XENON
The Industry-leading Expert in the Design and Manufacturing of High Energy Pulsed Light Systems

IFT19

Presented by

Louis R. Panico, CEO

XENON
The Pulsed Light Experts

OUTLINE

- **XENON & University of Minnesota Strategic Partnership**
- **About XENON, Why We Do What We Do**
- **The Amazing Technology of Pulsed Light**
- **Key Applications & Uses**
- **Available Systems**
- **Resources**

UNIVERSITY OF MINNESOTA

XENON
The Pulsed Light Experts

XENON / University of Minnesota Strategic Partnership

- Allows for a small core technology company to stay the day with innovation.
- We each bring something different to the table.
- Collaboration: not individuals with ideas.
- Allows for comprehensive response to commercial needs.
- Laboratory to pilot scale testing to production.

Why We Do What We Do

To change the way light is used for the good of all.

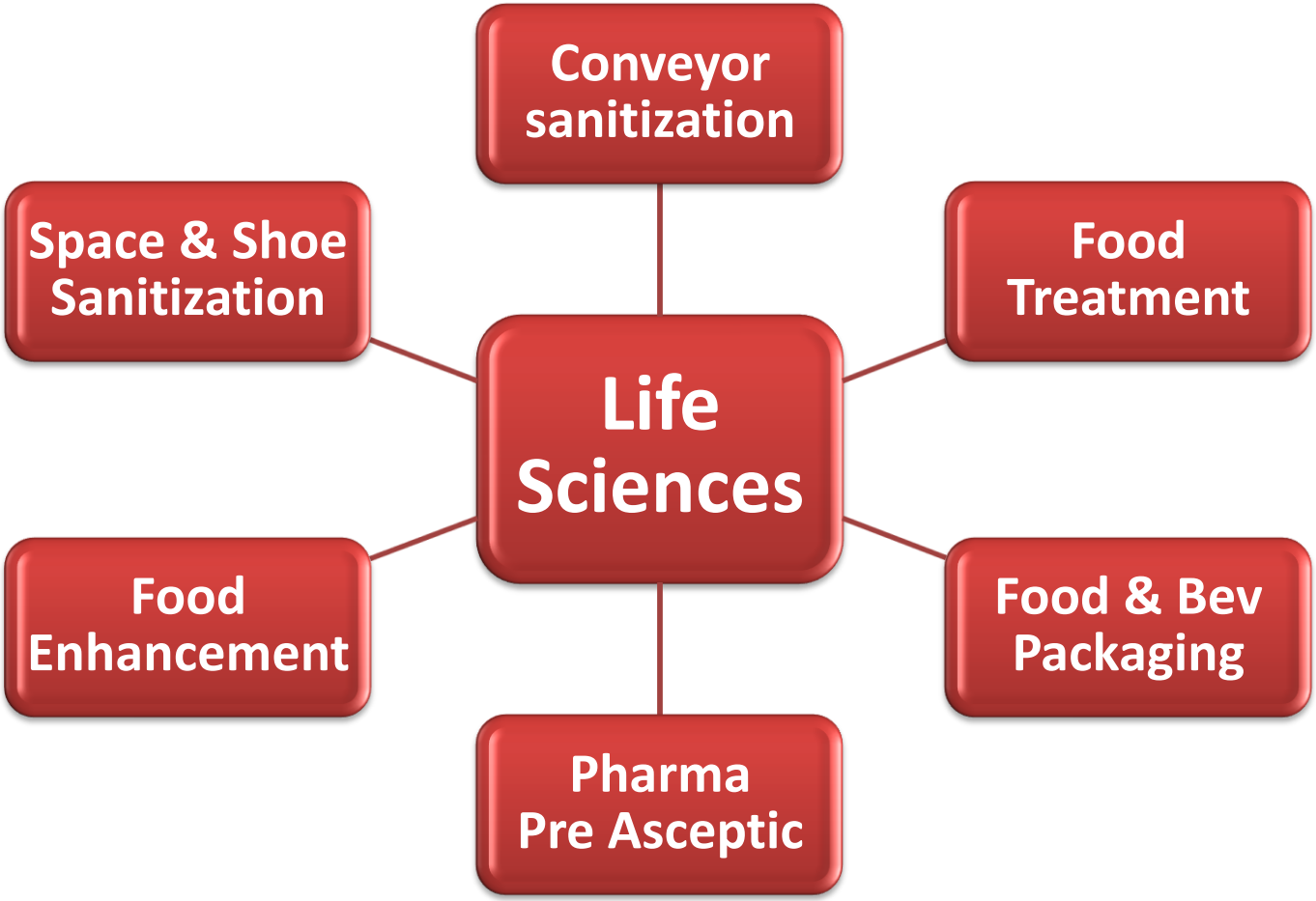
About XENON Corporation

- Privately Owned Family Business
- Founded in 1964
- Based in Wilmington, Massachusetts, USA
- Specialize in High Energy Pulsed Light Systems
- Solutions for Research & Commercial Uses

XENON's Core Strength

- Pulsed Light is our expertise and only core technology.
- We manufacture our own lamps and electro-optical systems.
- We design and build "the engine" that integrates into industrial and commercial systems that operate 24/7.
- As of today, there are over 4,000 XENON Pulsed Light systems running 24/7 world-wide.

Our Markets



XENON
The Pulsed Light Experts

What The Universe Allows

- Pulsed Light delivers very high energy pulses in extremely short periods of time.
- Pulsed Light can deliver peak energies 100,000 times higher than the sun's intensity on the earth's surface!

- Continuous Light delivers low energy levels over relatively long periods of time.

SteriPulse™

Lots of Photons Fast

XENON
The Pulsed Light Experts

U.S. FDA APPROVAL

U.S. Food and Drug Administration — Department of Health and Human Services

Food and Drug Administration Issues Approval for Pulsed UV Light in the Production, Processing and Handling of Food

Code 21CFR179.41, issued by the Food and Drug Administration (FDA), Department of Health and Human Services, approves the use of Pulsed UV light in the production, processing and handling of food.

Title 21 – FOOD AND DRUGS (Page 438)

Chapter I – FOOD AND DRUG ADMINISTRATION, DEPARTMENT OF HEALTH AND HUMAN SERVICES

Part 179 – IRRADIATION IN THE PRODUCTION, PROCESSING AND HANDLING OF FOOD

Subpart B – Radiation and Radiation Sources

Sec. 179.41 Pulsed light for the treatment of food

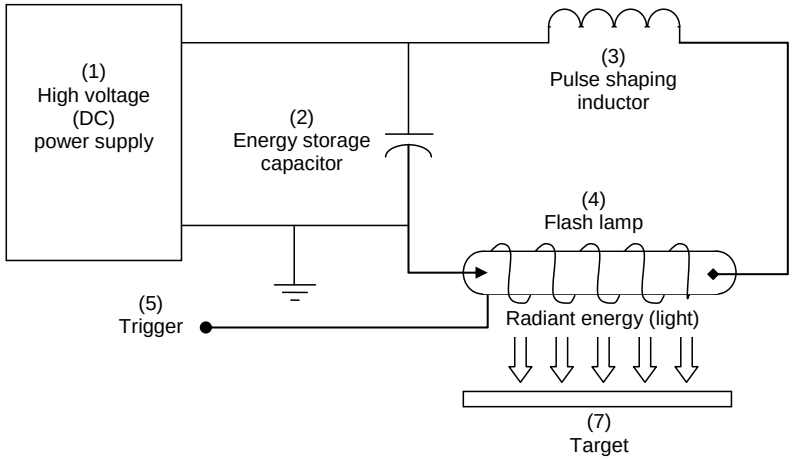
Pulsed light may be safely used for the treatment of foods under the following conditions:

(a) The radiation sources consist of xenon flashlamps designed to emit broadband radiation consisting of wavelengths covering the range of 200 to 1,000 nanometers (nm), and operated so that the pulse duration is no longer than 2 milliseconds (ms);

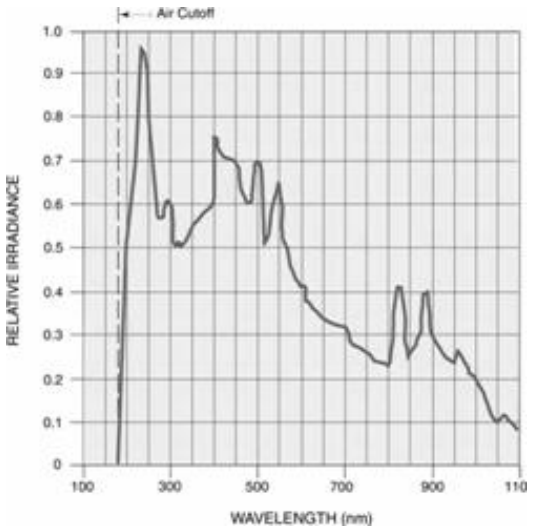
(b) The treatment is used for surface microorganism control;

(c) Foods treated with pulsed light shall receive the minimum treatment reasonably required to accomplish the intended technical effect; and

The Fundaments of Pulsed Light

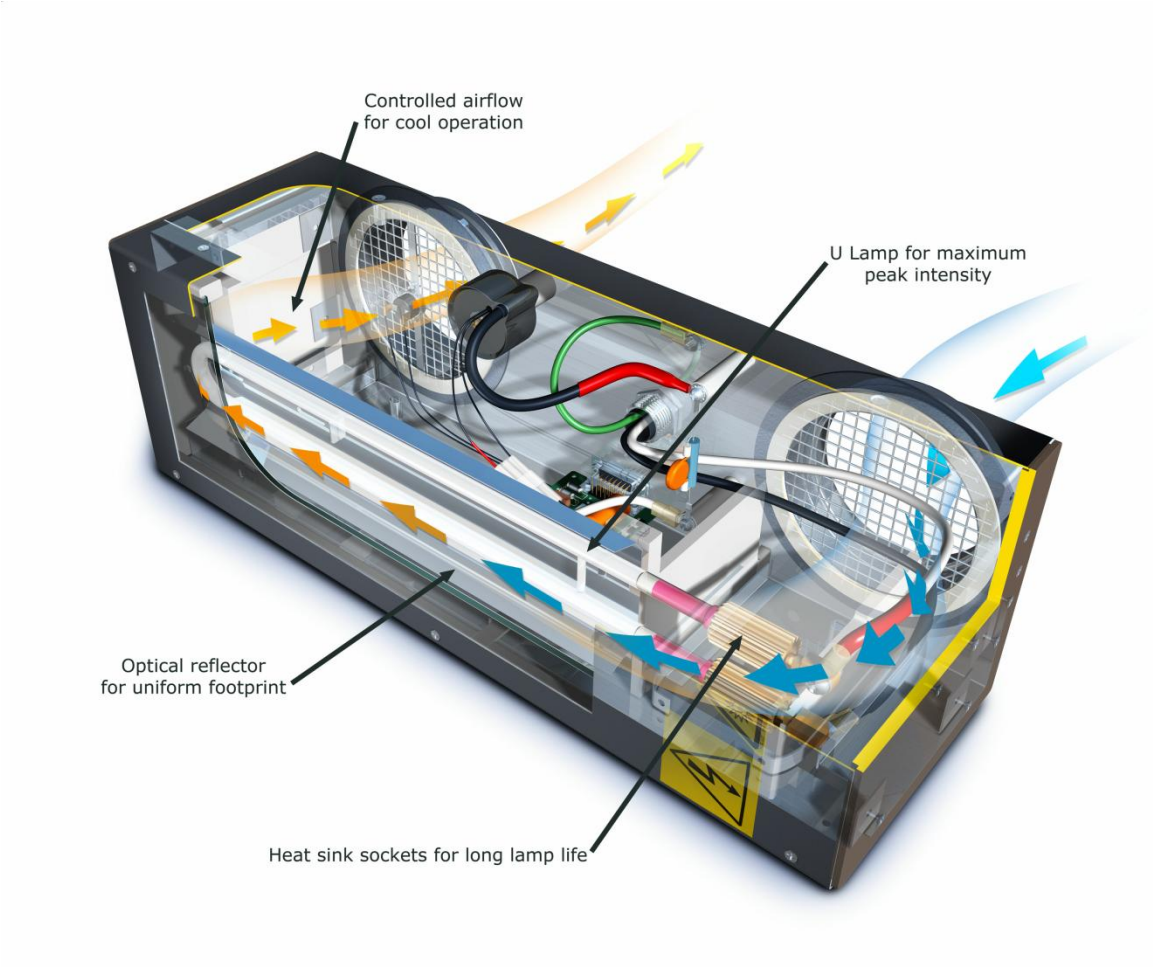


- Electro-Optical System
- Output Spectrum
- Lamp Configurations



XENON
The Pulsed Light Experts

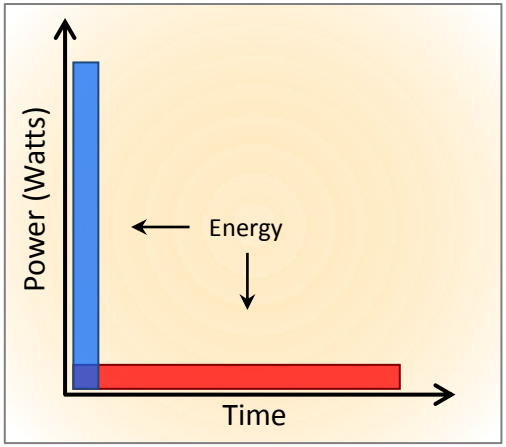
The Core of The System

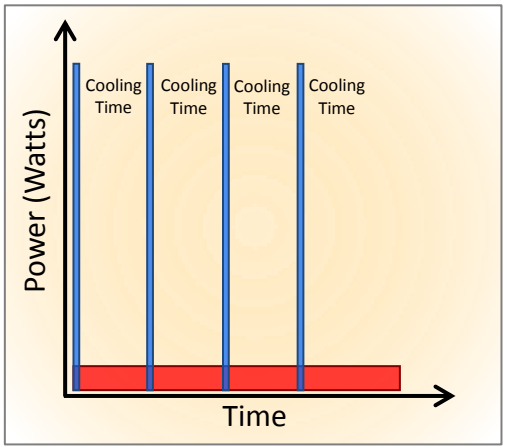


XENON
The Pulsed Light Experts

The Pulsed Light Advantage

- 100 Joules of energy can be expended two ways
  - 10 Watts for 10 seconds, or
  - 1 Megawatt pulse for 1 micro second.
- High peak power means the system is more efficient at delivering useful energy.
- Peak power phenomenon allows for deeper penetration depths.
- Shorter pulse duration means that the process can take place cooler and quicker.
- Pulsed Light is instant on-off; no warm up.
- Pulsed Light can be frequency adjusted to allow time for enhanced cooling.

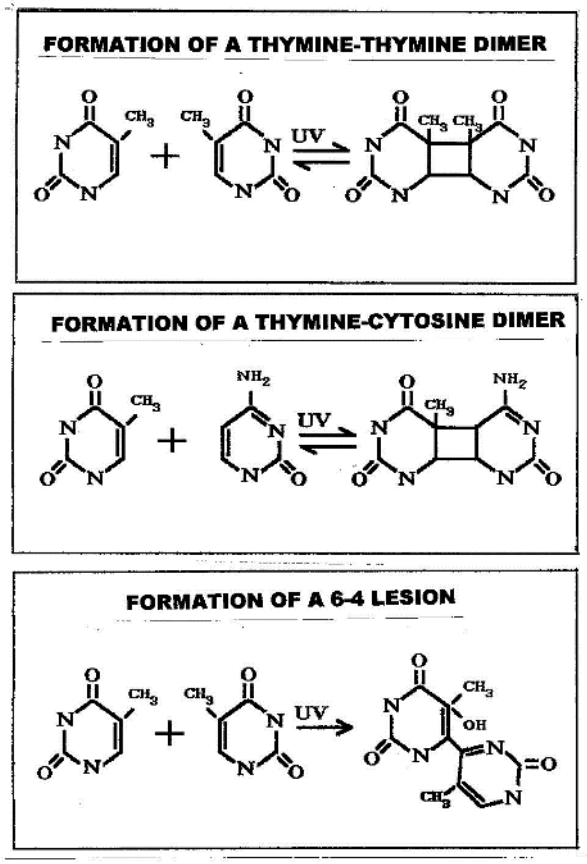




XENON
The Pulsed Light Experts

Pulsed UV Exposure

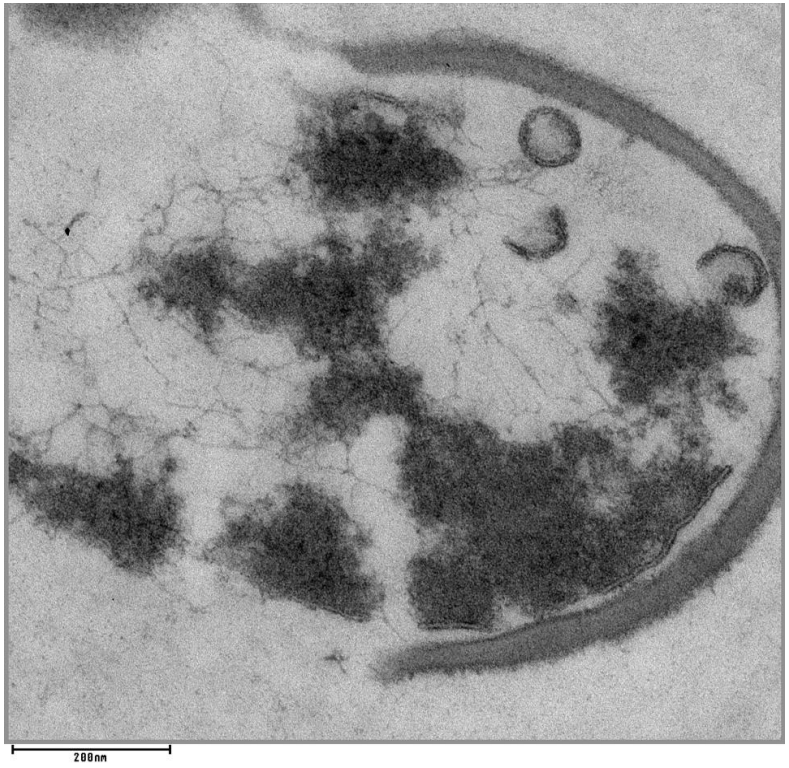
Formation of Dimers and 6-4 Lesions



- DNA damage caused by UV exposure includes formation of pyrimidine dimers and (6-4) photoproducts
- These damages result in mutations, impairment of replication and gene transcription – leading to the death of the organism
- Cells have evolved mechanisms for repairing DNA damage
- Pulsed UV radiation leads to ultimate genetic destruction of microorganisms
  - Ability to adjust light intensity
  - Ability to adjust pulse duration
  - Ability to select number of pulses

A Closer Look

Before pulsed UV-light treatment

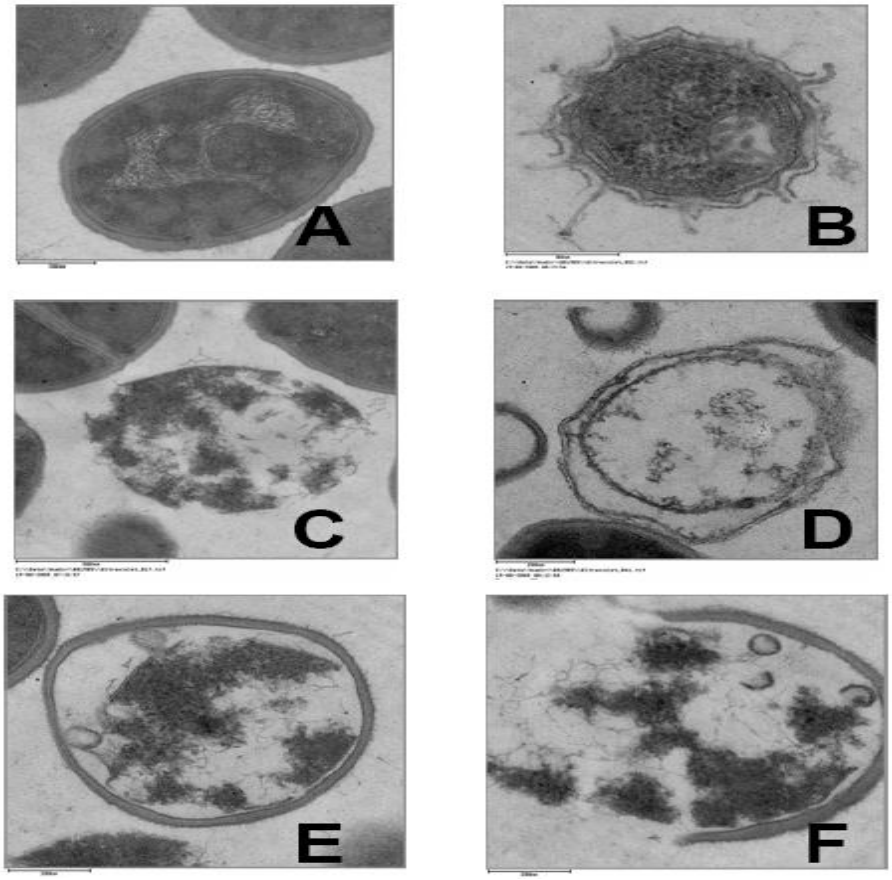


After 5 sec treatment with pulsed UV-light

Source: Krishnamurthy et al., Penn State University

XENON
The Pulsed Light Experts

Effects of pulsed UV-light treatment on *S. aureus* after 5s



A. control sample

B. cell wall rupture

C. lack of cell wall

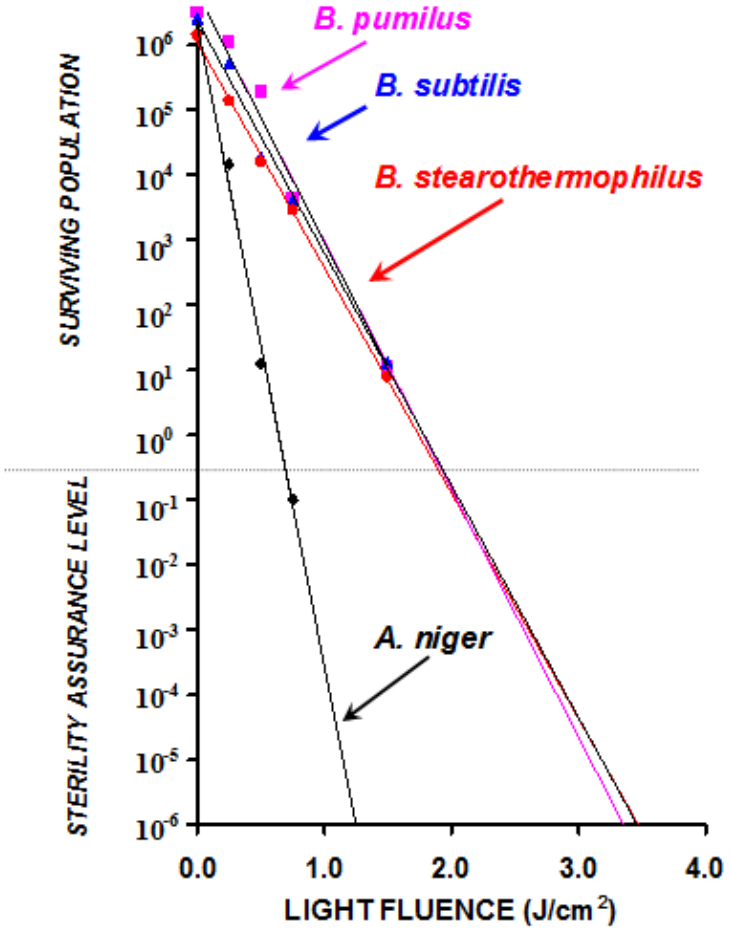
D. cytoplasm shrinkage and damage on cell wall

E. cytoplasm shrinkage and membrane damage

F. cell wall damage and cellular content leakage

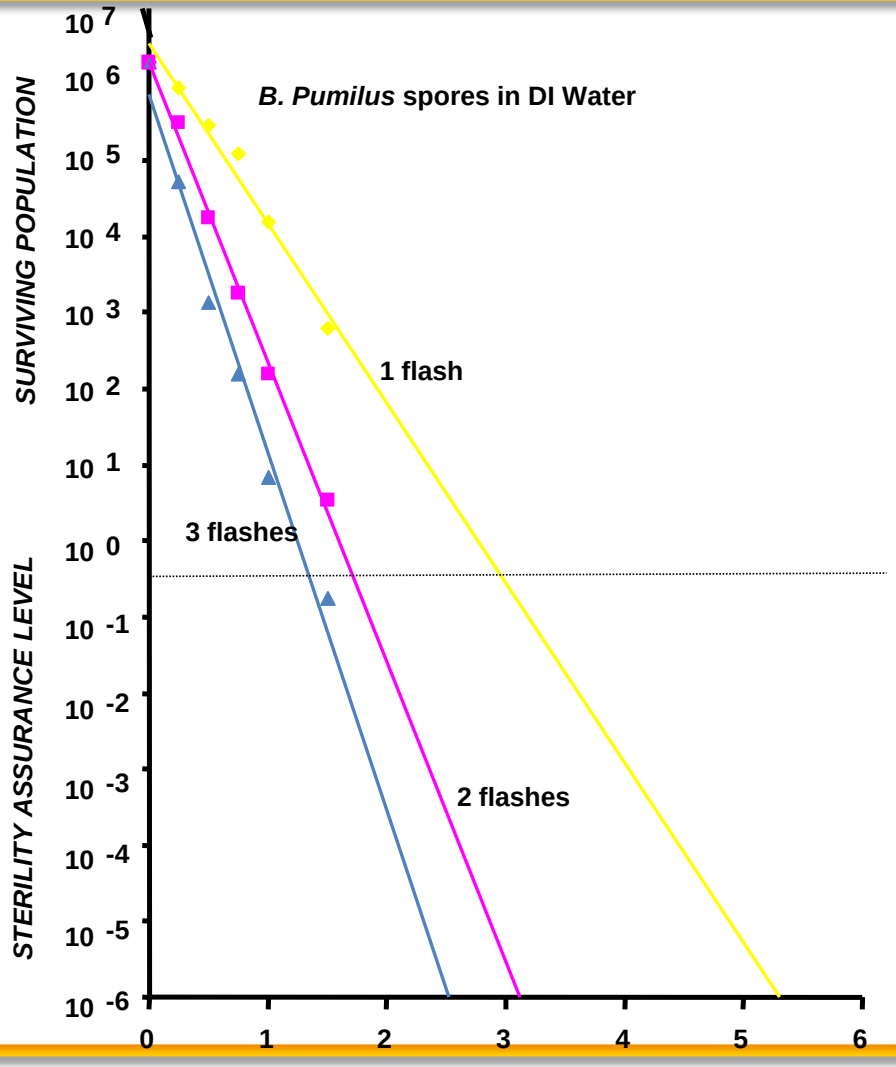
Source Krishnamurthy, Demirci et al. Food Bioprocess Technology

Dry Surface Survival Kinetics



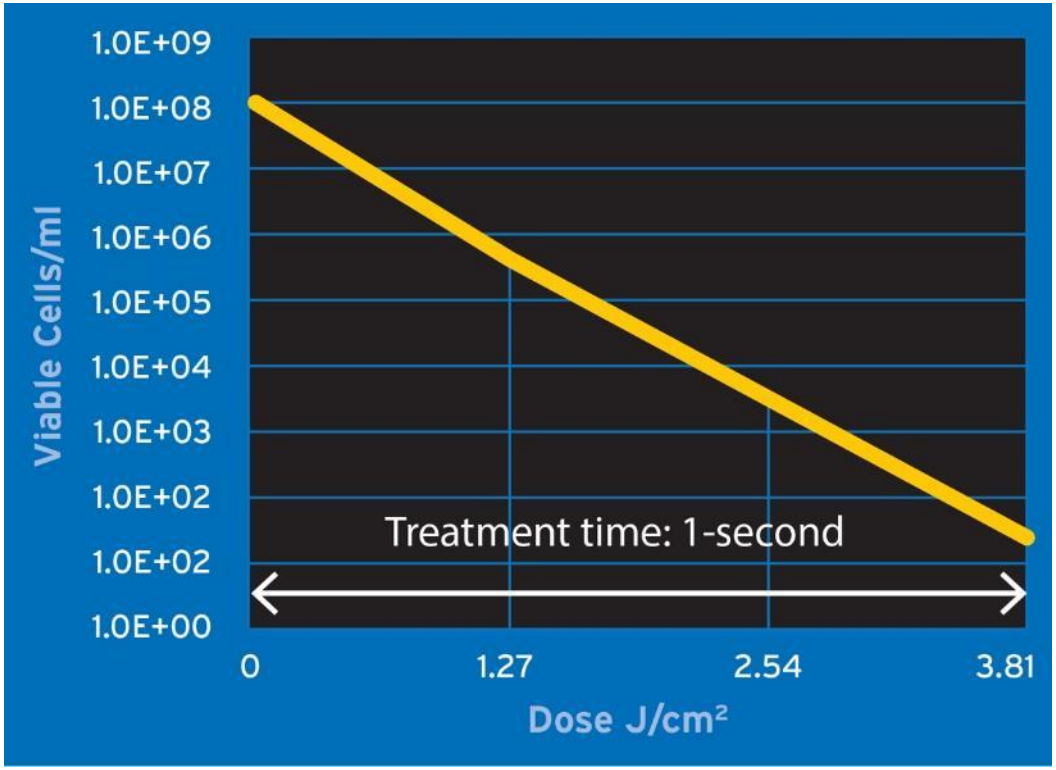
XENON
The Pulsed Light Experts

Static Liquid Survival Kinetics



XENON
The Pulsed Light Experts

Killing B. subtilis Spores



Destruction of B. subtilis in suspension exposed to Pulsed Light.
Reduction of >6 log CFU/ml achieved within 1-second treatment time.

XENON
The Pulsed Light Experts

APPLICATIONS and USES

- Food Production Conveyor Treatment.
- Blueberries.
- Yogurt Cups.
- Food Packaging Film.
- I-V bags.
- Food Production Floor Protection.
- Contact Lens Solution.
- In Trial Stages: Spices, Poultry, Pet Food, Petri Dishes, Grapes, Strawberries, Seeds, Flour.

XENON
The Pulsed Light Experts

Decontaminate Blueberries

Extend Shelf Life without Losing the Bloom

Aseptic Packaging

- Xenon pulsed UV lamps are at the heart of equipment designed and built to sanitize food packaging and packaging material.
- Food products and packaging are sterilized separately.
- Subsequently combined and sealed under sterilized atmosphere conditions.

Food Cup Sanitization

- XENON equipment is installed on continuous motion, aseptic filling of yogurt cups.
- Model LH-840 lamp housing, with a 16-inch linear lamp, is enclosed in an IP 65 class enclosure enabling wash-down protocols while XENON equipment is integrated into processing system.

Chemically Free Dry Zap (Clean Beam LLC)

Space Sanitization

- Xenon pulsed UV lamps are at the heart of a unique product being used for space sanitization including hospital-rooms.
- Approximately 1,100 systems in use worldwide.
- Unit kills bacteria and virus on exposed surfaces in about 5 minutes.
- Replaces the use of many hazardous chemicals and/or use of traditional UV lamps which contain Hg and take up to 5 to 10 times longer.

XENEX®
GERM-ZAPPING ROBOTS™

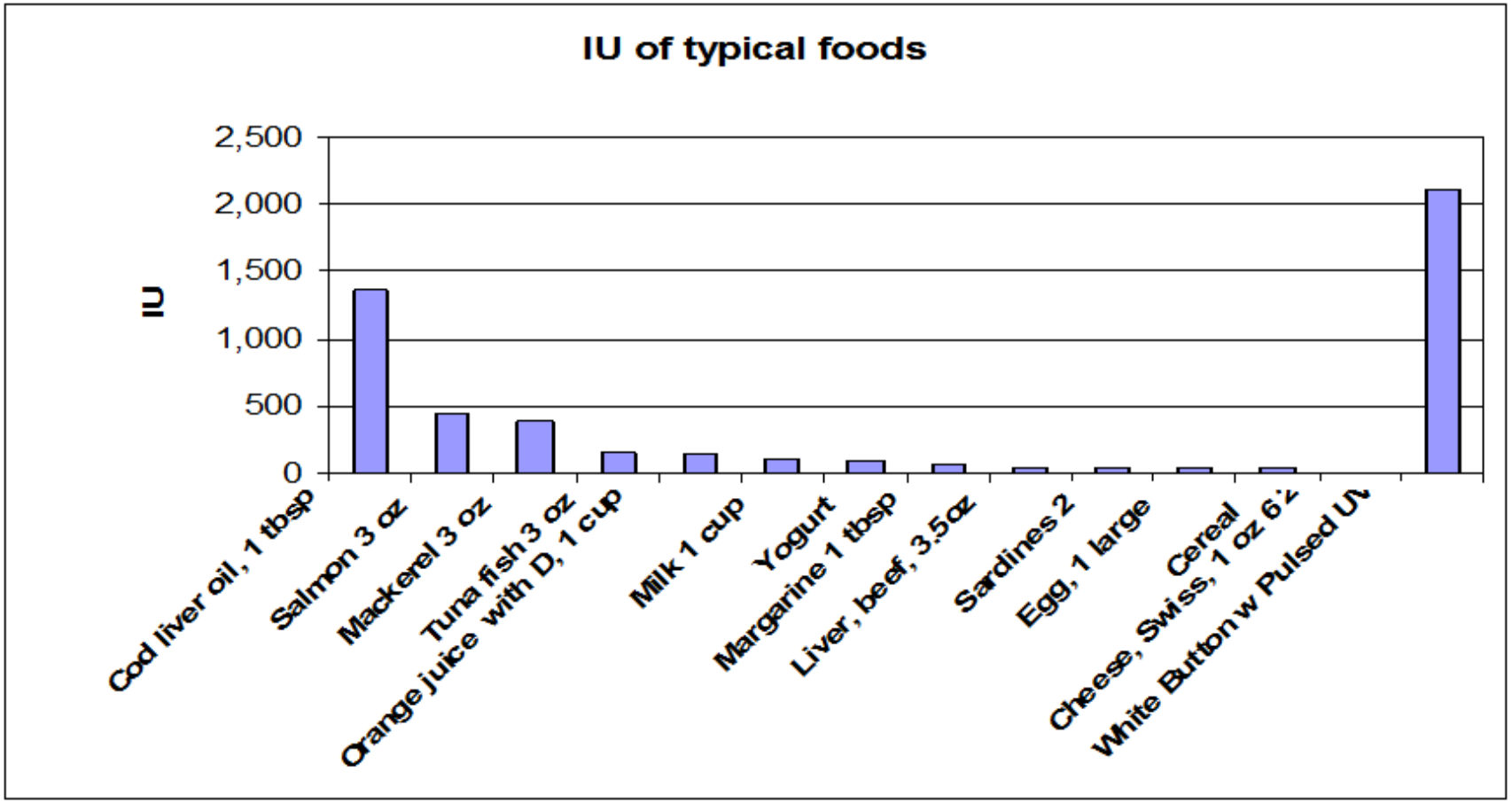
Food Enhancement - Mushrooms

- Convenient: Can be done post harvest.
- Flexible: Usually done before packaging/processing.
- Simple: Requires installation of a Flash lamp system on a conveyor line.
- Fast: Requires 1 to 3 pulses from flash lamp which can be delivered in a second.
- Cheap: no additives, chemicals, gases.
- Process takes place in air.

XENON
The Pulsed Light Experts

Vitamin D Source Comparative

CAN BE THE LARGEST SOURCE FOR VITAMIN D PER SERVING



Commercialization of Vitamin D Enhanced Mushrooms

- Many major companies are introducing vitamin D enriched mushrooms into the market
- Post treatment shelf life is good
- Creates an advantage for product sales

R&D System / X-1100

- The X-1100 is an advanced, affordable laboratory R&D system
- High intensity light – delivers 7J/cm2, max radiant pulse energy.
- Standard mains outlet – 90 to 250 Vrms, 50/60Hz {10 amp @ 115 Vrms; 5 amp @ 240 Vrms}
- Programmable via multiple user screens using graphical user interface (GUI)

XENON's Z-Series

The Power of Pulsed UV Light to Control Pathogen Contamination

XENON
The Pulsed Light Experts

Z-2000 System

XENON Z-2000

High-Energy Pulsed Light System

CLICK TO PLAY VIDEO

XENON™

Z-2000 System

Features

- Meets IP67 and NEMA 4X standards
- Stainless steel construction; designed for wash-down cleaning
- Continuously decontaminates food-contact surfaces
- FDA-approved for use with food
- Deactivates microorganisms in seconds without residuals

Applications

- Conveyor Treatment
- Blueberries
- Food Packaging
- Pre-Aseptic
- Many Others In Trials

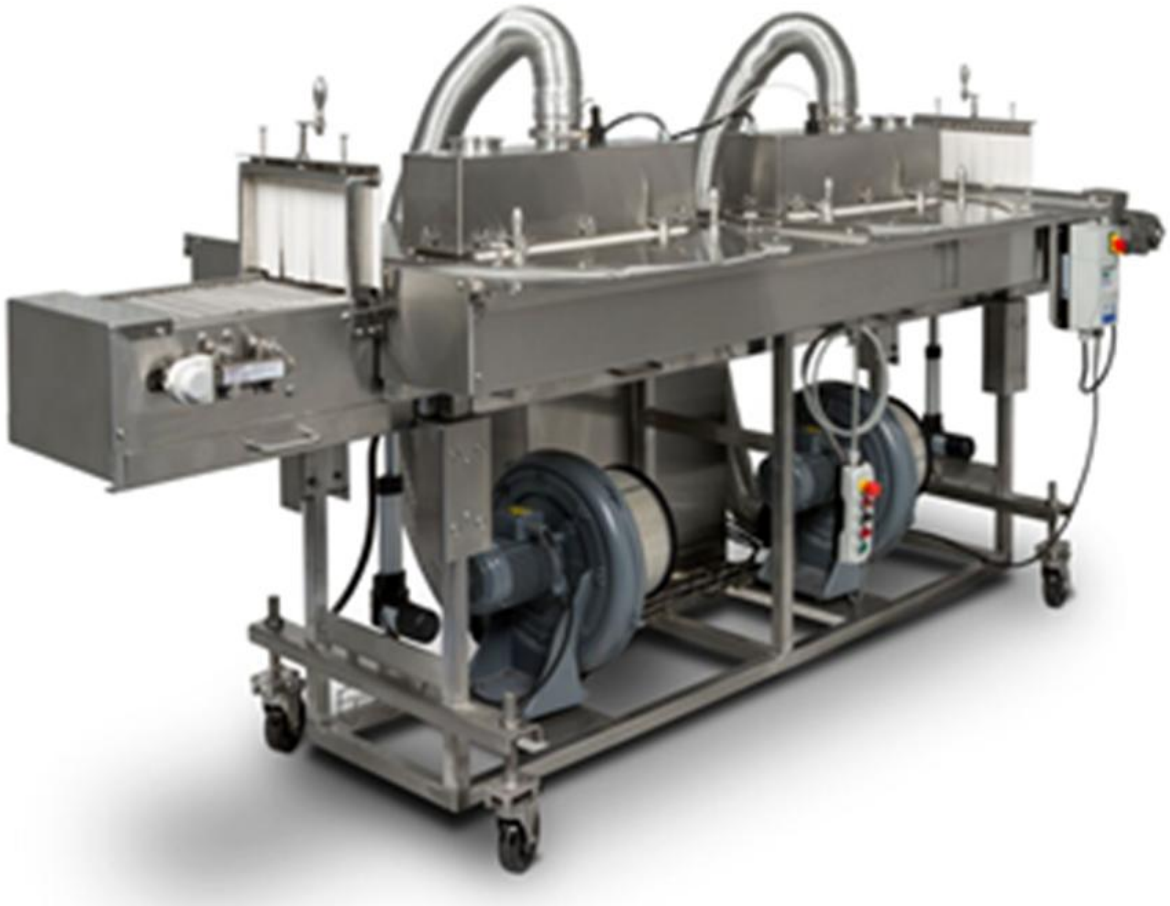
Industry Sectors

- Food & Beverage
- Food Production Equipment
- Pharmaceutical
- Space Decontamination

Industrial Integration

- A modular system designed for ease of integration into small or large scale existing or new production systems.
- Includes a power supply, modular controller and standalone lamp housing with Pulsed UV Lamps and related optical system.
- The LiteMark-XL light monitor is affixed to the lamp housing.
- System control is via a remote PLC.
- The ability to implement remote Programmable Logic Control (PLC) for timed (stop and sterilize) treatment.

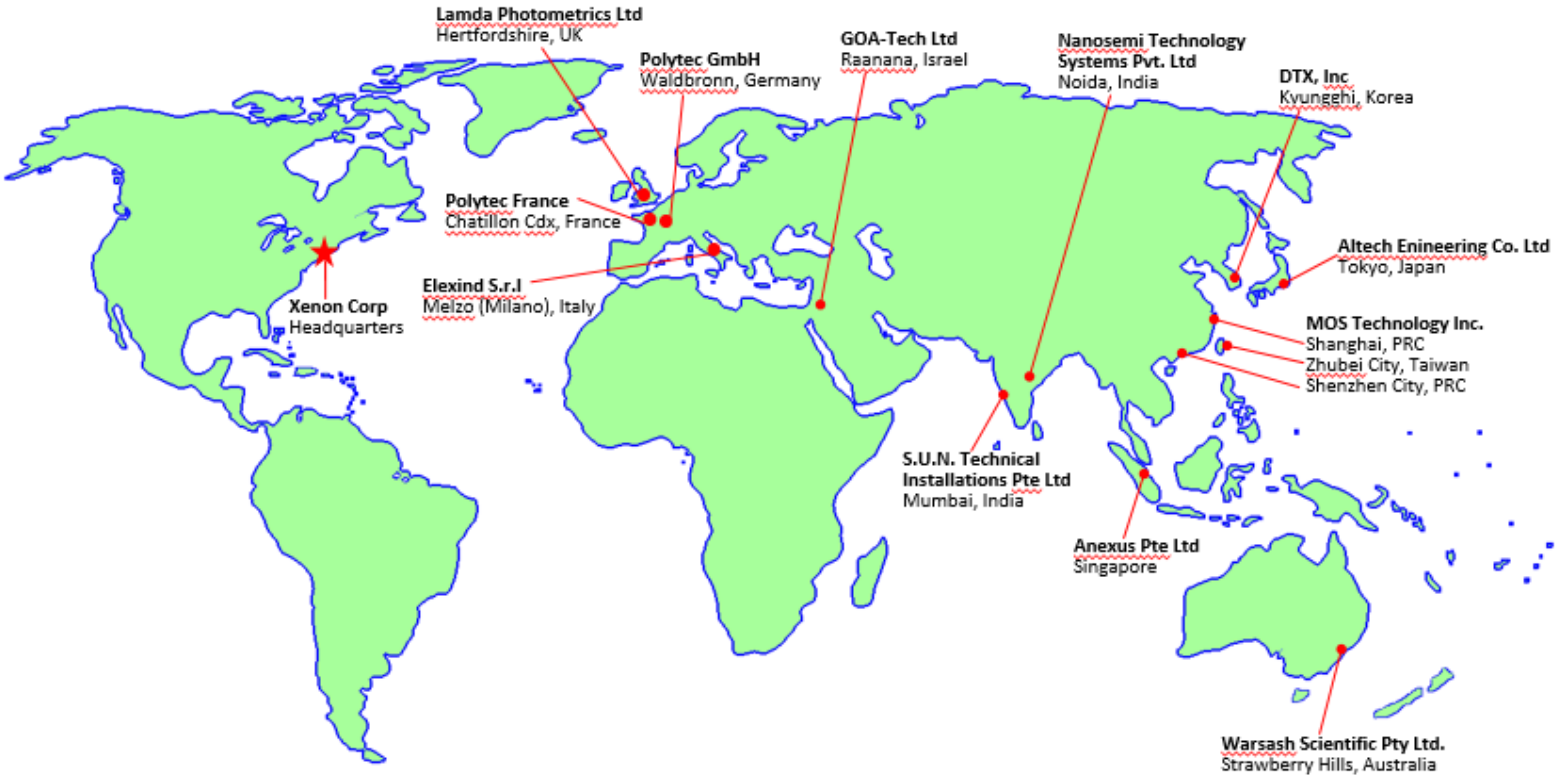
Food Handling PUV System



XENON
The Pulsed Light Experts

Global Distribution Network

Selling And Promoting Our Technology Around The World



XENON
The Pulsed Light Experts

Pulsed Light Researchers

- Dr. Roger Ruan, University of Minnesota, 612-625-1710, ruanx001@umn.edu
- Dr. Ali Demirci, PSU, 814-863-1098, axd29@engr.psu.edu
- Dr. Carmen Moraru, Cornell, 607-255-8121, cim25@cornell.edu
- Dr. David Katz, GSU, 404-413-6572, biodkkx@langate.gsu.edu
- Dr. Pratik Banerjee, Alabama A&M University, 256-372-4165, pbnerjee@memphis.edu
- Dr. Wade Yang, University of Florida, 256-372-4158, wade.yang@ufl.edu
- Dr. Kadir Krishnamurthy, National Center for Food Safety & Technology,708-563-8272, kkrishn2@iit.edu
- Dr. Zhongli Pan, UC Davis, 530-752-4367, zlpan@ucdavis.edu
- Dr. Michael Ngadi, McGill University, Quebec, Canada, 514-398-7779, michael.ngadi@mcgill.ca
- Dr. Julie Jean, U Laval, Quebec City, Canada 418-656-2131 x13849, Julie.jean@fsaa.ulaval,ca
- Dr. Jean-Tyes Lecompte, Cintech/Agroalimentaire, Saint- Hyacinthe, Canada, 450-771-4393, jylecompte@cintech.ca

Pulsed UV-Studies at Penn State University

Sharma, R. R., A. Demirci. 2003. Inactivation of *E. coli* O157:H7 on alfalfa seeds with pulsed ultraviolet light and response surface modeling. J. Food Science. 68:1448-1453.

Hillegas, S. L. and A. Demirci. 2003. Inactivation of *Clostridium sporogenes* in clover honey by pulsed UV-light treatment. CIGR J. AE Sci. Res. Dev. Manuscript FP 03-009. Vol. V. 7 pp.

Jun, S., J. Irudayaraj, A. Demirci, and D. Geiser. 2003. Pulsed UV-light treatment of corn meal for inactivation of *Aspergillus niger*. Int. J. Food Sci. Technol. 38:883-888.

Ozer, N. P. and A. Demirci. 2006. Inactivation of *E. coli* O157:H7 and *L. monocytogenes* inoculated on raw salmon fillets by pulsed-UV light treatment. International Journal of Food Science and Technology. 41 (4): 354-360.

Demirci, A. and K. Krishnamurthy. 2006. Disinfection of water by flow-through Pulsed ultraviolet light sterilization system. Ultrapure Water Journal. 24 (1): 35-40.

Bialka K. L., A. Demirci. 2007. Decontamination of *Escherichia coli* O157:H7 and *Salmonella* Enterica on blueberries using ozone and pulsed UV-Light. Journal of Food Science 72 (9): M391-M396.

Bialka, K. L., and A. Demirci. 2008. Efficacy of Pulsed UV-Light for decontamination of *E. coli* O157:H7 and Salmonella spp. on Raspberries and Strawberries. Journal of Food Science. 73(5):M201-M207.

Krishnamurthy, K., A. Demirci, and J. Irudayaraj. 2008. Inactivation of *Staphylococcus aureus* in milk and milk foam by pulsed UV-light treatment and surface response modeling. Transactions of the ASABE. 51(6): 2083-2090.

Keklik, N. M., A. Demirci, and V. M. Puri. 2010. Decontamination of unpackaged and vacuum packaged boneless chicken breast with pulsed UV-light. Poultry Science. 89:570-581.

Keklik, N. M., A. Demirci, and V. M. Puri. 2009. Decontamination of unpackaged and vacuum-packaged chicken frankfurters with pulsed UV-light. Food Science. 74:M431-M439.

Keklik, N. M., A. Demirci, P.H. Patterson, and V. M. Puri. 2010. Pulsed UV light inactivation of *Salmonella* Enteritidis on eggshells and its effects on egg quality. Food protection. 73(8):1408–1415.

Resources

The following white papers are available from XENON's web site.

http://www.xenoncorp.com/markets/sterilization/

- Pulsed Light for Antimicrobial Processing
- Pulsed Light for Clean Rooms
- Pulsed Light Research Articles
- Killing of Bacillus Spores by Pulsed Light
- Scientific Abstracts on Pulsed Light Sterilization
- Applications of Pulsed Light for Sterilization

Conclusion

What is upon us is that Pulsed Light is touching all aspects of food safety including produce, packaging, food production equipment, floor protection, and food production space. In the midst of this strong trend, I am looking forward to our continued work with the University of Minnesota to bring the powder treatment program to production as soon as possible for the good of all.

Thank You

XENON Corporation
Wilmington, Massachusetts 01887 USA
www.XENONcorp.com

The Pulsed Light Experts