Bacterial Inactivation in Apple Juice by UV-light and Radio Frequency Electric Fields Processing

Dike O. Ukuku Ph.D.

FSIT-ERRC-ARS-USDA

Wyndmoor, PA 19038

Eastern Regional Research Center

Human bacterial pathogens

- *Escherichia coli* O157:H7, *Listeria monocytogenes* and *Salmonella* are recognized foodborne pathogens and are capable of surviving in low acid foods like fruit juices
- Outbreaks involving *E. coli* O157:H7 in apple cider and *Salmonella* in orange juices have raised concerns about the safety of consuming unpasteurized fruit juices

Foodborne Illness in the U.S.

- 76 million illnesses each year
- 325,000 hospitalizations
- 5,200 deaths
- $3 Billion in hospitalizations
- $20-40 Billion = lost productivity

Recent outbreaks of *E. coli* O104:H4 linked to contaminated organic bean sprouts (Bill Marler, 23, June , 2011)

The European Union

- 3798 sickness, 865 with HUS cases, 2,930 with non-HUS cases, 44 deaths reported

- Source : http://www.marlerblog.com/legal-cases/new-world-wide

USA

- 5 confirmed cases (Three with HUS) connected to the outbreak (Michigan, Massachusetts, Wisconsin and North Carolina)

- * 1 death in Arizona linked to the outbreak

Japan

- In May of 2011 there was *E. coli* O111 outbreak
- 90 people sick, 23 with hemolytic uremic syndrome
- 4 deaths tied to a raw beef dish called yukhoe

Processing treatments for juices

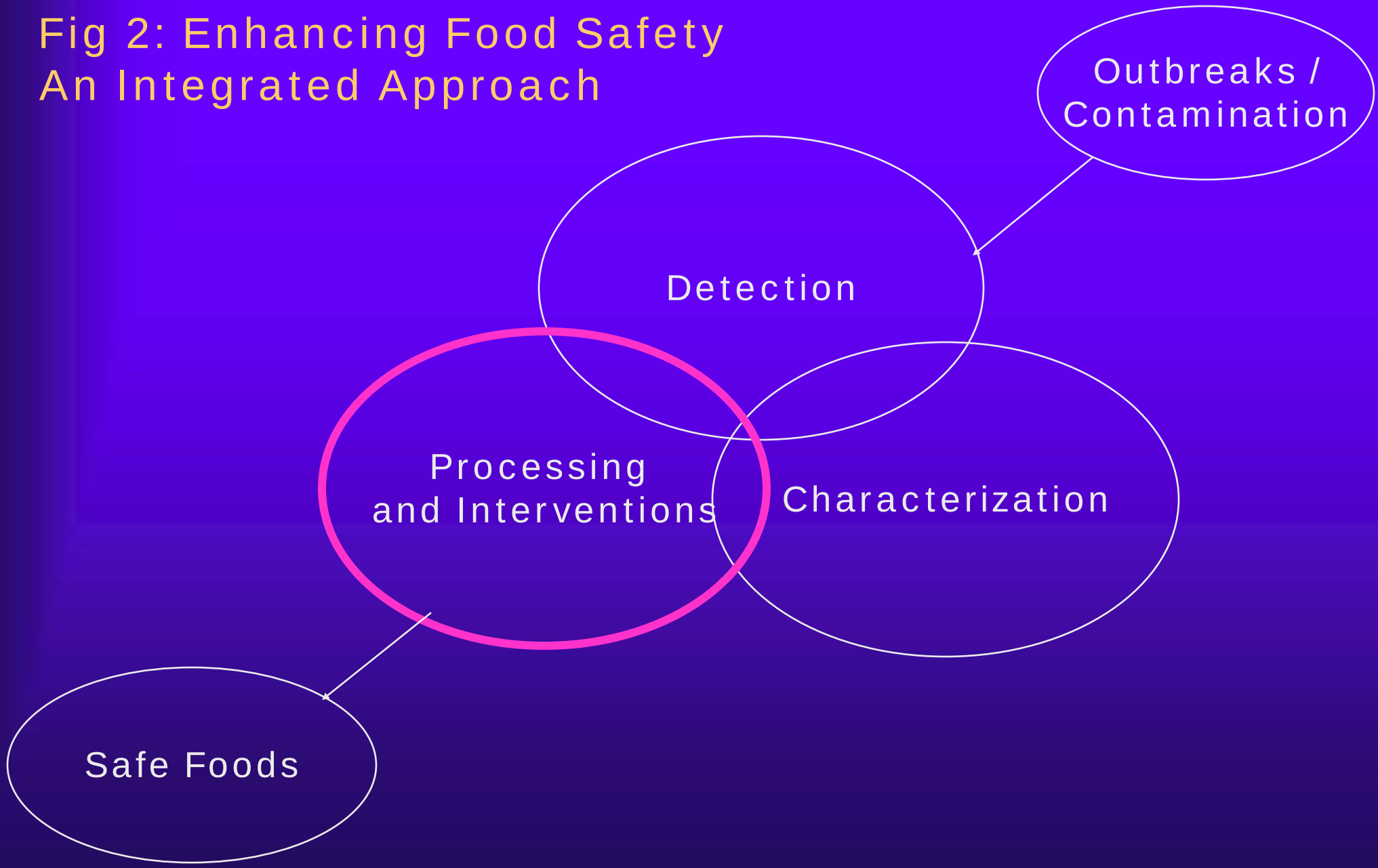
- Physical and chemical treatments have been used in food processing to eliminate or at least reduce the presence of pathogenic and spoilage microorganisms in foods

- Thermal processing is used by the juice industry to inactivate food borne pathogens however; it impairs the characteristic flavor of juices

Objective

- To develop, evaluate, validate, recommend and transfer post-harvest handling intervention technologies to enhance the quality and safety of the nation's food supplies

Fig 2: Enhancing Food Safety
An Integrated Approach



Technologies in use

- Pulsed electric fields
- Radio frequency electric fields
- UV and pulse light
- Super-critical carbon dioxide
- High hydrostatic pressure
- Ohmic heating
- HTST/UHT, TDT devices
- Aseptic Processing and Packaging

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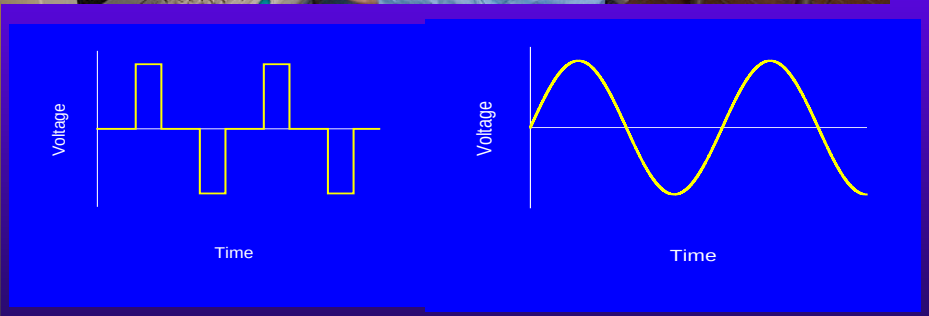
Fig 3: Radio Frequency Electric Fields Processing

- 80 kW RFEF Unit – World's most powerful
- Operates at 20, 30, and 40 kHz
- Similar to Pulsed Electric Field



Modification of UV-light equipment

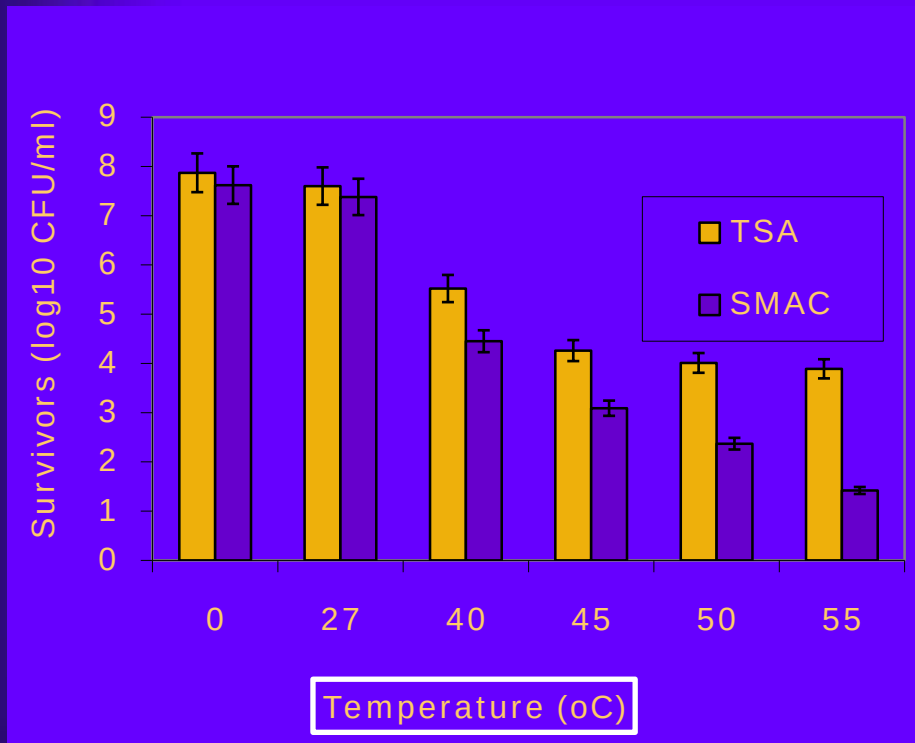
- A UV apparatus was assembled at the Eastern Regional Research Center, Agricultural Research Services of United States Department of Agriculture with slight modification (Geveke, 2008)
- The UV lamp was surrounded by a coil of tubing instead of having the tubing surrounded by UV lamps
- The apple juice flowed through the UV transparent Chemfluor tubing. One, two, three, or four UV bulbs were used in series, depending on the experimental condition.

Ultraviolet light equipment

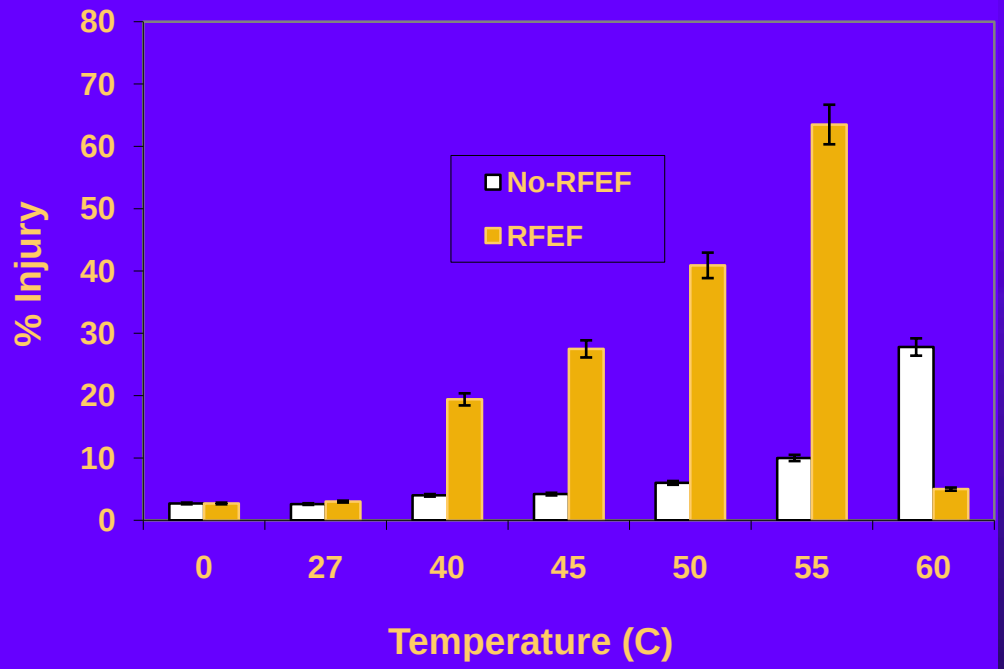
Effect of RFEF treatment on the survival and injured populations of *E. coli* cells in apple juice

Ukuku et al., 2008 J. Food Prot.71:684-690

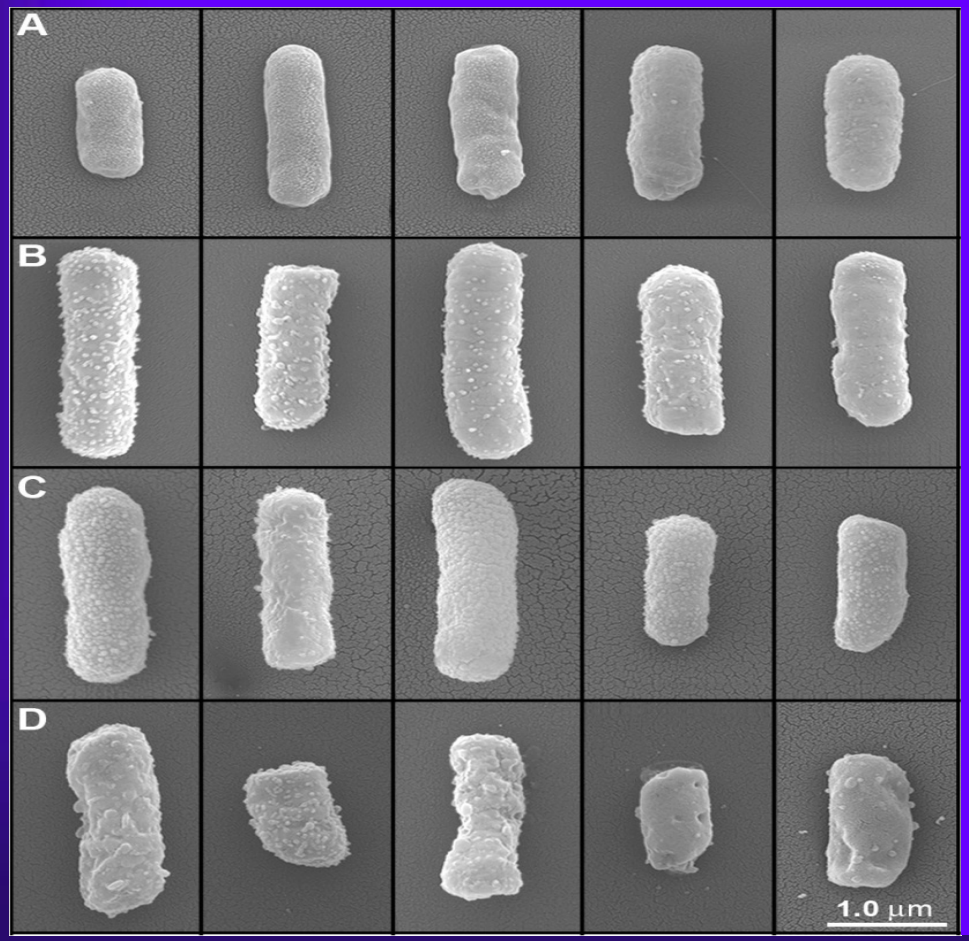
Survival of *E. coli* cells in apple juice

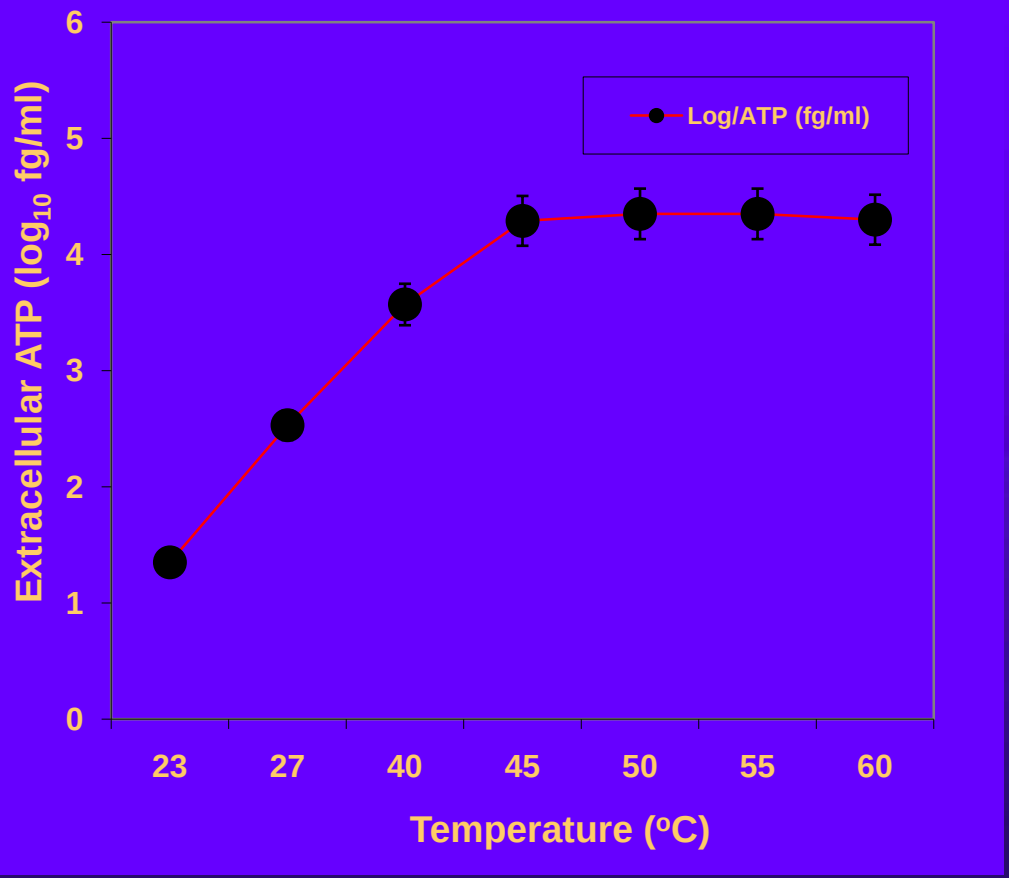


Injured populations in apple juice

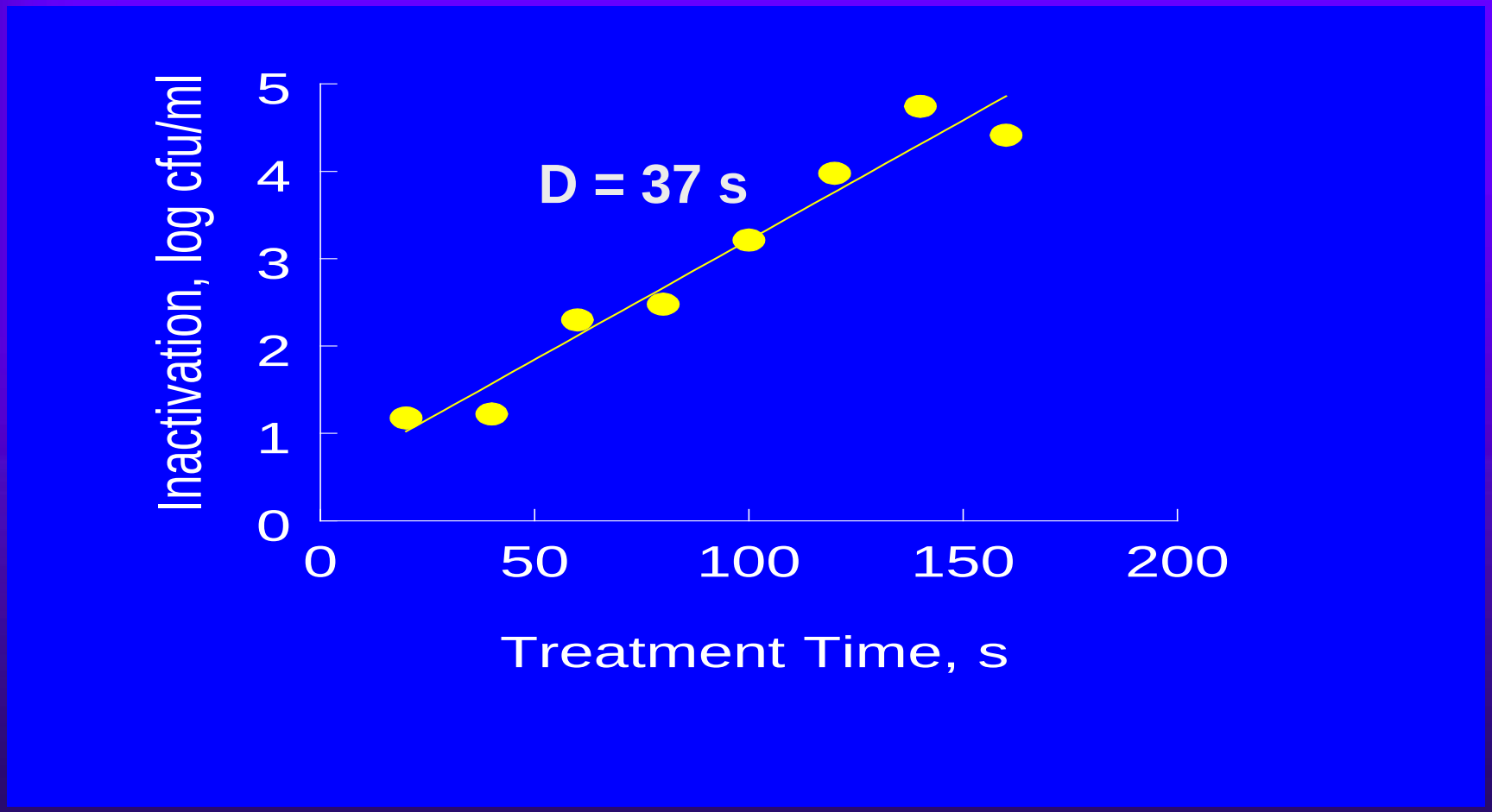


Damage to membrane surface structure of bacteria by RFEF treatment led to leakage of intracellular ATP [SEM (Figure 1, A= Control, B=40C, C= 50C and D= 55C)] Ukuku et al., 2008 J. Food Prot.71:684-690

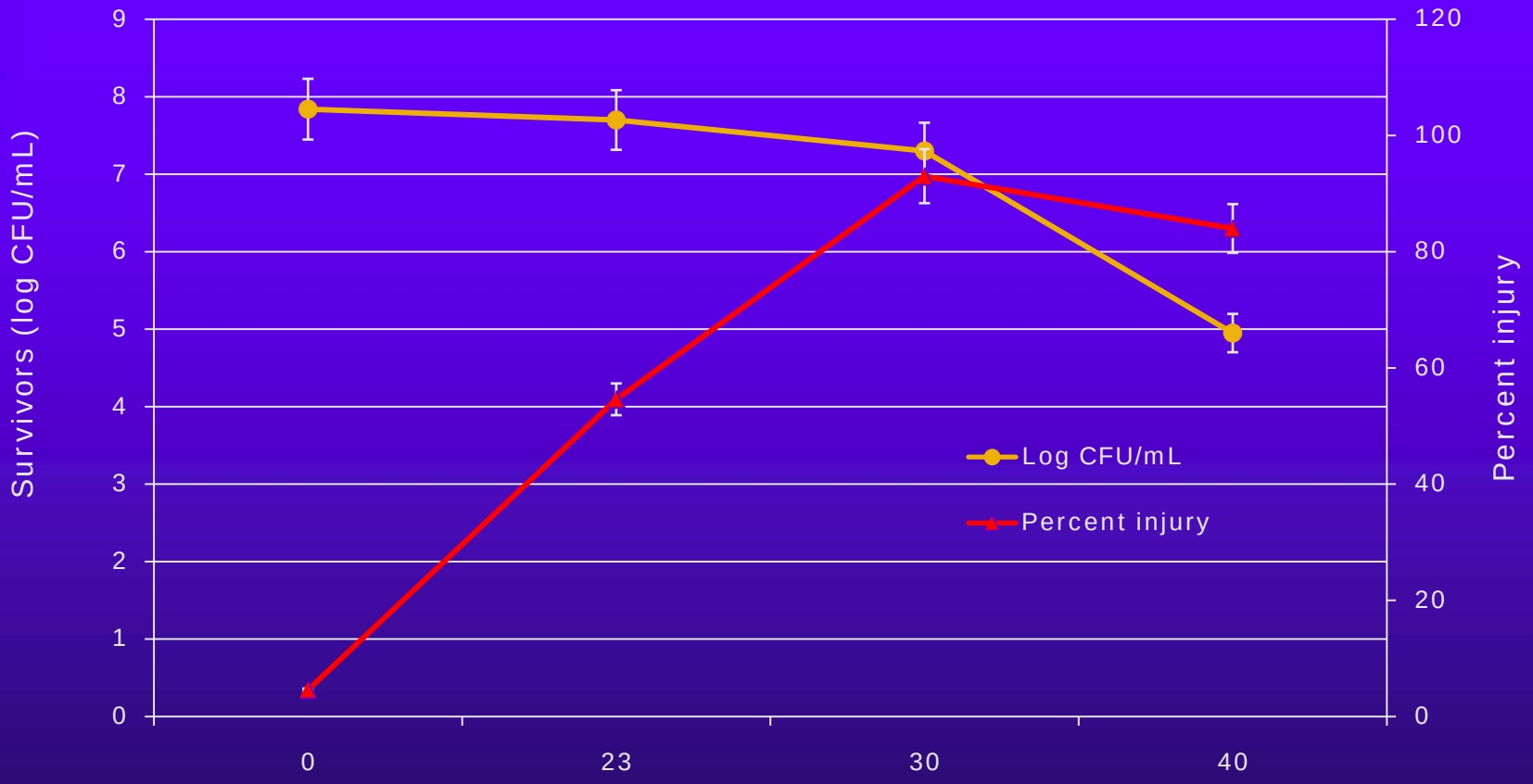




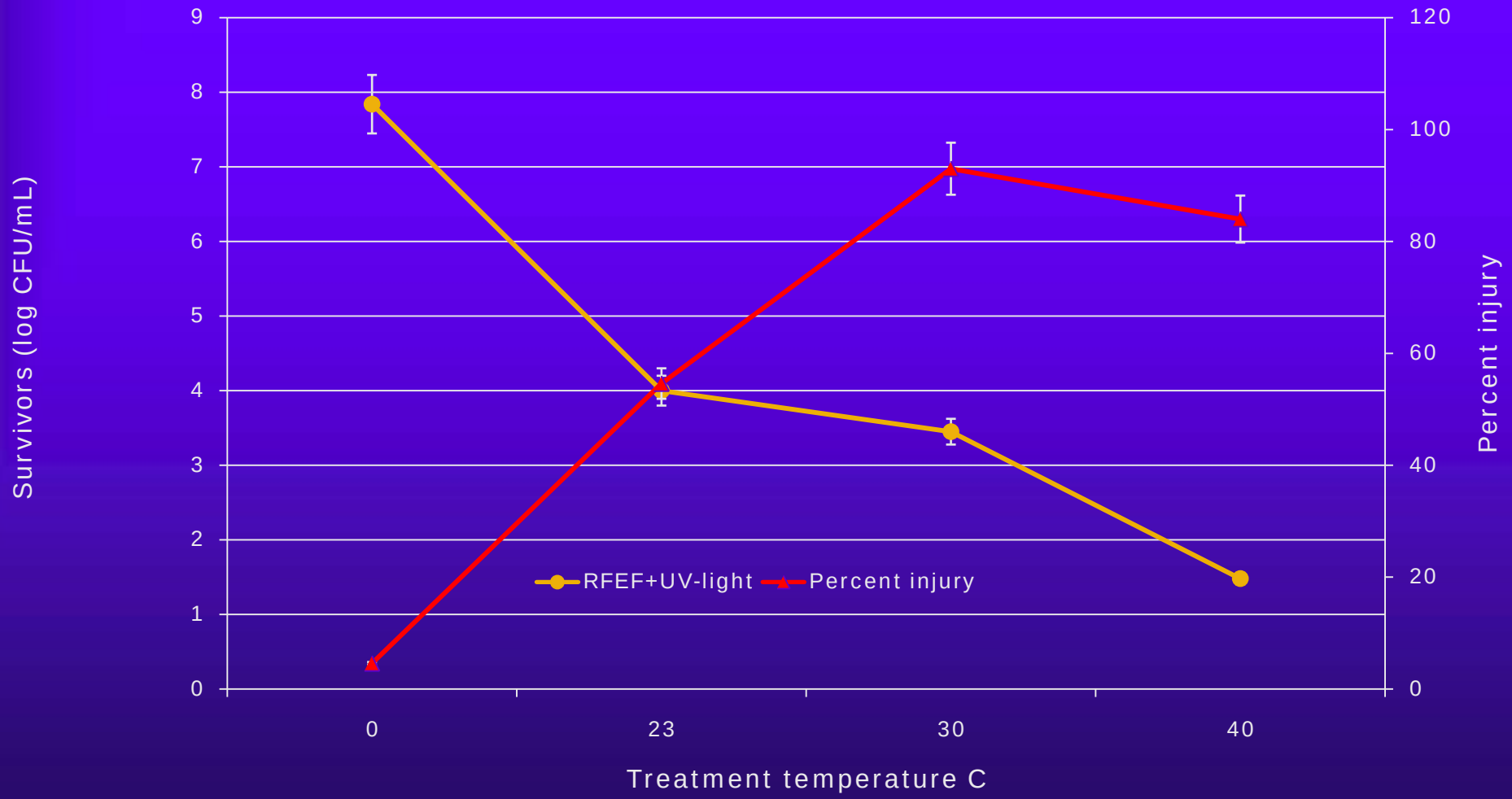
UV-light inactivation of *E. coli* in liquid eggs



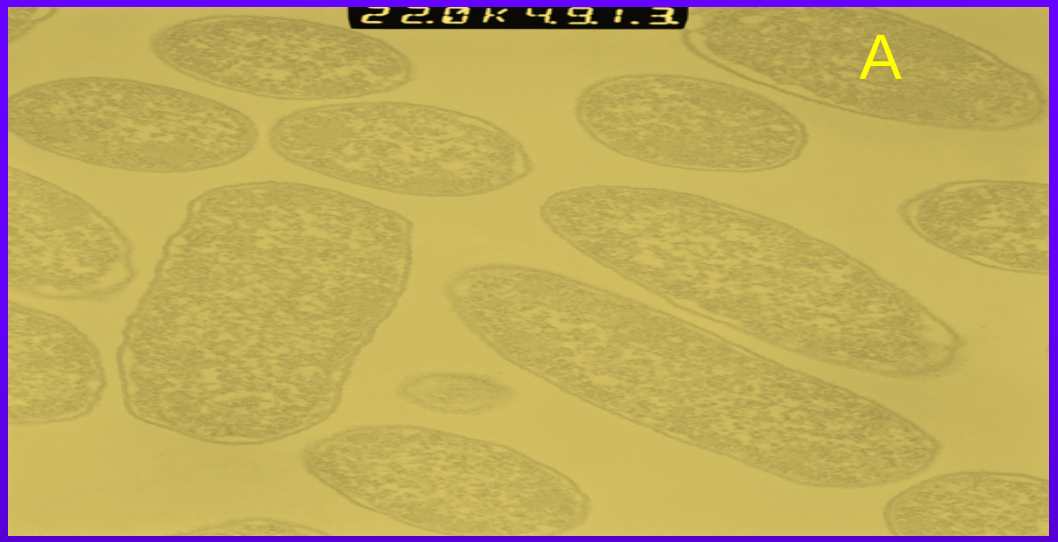
Survival and percent injury by RFEF treatment

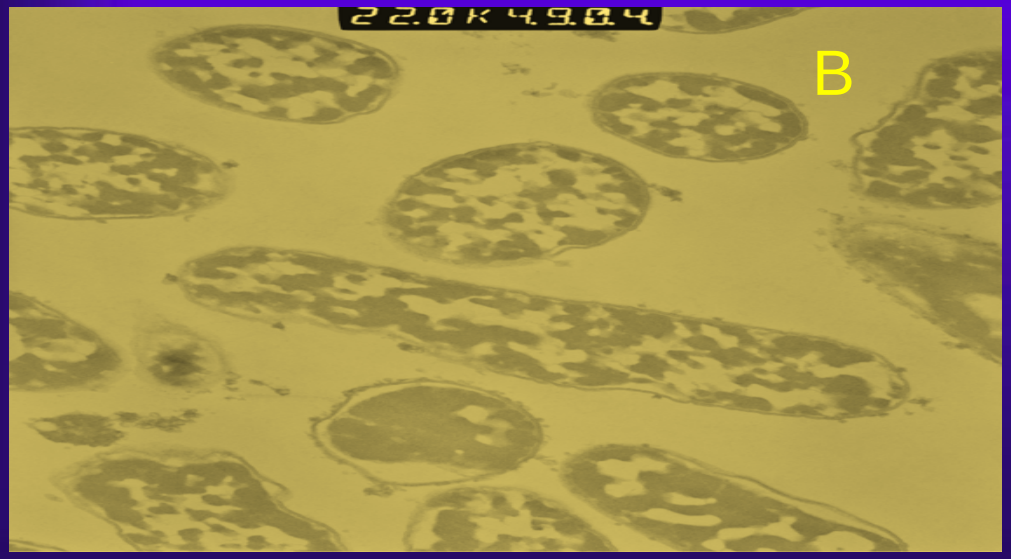


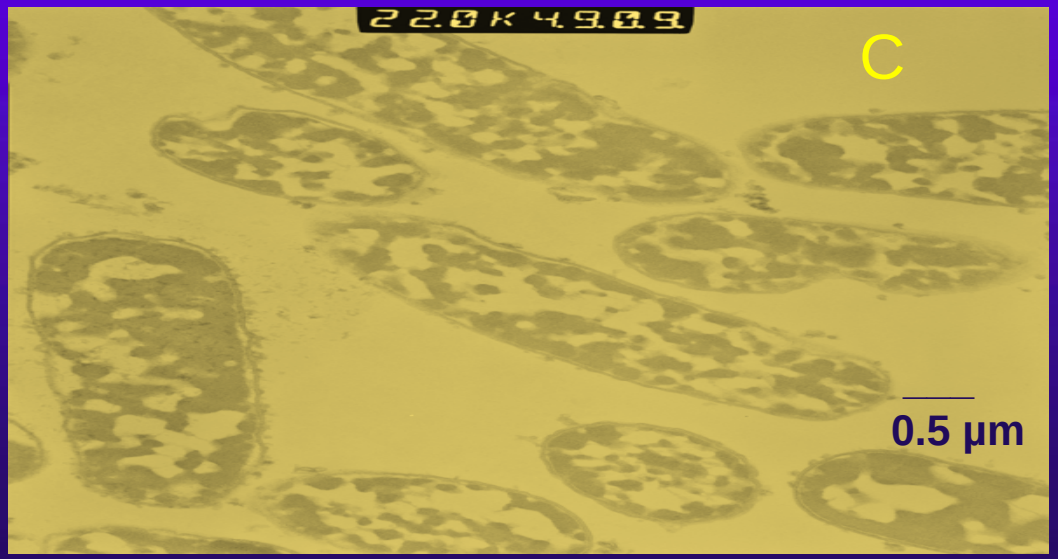
Effect of combined UV-light and RFEF treatment



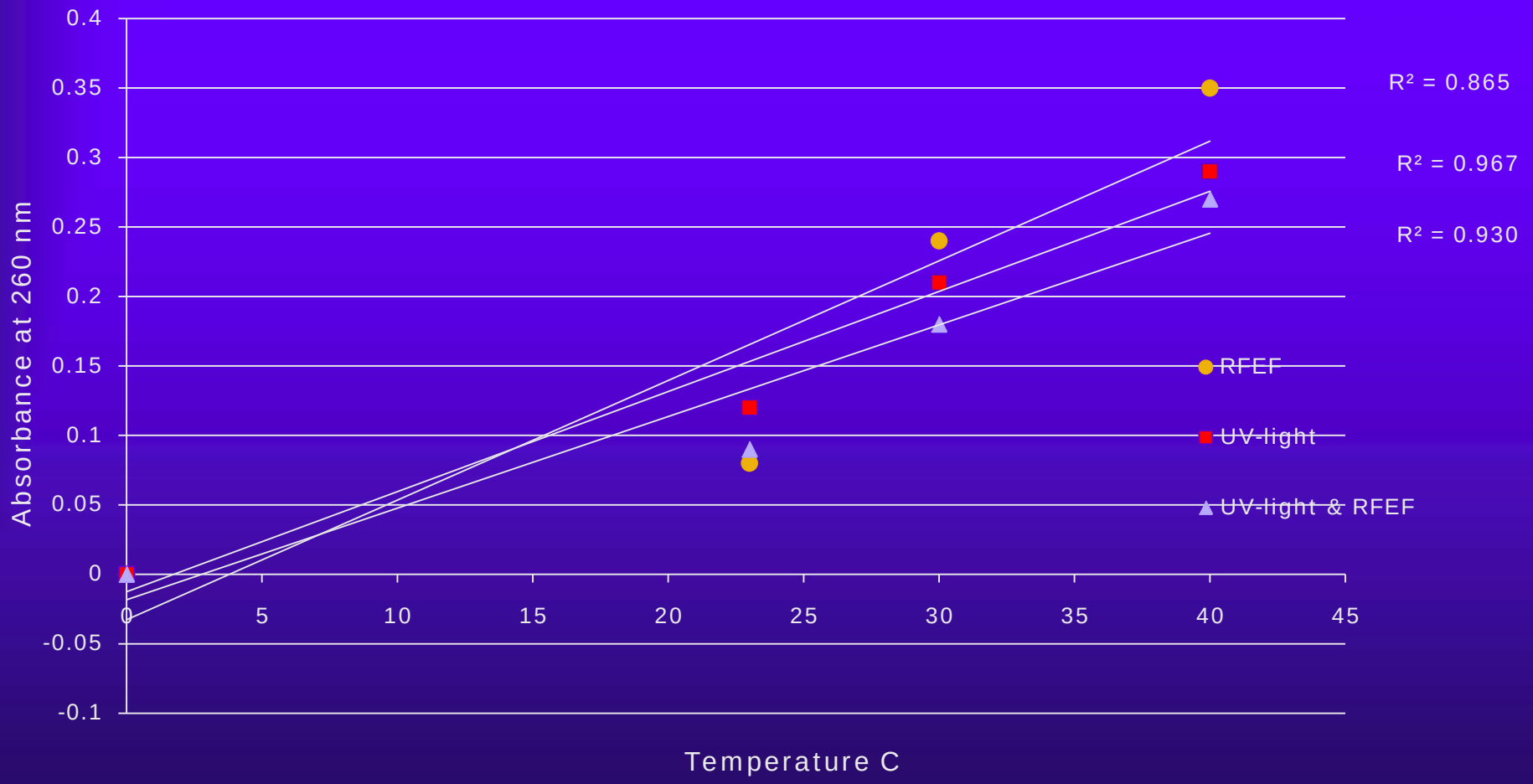
TEM observation of *E. coli* cells (A= control; B= Heat@75C; C= RFEF+55C







Leakage of UV-materials at 260 nm



CONCLUSION

- The results of this study clearly showed the differences in bacterial inactivation by UV light alone, RFEF treatment and a combine UV light + RFEF treatment

- Proper modifications of treatment parameters is likely to improve process treatment and enhanced the microbial safety of treated juices

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- A combination of the two processing treatments did not increase cell injury or leakage of UV-substances
- Mechanism of bacterial inactivation by RFEF treatment is different from UV-light treatment
- RFEF treatment caused more membrane injury and cellular leakage of UV-substances than UV-light treatment

Process commercialization/products

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For more information

Contact:
Dr. Dike O. Ukuku
Senior Scientist, FSIT- ERRC- ARS-USDA
600 E. Mermaid La, Wyndmoor, PA 19038
215-233-6427, Fax 215-233-6406
dike.ukuku@ars.usda.gov
http://www.ars.usda.gov/naa/errc