Food Irradiation Today: What's Allowed, Where, and Why

May 13 - Session 11

Produced by FoodSafety magazine

Moderator – Larry Keener, IPSC

Panelist

- **Michael Ablan, CDC**
- **Taryn Horr, Food Science Consultant**
- **Katherine Marshall, CDC**
- **Christian Perversi, Omaha Steaks**
- **Suresh Pillai, Texas A&M University**

Food Irradiation Today: What's Allowed, Where, and Why

Contamination

The ***inadvertent, prohibited exposure*** of food or foodstuffs to radioactive materials is **adulteration** or **contamination** (Chernobyl and Fukushima)

Irradiation

The deliberate act of exposing food to a radiation source for a technical or functional effect such as pathogen reduction, disinfestation or sprout inhibition

Food Irradiation Today: What's Allowed, Where, and Why

In 2025 several recalls were announced by FDA involving frozen shrimp that were **contaminated** due to exposure to the radioactive isotope Cesium 137. The contaminated shrimp reported radio activity at the level of 68 Bq/Kg . FDA's safety limit is 1200 Bq/Kg.

FS & QA

Annually about half a million tons of food and food ingredients are irradiated and marketed globally, including ground beef, poultry, tropical fruit and spices

Irradiated foods *are not* radioactive

Public Health Protection

Irradiation has a long history of use by the global food industry and without reports of adverse public health effects. The food industry uses gamma rays, electron beams, and X-rays to treat food.

Order of Discussion

Ms. Taryn Horr- Overview of Food Irradiation

Dr. Suresh Pillai – The Science of Food Irradiation

Mr. Christian Perversi – Case Study

Dr. Katherine Marshall & Dr. Michael Ablan – CDC perspective on Food Irradiation

Q& A

Overview of Food Irradiation:

What It Is, What It's *Not* & How its Used

May 13, 2026

Taryn Horr, M.S., CFS, CCFS
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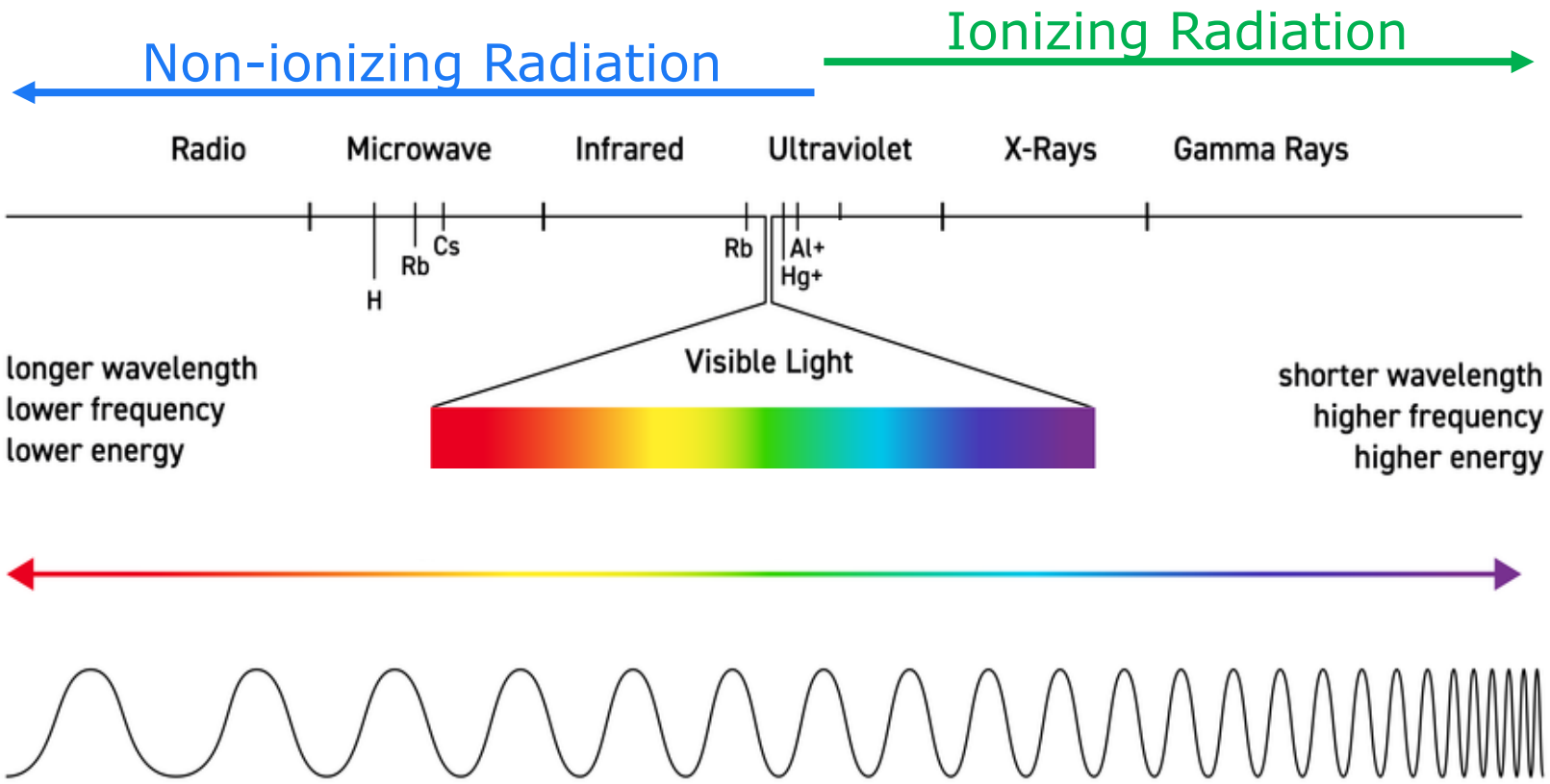
RAMBOLL Bright ideas. Sustainable change.

VS

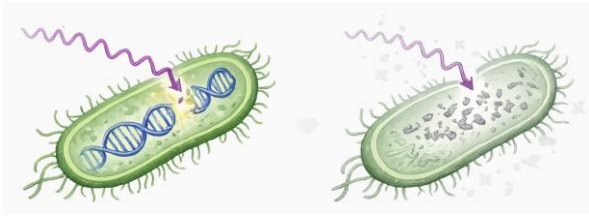
Radiation & Food Irradiation

- **Radiation =** Energy that travels in waves or particles
- **Ionizing Radiation** has energy/power to remove tightly bound electrons and disrupt DNA
- **Food Irradiation =** The *controlled* use of specific types of ionizing radiation to achieve a *defined food safety or quality purpose* (reducing pathogens, controlling pests, or extending shelf life).



Energy Source generates radiation (waves/particles) DOES NOT COME IN CONTACT WITH FOOD → Radiation travels via controlled beam or stream toward bulk or packaged food in a chamber → Radiation enters food and breaks DNA in microorganisms/pests → Microorganisms and pests are inactivated or prevented from reproducing

1. **Gamma Rays (radioactive isotopes)**
2. **Electron ("E") Beam**
3. **X-Rays (electromagnetic waves)**



History of Food Irradiation

1905 — First patent issued in the United Kingdom. Use of ionizing radiation proposed for food preservation.

1953 — U.S. Army begins major research program. The Quartermaster Corps launches systematic studies on irradiation for military rations.

1958 — U.S. Food Additives Amendment enacted. Irradiation is formally regulated in the US as a food additive under federal law.

1963 — First FDA approval. Irradiation of wheat and wheat flour authorized for insect control.

1964 — Approval expanded. Irradiation of white potatoes approved to inhibit sprouting.

1971 — NASA begins routine use. Irradiated foods used for astronaut safety during space missions.

1979 — Codex Code of Practice for Radiation Processing of Food

1980 — Joint WHO, FAO, and International Atomic Energy Agency (IAEA) expert committee concludes that food irradiated up to an overall average dose of 10 kGy presents no toxicological hazard.

1983 — Codex Alimentarius Commission adopts the first global standard for irradiated foods based on this ^^ scientific evaluation → Irradiation is justified only when it provides a technological benefit and protects consumer health.

1985-2008 — FDA approves uses in pork, poultry, red meat, shelled eggs and produce.

Today → Used in more than 60 countries across dozens of food categories, including spices, fresh produce, meat, poultry, seafood, and grains.

WHAT ITS NOT – Radioactive Material

Radioactive material is a substance that contains unstable atoms that emit radiation continuously until they decay.

FDA warns public not to eat possibly radioactive shrimp sold at Walmart

No shrimp that tested positive has entered the U.S. food supply, the FDA said.

By Sony Salzman and Bill Hutchinson
August 19, 2025, 12:50 PM

More potentially radioactive shrimp recalled in 17 states. See list.

Mary Walrath-Holdridge and Michelle Del Rey USA TODAY
Dec. 23, 2025 | Updated Dec. 25, 2025, 1:14 p.m. ET

- This event involved shrimp and spices out of Indonesia
- This was **radioactive contamination**, ***not*** a food processing error
- Cesium-137 can a byproduct of nuclear reactions and industrial uses – suspected source here was recycled scrap metal production in the area where radioactive material was released into the environment
- The FDA detected the radionuclide during routine screening and took action to prevent distribution of potentially contaminated food.

August 2025 Louisiana Republican John Kennedy claimed that eating recalled radioactive shrimp could make people resemble the creature from the sci-fi horror movie *Alien*

Irradiation is a controlled food safety process.
The shrimp recall was an environmental contamination event by radioactive material.

Food Irradiation Uses

- Preventing foodborne illness (Ex *Salmonella, E.coli)*
- Extending freshness and reducing waste
- Controlling pests in imported produce
- Delaying sprouting and ripening
- Supporting sterilized foods for medical and space use (YES some of the Artemis II food was irradiated)
  - All flights from Apollo 12 through 17 carried irradiated fresh bread

Ref: Mshelia, R. D., Dibal, N. I., & Chiroma, S. M. (2023). *Food irradiation: An effective but under-utilized technique for food preservation.* **Journal of Food Science and Technology, 60(10), 2517–2525.** https://doi.org/10.1007/s13197-022-05564-4

FOOD IRRADIATION AROUND THE WORLD

NORTH AMERICA
Food Safety and Retail Applications

Common foods
- Spices
- Ground beef
- Poultry
- Fresh produce
- Pet treats

EUROPE
Limited but Regulated Use

Common foods
- Dried herbs
- Spices
- Vegetable seasonings

Important regulatory note
EU regulations generally restrict irradiation primarily to herbs, spices, and seasonings at the regional level.

ASIA
Largest Volume and Broadest Use

Common foods
- Spices and dried herbs
- Garlic, onions, potatoes
- Seafood
- Rice and grains

Why
- Large spice production and export markets
- Post-harvest storage needs
- Export compliance

LATIN AMERICA
Export Produce and Quarantine Treatment

Common foods
- Mango
- Papaya
- Guava
- Citrus
- Dragon fruit

AFRICA & MIDDLE EAST
Growing Use

Common foods
- Spices
- Grains
- Dates
- Poultry

Why
- Shelf-life extension
- Food security and storage stability

Used in more than 60 countries worldwide

About 500,000 metric tons of food irradiated annually

Improves food safety, extends shelf life, and supports international trade

US Regulations

FDA Oversight

- Food irradiation is regulated as a food additive under the Federal Food, Drug, and Cosmetic Act.
  - Only the sources, doses, conditions, and uses listed in 21 CFR Part 179 are permitted.
  - Uses not listed require an approved Food Additive Petition (FAP).
  - Three approved Radiation Sources
    1. Gamma radiation (cobalt-60, cesium-137)
    2. Electron beam (e-beam)
    3. X-ray

Labeling

- Retail irradiated foods must display the Radura symbol and state: "Treated by irradiation" or "Treated with radiation."
- Radura labeling is ***not required*** if a product only contains irradiated ingredients, unless the treatment results in a material change.
- Irradiated foods and foods containing irradiated ingredients ***cannot*** be labeled Organic.

Imports & USDA APHIS

- Imported foods must meet the same irradiation requirements as domestically produced foods.
- USDA APHIS regulates irradiation used as a phytosanitary (quarantine) treatment for imported agricultural commodities under 7 CFR Part 305.
  - Treatments must follow APHIS-approved schedules and dose ranges (typically 60–400 Gy) and be performed at APHIS-certified foreign or U.S. irradiation facilities under formal compliance agreements.

Regulations around the World

European Union

- Governed by Directive 1999/2/EC (general rules) and 1999/3/EC (approved food list).
- EU-wide approvals are limited; additional foods may be authorized by individual Member States.

Labeling

- Mandatory labeling of irradiated foods, including identification of irradiation treatment.
- Strong consumer-information requirements across Member States.

Industry impact

- Very limited approved food categories.
- Regulatory fragmentation and strict labeling constrain market adoption.

China

- Regulated under national food safety standards (GB standards).
- Oversight by the National Health Commission and related authorities.

Labeling

- Labeling required for irradiated foods, consistent with national food safety rules.

Industry impact

- Widely adopted for food safety, shelf-life extension, and pest control.
- Significant commercial infrastructure and government support.

India

- Oversight by the Atomic Energy Regulatory Board (AERB) and Food Safety and Standards Authority of India (FSSAI).
- Clear regulatory pathway for approved food categories and uses.

Labeling

- Irradiated foods must comply with national labeling requirements, including treatment disclosure.

Industry Impact

- Extensive use for spice sterilization, export compliance, and post-harvest loss reduction.
- Irradiation is a key tool for agricultural export

Mexico

- SENASICA oversees agricultural and phytosanitary uses.
- COFEPRIS regulates food safety, public health, and labeling requirements.

Labeling

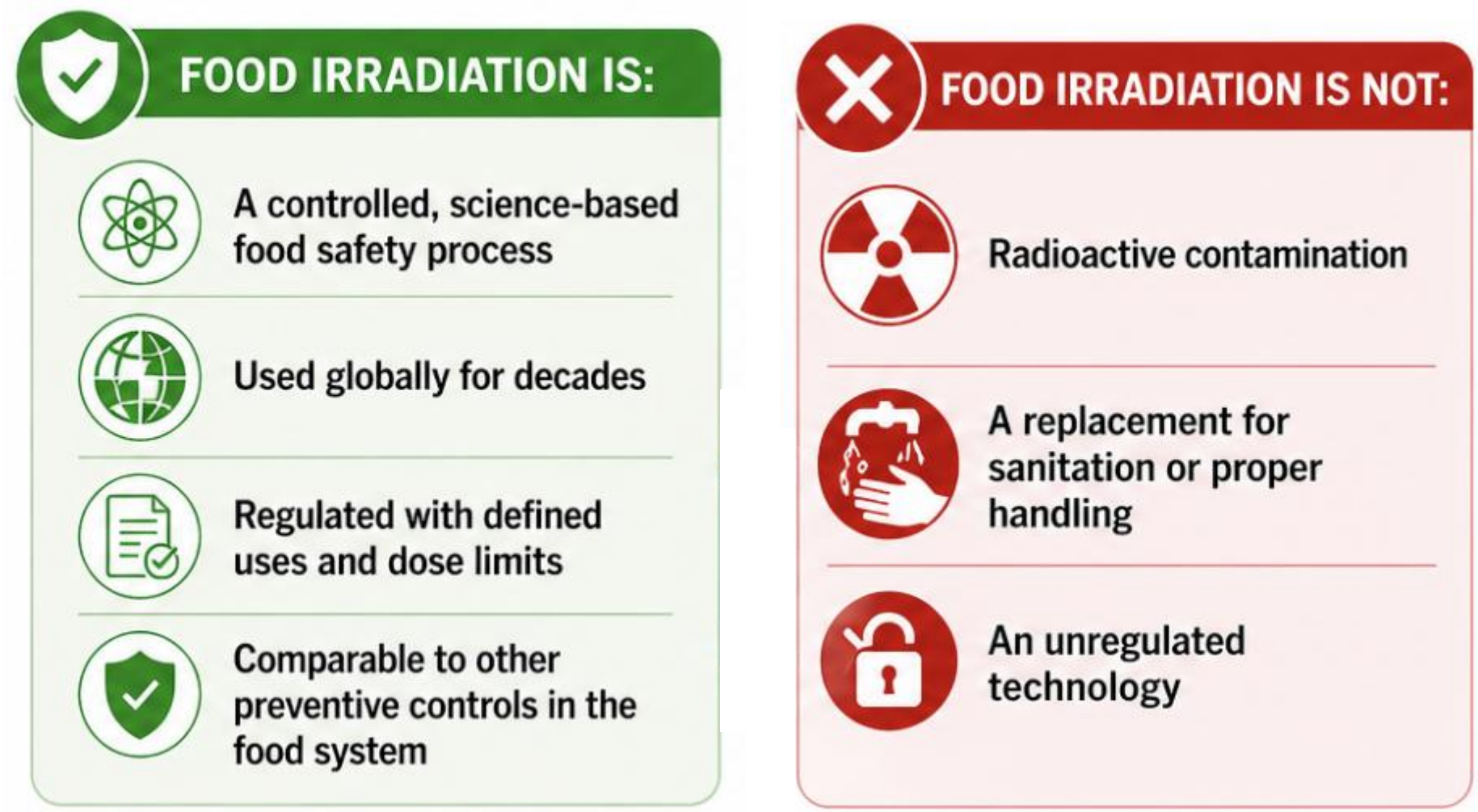
- Irradiated foods must meet Mexican sanitary labeling rules; export products must also meet destination-country requirements.

Industry Impact

- Heavy use of irradiation for quarantine pest control and export to the United States.
- Mexico is a major supplier of irradiated fresh produce.

Regulatory acceptance varies widely across regions from restrictive (EU) to broadly implemented (China, India, Mexico).

A Proven Effective & Regulated Food Safety Tool

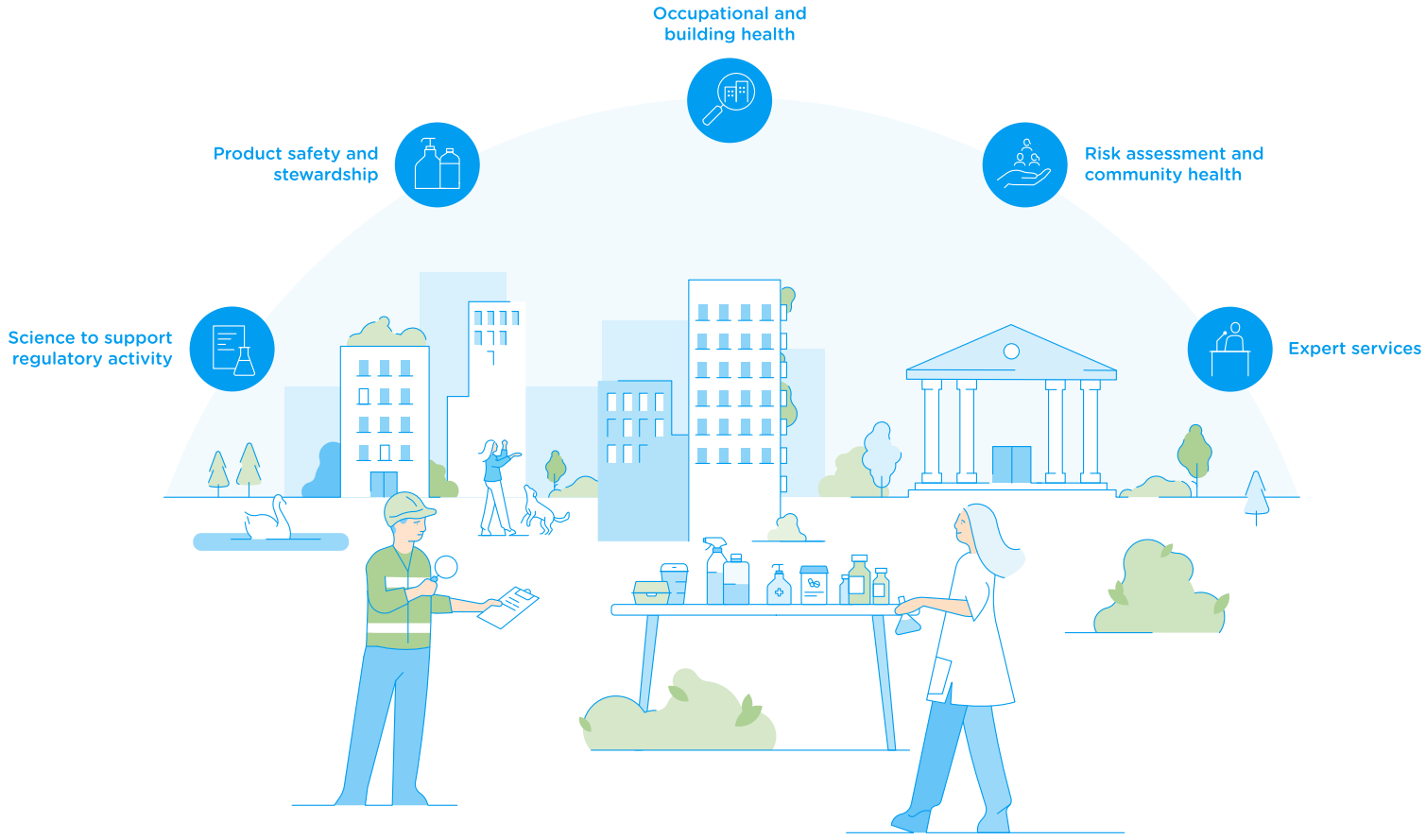


When used as approved, irradiation is a safe, effective, and well-regulated tool that supports modern food safety and global food supply chains.

Applying science for a healthy society

- Our 300+ health sciences specialists work in seamless interdisciplinary global teams to create sustainable solutions for a healthy, flourishing society.

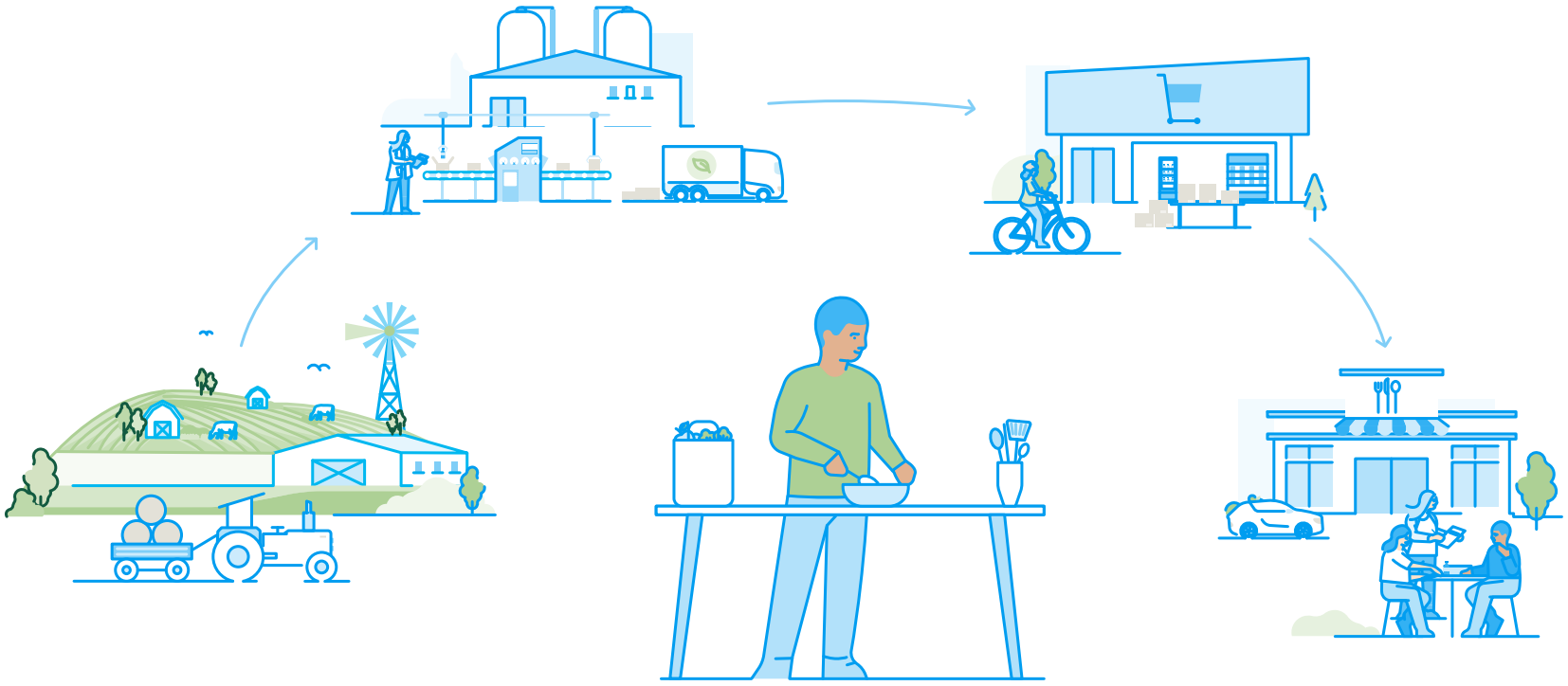
Health sciences services



Applying science for a healthy society

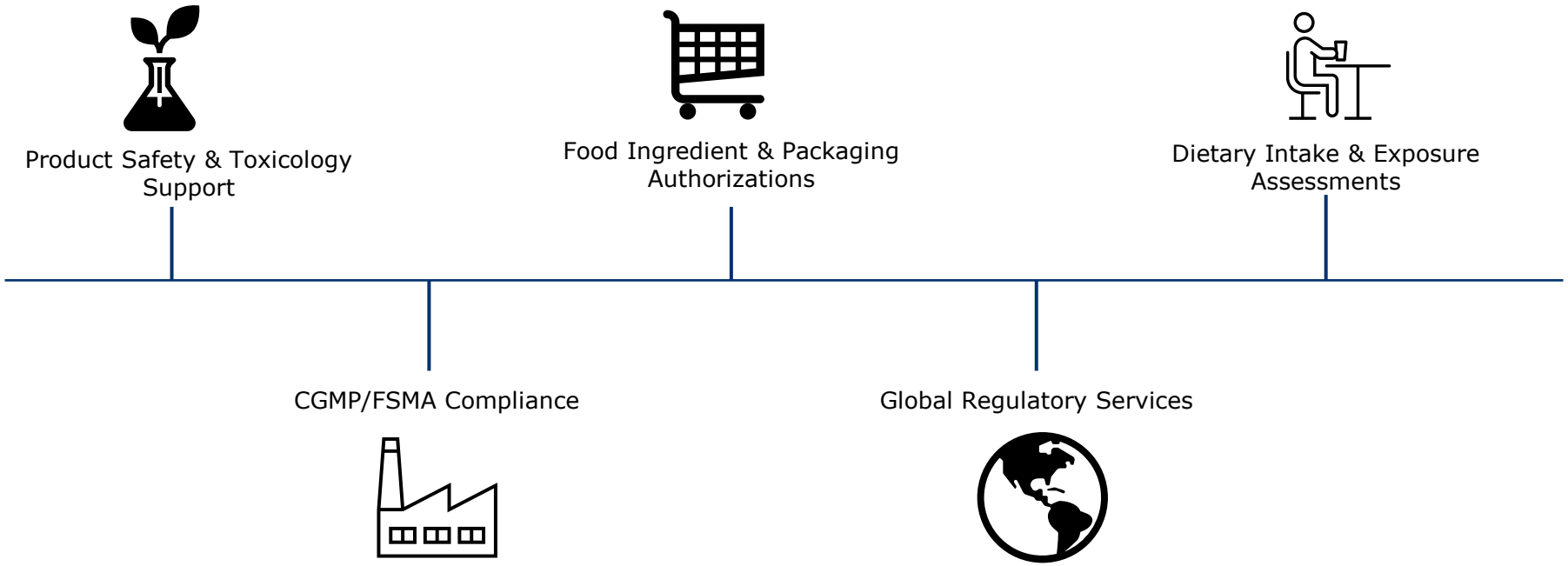
A trusted advisor

A global consultancy, Ramboll has earned a reputation as a trusted advisor that evaluates products, their ingredients, manufacturing processes, and packaging components. We provide expert solutions to support new ingredient authorization and commercialization strategies and offer insights and support for safety, sustainability, and regulatory compliance requirements for the food, dietary supplement, and personal care product industries as well as management consultancy services to optimize regulatory organizational efficiency.



Contact: healthsciences@ramboll.com

Product Safety & Stewardship Services



Food & cosmetics product stewardship:

1.Product and ingredient compliance

2.Ingredient authorizations: GRAS, NDI, NOP, Novel Foods, Colors, FCS, AAFCO

3.INCI, TSCA, MoCRA, State registrations & notifications

4.CGMP/FSMA compliance

Global regulatory services:

1.Regulatory surveillance: food, pet food, flavor & cosmetics

2.Food fraud prevention and litigation

3.Expert witness services

4.Management consulting and staff augmentation

Research & innovation strategy:

1.Concept assessment for regulatory compliance

2.Ingredient safety evaluations

3.Ingredient and product dietary intake and exposure assessments

4.Product labeling (FDA/USDA), marketing and claims development.

Produced by FoodSafety magazine

Ionizing Technology in the Food Industry

Prof. Suresh Pillai

National Center for Electron Beam Research

Texas A&M University

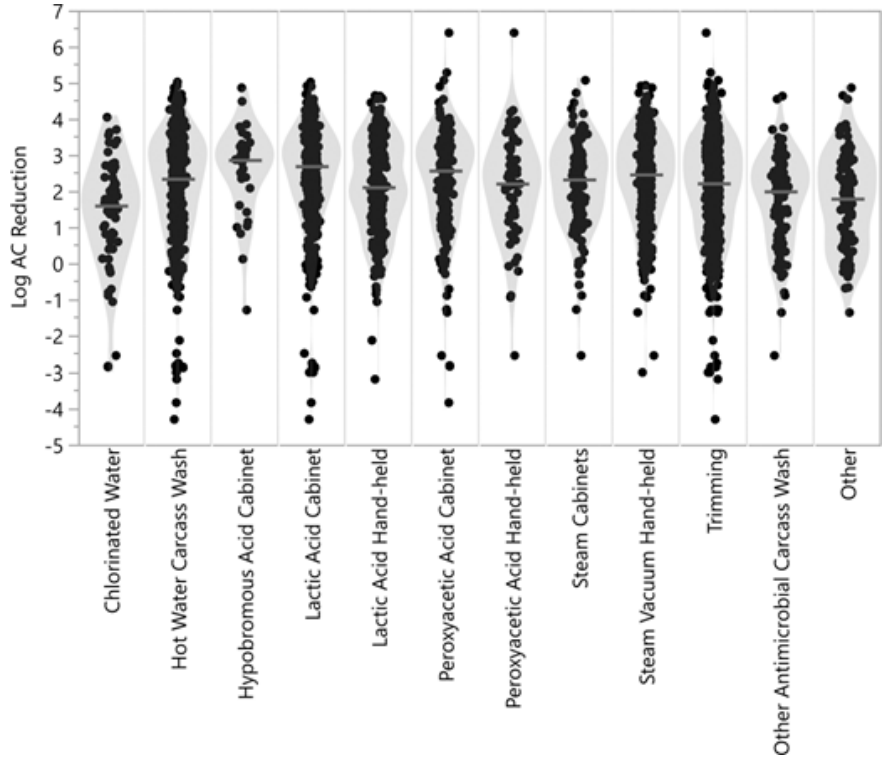
Harnessing Electrons for Cleaning, Healing, Feeding, and Shaping this World and Beyond…

TEXAS A&M UNIVERSITY

You Cannot Spray and Pray your Way to Food Safety

Salmonella in peripheral lymph nodes

- *Arthur et al., 2008*
- *Haneklaus et al., 2012*
- *Gragg et al., 2013*
- *Li et al., 2015*



- Presence in peripheral lymph nodes protects Salmonella against carcass decontamination sprays and washes
  - Explains greater presence in ground beef relative to beef trim

- Jan – Nov 2015 (n= 1200 pork heat and cheek samples)
  - Cheek meat – 63% positive for *Salmonella* enterica
  - Head trim – 66%
    - *Harvey, 2017*

Effects of antimicrobial interventions on indicator organisms during beef carcass dressing – Carter et al., 2021

Efficacy of single intervention ~ 0.4 – 1.9 log aerobic count reduction
Efficacy of multihurdle intervention ~1.6 -2.9 log aerobic count reduction

A HISTORICAL ROAD MAP OF FOOD PROCESSING TECHNOLOGIES

The evolution of preserving and enhancing food: from ancient wisdom to innovative technologies

THERMAL FOOD PROCESSING TECHNOLOGIES

Using HEAT to make food safe, stable and palatable

Ancient Times Before 1500

- Fire cooking, roasting, baking, boiling
- Early preservation through cooking and heat

~1800s Traditional Heat Methods

- Smoking, salting, drying, fermentation, sugar preservation
- Heat assisted methods for flavor and preservation

1795 Appertization (Canning)

- Nicolas Appert develops heat sterilization in sealed containers
- Birth of modern thermal preservation

1860s–1880s Commercial Sterilization

- Development of retorts and steam pasteurization
- Industrial scale thermal processing begins

1920s–1940s Pasteurization Expansion

- HTST pasteurization developed (milk)
- Wider application to juices, beer, wine
- Improved quality with microbiological safety

1950s–1970s UHT & Aseptic Processing

- UHT treatment (> 135 °C for 2–5 s) and aseptic packaging
- Shelf-stable foods without refrigeration

1980s–2000s Advanced Thermal Technologies

- Retort optimization, microwave heating, ohmic heating, infrared heating
- Energy efficiency, quality retention, process control

2010s–Present Intelligent & Sustainable Thermal Processing

- AI-optimized heating, precision processing, renewable energy integration
- Smart, safe, sustainable and consumer-centric

NON-THERMAL FOOD PROCESSING TECHNOLOGIES

Using physical, chemical or biological means other than heat to ensure food safety and quality

Ancient Times Before 1900s

- Fermentation, pickling, curing, lime, smoke
- Natural biopreservation and chemical preservation

Early 1900s Cold Storage & Refrigeration

- Mechanical refrigeration developed
- Slows microbial growth and extends shelf life

1895 Discovery of X-rays

- Wilhelm Conrad Röntgen discovers X-rays
- Foundations for future applications in food technology

1905 X-RAY PATENT (Ionizing Technology)

- X-ray patent for food application
- Pioneering step in ionizing technologies for food

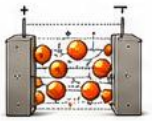
1950s–1960s Ionizing Technology (Food Application)

- Gamma irradiation approved for spices (1950s)
- Electron beam developed (1960s)

1970s High Pressure Processing (HPP)

- First commercial HPP systems developed
- Inactivates microbes at room temperature under high pressure

1980s Pulsed Electric Fields (PEF)



- PEF technology emerges for liquids and semi-solids
- Enhances safety, quality and extraction efficiency

1990s Ultrasound Processing

- Ultrasound applied for microbial inactivation and quality enhancement
- Improves texture, extraction and shelf life

2000s Emerging Technologies

- Cold plasma, ozone, UV-C, electroporation, supercritical CO_2
- New frontiers in microbial control and quality

2010s–Present Integrated & Smart Non-Thermal Technologies

- Hybrid technologies, real-time monitoring, AI-driven control
- Maximum quality, minimal processing, sustainable future

Ionizing Radiation 121 years ago!!!

KEY DRIVERS ACROSS THE JOURNEY

FOOD SAFETY
Protecting consumers across generations

QUALITY & NUTRITION
Better taste, texture and nutrition retention

EFFICIENCY & SUSTAINABILITY
Lower energy, less waste, responsible processing

INNOVATION FOR THE FUTURE
Science, technology and tradition working together

From preservation to performance – Shaping the future of food

AI-assisted graphic generated and curated by Prof. Pillai

Wholesomeness of irradiated food

Report of a Joint FAO/IAEA/WHO Expert Committee

World Health Organization
Technical Report Series
659

World Health Organization, Geneva 1981

WHO Technical Report Series
890

HIGH-DOSE IRRADIATION: WHOLESOMENESS OF FOOD IRRADIATED WITH DOSES ABOVE 10 kGy

Report of a
Joint FAO/IAEA/WHO Study Group

World Health Organization
Geneva 1999

CODE OF PRACTICE FOR RADIATION PROCESSING OF FOOD (CAC/RCP 19-1979)

INTRODUCTION

Food irradiation is the processing of food products by ionizing radiation in order to, among other things, control foodborne pathogens, reduce microbial load and insect infestation, inhibit the germination of root crops, and extend the durable life of perishable produce. Many countries are using industrial irradiators for processing of food products for commercial purposes.

The regulatory control of food irradiation should take into consideration the *General Standard for Irradiated Foods* (CODEX-STAN 106-1983) and this Code.

The purpose of regulatory control of irradiated food products should be:

a) to ensure that radiation processing of food products is implemented safely and correctly, in accordance with all relevant Codex standards and codes of hygienic practice;

b) to establish a system of documentation to accompany irradiated food products, so that the fact of irradiation can be taken into account during subsequent handling, storage and marketing; and

c) to ensure that irradiated food products that enter into international trade conform to acceptable standards of radiation processing and are correctly labelled.

The purpose of this Code is to provide principles for the processing of food products with ionizing radiation that are consistent with relevant Codex Standards and codes of hygienic practice. Food irradiation may be incorporated as part of a HACCP plan where applicable; but a HACCP plan is not required for the use of

GENERAL STANDARD FOR IRRADIATED FOODS

CODEX STAN 106-1983, Rev.1-2003

1. SCOPE

This standard applies to foods processed by ionizing radiation that is used in conjunction with applicable hygienic codes, food standards and transportation codes. It does not apply to foods exposed to doses imparted by measuring instruments used for inspection purposes.

2. GENERAL REQUIREMENTS FOR THE PROCESS

2.1 Radiation Sources

The following types of ionizing radiation may be used:

a) Gamma rays from the radionuclides ^{60}Co or ^{137}Cs;

b) X-rays generated from machine sources operated at or below an energy level of 5 MeV;

c) Electrons generated from machine sources operated at or below an energy level of 10 MeV.

2.2 Absorbed Dose

For the irradiation of any food, the minimum absorbed dose should be sufficient to achieve the technological purpose and the maximum absorbed dose should be less than that which would compromise consumer safety, wholesomeness or would adversely affect structural integrity, functional properties, or sensory attributes. The maximum absorbed dose delivered to a food should not exceed 10kGy, except when necessary to achieve a legitimate technological purpose.[1]

2.3 Facilities and Control of the Process

2.3.1 Radiation treatment of foods should be carried out in facilities licensed and registered for this purpose by the competent authority.

2.3.2 The facilities shall be designed to meet the requirements of safety, efficacy and good hygienic practices of food processing.

2.3.3 The facilities should be staffed by adequate, trained and competent personnel.

2.3.4 Control of the process within the facility should include the keeping of adequate records including quantitative dosimetry.

2.3.5 Facilities and records should be open to inspection by appropriate authorities.

2.3.6 Control should be carried out in accordance with the Recommended International Code of Practice for Radiation Processing of Foods (CAC/RCP 19-1979, Rev.1-2003).

3. HYGIENE OF IRRADIATED FOODS

3.1 The irradiated food should be prepared, processed, and transported hygienically in accordance with the provisions of the Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP 1-1969, Rev. 3-1997), including the application of the seven principles of Hazard Analysis and Critical Control Point (HACCP) system where applicable for food safety purposes. Where appropriate, the technical requirements for the raw materials and end product should comply with applicable hygienic codes, food standards, and transportation codes.

3.2 Any relevant national public health requirement affecting microbiological safety and nutritional adequacy applicable in the country in which the food is sold should be observed.

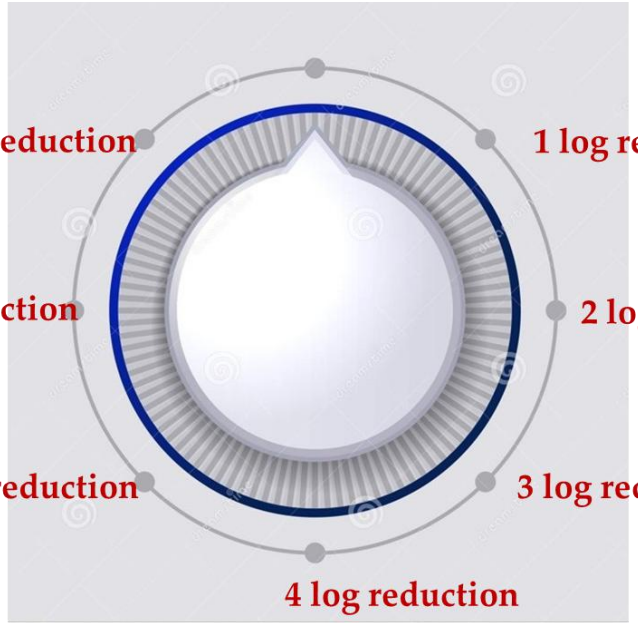
4. TECHNOLOGICAL REQUIREMENTS

Ionizing technology represents one of the most extensively studied food processing technologies in history, rivaled only by conventional thermal processing technologies

Table 1: Food Products Approved for Irradiation in the United States

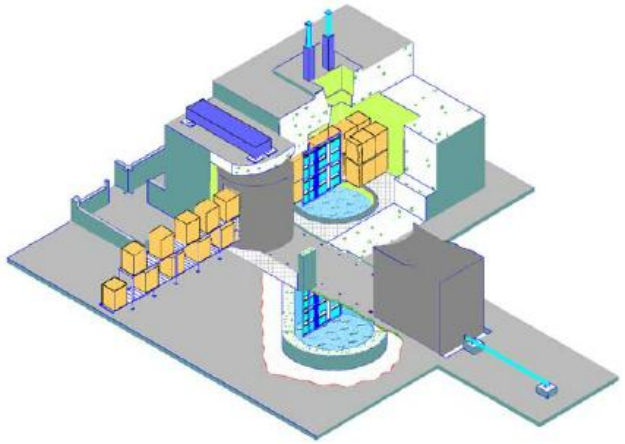
Food product	Agency and approval date	Purpose of irradiation	Maximum permitted dosage (kiloGray)
Dry or dehydrated enzyme preparations	Food and Drug Administration (FDA), June 10, 1985	Control of insects and micro-organisms	10.0
Pork carcasses or fresh nonheated processed cuts	FDA, July 22, 1985 United States Department of Agriculture (USDA), January 15, 1986	Control *Trichinella spiralis*	0.30 to 1.00
Fresh foods	FDA, April 18, 1986	Delay maturation	1.0
Food	FDA, April 18, 1986	Arthropod disinfestation	1.0
Dry or dehydrated aromatic vegetable substances	FDA, April 18, 1986	Microbial disinfection	30.0
Fresh, frozen uncooked poultry	FDA, May 2, 1990 USDA, September 21, 1992	Control foodborne pathogens	3.0
Refrigerated and frozen uncooked sheep, cattle, swine, and goat	FDA, December 3, 1997 USDA, December 23, 1999	Control foodborne pathogens and extend shelf-life	4.5 (refrigerated) 7.0 (frozen)
Fresh shell eggs	FDA, July 21, 2000	Reduction of *Salmonella*	3.0
Seeds for sprouting	FDA, October 30, 2000	Control microbial pathogens	8.0
Fresh or frozen molluscan shellfish	FDA, August 16, 2005	Control *Vibrio* bacteria and other foodborne pathogens	5.5
Fresh iceberg lettuce and fresh spinach	FDA, August 22, 2008	Control foodborne pathogens and extend shelf-life	4.0

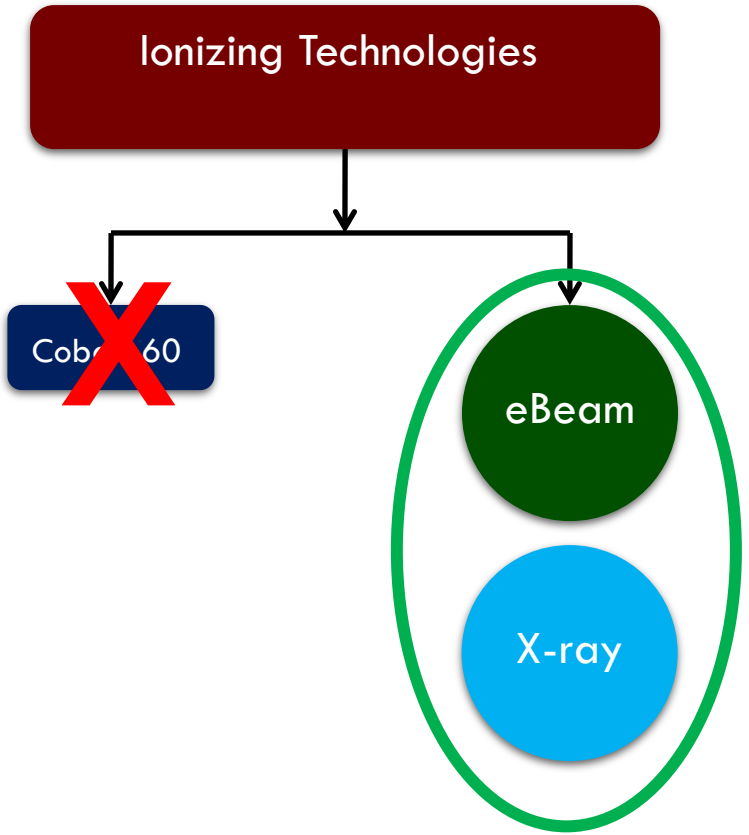
Source: GAO presentation of information from 21 C.F.R. 179.26 and *Federal Register* notices.

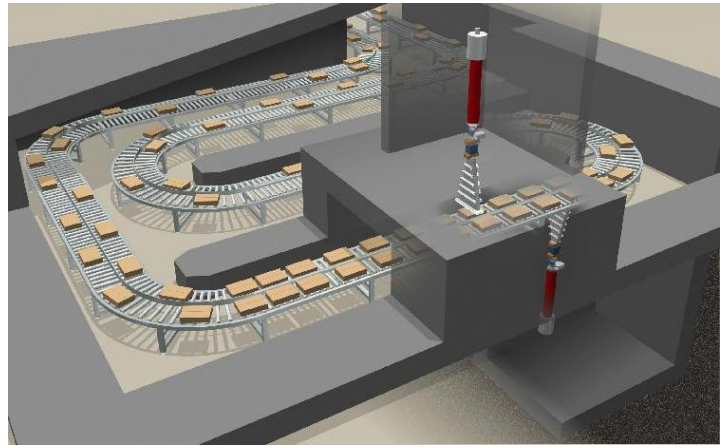


Ionizing Technologies

- Isotope based radiation
  - **Gamma radiation** (cobalt-60 and cesium-137)







Machine generated (accelerators)

Electron Beam (eBeam): electrons

X-ray: photons

Why this technology has become obsolete

- Cost and supply chain
- Source cannot be switched off
- Radioactive material storage and return
- Slow process – quality implications
- Process becomes slower as time goes on

Why this technology is expanding

- No radioactive materials
- Electricity based
- Switch on/Switch-off technology
- In-house technology
- Rapid decline is adoption costs

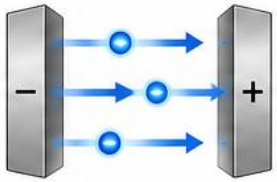
FROM ELECTRICITY TO eBEAM TECHNOLOGY

Speed up electrons with electricity to almost the speed of light— and you get eBeam technology.

1 ELECTRICITY CREATES ELECTRONS

Electric current supplies energy that frees electrons in a cathode (electron gun).

2 ELECTRIC FIELDS ACCELERATE ELECTRONS



A high voltage is applied across an accelerator tube, creating an electric field that pushes electrons forward and speeds them up.

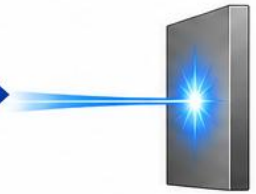
3 SPEED INCREASES TO NEAR LIGHT SPEED

Electrons gain tremendous kinetic energy as they are accelerated to very high speeds—close to the speed of light.

4 FOCUSED INTO A PRECISE BEAM

Magnetic lenses focus and shape the high-speed electrons into a narrow, powerful beam with precise control.

5 HIGH-ENERGY eBEAM DELIVERED



The concentrated beam delivers high energy at the target, enabling powerful effects such as ionization, sterilization, crosslinking, or material modification.

6 eBEAM TECHNOLOGY

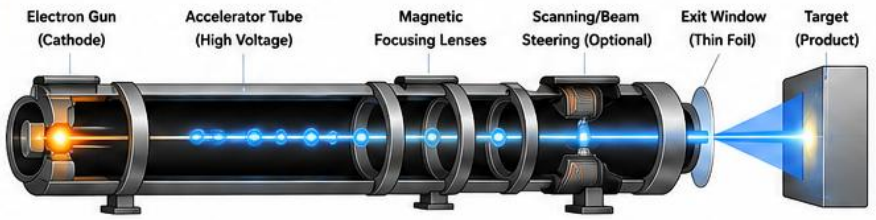
This is eBeam technology—clean, precise, efficient, and highly controllable using electricity.

THE SCIENCE IN SIMPLE TERMS

- Electricity provides energy.
- Electrons are released.
- High voltage accelerates them.
- They reach near light speed (>99.9% of c).
- Magnetic systems focus the beam.
- High energy is delivered with precision.

The result: a powerful eBeam controlled by electricity.

HOW AN eBEAM SYSTEM WORKS



Voltage	Beam Current	Beam Power
50 kV – 10 MeV+	mA to Amps	kW to MW level

KEY ADVANTAGES

- ✓ Uses electricity
- ✓ No chemicals
- ✓ On-demand (switch on/off)
- ✓ Precise and controllable
- ✓ Environmentally friendly

REAL-WORLD APPLICATIONS

FOOD SAFETY
Eliminates pathogens, extends shelf life, maintains quality.

MATERIALS PROCESSING
Crosslinking, polymer modification, shrink tubing, cable insulation.

WATER & WASTEWATER TREATMENT
Decontamination and purification.

MEDICAL & PHARMACEUTICAL
Sterilization of medical devices, disposables, and more.

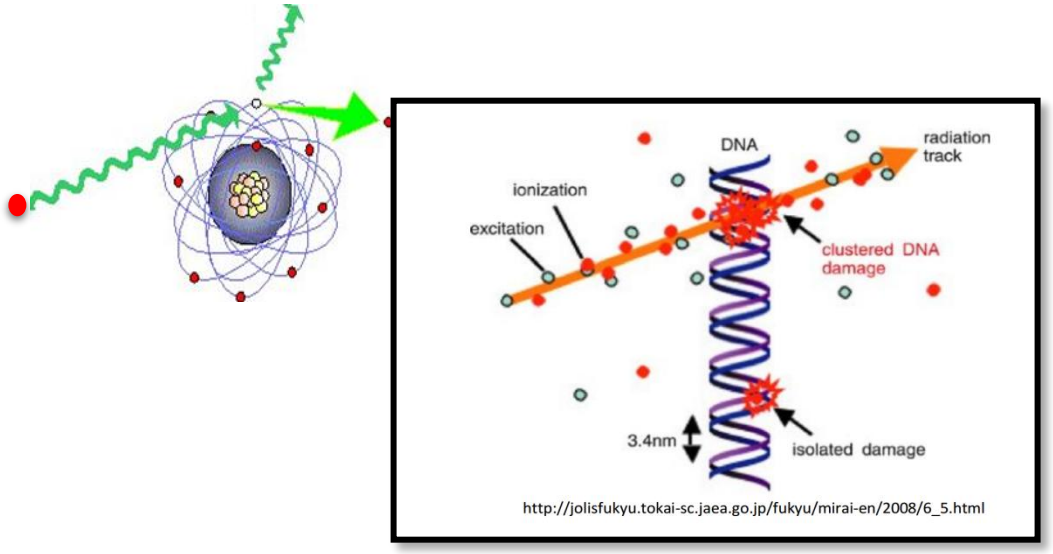
ENVIRONMENTAL SOLUTIONS
Advanced oxidation, emission control, sustainable processing.

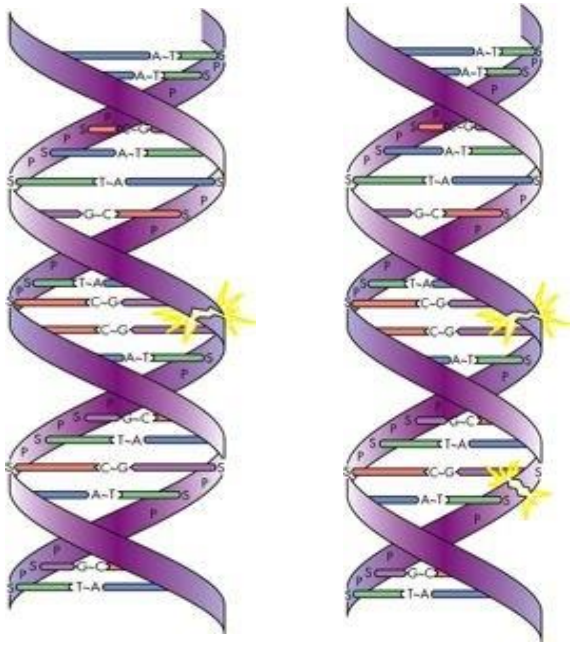
eBEAM TECHNOLOGY = ELECTRICITY + HIGH VOLTAGE + PRECISION ENGINEERING

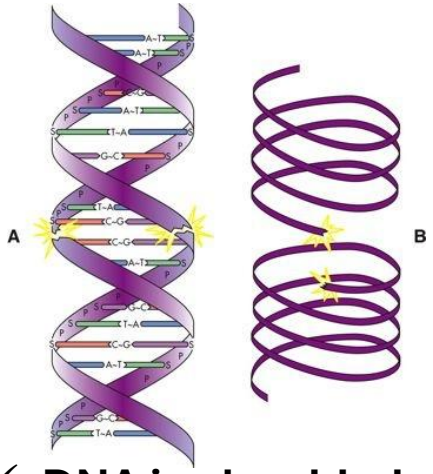
Harnessing the power of electrons at near light speed to create safer, better, and more sustainable solutions.

AI-assisted graphic generated and curated by Prof. Pillai

How does Ionizing Technology Work?







- ✓ **DNA is shredded**
- ✓ **Microbes permanently inactivated**

Direct damage: when electrons/photons cause direct damage to molecules
Indirect damage: the active species produced during radiolysis of water molecules

The technology is used by US consumers

The Technology is Commercially Available

Wasik

Tetra-Pak

Mevex
Accelerad Technologies
Radiabeam

IBA Industrial
Mevex
Accelerad Technologies

ITHPP-ALCEN

Low Energy eBeam
Low Energy Xray

LEEB
LEEX

Low Energy
(80 keV – 1 MeV)

Medium Energy eBeam
Medium Energy Xray

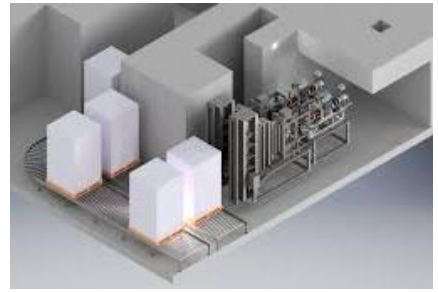
MEEB
MEEX

Medium Energy
(1 MeV – 4 MeV)

High Energy eBeam
High Energy Xray

HEEB
HEEX

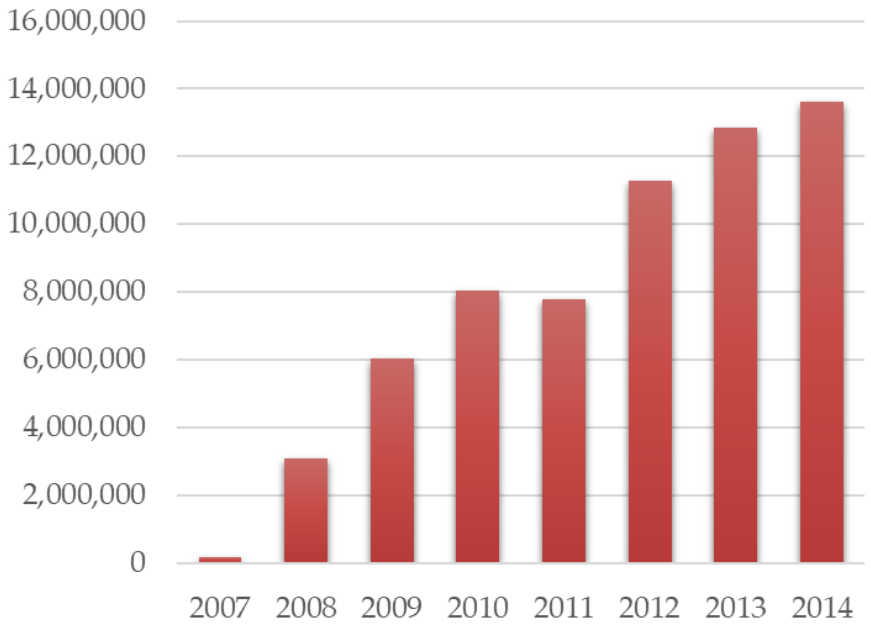
High Energy
(5 MeV – 10 MeV)



Energy (MeV)

US Consumers Have Been Purchasing & Consuming Irradiated Foods For a Very Long Time

Food Safety	Shelf-life Extension /Food Quality	Phytosanitary Treatment/Plant Protection
• Meat products • Spices • Food additives	• Sprouting inhibition • Avoiding chemicals	• Imported fruits and vegetables • Sterile Insect Technology

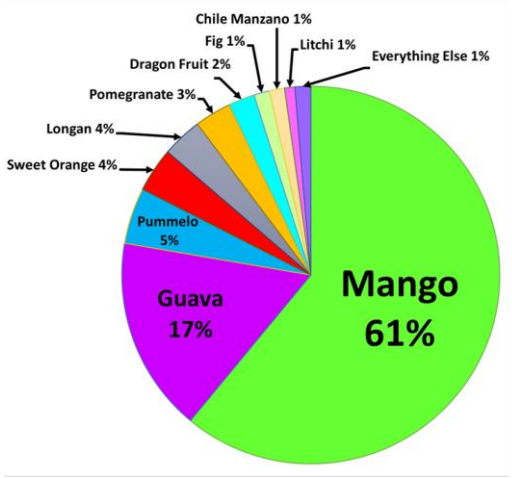


Amount (kg) of irradiated fresh produce arriving in the US

EXPORTING COUNTRY	UNITED STATES IMPORTED AMOUNT (Kg)		
	2019	2022	% difference
Mexico	21,136,034	42,759,025	102 %
Vietnam	8,286,273	2,012,085	-75%
Peru	195,255	1,005,869	414%
India	1,344,755	982,500	-26%
South Africa	195,663	467,745	139%
Chile		303,269	-
Australia	57,928	292,535	404%
Pakistan	106,410	223,535	110%
Jamaica	9,010	27,472	205%
Grenada	19,379	19,159	-1%
Total	**31,833,197**	**48,093,194**	**53%**

2025 Import Totals

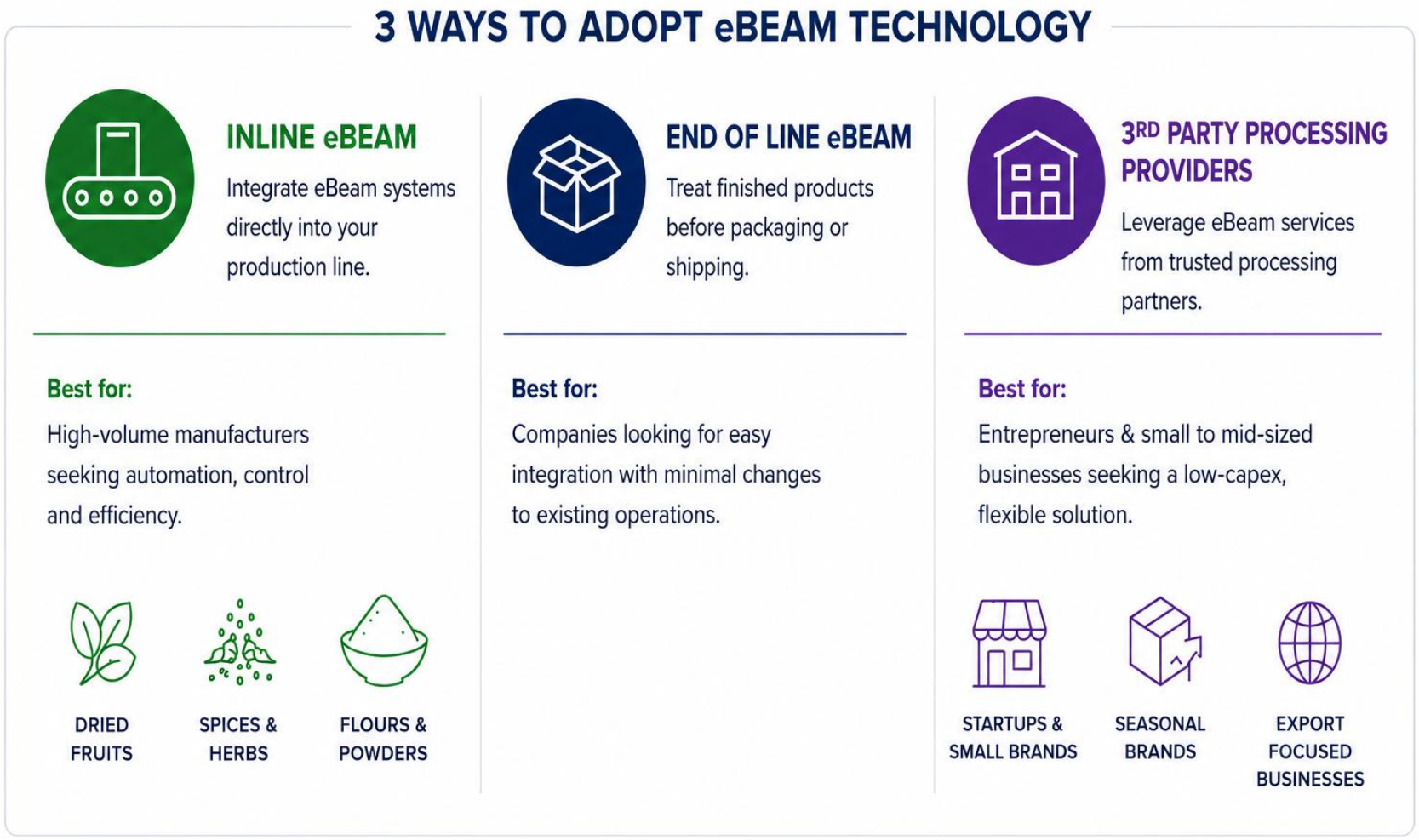
by Commodity



Commodity	Weight (kg)
Mango	62,724,915
Guava	17,184,203
Pummelo	4,943,858
Sweet Orange	3,915,259
Longan	3,535,518
Pomegranate	3,225,807
Dragon Fruit	2,315,791
Fig	1,378,735
Chile Manzano	1,323,968
Litchi	903,767
Pitaya	757,744
Star Apple	275,384
Carambola	146,488
Mangosteen	74,200
Ambarella	57,362
Grapefruit	48,390
Sweet Lime	31,681
Rambutan	1,583
Total	**102,844,653 kg** **102,845 MT**

Ref: *USDA-APHIS*

Adopting eBeam/X-ray Technologies



Suresh Pillai
s-pillai@tamu.edu

Food Irradiation Today at Omaha Steaks

May 13th, 2026

AMERICA'S ORIGINAL BUTCHER
OMAHA STEAKS
SINCE 1917

Who We Are:

America's Original Butcher

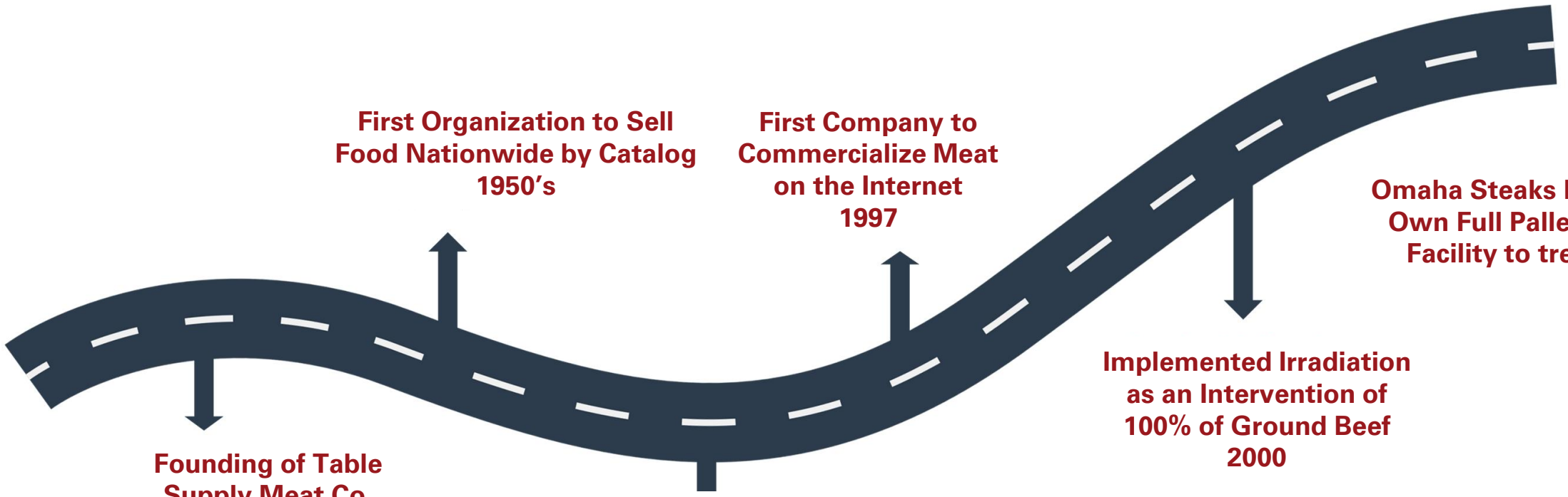
Who is Omaha Steaks?

OUR CORE VALUES

- We Put Our CUSTOMERS Above Everything
- We Deliver QUALITY Without Compromise
- We are NEVER SATISFIED with the Status Quo
- We Drive RESULTS
- We are a Thriving TEAM
- We Fearlessly and Thoroughly Focus on the FUTURE

A History of Firsts

What sets us apart



AMERICA'S ORIGINAL BUTCHER

Who are our Customers?

Voice of Customer

Food Safety Survey

March 2025

In 2025, Omaha Steaks broke ground on our new Food Safety Treatment Facility where ground beef and ground beef products will be made safer with the use of **x-ray irradiation**.

While this is a proud moment internally for the company, we wanted to understand how the lay-consumer would interpret and react to this information if we were to be proactive with this message.

This survey also attempts to size just how top of mind food safety is among consumers today. Are they already thinking about these things? Or will this introduce an 'issue' that's not really an issue?

Survey details

This survey was 29 questions and took 8 minutes to complete.

This survey was designed and fielded as a blind survey. Meaning, respondents never knew that the questions were regarding Omaha Steaks or that Omaha Steaks had designed the survey.

This survey was in field March 27th - 30th, 2025.

Sample

600n responses

Survey respondents came from a general population consumer panel provided by quantilope (96n/16% were Omaha Steaks Buyers).

Everyone that took this survey matched our target demographic: Age 35+ and annual household income of $75k or more

Everyone that took this survey had purchased ground beef or hamburger patties in the past 3 months.

Sizing the Food Safety 'issue'

Open text question: **How do you define quality when it comes to food, specifically meat?**

Food Safety came up unaided **1%** of the time when asking consumers to define quality meat.

"If it is fresh and looks fresh as well as high safety standards."

"It should be fresh and prepared safely."

However, **Freshness** could be considered a proxy for Food Safety in some cases i.e. if meat doesn't look fresh it's likely

Do our customers want to know? How much?

When asked how they define quality when it comes to meat, **only 5 of 600 respondents (1%) mentioned something about food safety** (aka 'unaided').

Fat content, freshness, appearance, taste and origin were the most common quality factors that came to mind.

Open text question: **How do you define quality when it comes to food, specifically meat?**

Food Safety came up unaided **1%** of the time when asking consumers to define quality meat.

"If it is fresh and looks fresh as well as high safety standards."

"It should be fresh and prepared safely."

However, **Freshness** could be considered a proxy for Food Safety in some cases i.e. if meat doesn't look fresh it's likely to be perceived as 'unsafe'. **23%** of open text responses mentioned something about Freshness.

"Fresh smell and not discolored."

"Fresh, pink color, date, smell of the product."

"Fresh and visually appealing."

"Quality meat is fresh, tasty, packaged correctly."

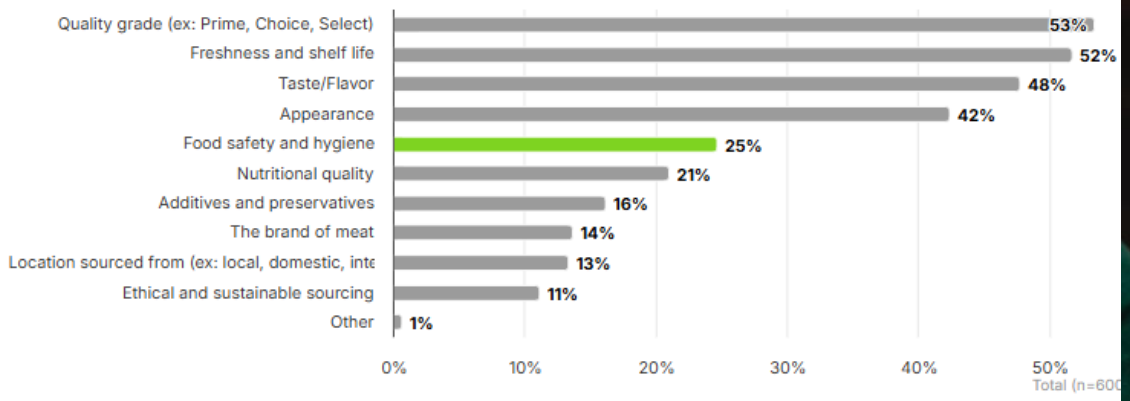
Other top themes:

Fat content (33%) - *"Low fat, no gristle.", "Lean and low-fat.", "I generally define it between prime, choice and select."*

Appearance (22%) - *"It looks good and smells good.", "I like it to look fresh and red.", "I look at the color and where it came from."*

'Food safety and hygiene' is a Top 3 factor for 25% of consumers when evaluating meat quality among a list of other quality factors.

Which factors are most important to you when it comes to evaluating the quality of meat? Pick your top 3.

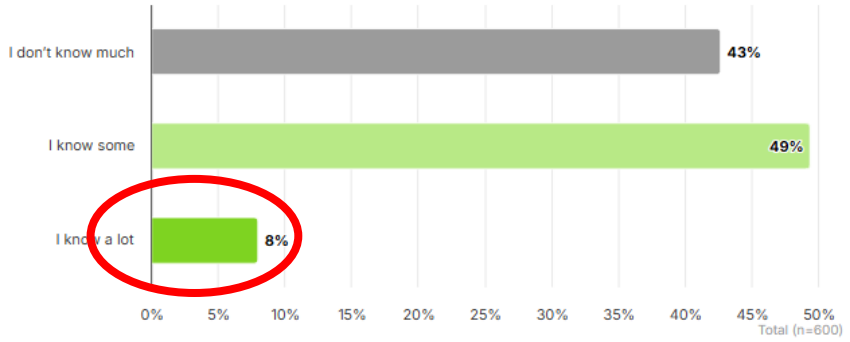


Opportunities to Educte as an Industry.

Food Safety knowledge

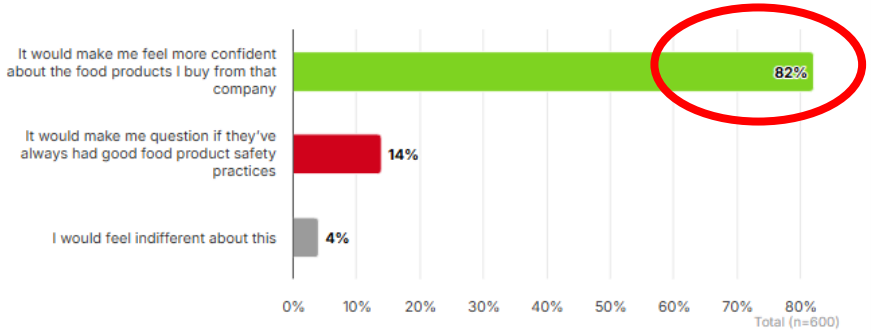
About **50%** claim to **know 'some'** about the lengths companies go to to keep food safe. **43% don't know much** about this. Only 8% say they know a lot.

Survey question: How much would you say you actually know about the processes companies and retailers go through to keep your ground beef products safe?



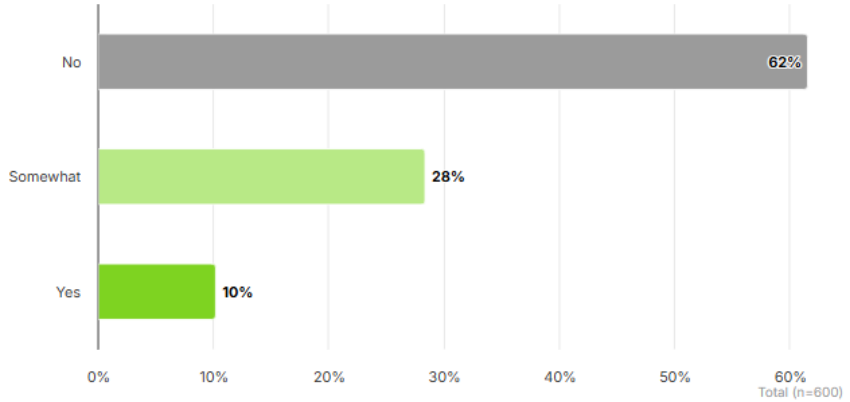
82% say they would **feel more confident** about food products if they were to find out that a company was investing in better and more-advanced food safety practices

Survey question: If you found out that a company was investing in better and more-advanced food safety practices for their ground beef products, what would be your reaction?



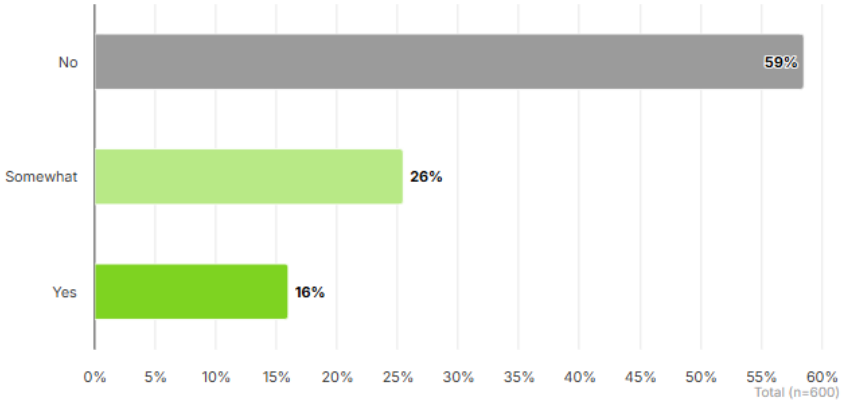
62% know nothing about Cold Pasteurization today

Survey question: Do you know what **cold pasteurization** is when it comes to food safety?

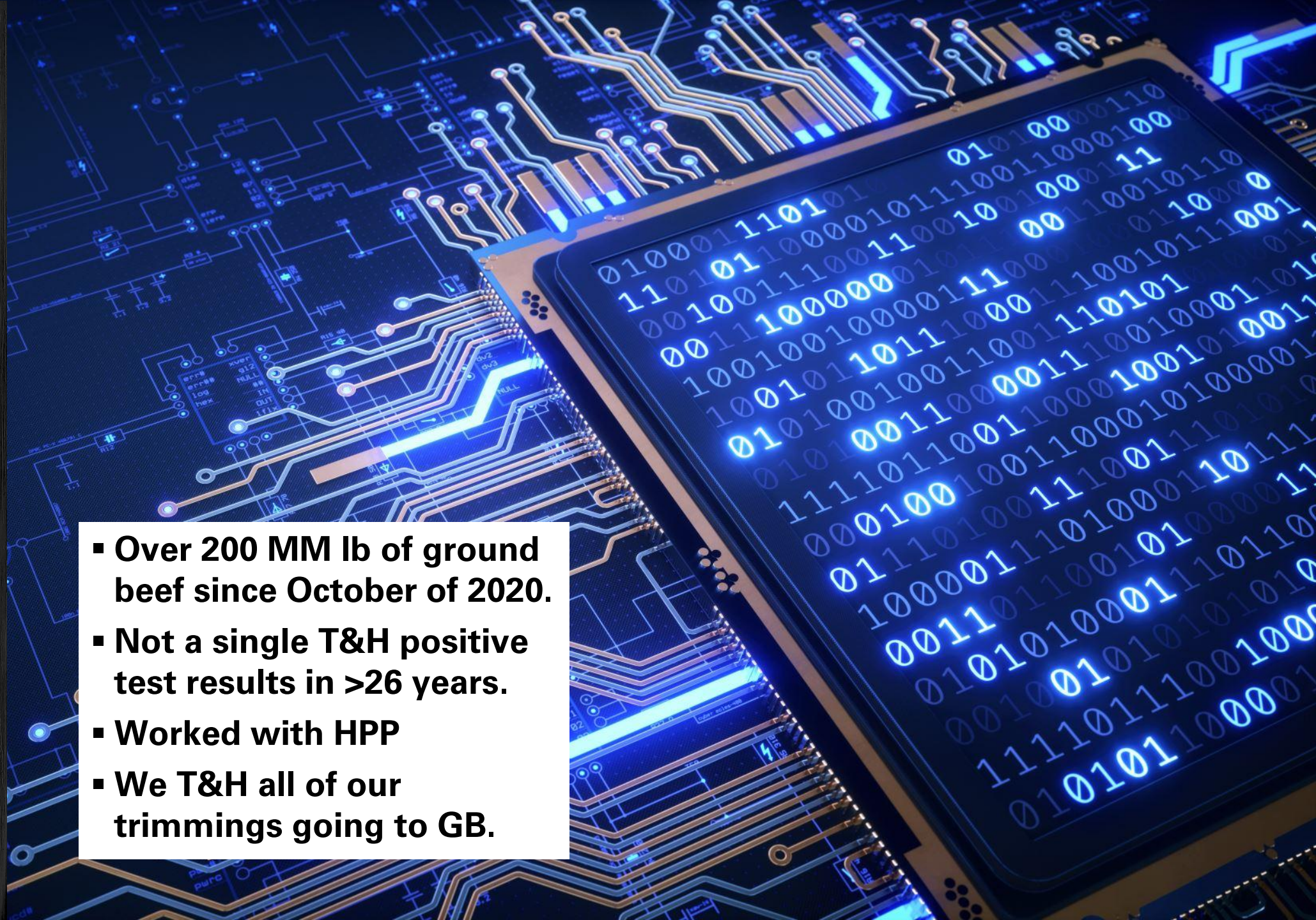


59% know nothing about Irradiation today

Survey question: Do you know what **irradiation** is when it comes to food safety?



What is the right Technology choice for US?

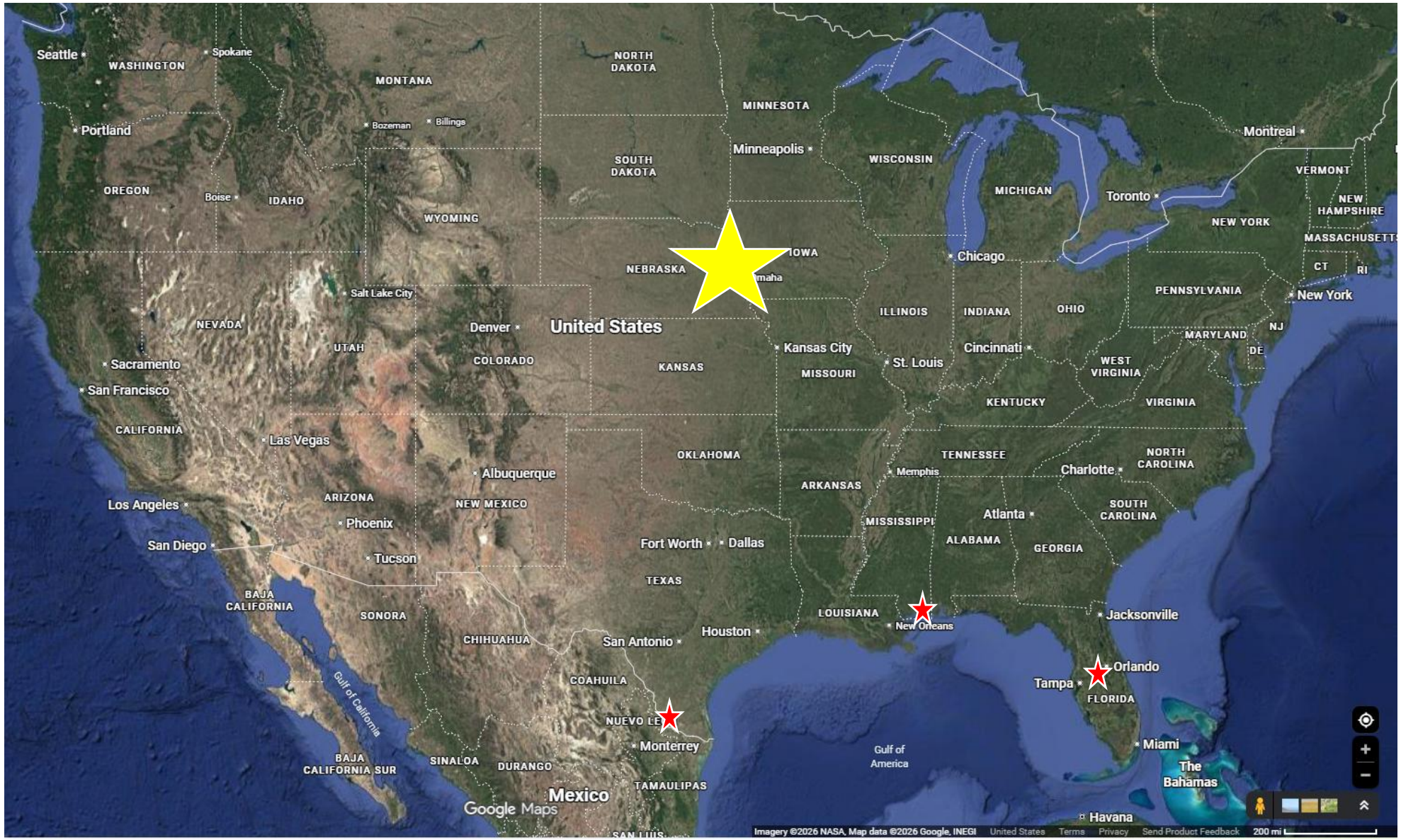


- **Over 200 MM lb of ground beef since October of 2020.**
- **Not a single T&H positive test results in >26 years.**
- **Worked with HPP**
- **We T&H all of our trimmings going to GB.**

Technology fit with Brand

Can we Procure Gamma Irradiation in the Midwest?

Generating Local Capacity



To Build or Not to Build???

Mission and Core Values and Protection

Thank You!

Food Irradiation as a Public Health Intervention: Consumer Knowledge and Behavior

Kate Marshall, MPH

Michael Ablan, MPH

Prevention, Evaluation, and Analysis Team

Outbreak Response and Prevention Branch

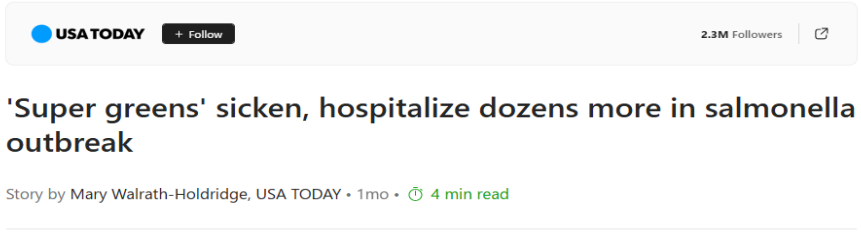
Division of Foodborne, Waterborne, and Environmental Diseases

5/13/2026

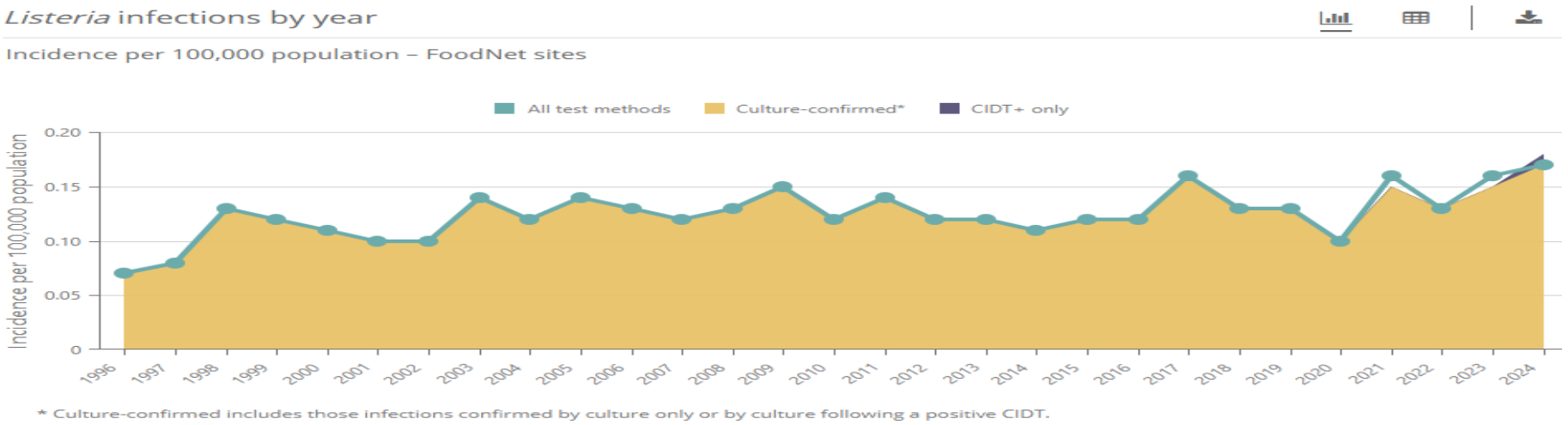
Foodborne infections are common, costly, and preventable

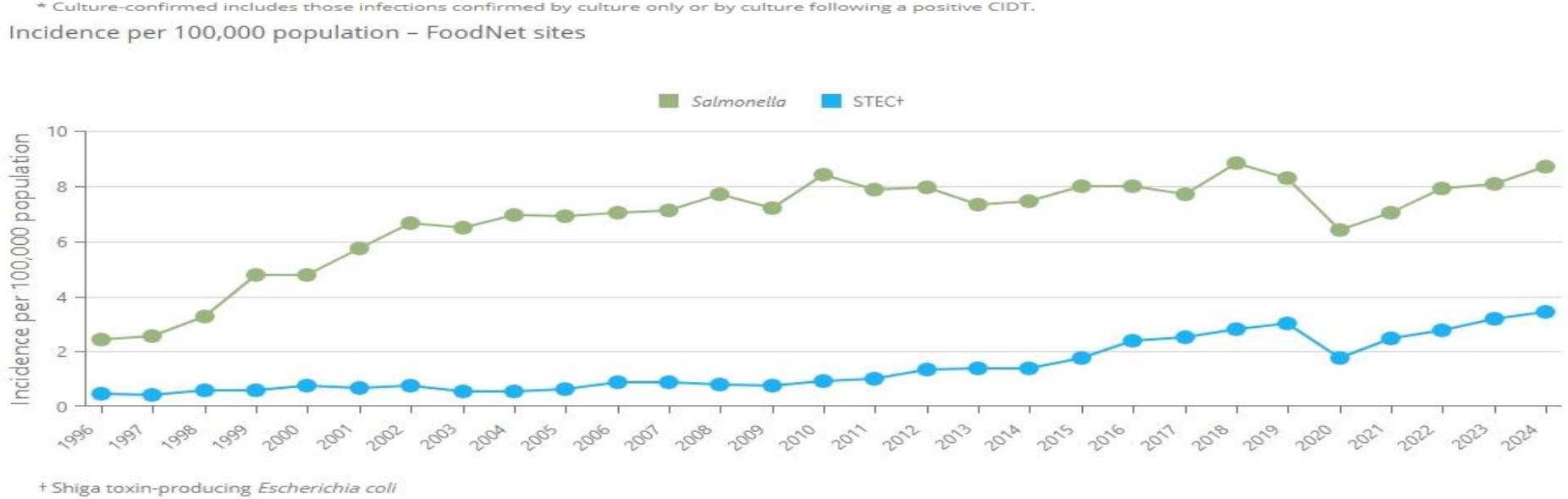
Each year an estimated **48 million people get sick** from a foodborne illness, **128,000 are hospitalized**, and **3,000 die**

CDC coordinates **17-36** multistate foodborne illness investigations each week



Rates of *Salmonella*, STEC and *Listeria* infections aren't decreasing





Multiple opportunities and tools to prevent foodborne illness from farm to fork

Vaccines

Cold plasma

UV-C

Cooking

HACCP

Bacteriophage

Irradiation

HPP

Probiotics

Biosecurity

Pasteurization

Consumer education

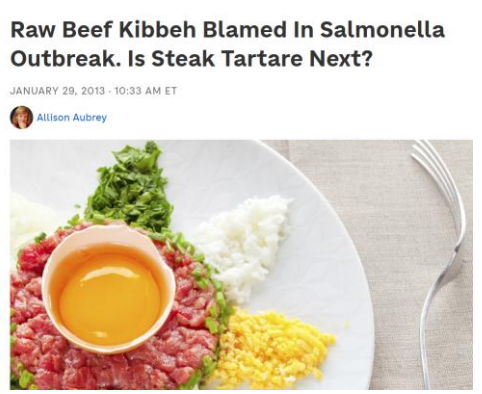
Good Agricultural Practices

Cleaning and disinfection

Food safety culture

Irradiation is one tool that could help prevent foodborne illness particularly for certain populations or foods

- **Foods like:**
  - Raw or undercooked ground beef
  - Undercooked liver pate
  - Raw flour
- **Foods served to vulnerable populations**
  - People who are hospitalized
  - Older adults
  - People with immunocompromising conditions
- **People who wish to lower their risk for foodborne illness**



CDC's work to understand possible public health impact of irradiation

During 2009-2020, **155 outbreaks** were linked to **irradiation-eligible** foods

Irradiating **50%** of the currently unirradiated **ground beef** supply could prevent an estimated ***each year:***

	Illnesses	Hospitalizations	Deaths	Direct healthcare costs
***E. coli* O157**	**3,285**	**135**	**2**	**$2,972,656**
Salmonella	**20,308**	**400**	**6**	**$7,318,632**

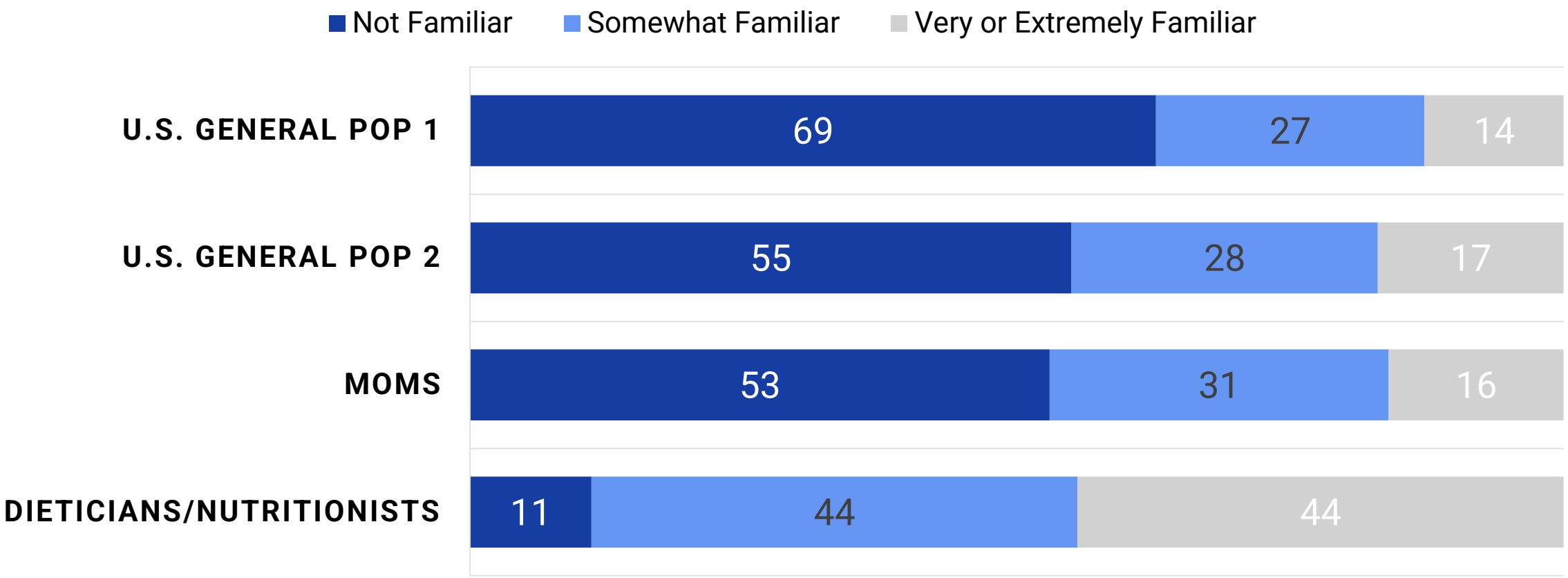
CDC's Consumer Focused Projects

2021-2022 focus groups and surveys

- 10 Focus groups (79 participants)
  - Parents of children ages 0-4
  - Adults ages 18-64
  - Adults ages 65+

- 5 Surveys (2,508 participants)
  - "Food Influencers" (Dieticians and Nutritionists, 187 Participants)
  - General U.S. Population (2,017 participants)
  - Moms w/ children <18 (304 participants)

Most people surveyed were **not familiar** with food irradiation



Lack of knowledge ≠ Lack of interest

67%

of people **didn't know if irradiated foods are sold** where they shop

50%

didn't know what to look for on food label to identify irradiated foods

57%

didn't know where to buy irradiated foods

58%

want to **know more about irradiation**

"I don't know that I would go out and buy something right now, but hearing more about the process, and how long they've been doing this does make me more comfortable. I'm a little excited." (Parent)

Older adults may be more knowledgeable about irradiation

MYTH

Irradiated foods are bad for my health in the long term

18-29 years		65+ years	
27%	vs	**7%**	Agreed ✕

Irradiation makes food radioactive

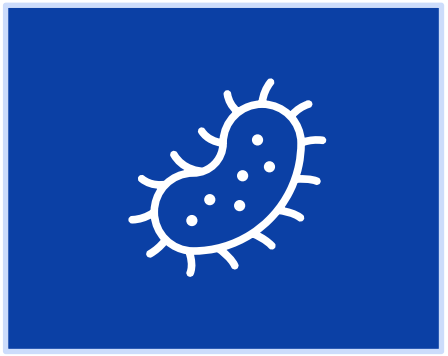
18-29 years		65+ years	
25%	vs	**4%**	Agreed ✕

FACT

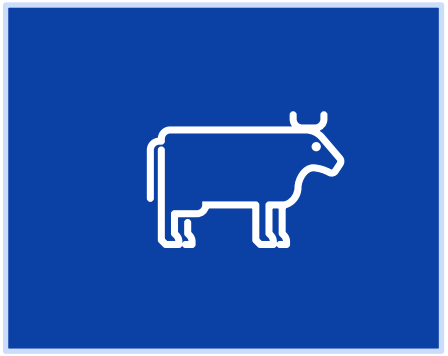
Irradiation makes food safer

18-29 years		65+ years	
22%	vs	**7%**	Disagreed ✕

Perception that foods carry germs may influence **interest in buying** irradiated foods

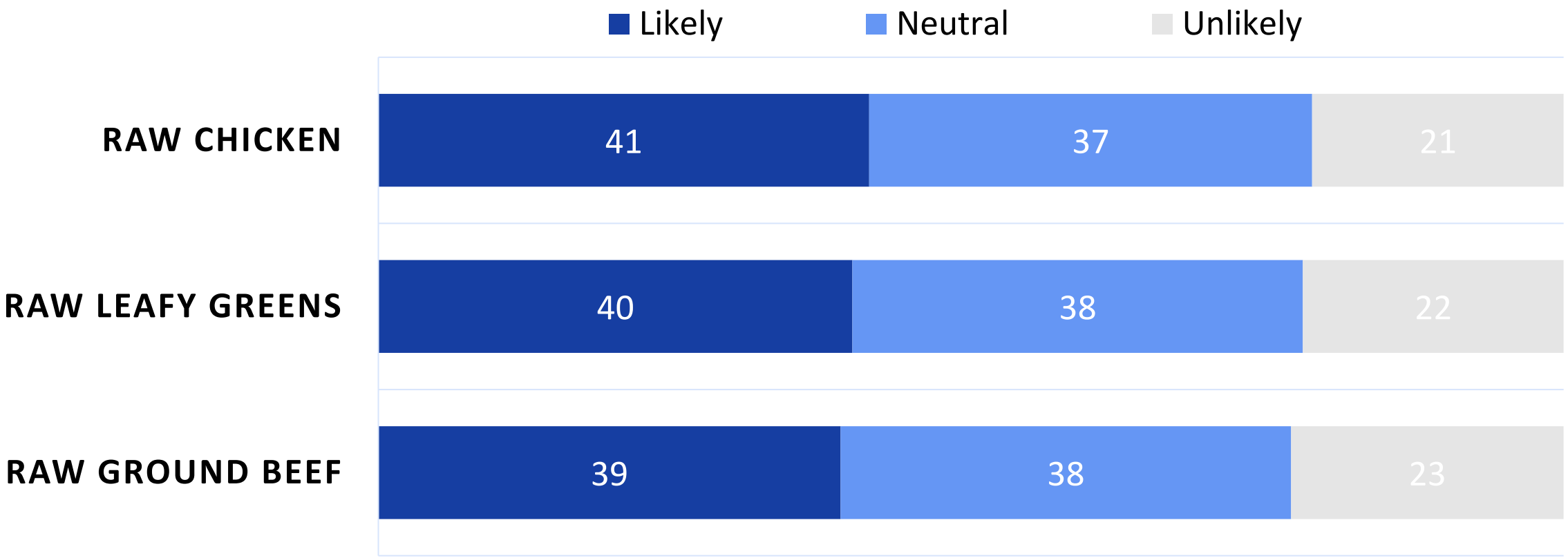


"I don't like to have to worry about foodborne illnesses. To know that there was an extra step to make sure that any kind of germ that could make the meat bad was irradiated out of it…that doesn't scare me that much." (Parent)



"But beef…you can't really wash it too-too well like some things. So…I think having that irradiated would be safer, in my opinion." (Adult, 18-64)

Even with limited knowledge, many people report being **likely** to buy irradiated versions of foods…



CDC's work on Food Irradiation

CDC's webpage about Food Irradiation

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For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

How Food Irradiation Works

For Everyone
FEBRUARY 27, 2024

KEY POINTS

- Food irradiation is a tool to help keep food safe from germs.
- It does not change the texture or appearance of food.
- Food does not become radioactive.
- The process is safe and effective.