Quantitative Microbial Risk Assessment to Accelerate Adoption of Electron Beam Technologies for Fresh Produce Safety and Quality in the United States

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an IAEA Collaborative Center for eBeam technology

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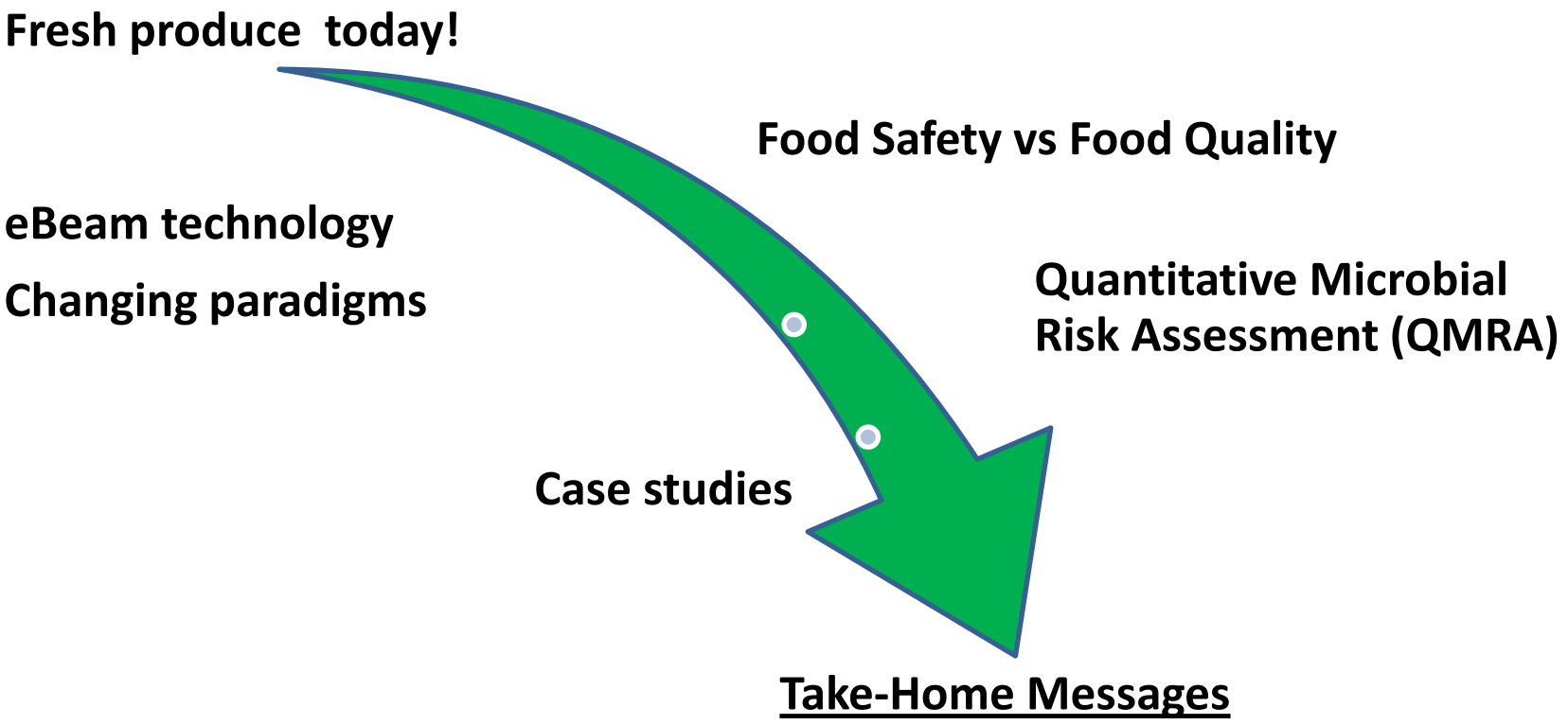
Outline


Fresh produce today!
Food Safety vs Food Quality
eBeam technology
Changing paradigms
Quantitative Microbial Risk Assessment (QMRA)
Case studies
Take-Home Messages

What's going on???

- **23 million US children are either obese or overweight because of poor dietary habits (*IFT, 2005*)**

21st Century Reality

Globalization is Changing Everything

- The structure of the global food industry is continually changing
- Global food supply is evolving as food suppliers, manufacturers, & retailers adjust to meet the expectations of consumers
- Global Food Safety Initiative (GFSI)
- *Affecting food sourcing*
- *Affecting food production and organization*
- *Affecting food ingredients*
- *Affecting food processing*

Reality today

- Food Safety is NOT a competitive advantage!

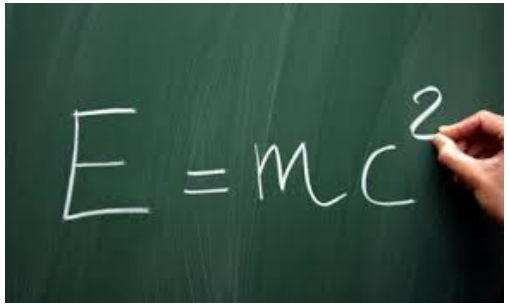
- **Food quality is # 1**
- Global harmonization

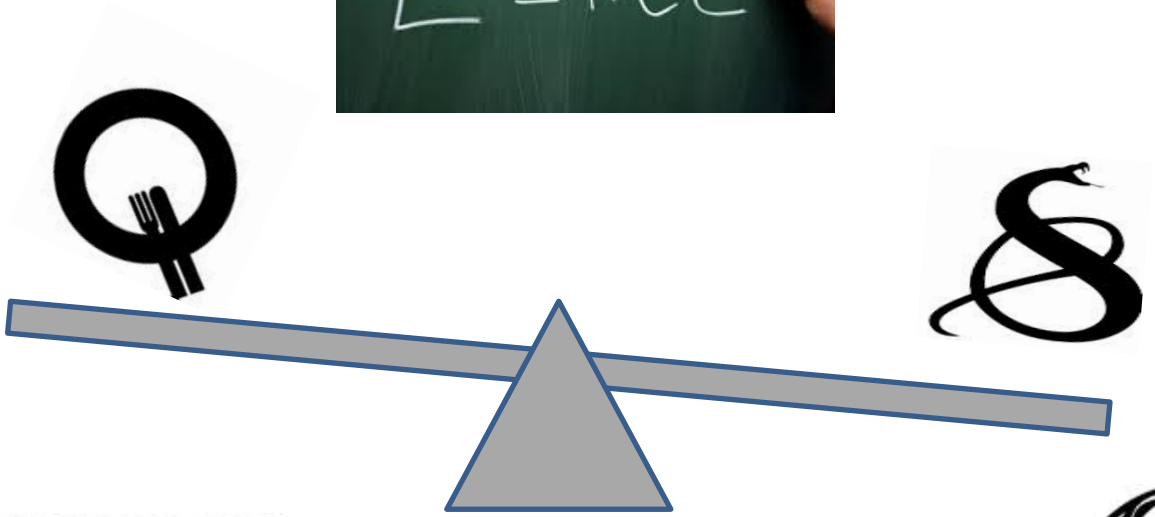
  Diminishing regional influence

  Corporate influence is supreme

  Either Play or get out!

Key Question



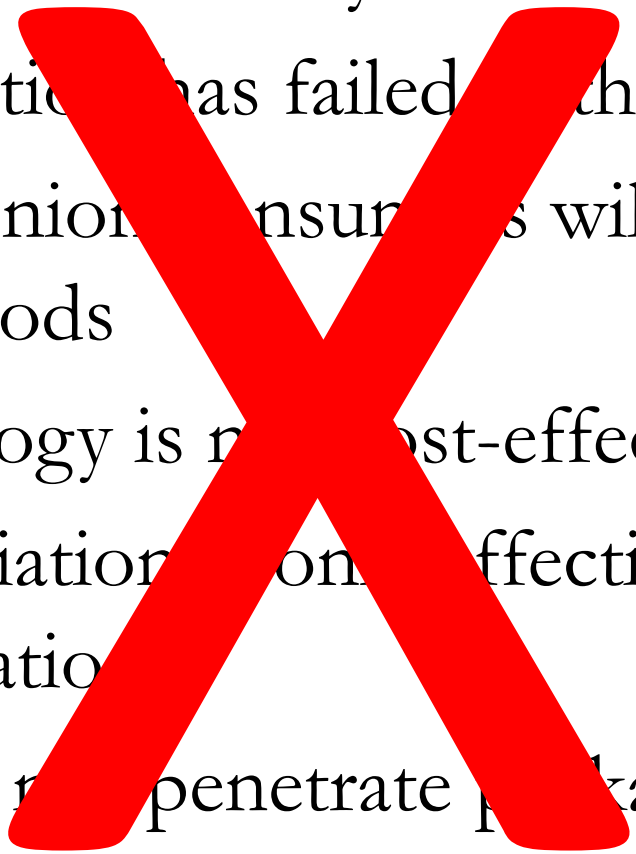


Food Irradiation Technology

- Most extensively studied technology with over 100 years of data
- Approved in over 60 countries
- Used routinely in the United States, Europe and Asia
  - In the US, irradiated fresh produce increased > 6000% since 2007!!
  - In the US, volume increased over 13% from 2012-2013!!
- NOT ONE irradiated food item has been removed from shelves due to consumer complaints
- Consumer Acceptance is NOT an issue

Widespread Erroneous Information

- Consumers will not buy irradiated foods
- Food irradiati as failed the United States
- European Union nsum s will not accept irradiated foods
- The technology is n st-effective
- eBeam irradiation on ffective for surface decontaminatio
- eBeam does n penetrate p kaged products



Imported Fruits and Vegetables in US by Irradiation

Guava

Mango

Papaya

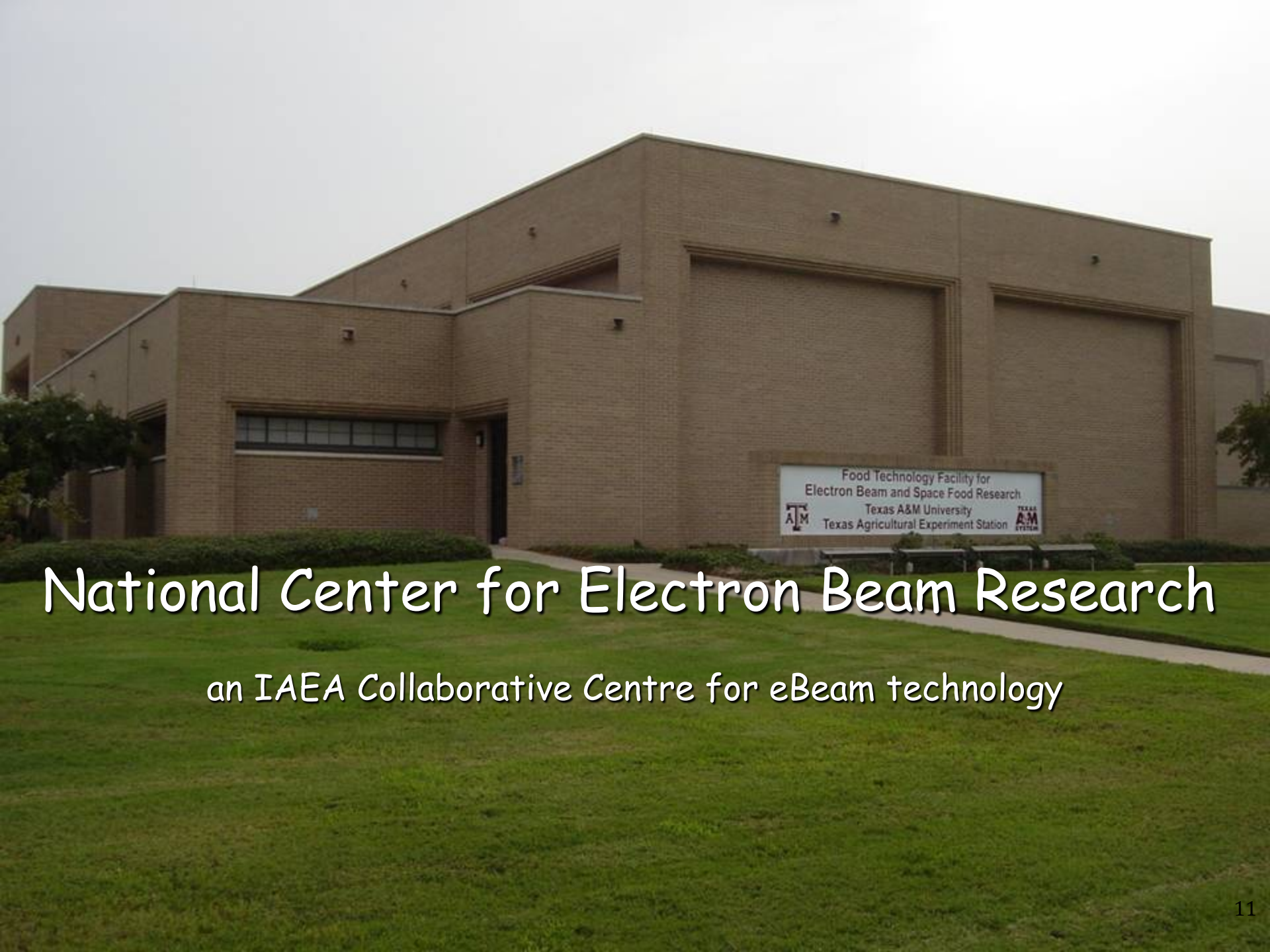
Star Fruit

Cuban Sweet Potato

Okinawa Sweet Potato

Lychee

Rambután



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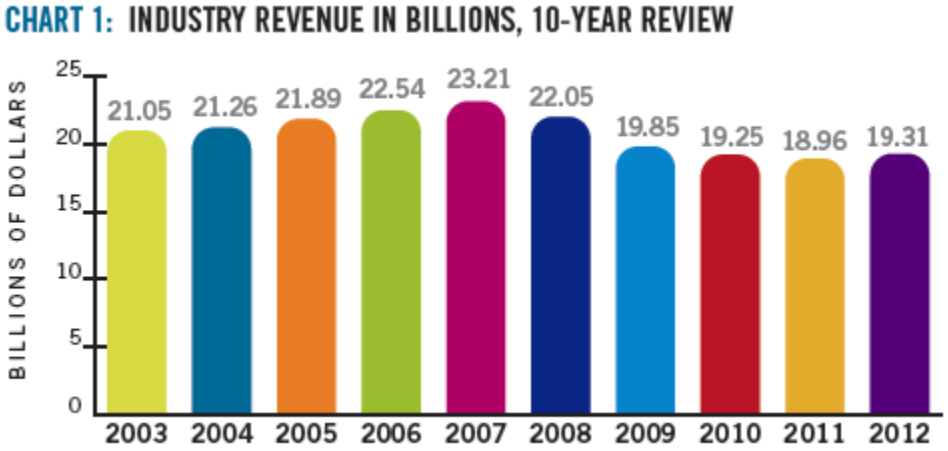
eBeam processing of imported produce at Texas A&M

eBeam Doses and Applications

Application	eBeam dose
Sprouting Inhibition	0.1 kGy – 0.2 kGy
Insect Disinfestation	0.1 kGy – 0.4 kGy
Protozoan Control	0.3 kGy -0.5 kGy
Delay of Ripening	0.5 kGy – 1.0 kGy
Controlling Fungi	1.5 kGy – 3.0 kGy
Bacterial Pathogen Control in foods	1.5 kGy – 3 kGy
Viral pathogen Control in foods	3 kGy – 10 kGy
Terminal Sterilization	15 kGy – 30 kGy
Polymerization	25 kGy – 50 kGy
Polymer Grafting	25 kGy – 50 kGy
Polymer Crosslinking	50 kGy – 150 kGy
Material degradation	500 kGy – 1500 kGy
Coloring gemstones	>>> 1500 kGy

U.S. Food Vending Business

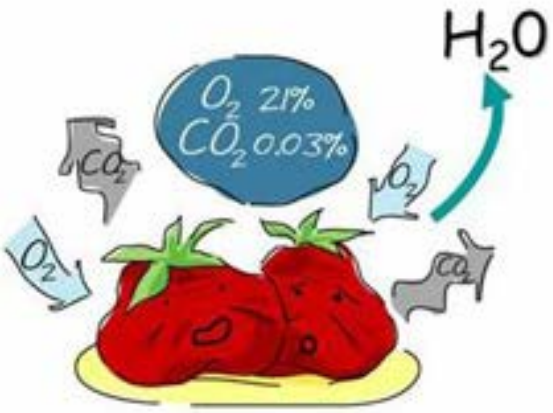
~ $ 20- billion vending industry



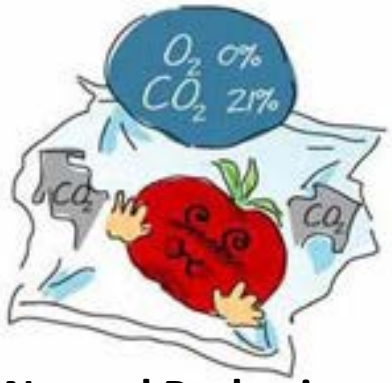
100 million people use food vending machines **daily**

market vendingwatch.com
IFT, 2005

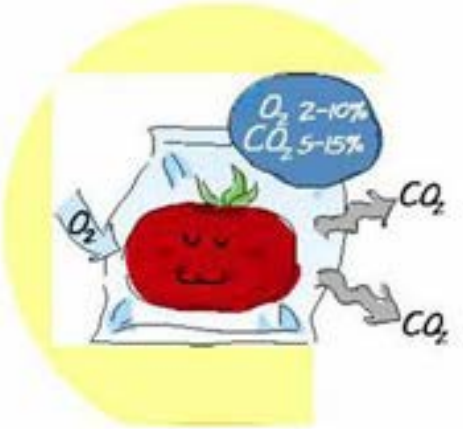
Synergistic effect of eBeam with MAP



Normal Atmosphere



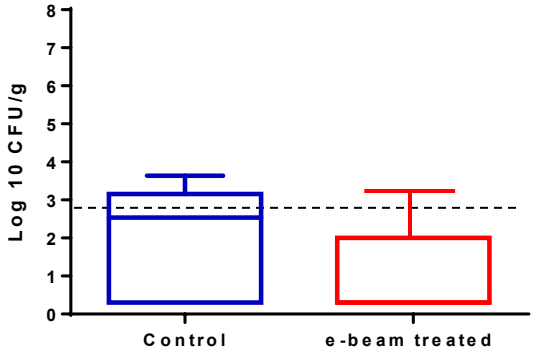
Normal Packaging



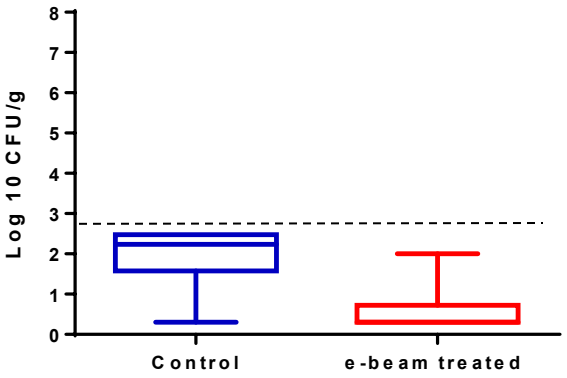
MAP

MAP + **eBeam**

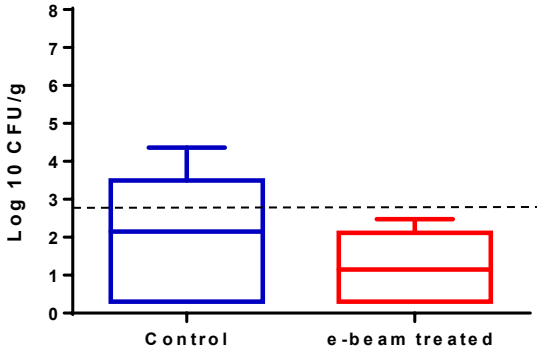
Lower bioburden was seen in eBeam treated grapes under modified atmosphere



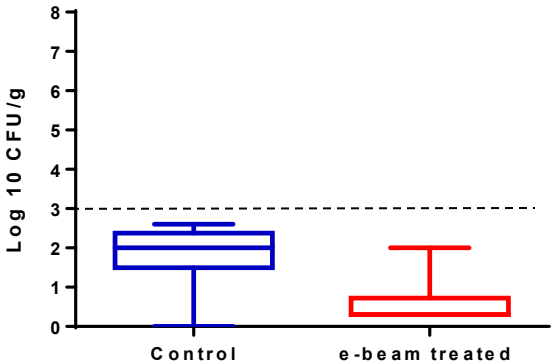
Day 0



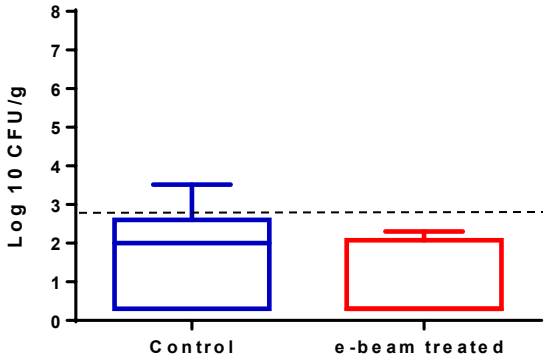
Day 1



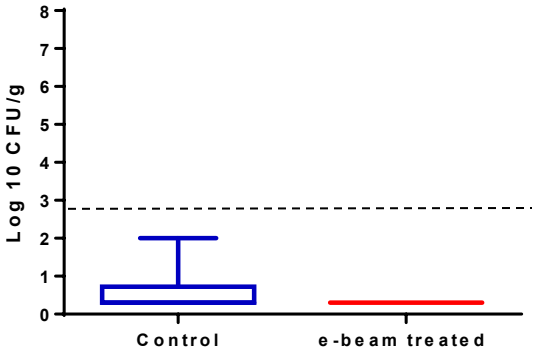
Day 3



Day 7



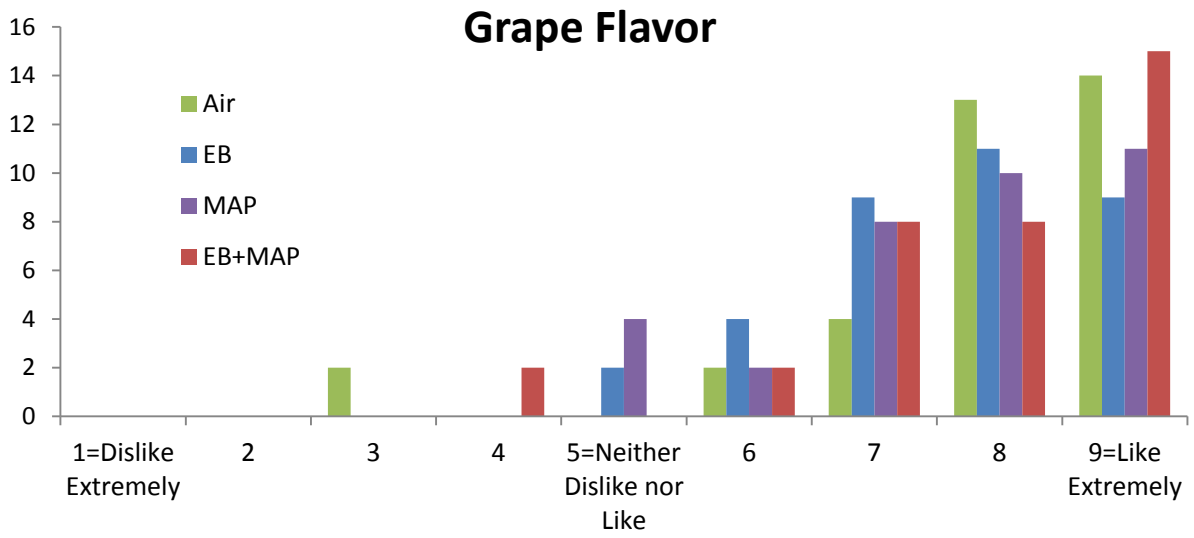
Day 14



Day 21

- **The bioburden of grapes in modified atmospheres was reduced using eBeam technology**

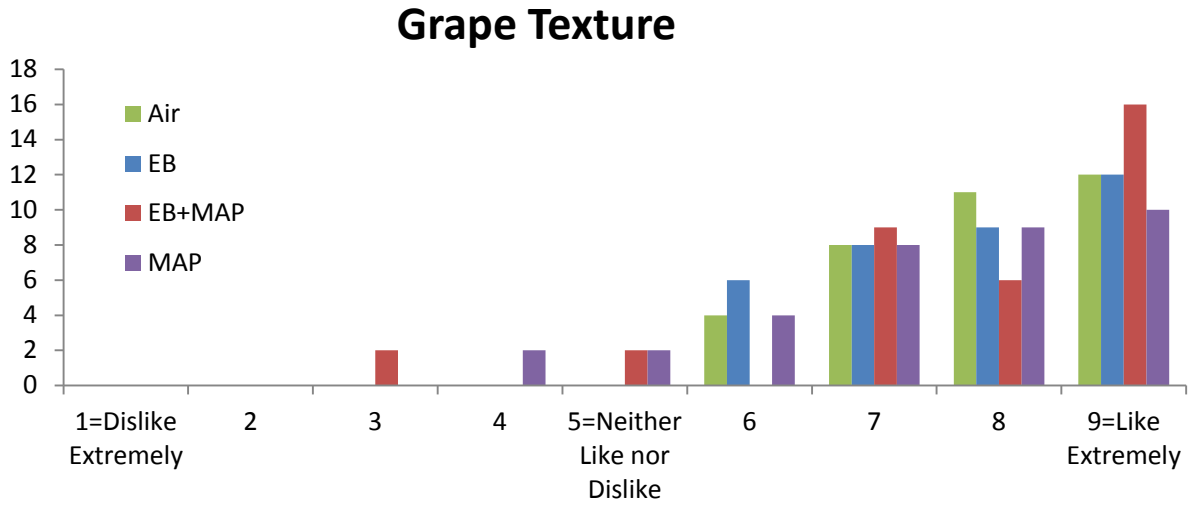
Sensory Evaluation in Grapes



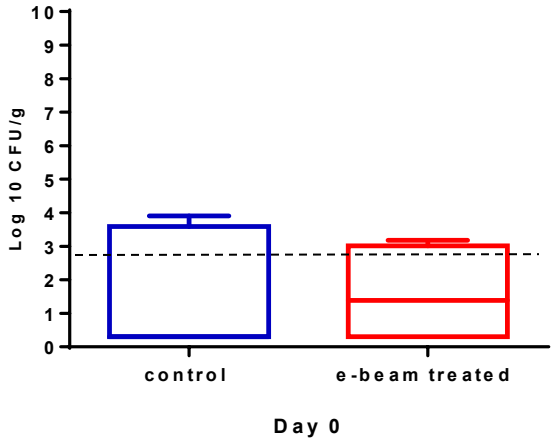
EB = 82%
EB+M= 88
Air = 88
MAP = 82

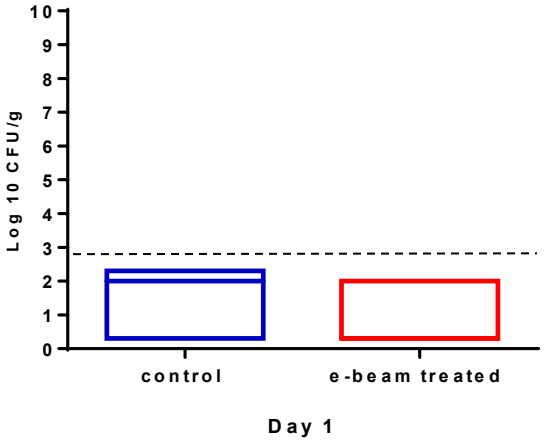
Grape flavor and texture was highly liked by consumers

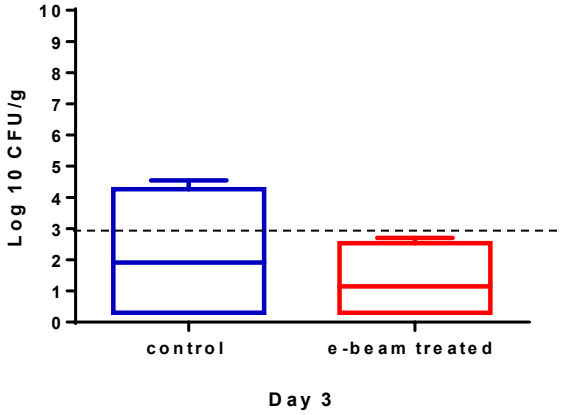
EB = 82%
EB+M = 88
Air = 88
MAP =77

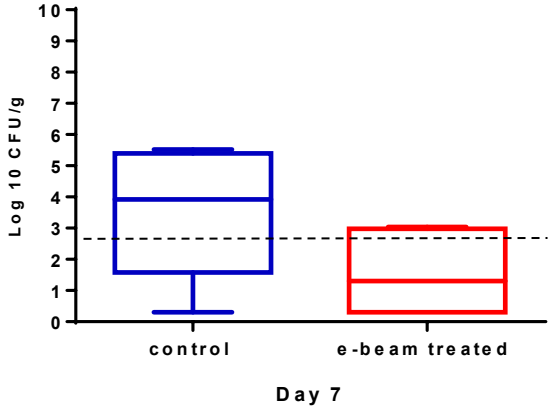


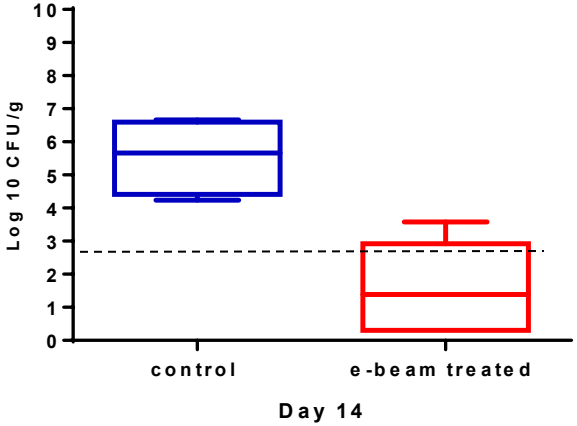
eBeam reduced bioburden in modified atmosphere packaged watermelon

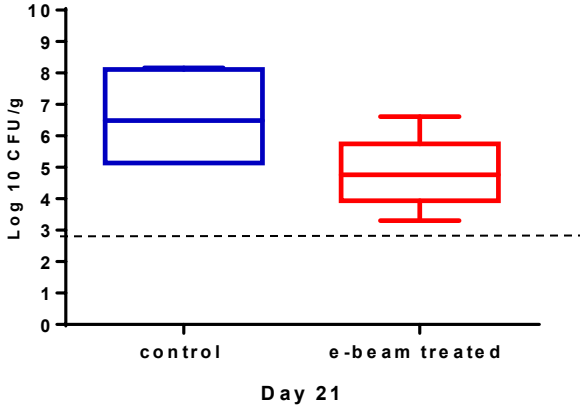






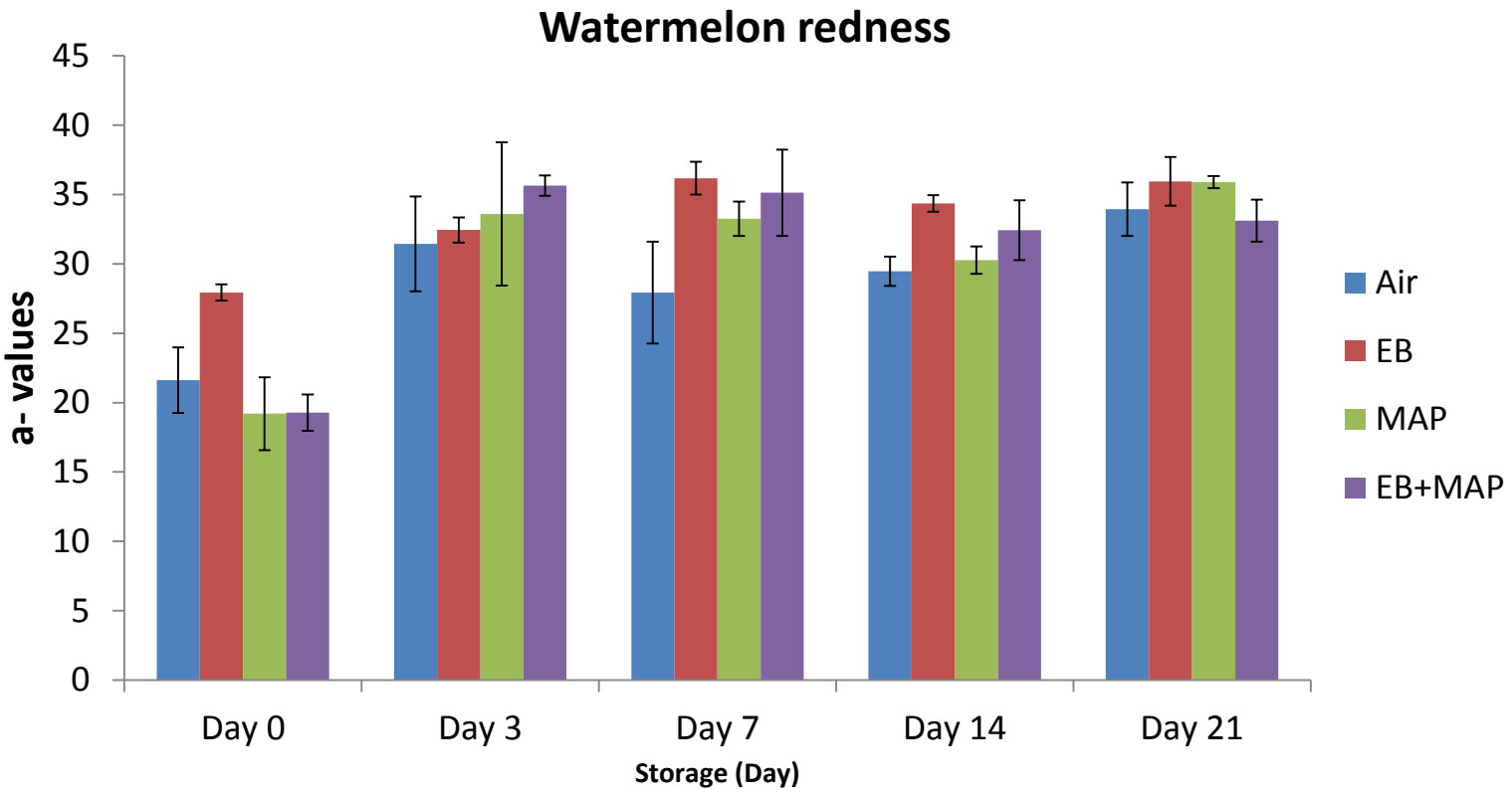






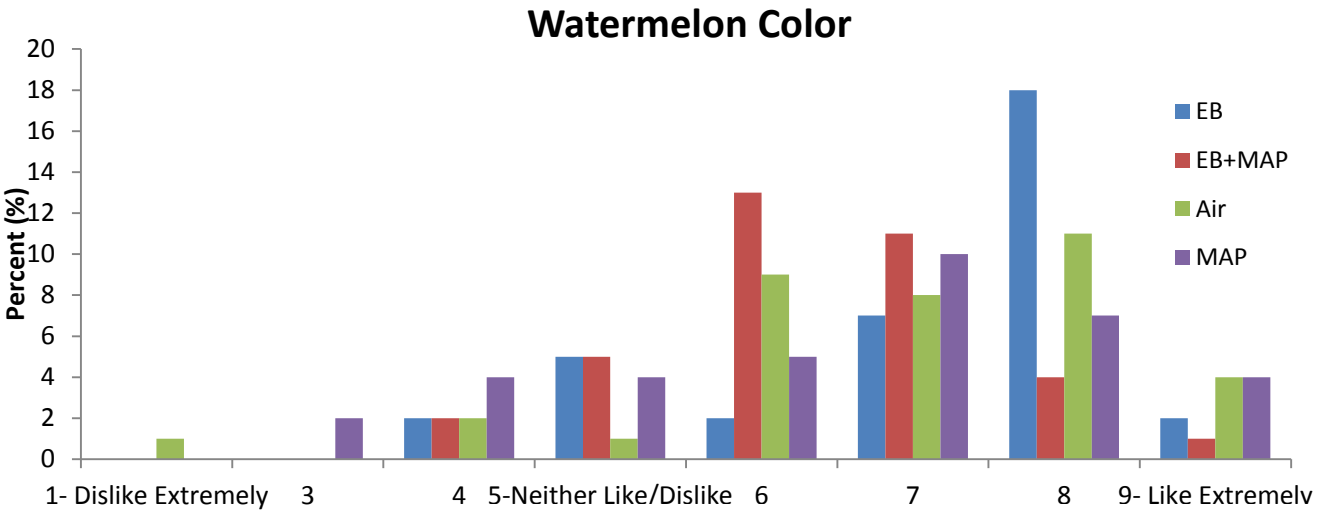
- **eBeam lowered bioburden levels in MAP watermelon on all days of storage**

Watermelon redness not affected by eBeam or modified atmospheres



- E-beam did not adversely affect watermelon redness (lycopene)
- Modified atmospheres did not affect redness of watermelon

Sensory Evaluation in Watermelon

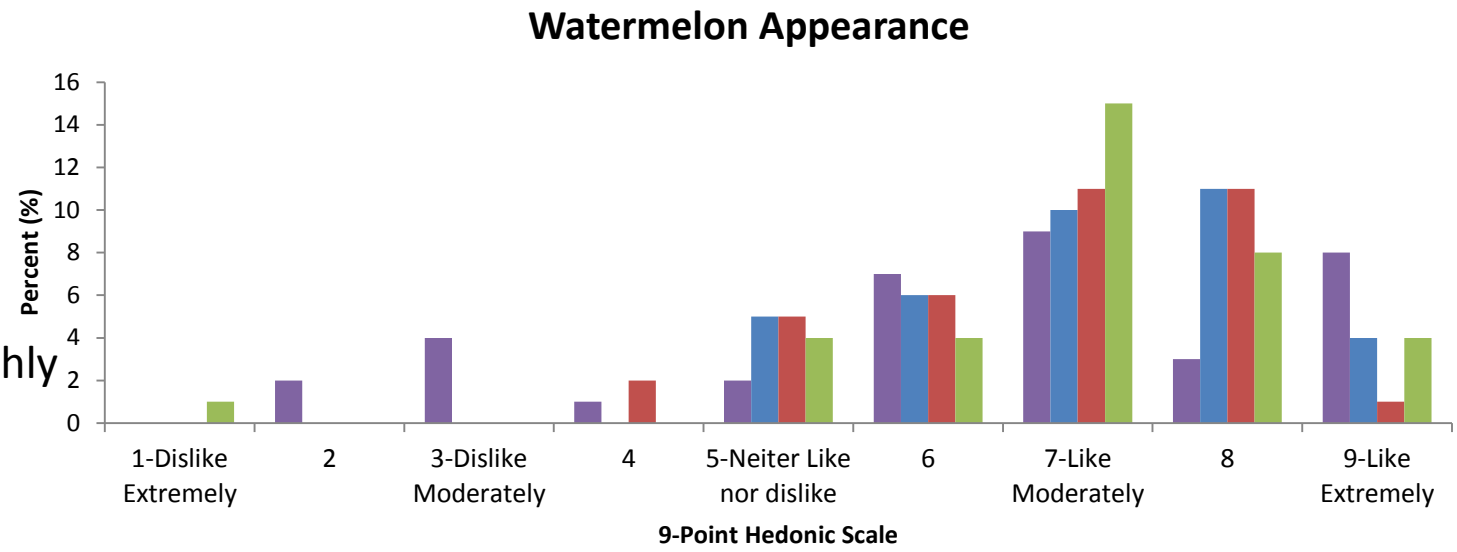


EB	75%
EB+MAP	44%
Air	63%
MAP	58%

75 % of consumers rated e-beam (in air) as 7-moderately to 9-extremely like

EB	69%
EB+MAP	63
Air	75
MAP	55

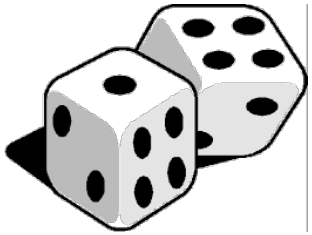
Watermelon appearance was highly liked.



Harnessing

How is your food ?

Quantitative Microbial Risk Assessment (QMRA)



Risk Analysis Framework

Calculate number of Infections/year

Suggest preventive actions eg., eBeam pasteurization

Explain to decision makers number of illnesses or deaths preventable

Risk Assessment

- Involves 4 basic steps

- **Hazard identification**
- **Exposure assessment**
- **Dose-response assessment**
- **Risk characterization**

QMRA Overview

- **Hazard Identification**
  - Which pathogen(s)?
- **Exposure Assessment**
  - How many pathogens are individuals or populations exposed to?
  - What are the contamination scenarios?
  - What are the adverse health effects?
- **Dose-response Assessment**
  - What is the relation between exposure and health effects?
  - What is the infective dose of the pathogen(s)?
- **Risk Characterization**
  - How does temporal, spatial and inherent variability affect risk?
  - Do properties that are unique to the pathogen or infectious diseases (such as person-person transmission or immunity) need to be accounted for?
  - What methods are appropriate or needed to characterize risk?

Can eBeam Reduce Infection Risks from Rotavirus and Poliovirus on Lettuce?

Assuming Serving size of lettuce (14 g) contaminated ~ 10 viruses

What would be the reduction in Infection Risks if eBeam pasteurization at 3 kGy is performed?

Espinosa et al., AEM, Feb 2012

Quantitative Microbial Risk Assessment in Lettuce

- standard US single serving sizes of lettuce (14g)
- HAV and NoV virus loads were assumed to be 1, **10, 100** and **1000 PFU/g** of either lettuce or spinach
- Infection risks calculated based on beta-Poisson model for rotavirus and Exponential model for poliovirus
- Single exposure

The beta-Poisson model, $P_i = 1 - (1 + N/\beta)^{-\alpha}$,

P_i *= the probability of infection, N = the number of viruses ingested. The parameters* α *(0.2531) and* β *(0.42) represent parameters of the dose-response curve.*

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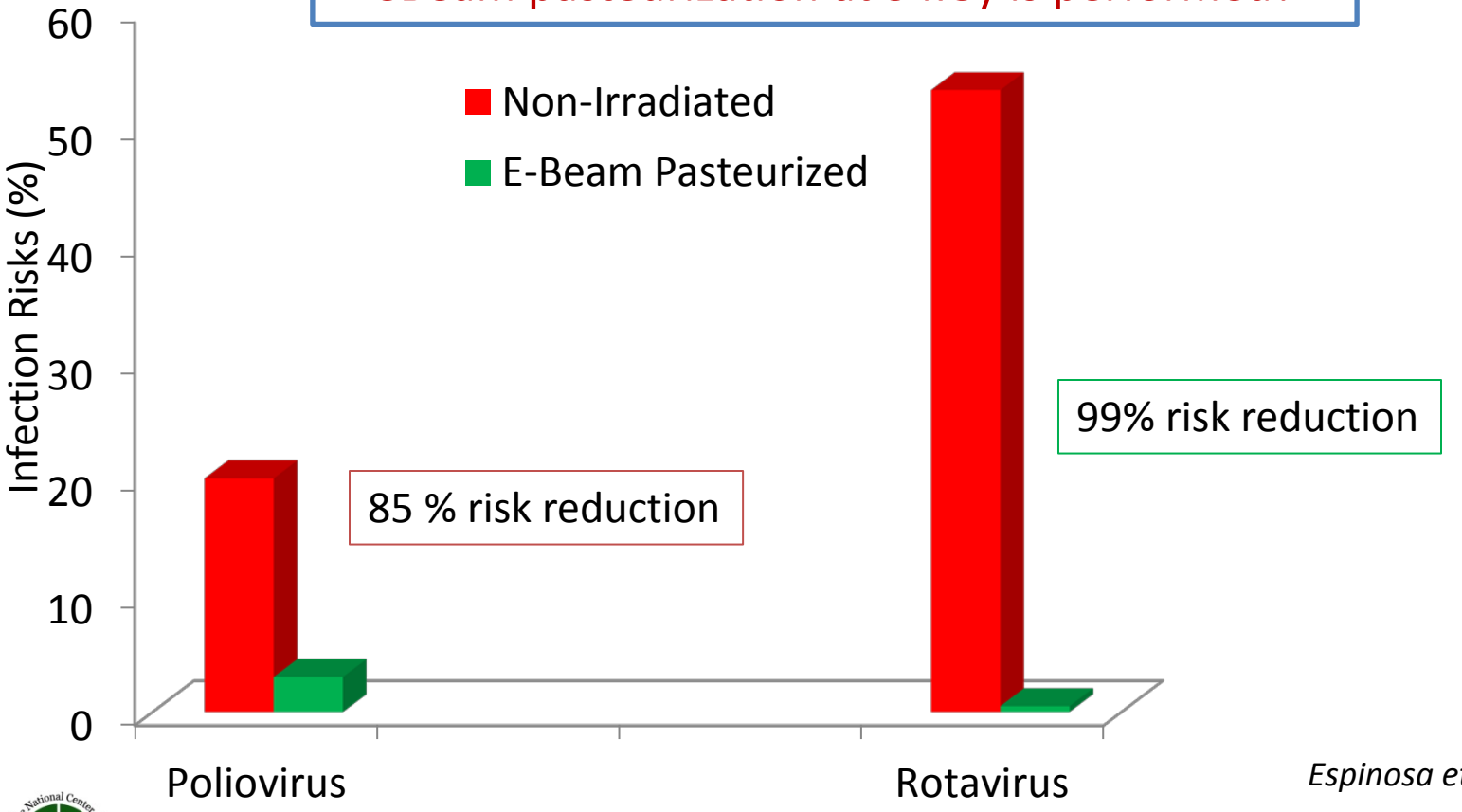


Espinosa et al., AEM, Feb 2012

AEM
Journals.ASM.org

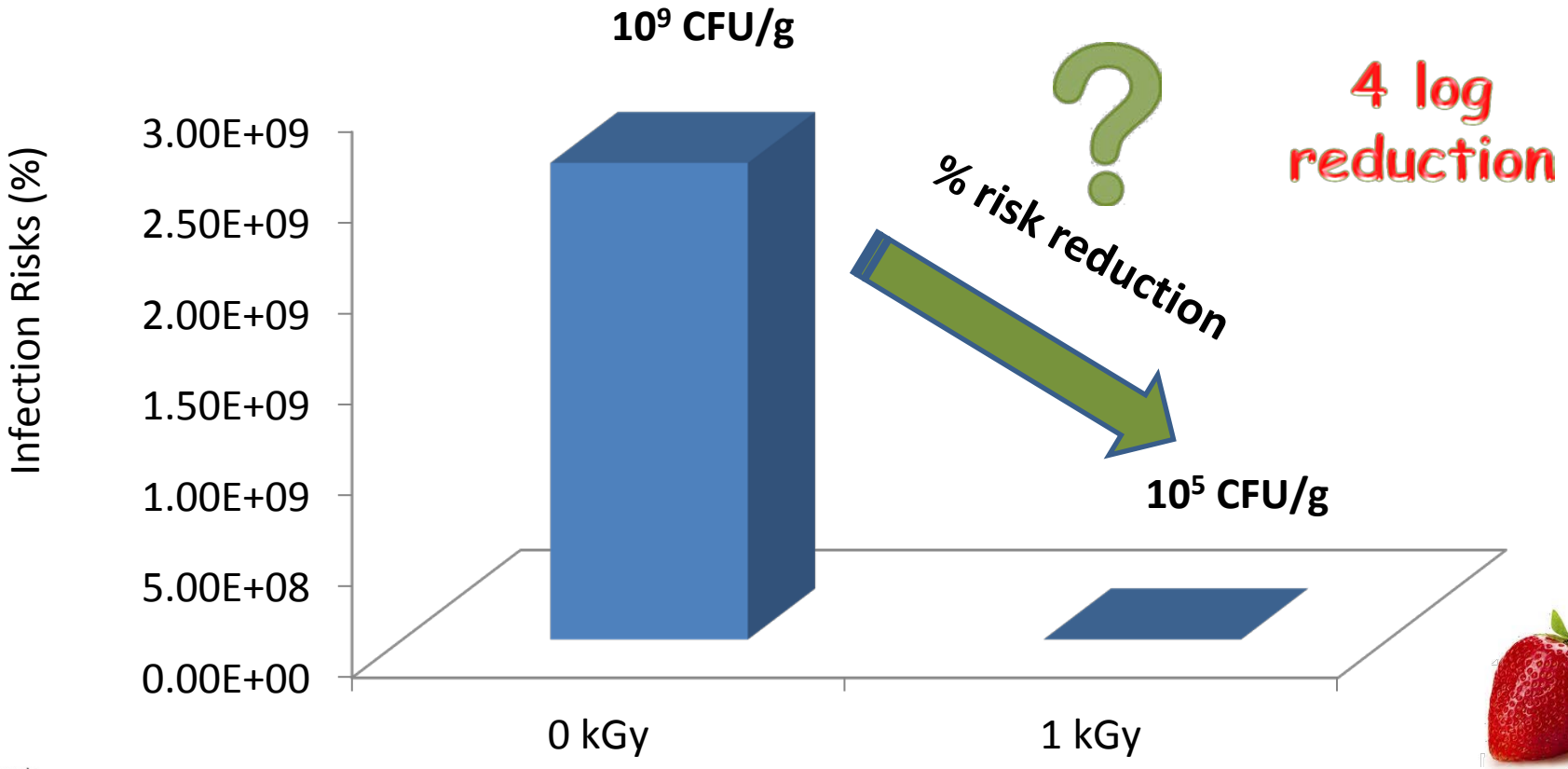
Quantifying the Reduction in Potential Health Risks by Determining the Sensitivity of Poliovirus Type 1 Chat Strain and Rotavirus SA-11 to Electron Beam Irradiation of Iceberg Lettuce and Spinach

Ana Cecilia Espinosa,[a] Palmy Jesudhasan,[b] René Arredondo,[a] Martha Cepeda,[b] Marisa Mazari-Hiriart,[a] Kristi D. Mena,[c] and Suresh D. Pillai[b]

Universidad Nacional Autónoma de México, Laboratoria de Ecologia Quimica, Instituto de Ecología, Mexico City, Mexico[a]; National Center for Electron Beam Research, Food Safety & Environmental Microbiology Program, Texas A&M University, College Station, Texas, USA[b]; and University of Texas Health Science Center at Houston, School of Public Health, El Paso Regional Campus, El Paso, Texas, USA[c]

QMRA of non-O157 Toxigenic *E.coli Reduction by eBeam* on Strawberries

Serving size of strawberries (1 cup, (152 g)) contaminated ~ 10 CFU of STEC treated with eBeam at < 1 kGy

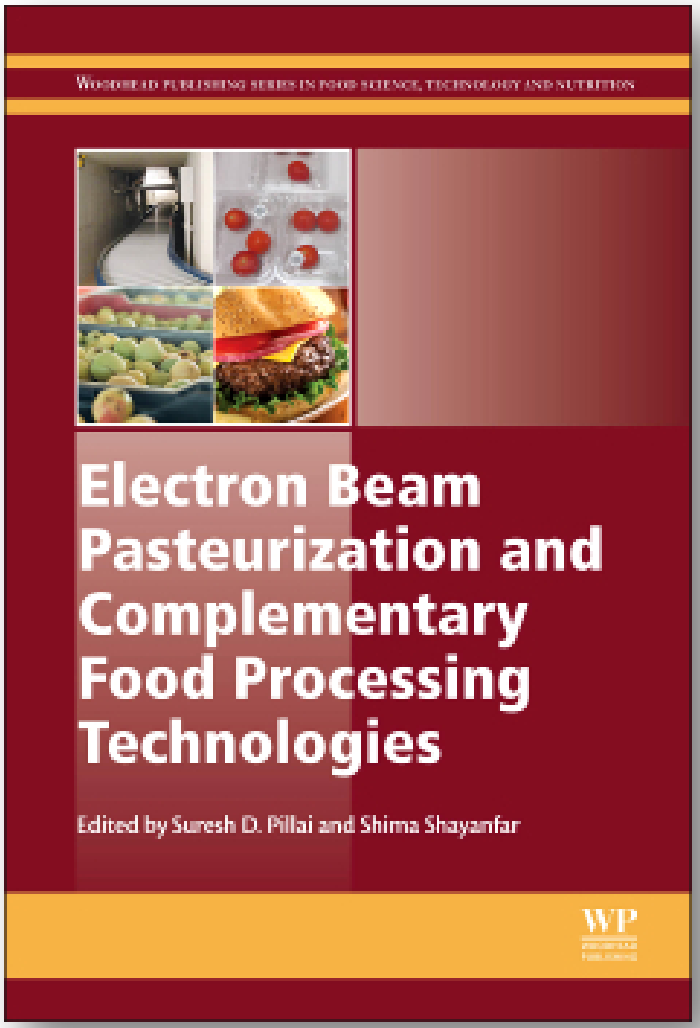


Take-Home Messages!

- Safety is essential for fresh produce …. However quality is a value addition
- Food irradiation SHOULD NEVER be used as a clean-up technology
- Food irradiation SHOULD ONLY be used as an integral step of comprehensive GAP, GMP, HACCP plans

- Microbial studies limited to log reductions cannot be an ultimate indication of safety of food
- Risk assessment provides risk management and risk communication tools for decision makers

New Book!!!



- Combining eBeam technology with
  - *Pulsed electric field (PEF)*
  - *High Pressure Processing (HPP)*
  - *Infrared*
  - *Ultrasound*
  - *Cold plasma*
  - *Active packaging*
  - *Modified atmosphere packaging (MAP)*

.....coming out January 2015

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http://ebeam.tamu.edu