Food Irradiation

- Lane A. Highbarger, Ph.D.
- Division of Food Ingredients
- Office of Food Additive Safety
- Center for Food Safety and Applied Nutrition

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A Brief History of Food Irradiation

- **1905** Begins the era of food irradiation.
- **1958** Congress defines a source of radiation as a food additive.
- **1980** Foods irradiated up to 10 kGy considered to be safe and wholesome.
- **1997** Foods irradiated at any dose should be considered as safe and as wholesome as foods treated by any other conventional process.
- **2001** Irradiation is used to eliminate possible traces of Anthrax.
- **1984-Present** FDA approves the use of irradiation in a variety of foods.

Federal Food, Drug, & Cosmetic (FD&C) Act

Food Additives Amendment - 1958

- Defines "food additive" (w/ GRAS exemption)
- Requires premarket approval of new uses of food additives, if not GRAS or otherwise exempt from the definition
- Establishes the standard of data review
- Establishes the standard of safety
- Establishes formal rulemaking procedures

Food additive regulations are located in Title 21 of the U.S. Code of Federal Regulations (21 CFR)

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Federal Food, Drug, and Cosmetic Act

- **Sec. 201(s): Food Additive Definition**

- Any substance the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting, or holding food; **including any source of radiation intended for any such use**)***

Source of FDA's Authority over Food Irradiation

Section 409 Defines "unsafe food additive"

A food additive is considered unsafe unless:

- An exemption for investigational use; or
- A regulation that prescribes the conditions under which such additive may be safely used

Under section 402 of the Act, Foods are adulterated if they contain unapproved food additives

Section 402(a)(7) – "**a food shall be deemed adulterated if it has been intentionally subjected to radiation**, unless the use of radiation was in conformity with a regulation or exemption in effect pursuant to section 409…"

Sources of Ionizing Radiation

- Cobalt 60 – 1.33 MeV
- Cesium 137 – 662 keV
- Electron accelerators operated at10 MeV or less
- X-ray generators operated at 7.5 MeV or less

Dose – What it means

- Irradiation doses are measured in gray (Gy)
  - Gy is measured in joule/kg absorbed energy
  - $1\ Gy = 1\frac{J}{Kg} = 1\ m^2\ x\ s^{-2}\ == 1\ Sievert$
- Applied dose = energy source· time exposed
- Absorbed dose depends on many factors

Food Irradiators

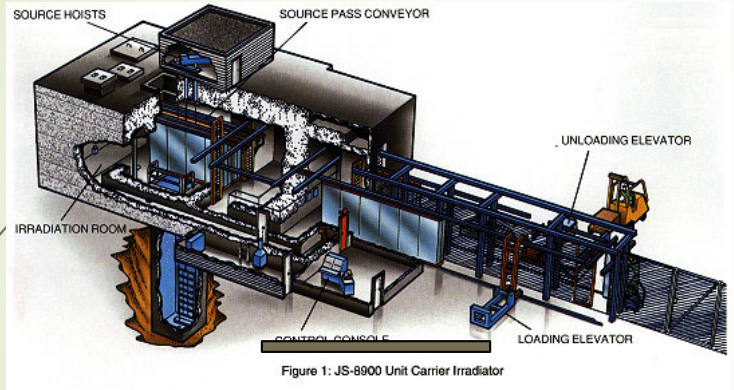
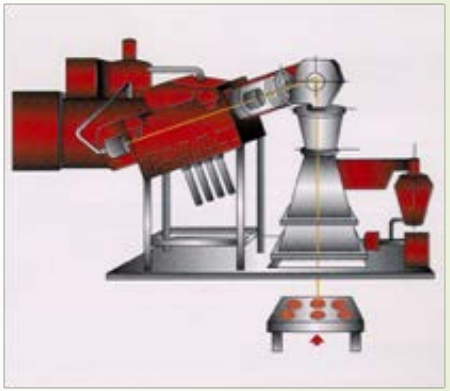


Figure 1: JS-8900 Unit Carrier Irradiator

Gamma



Electron beam

Why Irradiate Food?

- **Low Dose (<1 kGy)**
  - Control insects
  - Inhibit maturation
  - Inhibit sprouting
- **Medium Dose (1-10 kGy)**
  - Extend shelf life
  - Reduce microorganism level
- **High Dose (> 30 kGy)**
  - Sterilize - analogous to canning
  - Decontaminate certain food additives, e.g., spices

Foods Permitted to be Irradiated Under FDA's Regulations

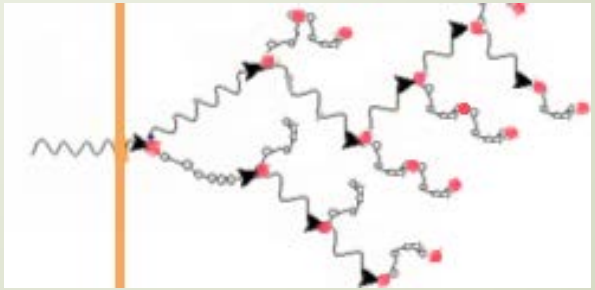
All foods	Arthropod Control 1 kGy max
Dry Enzyme Preps.	Microbial Control 10 kGy max
Fresh Foods	Maturation Inhibition 1 kGy max
Spices/Seasonings	Microbial Control 30 kGy max
Poultry	Microbial Control 4.5 kGy/7 kGy
Seeds for sprouting	Microbial Control 8 kGy max
Shell eggs	Microbial Control 3 kGy max
Meat and meat byproducts	Microbial Control 4.5 kGy/7 kGy
Molluscan shellfish / Crustaceans	Microbial Control 5.5 / 6.0 kGy max
Fresh lettuce and spinach	Microbial Control 4 kGy max
NASA	Sterilization 44 kGy min

Other irradiated substances

Medical equipment	Microbial Control
Laboratory animal diets	Microbial Control 50 kGy max
Poultry feed	*Salmonella* spp. 25 kGy max
Pet foods, treats and chews	*Salmonella* spp. 50 kGy max

Method of Action

- **E-beam** – shallow penetration
  - Converted to **x-ray** for more penetration
- **Gamma** – 'deeper' penetration
- All act *via* similar mechanisms



Susceptibility

- Mammals > Insects > **Single Cell Organisms** > Viruses; (Prions Likely Resistant)

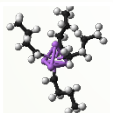
- **D_{10}** – The radiation dose needed to inactivate 90% of the microbial load in the food matrix

Bacterial Susceptibility

- All bacteria have different susceptibilities to radiation (values in kGy)
  - *Salmonella spp.* – *0.3 - 0.8 kGy*
  - *Listeria monocytogenes* – *0.35 - 0.7 kGy*
  - *E. coli* O157:H7 – *0.25 - 0.4* kGy
  - Spores – *2.5 - 5*+ kGy
- A 99.999% reduction = 5 x D_{10} value

Safety Considerations

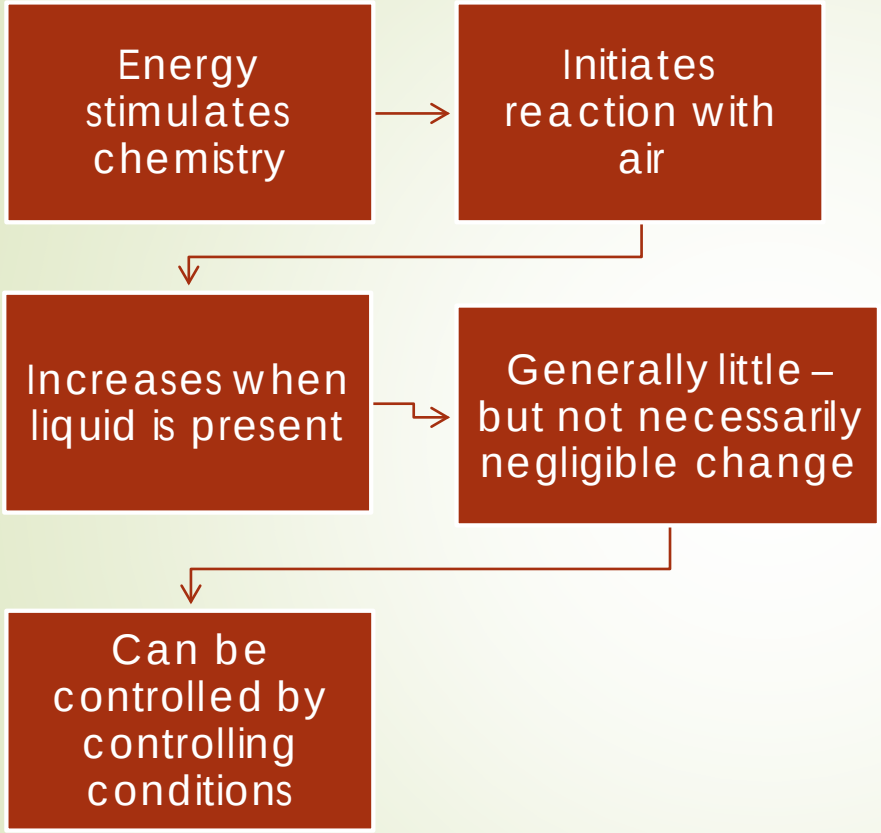
Radiological Safety



Chemical Change and Potential Toxicity

Nutritional Adequacy

Potential Microbiological Hazard



Chemical Change

Heated Lipid
(180 ºC for 1 hour)

vs.

Irradiation at 120 kGy

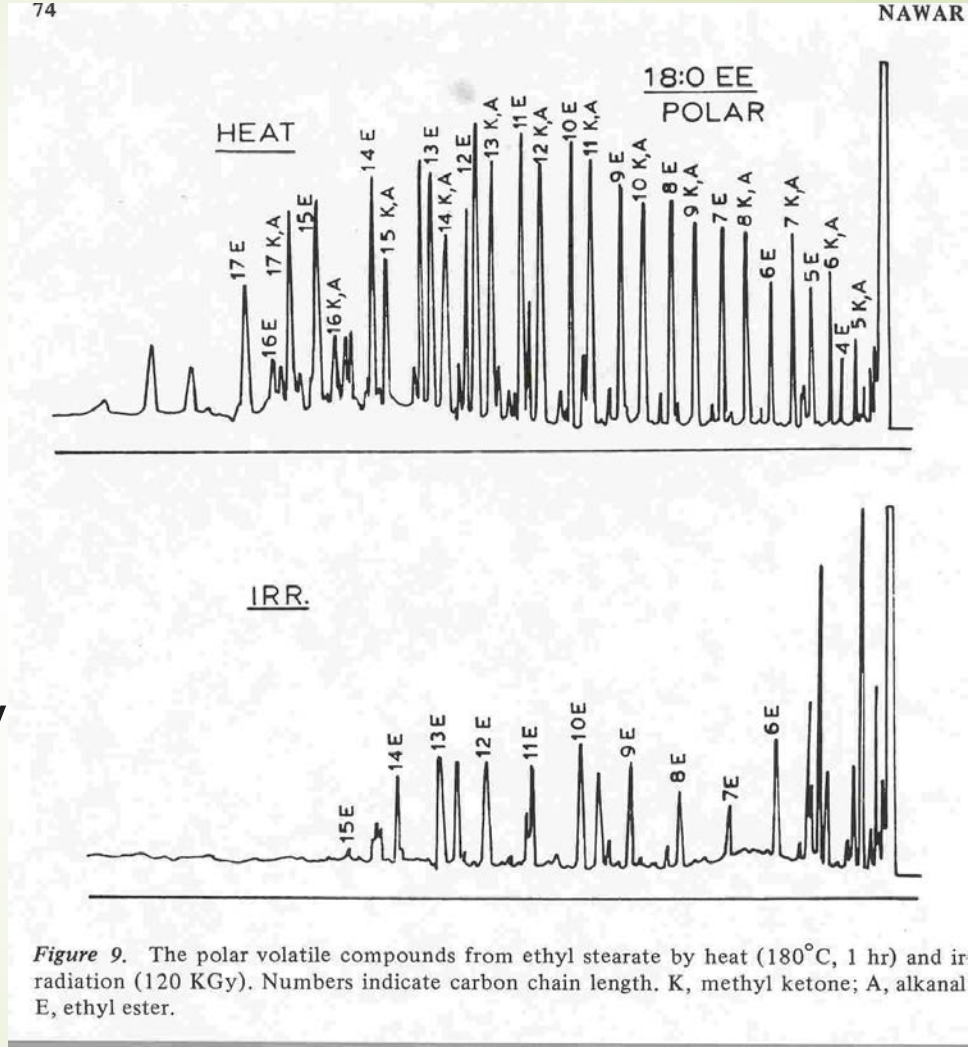


Figure 9. The polar volatile compounds from ethyl stearate by heat (180°C, 1 hr) and ir radiation (120 KGy). Numbers indicate carbon chain length. K, methyl ketone; A, alkanal E, ethyl ester.

Nutrition Issues

Vitamins are labile to heat and radiation

Minerals insensitive

Microbiological Safety

Radiation sensitivity varies with species

Sensitivity varies with environment

- Temperature; water activity; pH; salt; etc.

Labeling Criteria

- The FDA requires that irradiated foods bear the **radura label** and must state on the label "**Treated with radiation**" or "**Treated by irradiation**"

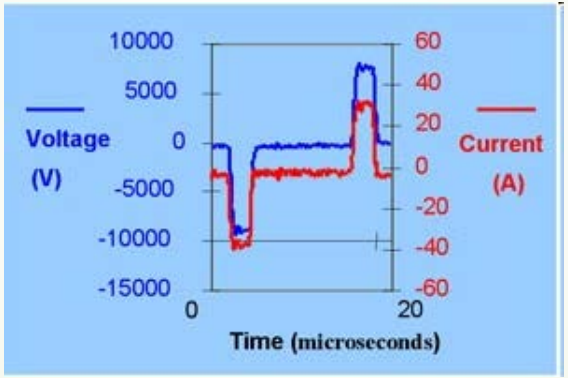
Other Non-thermal Processing Techniques

High Pressure Processing

- $80k - 130k\frac{lb}{in^2} - or - 5.5x108 - 9x108$ pascal
- Effective at elimination of microbial contamination
- Spores are resistant
- Expensive

Pulsed Field

- Short bursts of electricity used for microbial control.



- Liquids, e.g., juice, milk, liquid eggs.
- Low cost.

UV Irradiation

- Effective at microbial decontamination in liquids.
- Approved for use in surface decontamination.
- Approved for use in juices.

Web Based Information Resources
Food Safety and Irradiation

- Kansas State University - https://www.ksre.k-state.edu/historicpublications/pubs/mf2426.pdf
- Questions and Answers. Food Irradiation Processing Alliance – http://www.foodirradiation.org/PDF/FIPA%20QandA.pdf
- FDA – Food Irradiation: What You Need to Know – https://www.fda.gov/food/buy-store-serve-safe-food/food-irradiation-what-you-need-know
- USDA – Irradiation and Food Safety Answers to Frequently Asked Questions – https://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/production-and-inspection/irradiation-and-food-safety/irradiation-food-safety-faq
- Food Safety dot gov – http://www.foodsafety.gov/
- Food Irradiation – http://www.foodirradiation.org/
- WSJ Blog on *E. Coli* – http://blogs.wsj.com/health/2010/05/07/health-blog-qa-what-to-do-about-e-coli/

Questions?


NON - IRRADIATED -
IRRADIATED - (0.2 M RAD)
STRAWBERRIES -
15 DAYS STORAGE 38°F (4°C)