



FOOD IRRADIATION

FScN 1102
Food: Safety, Risks and
Technology
Topic 13

FOOD SCARES

- BSE in meat
- Cryptosporidium in water
- Salmonellae in intact eggs
- Cyclospora in raspberries
- Hepatitis A in strawberries
- E. coli H157:O7 in apple juice and hamburger
- Listeria in hot dogs






Resurgence of deadly bacterium spurs action to curb contamination

As food recalls mount, scientists go back to basics

With, Deputy administrator for the office of public health and safety of the Department of Health and Human Services, says that in 1996, contamination of hot dogs and chili was by a bacterium that had been found in 1980. The bacterium, which is now known as *Salmonella enteritidis*, is a common cause of food poisoning. The bacterium is found in many foods, including hot dogs, ground beef, and poultry. The bacterium is also found in raw milk and raw eggs. The bacterium is a common cause of food poisoning, and it is also a common cause of illness in young children, the elderly, and people with weakened immune systems. The bacterium is also found in raw milk and raw eggs. The bacterium is a common cause of food poisoning, and it is also a common cause of illness in young children, the elderly, and people with weakened immune systems. The bacterium is also found in raw milk and raw eggs. The bacterium is a common cause of food poisoning, and it is also a common cause of illness in young children, the elderly, and people with weakened immune systems.

Food Drug and Cosmetic Act

- 402(a)(1) - a food is adulterated if it contains any poisonous or deleterious substance which may render the food injurious to health
 - ➔ microbes : pathogens such as E. coli O157:H7
 - ➔ chemicals :
 - ↪ DDT, PCBs
 - ↪ Pb, Hg



Pathogens


- no regulations setting standards for maximum amount
- CPGM 7106.18 guidelines for dairy
- zero tolerance ie may be injurious to health ie one organism can lead to problem for some one
- actual action level based on ability to detect, eg 1 Listeria / 25 g

Food Drug and Cosmetic Act

- 402(a)(4) - a food is adulterated if it is prepared or held under conditions whereby it may become contaminated with filth or rendered injurious to health

standard says no need to prove food is actually contaminated

USDA Approach :HACCP vs continuous inspection



E. coli O157:H7

- Estimated 10-20,000 cases vs 24,000-120,000 Salmonellosis cases
- 49% from beef vs 3% of salmonellosis from beef
- 1993 Jack in the Box 700 ill with 4 deaths due to HUS (5% of cases)
- Hudson Beef recall and demise
- Health cost \$200-\$400 MM

beef problem


- infected cow sheds at 10^7 to 10^8 e. coli per gram feces ~1% infected randomly
- carcass ~ 200 lbs with one gram
- hamburger batch 2 to 5 tons
- $5 \times 2000 \times 454 = 4.5 \times 10^6$ grams
- contamination ~ 2/g or 50/ 25g meat
- Legal limit < 1/25 grams

Listeria

- Cleaning promotes presence
- Needs moist environment
- Symptoms show up 7 to 14 days after consumption
- 20% death rate
- 1998/9 Bil Mar Foods - cured RTE meats 21 deaths
 - Possible temperature abuse and consumption near end of shelf life

USDA HACCP Policy

- USDA Wholesome & Inspected Seal
- On-line inspection changed to HACCP started 1/31/98
- poultry >30% contaminated with Salmonellae or Campylobacter
- now require testing of meat - for generic E coli and must meet salmonella performance standard (made same for beef & poultry)
- 2/6/98 USDA withdraws inspection for visible fecal matter in a HACCP plant
- 1999 Supreme Beef - violates Salmonellae performance standard 3 times-now in court



Beef processing solutions

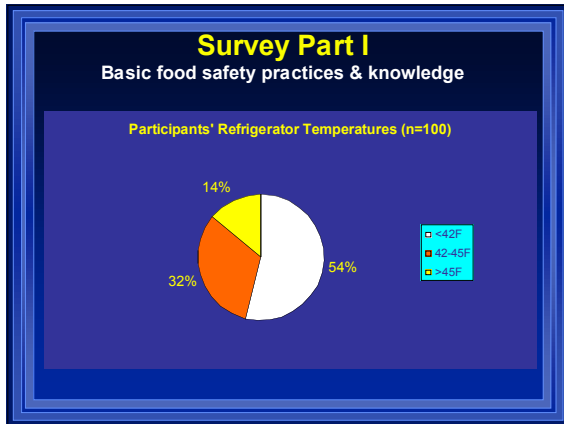
- mandatory USDA HACCP
 - set CCPs for generic E. coli for slaughter plants rolling 13 test results with > 3 marginal
 - Salmonellae performance standard for raw and ground meat -
 - 63 FR 1800-02 1/12/98
 - 64 FR 732-49 1/6/00
 - Ground beef >7.5% eg 5 of 53 samples

TRFIC Home Food Safety Survey



<http://trfic.umn.edu>

- 100 New Brighton MN residents
- 64% very to extremely aware of Hudson beef and Bil Mar foods recalls
- 39% stopped buying specific brands
- 14% stopped buying product category




- ### Logical Solution - kill step
- Pre- processing reduction
 - Post-packaging kill
 - Canned foods 1 in 10 billion risk
 - Risk assessment for meats e.g. 1 in 1 million ie. 6 log cycle reduction


- ### 1997 Lauren Beth Rudolph Act
- California Informed Consent
 - specific temperatures for cooking ground meat (155 F 15 sec), eggs, pork, poultry
 - customer can order rare meat
 - no rules for solid meat or fish (sushi)
 - three year sunset rule

Technology Solutions

- irradiation



PRELIMINARY: Ag & Fd Division Food
Inspection Control sample experiments
for irradiation of hamburgers.



FDA allows irradiation of red meat

Food safety experts are pleased; consumer acceptance uncertain

12/3/97
Pioneer Press



Business

Beefing up food irradiation

12/3/97



Milk Pasteurization Prologue

- early 1900's - raw milk identified as major carrier of pathogens
 - ➔ Tuberculosis
 - ➔ Brucellosis
- scientists, public health officials call for pasteurization treatment (heat)

Milk Pasteurization Prologue

- Consumer groups argue process is excuse for sale of contaminated milk
- argue diminishes nutritional value
- leads to harmful products
- takes life out of milk
- may be done carelessly
- diminishes fertility
- Mass. requires "Heated Milk" label

Food Irradiation History

- 1896 discovered by Becquerel
- 1900 experiments by Prescott MIT
- 1920's US & French patents for killing parasites in pork, canned food
- 1940 Manhattan Project
- 1943-68 MIT/US Army research on food
- 1957 Ted Labuza irradiates meat & eggs

Food irradiation

- WHO approval 1980
- JECFA-FAO approval 1980
- approved in 35 countries
- products in 28 countries
- 18 countries approved for muscle foods
- CAST acceptance 1984
- level approved does not make food radioactive


Food Additives Amendment 1958

- 402(a)(2) A food is adulterated if it contains any added poisonous or deleterious substance except one that is either:
 - Generally Recognized As Safe 201(s)
 - Food Additive (Sec 409)
 - Color Additive (Sec 706)
 - New Animal Drug (Sec 512)
 - Tolerance Setting (Sec 406)
 - Pesticide (Sec 408)
- Note that added means intentional addition




FD&C Act Sec 201(s)

The term food additive means any substance the intended use of which results or may reasonably be expected to result, directly or indirectly, in its becoming a component of food or otherwise affecting the characteristics of any food and including any source of radiation intended for any such use



Packaging Materials



packaging materials are additives since contact food or extracted by food

21 CFR 170.3 (e) defines packaging as additive
21 CFR 179.45 requires specific approval if irradiated

Food Irradiation Technologies

- Gamma radiation
 - Cobalt 60 (5 yr half life) > 3" penetration
 - Cesium 137 (30 yr half life)
- High energy electrons 10 MeV
 - 1 1/2 inch penetration
 - Electronic pasteurization, "SureBeam"

21 CFR 179 Regulations

- promulgated for meat, pork, poultry, spices, fresh produce and fruits
- level of radiation allowed is limited
- gamma , X-ray and electron beam
- informed consent label

Approvals

- insect deinfestation of wheat (0.2-0.5 kGy) 1963
- sprouting inhibition potatoes 0.05-0.15 kGy 1964
- NASA Space Foods 1960s through today
- Trichinellae in pork 0.3 to 1.5 kGy 1985
- fresh produce 1 kGy 1986
- Herbs & Spices 30 kGy (100 MM lbs) 1986
- poultry 3 kGy 1990
- animal feed and pet food 2-25 kGy 1995
- beef 4.5 kGy fresh, 7 kGy frozen 12/2/97
- 62FR 64107-64121 12/23/99



Defect Action Levels

- High levels of contamination in spices
- Cinnamon
 - < 5% insect infested pieces by weight
 - < 5% moldy pieces by weight
 - < 1 mg mammalia excreta per lb..
 - < 400 insect fragments / 50 g in ground product
 - < 11 rodent hairs per 50 g ground



Special Food Uses

- Florida Nursing homes
- Marriott Intl Food Service
- Carrot Top - Chicago
 - ➔ Chicken & fruits
- Church Street Station Orlando
 - ➔ 50,000 lb chicken/year
 - ➔ Food Technology Inc Mulberry FL



Control vs 2 kGy 2 weeks at 4°C
Carrot Top Market Chicago IL



Onions 3 months @ room temperature

Other major uses

- Drugs
- Tampons
- Bandages
- Baby bottle nipples
- Medical devices
- Body bags
- Packaging

USDA Final Approval




Red Meat Irradiation

- 62 FR 64107 FDA approval 12/3/97

72159 Federal Register / Vol. 64, No. 246 / Thursday, December 23, 1999	
DEPARTMENT OF AGRICULTURE	Food Irradiation
Food Safety and Inspection Service	Food irradiation is the process of exposing food to high levels of radiant energy. Forms of radiant energy include: microwave and infrared radiation that heat food during cooking; visible light or ultraviolet light used to dry food or kill surface microorganisms; and ionizing radiation, resulting from cobalt-60, cesium-137, x-ray machines, or electron accelerators, that penetrates deeply into food, killing insect pests and microorganisms without raising the
8 CFR Parts 301 and 434	
[Order No. 10-0707]	
Irradiation of Meat Food Products	
AGENCY: Food Safety and Inspection Service	
ACTION: Final rule.	

Process Alternatives

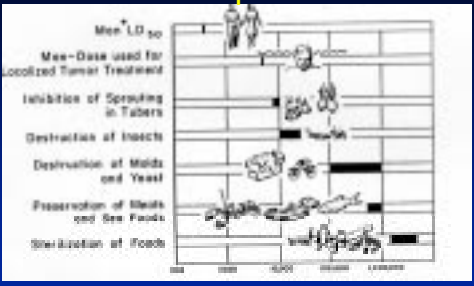
- gamma radiation
 - ➔ Cobalt - 60 (5 yr. half life) >3" penetration
 - ➔ Cesium 137 (30 yr. half life)
- high energy electrons 10 MeV
 - ➔ 1 1/2 inch penetration
 - ➔ D. Olson Iowa State Univ. test unit
- X-rays 5 MeV
- 1 kGy dose ~ 10 bonds broken per 10 MM similar to cooking
- 1 kGy = 10 million chest X-rays



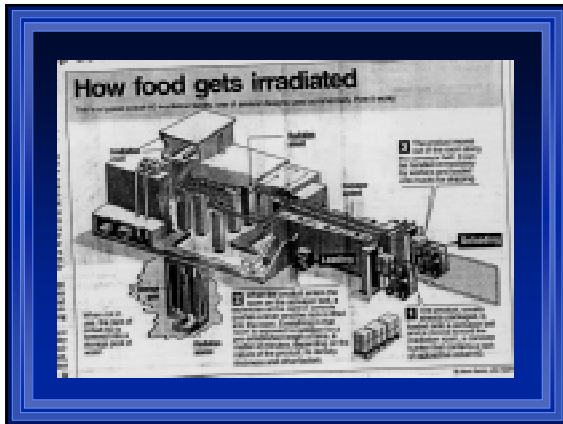
Dose/Response

- The smaller the organism the higher the dose
- Radiation dose is measured in kiloGray, kGy
1kGy = absorption of 1 Joule of energy per kg of food
- Dose depends on the type of food

Dose response




dose in rads 1 kGy = 100,000 rad



Irradiation process

- labyrinth for safety
- 6 ft thick cement walls or 2 ft steel
- gamma emitting pencils 18" by 1/2"
- stored in 15 ft deep water pool
- treatment time 5 to 15 minutes
- done in package to prevent recontamination





High-energy Electrons



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preservation mechanism

- produces free radicals in water
- radicals attack proteins and DNA
- cells die as DNA disrupted



Organism D_{value} resistance

- salmonellae 0.4 to 0.8 kGy
- Campylobacter 0.2 kGy
- E. coli 0157:H7 0.24 kGy
- Listeria 0.45 kGy

1 D = amount to reduce to 10% of original
need > 6 log kill for pasteurization

Beef Needs

- 9 billion lbs ground beef consumed
- many people used to eating rare
- learn to cook well done (pork as an example)
- problem is much meat eaten out
- need to build >300 plants @ 25 MM lbs per year NIMBY
- Need to change from chub to patty
- Similar requirements for poultry

Irradiation costs

- average plant \$7 to \$12 MM
- handle 250,000 lb per day
- need isolated facility
- need radiation safety officer (3) 25% of cost
- cost at plant 1.3 to 7 ¢/ lb (1989)
- cost to consumer ~ 7 to 10 ¢/ lb

Cobalt 60

- half life ~ 5 years
- all rods from Canada (Nordion)
- replace (add new) 12% per year
- leave old rods in water pool
- more penetration depth than electrons
- cheaper
- but leaves radioactive rods in plant



It is a proven, reliable method used to study food safety to eat. It kills germs and molds while leaving no chemical residues. According to former assistant U.S. Surgeon General "Irradiation... will ensure the world's one step closer to 100% food safety for all."

• Gamma irradiation is the smart choice for...
It is a safe process. Gamma energy penetrates...
killing 99.9% of the product's microorganisms...
the SteriGenics process costs only 1¢ per package...
can require total plant costs of $\\$1000$ with the fact...
that your product's shelf life and quality will be more...

For more information on SteriGenics and how gamma irradiation can benefit your business, call 800-773-4141. You'll receive free copies of "A Working Guide to Food Irradiation" and "The Advantages of SteriGenics." Contact Food Safety (SHEC) for the Food Industry.


SteriGenics
Fast. Proven. In Quality. SteriGenics.

Transportation safety



Dropping metal casks

NIMBY



2/14/00

Current processors

- Vindicator - now Food Technology Mulbury FL
- Steris (Isomedix) New Jersey
- Sterigenics (California + other locations)
- Gray*Star (Cesium unit)
- Currently 40 commercial units
- High Voltage Engineering

Excell - ConAgra IBP Solution

- Use electron beam (Titan)
- Build large plant in Midwest
- Ready in 2 years
- < 1% of all ground beef

Informed consent

- ingredient list
- additives
- saccharin warning
- alcohol warning
- aspartame warning
- Olestra warning
- Radura symbol

FDA Modernization Act 11/21/97

- Sec 403C (a) No provision of 210(n), 403(a) or 409 shall be construed to require on label A separate radiation disclosure that is more prominent than the declaration of ingredients

Radura Symbol



"Treated by irradiation"



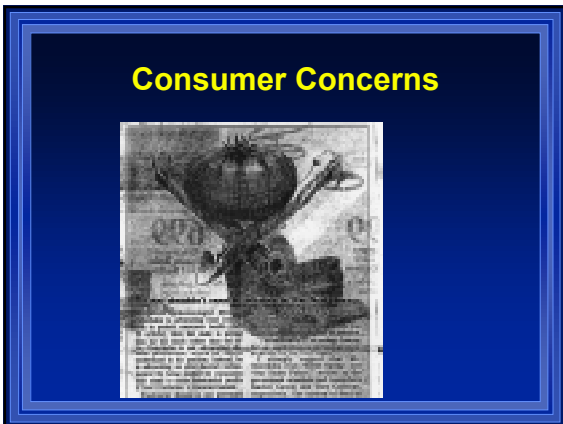
Questions

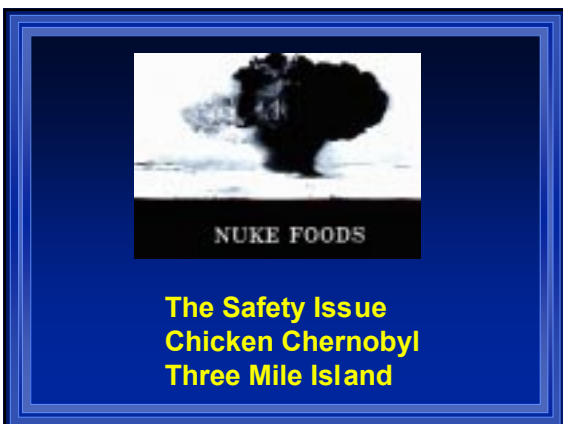
- Changes in practice - ie 10 lb chubs
- free radical stability -> URLs
- URL's - new toxic compounds
- mutation of organisms
- loss of nutrients
- Change of shelf life
- Long term feeding studies

Change of shelf life

- No competing organisms
- No flavor difference immediately after irradiation
- Flavor changes in storage especially if frozen








Food & Water Concerns

URLs
mutants
loss of nutrients
lack of GMPs
need for detection
method
trust us complex



What is the problem

Food and Water
Michael Colby started 1984



Food & Water Ad



Food and Water Campaign

City Pages MPLS 2/25/98

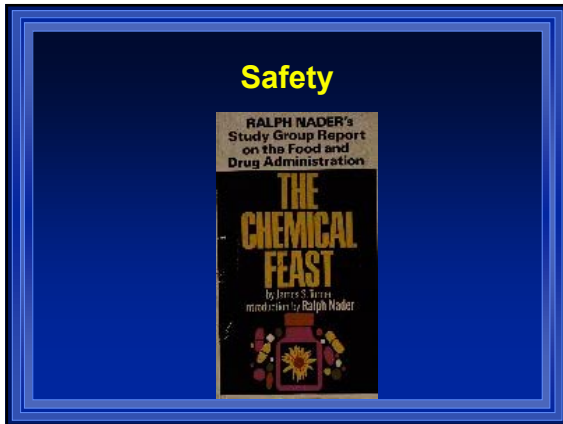




City Pages Response 3/18/98

Positive Outlook





**Sec 409 (c)(3)
Delaney Clause**

No regulation shall issue if a fair evaluation before the Secretary (FDA)

(a) fails to establish that the proposed use shall be safe

Provided that no additive shall be deemed safe if it is found to induce cancer when ingested by man or animal or if it is found after tests which are appropriate for their evaluation of the safety of food additives to induce cancer in man or animals

Natural Carcinogens

- Mushroom Example Agaratine- DNA breaker at 1.2 mg/70 Kg person
- present in mushrooms
- safe dose < 4 g mushroom per day or 1 meal every 100 days
- Foods are GRAS so exempt

Long term study

- Patterson Institute for Cancer Research, Manchester England
- 10 years
- >2000 mice
- 60 generations on radiation sterilized food
- no known effects

Chinese Study

- 1980s
- 400 volunteers
- eight studies
- 7 to 15 weeks duration
- no chromosomal damage

“Absolute safety doesn’t exist, but to be honest, I’ve not seen evidence of harm with this technology”

K. de Winter
EU Consumer Organizations

Ethical Controversy

- irradiation is the only kill step
Dr. Mike Osterholm
- ethics of processor to clean
- Due diligence
- duty of consumer to cook



CMF&Z Public Relations Survey Oct 1997

- 2/3rds say safe handling stickers on meat very important
- 57% want them on produce
- 45% aware of food irradiation (31% in 1996)
- 64% aware of irradiation say would likely purchase meat
- 66% would purchase irradiated produce

1997 FMI Study

- 1000 shoppers
- 70% said food spoilage was major threat to food safety
- 60% would buy irradiated food

Consumer acceptance

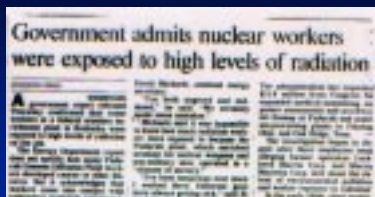
- Iowa State Univ. Studies
- 50 to 60% would buy even if not educated about process
- if told killed harmful bacteria rises to 80%
- 60% would pay a 10 to 20¢ premium



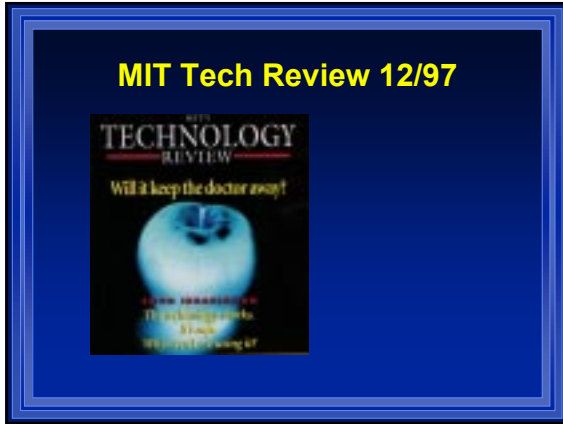
Other benefits

- replacement of harmful pesticides
 - ➔ methyl bromide (cereals) scheduled to be deleted 1/1/2001 Category I acute toxin
 - ➔ ethylene oxide for spices
 - ➔ reduction of food waste
 - ↔ overall 28%
 - ↔ in home 26%

Trust Us

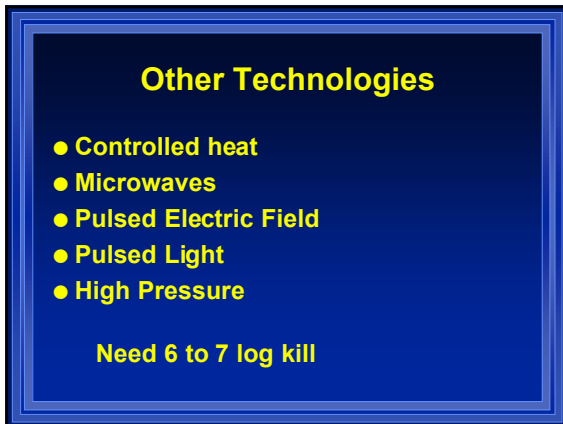


2/14/00



MIT Tech Review 12/97

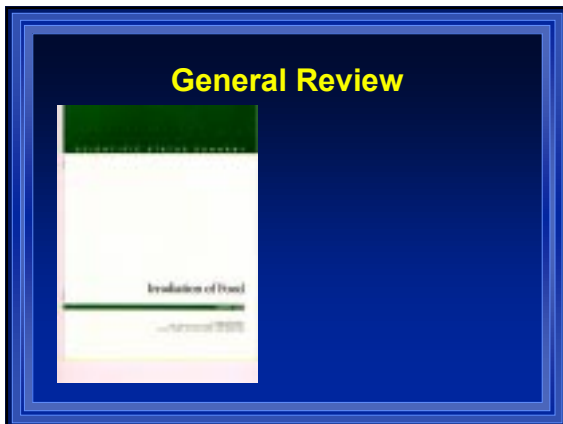




Other Technologies

- Controlled heat
- Microwaves
- Pulsed Electric Field
- Pulsed Light
- High Pressure

Need 6 to 7 log kill



General Review



Other references

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- M Osterholm Irradiation pasteurization of solid foods
 - <http://www.cdc.gov/ncidod/EID/vol3no4/osterhol.htm>
