residential potable water, wastewater, agriculture, laundry and a variety of other markets. Shaun graduated from Eastern Kentucky University with a degree in environmental health sciences. Areas of special study included water treatment, industrial hygiene, chemistry and microbiology..

ABSTRACT: Sierra Nevada Brewing Company in Chico, CA is the largest craft beer producer in the U.S. The CWT ozone system is installed on the brewery's plant-wide sterile rinse water system. The water is used for bottle rinsing and at various C.I.P. locations throughout the plant. Source water is municipal and is treated at the plant with ultraviolet light followed by ozone. To meet the water treatment goal, we installed a CWT Model CD4000-HO ozone system. Feed gas is supplied by two Sequal Model 15C oxygen generators. The injector is a Mazzei Model 1584, The ozone generator is controlled by a Signet ORP controller and the ozone residual is checked by a Rosemount dissolved ozone monitor. Ozone was selected to treat the rinse water because chlorine dioxide and hydrogen peroxide proved unsatisfactory.

Alan E. Pryor: Ozone Toxicology and Guidelines for Safe Use in Food Processing Ozonation Systems

Alan is president of Ozone Process Consultants, Inc. and Soilzone, Inc. His extensive first-hand experience in over 200 industrial ozonation projects involved system design, installation, maintenance and trouble-shooting. He chaired the Subcommittee on Ozone Toxicology and Safety Considerations at the National Association of Corrosion Engineers, and was the liaison for the International Ozone Association to the Uniform Fire Code Executive Committee where he helped develop the National Safety Standards embodied in the Uniform Fire Code.

Alan has undergraduate degrees in Chemistry and biology, and a Master's in Industrial Hygiene Engineering from the University of California. He has published over 20 technical papers on ozone applications including food processing. He would be happy to share these articles with any attendees. Simply provide your email address after the presentation with a note indicating you would like to receive these papers and he will forward them by email.

ABSTRACT: Ozone is used advantageously in many food processing applications due to its high oxidation potential, but like all oxidizing gases, ozone is potentially harmful. However, a number of aspects of ozone that reduce the potential exposure concerns to humans: 1**)** ozone is manufactured on-site at relatively low concentrations and pressures and is immediately consumed in the treatment process; 2) ozone has a comparatively short half-life; 3) ozone decomposes into simple diatomic oxygen upon breakdown; and, 4) ozone has a characteristically strong odor, providing an early warning of potential overexposure. This paper discusses the physical properties of ozone as they pertain to its safe handling, reviews the human toxicology of ozone gas, and describes current ozone exposure standards (Threshhold Limit Values) as promulgated by OSHA.

Rip G. Rice, Ph.D.: 1. An FDA-Approved Antimicrobial Agent for Foods 2. Recent Advances in the Uses of Ozone for Food and Agricultural Products

Dr. Rip G. Rice is President of his own consulting firm, Rice International Consulting Enterprises, located in Ashton, Maryland, and specializing in ozone technologies, particularly with respect to water and wastewater treatment and the uses of ozone in food and agricultural areas. For the U.S. EPA, Dr. Rice has conducted surveys of water treatment plants using ozone and chlorine dioxide, and lectured on Disinfection and Disinfection Byproducts for EPA-sponsored Workshops on Emerging Technologies for Drinking Water Treatment.

In other areas, Dr. Rice consults on and is knowledgeable in many specific applications of ozone, e.g., advanced oxidation techniques, uses for ozone in municipal and industrial wastewater treatment and air treatment, ozone for swimming pool water and cooling water treatments. He served as an Ozone Resource to the EPRI Expert Panel which declared ozone to be Generally Recognized As Safe in food applications in 1997. Later he was the Principal Writer for EPRI of the Food Additive Petition that resulted in U.S. FDA approval of ozone as an Antimicrobial Agent in Contact with Foods (2001). He wrote the "Ozone Reference Guide" for the Electric Power Research Institute.

Dr. Rice co-founded the International Ozone Institute (now the International Ozone Association) in 1973, and has served as its President, Editor-in-Chief of the Journal of the IOA, and Editor-in-Chief of its newsletter. He has authored more than 100 papers dealing with various aspects of ozone technology, and has edited or co-edited 20 books, proceedings or monographs in the field of ozone technology. In 1995, Dr. Rice received the Morton J. Klein Memorial Award for outstanding service to the IOA. In 1999, Dr. Rice co-founded the International Ultraviolet Association, and serves the IUVA as Editor-in-Chief of *IUVA News*.

ABSTRACT 1.: Ozone was approved by the U.S. FDA in June 2001 as an antimicrobial agent. In December 2001, the USDA/FSIS approved the use of ozone for direct contact with meats and poultry. Since FDA approval, many studies of the use of ozone to solve microbial issues are underway, with many success stories being reported. In this paper, the author will discuss the FDA approval of ozone, pointing out the meaning of the most significant sections of the regulation, and will summarize reported ozone dosage levels for application to a variety of foodstuffs. An Ozone Evaluation Protocol will be discussed, and the future potentials for ozone in the food and agriculture industry will be described.

ABSTRACT 2.: Since approval of ozone as an antimicrobial agent in gas or aqueous phases for direct contact with foods by the US FDA in June, 2001 and by the USDA/FSIS in December 2001 for use with meats and poultry, studies on ozone are being reported at a rapid rate. In this paper, the author will discuss some of these recently reported results. Newly developed equipment for applying ozone in water for the food industry will be described, and the application of ozone in combination with ultraviolet (UV) radiation also will be discussed.

Specific case examples of successful uses of ozone will include treatment of cattle drinking water at a dairy farm, increasing milk production; irrigation water treatment at a tomato farm, decreasing losses and increasing production; water treatment at a large brewery; treatment of potatoes to reduce losses during storage; potentials of Ozone + UV in tandem; photo-ionization – for grain, poultry and air treatment.

Joseph L. Smilanick, Ph.D.: Influence of Ozone Treatment on Microbe Populations and the Quality of Fresh Produce.

J. L. Smilanick, D. Margosan, M. Mansour, F. Mlikota, J. Aeiyabei

Joe is originally from Sacramento, California. He completed a B.S. in Plant Science at UC Davis, a M.S. in Plant Pathology at Colorado State University, and a Ph.D. in Plant Pathology at UC Riverside. He has been a Research Plant Pathologist with the USDA located in the Fresno area since 1986. Most of his research work has dealt with the control of pathogenic fungi on fresh produce, particularly fresh fruit.

ABSTRACT: In laboratory tests we determined the ozone doses in water needed to kill spores of common fungal rot pathogens of fresh produce. We passed fruit and vegetables through an ozonated water drench system at a produce packing facility to determine its impact on natural and artificially augmented microbe populations and produce quality. Natural yeast and mold populations on lemons and oranges were reduced from an average of 1,978,440 colony-forming units (cfu) per fruit to 356,294 cfu/fruit by water alone and to 198,144 cfu/fruit by ozonated water, and all were significantly different. Natural aerobic mesophilic bacteria populations on lemons, oranges, and grapes were reduced from an average of 190,961 colony-forming units (cfu) per fruit to 21,476 cfu/fruit by water alone and to 22,956 cfu/fruit by ozonated water. The number of viable spores of *Penicillium digitatum* on lemons and oranges was not reduced significantly by water or ozonated water treatments. The number of viable spores of *Geotrichum citri-aurantii* on lemons and oranges was reduced significantly from an average of 1,159,703 colony-forming units (cfu) per fruit to 54,860 cfu/fruit by water alone and to 80,901 cfu/fruit by ozonated water. Washing reduced the A506 population on peppers by approximately 90%. The addition of ozone injection further reduced the inoculated population by approximately 98% of the control population recovered from untreated peppers. Produce (Roma tomatoes, Serrano chiles, Jalapeno chiles, red chiles, green cucumber, bell peppers) was passed through the dump tank and drench system with water alone or ozone and stored one month at 2°C. All were in excellent condition and unchanged by treatment. Navel oranges, 'Eureka' lemons, and 'Crimson Seedless' table grapes were treated and stored 2- 4 days at 2°C and none were visibly harmed.

Jun Song, Ph.D.: Ozone Effects on Stored Horticultural Crops

J. Song, P. D. Hildebrand, C. F. Forney, L. Fan

Dr. Song received a B.S. and a M.S. from Beijing Agriculture University, Beijing, China (1984 and 1987), and a Ph.D. from University Hohenheim, Stuttgart, Germany (1994).

Dr. Jun Song's research activities focus on preserving the quality and ensuring the safety of fruits and vegetables. His research interests are physiology and biochemistry of fruits, vegetables, and flowers in relation to maturation, ripening, senescence and post-harvest preservation; and postharvest technology such as handling, transportation, and storage of perishable horticultural commodities. His specific areas of expertise include: non-destructive quality assessment, flavor biochemistry, analytical chemistry, use of natural volatiles to inhibit decay, modified atmosphere packaging and controlled-atmosphere storage.

ABSTRACT: Adding ozone to storage room air has been reported to prolong storage-life of fresh fruits and vegetables. However, the beneficial effects of ozone depend on many factors including the nature of the pathogens and the physiology of the commodity. We have evaluated the efficacy of ozone from commercial ozone generators for reducing decay and maintaining quality of a variety of fruits and vegetables including lemons, apples, cherries, grapes, blueberries, strawberries, onions, broccoli, carrots and lettuce. These results will be presented, along with ozone's reaction with ethylene in storage rooms, and visual and flavor damage to produce caused by ozone stress. In order to develop effective treatments, the potential application of ozone to reduce decay and maintain quality in horticultural products must take into consideration the effects of ozone on the decay organism and the physiological responses of the product.

Jurgen H. Strasser, Ph.D.: Use of Ozone as an Antimicrobial Agent in Poultry Process Water

J. H. Strasser, D. M. Graham, J. Mannapperuma, R. J. Enzweiler

Dr. Strasser received his M.E. and Ph.D. in Chemical Engineering from the University of Munich. His professional experience includes serving as Research Associate, US Army Labs, Natick, MA; Process Development Engineer, FMC Corp., Santa Clara, CA; and Manager of Process Engineering, Del Monte Research Center, Walnut Creek, CA. Since 1994 he has been a Process Water Management Consultant at Lafayette, CA.

Dr. Strasser has made over 80 presentations on food processing and water treatment technologies. He has authored 18 publications in scientific journals and holds 9 US patents.

ABSTRACT: The recent approval by the FDA now officially permits the use of ozone as an antimicrobial agent in contact with food, including meat and poultry. To study the effect of direct contact of ozone on the quality and microbial load of chickens, a test project was undertaken at two major poultry processors in California.

In a one-bird-per minute pilot operation, eviscerated chickens were pre-washed with ozonated, chilled tap water purified by various membrane systems. Pretreatment of the chiller water with a bubble accelerated flotation system improved the membrane performance.

Using USDA approved analytical procedures, a one-minute in-and-out spray wash with ozonated water was found to effectively reduce the bacterial counts on the birds, comparable to a commercial chiller operation using chlorine dioxide as the anti-microbial agent. The ozone-treated birds were fully acceptable as commercial product. However, control of fugitive ozone emissions will need close attention in any commercial installation.

Paul Vervalle: Ozone in Garlic Processing – Bakersfield, CA

Paul Vervalle and Shaun Porter

Paul Vervalle is a factory Field Sales Engineer for ClearWater Tech, LLC. of San Luis Obispo, CA. Serving Arizona, California and Nevada, Paul's duties include supporting customers with technical information, troubleshooting and installation support.

ABSTRACT: Located in Bakersfield, CA, the garlic company produces whole peeled garlic, private-labeled garlic purees and jalapeno pepper products, using water from a deep well. Ozone's primary use is to disinfect whole peeled garlic during spray bar rinse. Plans are also in place to use ozone for equipment wash-down.

In June, 2002, a CWT model HDO_3-II ozone system was installed to replace the sodium hypochlorite system. With the ozone system in place, pitting of the stainless steel equipment has stopped, taste is no longer imparted to the product, and the air filtration system has been turned off completely. The wastewater now has less than one ppm sodium hypochlorite and the company reports an overall decrease in micro counts in the finished product. The company is saving $3,000 per year in sodium hypochlorite and $150 per month since the air filtration system was turned off.

Ahmed E. Yousef, Ph.D.: Current Ozone Research at the Ohio State University

Ahmed Yousef received his Ph. D. in Food Science from the University of Wisconsin, Madison in 1984. He currently serves as Professor in the Departments of Food Science and Technology, and Microbiology at The Ohio State University, where he has taught since 1991. He teaches courses in food microbiology, food sanitation and protection, and cheese and fermented foods

His research focuses on microbial safety of foods including bio-preservation using bacteriocin-producing lactic acid bacteria, new applications of ozone in food processing, and safety of foods processed by novel technologies such as pulsed electric fields, high pressure processing and ohmic heating. Dr. Yousef has received the Departmental Research Team Award, the Outstanding Teaching Award, and the Departmental Research Award, and has published numerous books and papers.

ABSTRACT: At the Ohio State University (OSU), research on ozone use in food applications started in 1995, and more than 15 research projects have been completed. Some of the most significant research accomplishments include confirming the feasibility of decontamination of fruits and vegetables by aqueous ozone and defining the optimum conditions for elimination of bacterial spores by this sanitizer. Research on decontamination of produce emphasized the need for maintaining sufficient residual ozone during the treatment, producing proper agitation, and ensuring that the treatment eliminates microorganisms attached to the surface of produce. Current research on bacterial spores outlines the optimum conditions for maximum sporicidal action of ozone. Ozone research at OSU also emphasizes the need for novel approaches to measure and monitor ozone concentrations. Lack of reliable ozone measuring equipment causes great discrepancies in published research.

James T. C. Yuan, Ph.D.: 1. Ozone-Based Hurdle Technology: in Combination with Chemical Treatment
2. Ozone-Based Hurdle Technology: in Combination with Traditional Heat Processing

James is the Group Manager of Food Safety and Technology at the Chicago Research Center of Air Liquide. He holds a Ph.D. in Food Microbiology from Utah State University with a minor in Computer Science (Artificial Intelligence). He provides technical expertise to the food industry on food safety issues. His current research areas include ozone processing technology in food applications, other non-thermal food processing technologies, and novel packaging technologies to improve food quality.

He previously worked at Campbell Soup Company World wide R&D, and at Wescor, Inc. R&D. He is an affiliate of NFPA, IFPA, IOA, IAFP, ASM, and NCFST.

ABSTRACT 1: Food processors are exploring new methods to decontaminate fresh produce to achieve a minimum of 5-log reduction. Present work using acidic calcium sulfate, in combination with ozone may lead to the establishment of a new process technology which would satisfy the required reduction level. Our objective is to evaluate the efficacy of ozone-based decontamination technology and the removal of biofilm on fresh produce. We evaluated the efficiency of the use of acidic calcium sulfate with and without ozone treatment to remove biofilm from apples. Generic *E. Coli* and *Salmonella enteritidis* were tested during the study. Controls were conducted by washing apples with acidic calcium sulfate solution alone and ozonated water alone. Ozone combined with the acidic calcium sulfate was very effective in reducing the bio-load on apples. The addition of ozone has a synergistic effect when used in combination with the acidic calcium sulfate.

ABSTRACT 2: The use of ozone as an antimicrobial agent has been examined with regard to potential applications in the food industry. The efficacy of ozonated water in inactivating various pathogens in aqueous suspension has been well documented, as have the decreased pathogen reductions associated with ozone depletion in instances where competing oxidizable organics were present in foods containing the attached target microflora. This study examined stress adaptations in pathogen cells surviving ozonation, despite the likely occurrence. The *E. coli, L. monocytogenes*, and *C. perfringens* cells surviving ozone washes on beef had decreased D-values as compared to those cells surviving sub-lethal heat treatment. Increases in thermal resistance due to prior heat treatment were evident. Therefore, resistance to subsequent stress was low in the ozone-treated survivors. This has significance in enhancing the perceived antimicrobial effectiveness of ozone treatments beyond that which is initially apparent upon direct plating. In addition, results will also be presented which examine cross-protection against pH and osmotic limitations.

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