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Food Irradiation Update

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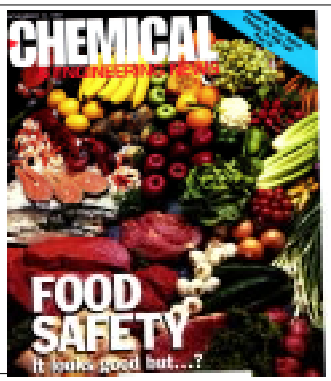
11/10/01



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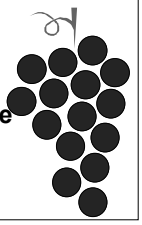
FOOD SCARES



- BSE
- FMD
- Cryptosporodium 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
- Anthrax

Pathogen Problem

- ~ 73 million illnesses a year
- ~ 5000 deaths ~ 0.5% of all deaths per year
- hospital costs ~ $23 billion
- productivity loss ~ $9 billion
- chronic long term illnesses possible
  - Eg Gulian Barr disease,
  - Creutzfeldt Jacob disease
- CDC http://www.cdc.gov/epo/preview/mmwrhtml/00056654.htm

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
    - radionucleotides

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- **US v Seabrook Int'l. Foods**
  501 F Supp 1086 (1980) 662F 2nd 157 (1980)
  - Court ruled that salmonellae are added substances due to human intervention so "may render"clause applies
  - under may render injurious ruling government can set maximum amount which can be zero, i.e. level of detection
  - less burden of proof for US - don't have to show injurious to health at that level, only that it may render injurious

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
- courses.che.umn.edu/00fscn1102-1s/general_food_safety/

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

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Current Pathogen Situation

- Better detection so allowable level decreasing as no set level
- Better reporting System FoodNet-PulseNet
- Emerging pathogens - genetics
- Potential for use of antibiotics on farm to cause microbial resistance
- increase in # of immune compromised
  - elderly
  - cancer
  - AIDS
  - children

USDA HACCP Policy

- USDA Wholesome & Inspected Seal
- On-line inspection changed to HACCP started 1/31/98
- 2/6/98 USDA withdraws inspection for visible fecal matter in a HACCP plant

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Salmonellae

- ubiquitous in animal intestine - fecal route
- 800,000 to 4 million infections / year
  - 3% from beef
  - poultry >30% contaminated with Salmonellae or Campylobacter
- S. enteridiidis in intact eggs
  - 400 outbreaks and 70 deaths-10 yr.
  - Schwanns ice cream > 200,000
- Salmonellae in orange juice
- increased use of antibiotics leads to antibiotic resistant strains eg. DT104

E. coli O157:H7

- Estimated 10-20,000 cases vs 24,000-120,000 Salmonellosis cases
- 49% 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

hamburger 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 x 2000 x 454 = 4.5 x 10^6 grams
- contamination ~ 2/g or 50/ 25g meat
- Legal limit < 1/25 grams

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Listeria problem

- Cleaning promotes presence
- Needs moist/cold environment (grows at < 4 ºC)
- 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

TRFIC Home Food Safety Survey

The Retail Food Industry Center

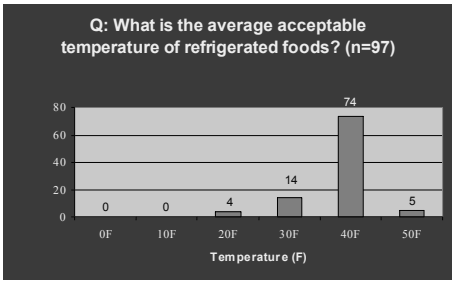
http://trfic.umn.edu

Paper # 01-04

- 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

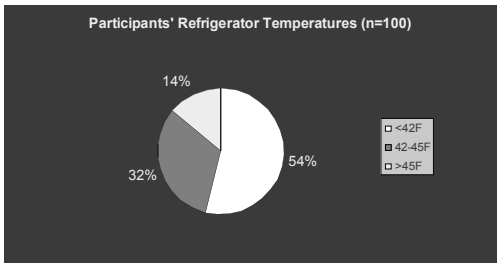
Survey Part I

Basic food safety practices & knowledge



Survey Part I

Basic food safety practices & knowledge



Survey Part I

Basic food safety practices & knowledge

Q: How often do you thaw your meat in the following ways? (Check a box in each row, i-v)

	Never	Rarely	Sometimes	Often	Always
i. In the refrigerator, the night before use (n=96)	6	18	33	37	6
ii. In the microwave (n=95)	17	18	33	30	3
iii. On the countertop the day of use (n=91)	32	26	28	14	0
iv. In the sink submerged in water (n=92)	44	38	14	4	0
v. In the sink submerged in running water(n=90)	61	24	13	1	0
vi. What are other ways you've done it?					

Informed Consent Label

i.e. Home and Food Service kill step and potential cross contamination

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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

Food Processing Problem

- On-line testing not rapid enough
- Can't test all foods
  - high volume processing
- JIT Processing (speed and economy)

Logical Solution kill steps

- 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

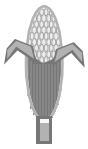
In Final Package Solutions

- irradiation

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

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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

21 CFR 179 Regulations

- level of radiation allowed is limited for specific uses
- gamma , X-ray and electron beam
- informed consent label

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

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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
- fresh produce 1 kGy 1986
- Herbs & Spices 30 kGy (100 MM lbs) 1986

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

Onions 3 months @ room temperature

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Meat and Poultry Approvals

- Trichinellae in pork 0.3 to 1.5 kGy 1985
- 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 USDA approval

Red Meat Irradiation

- 62 FR 64107 FDA approval 12/3/97

72150 Federal Register / Vol. 64, No. 240 / Thursday, December 23, 1999

DEPARTMENT OF AGRICULTURE

Food Safety and Inspection Service

9 CFR Parts 301 and 424

[Docket No. 97-076F]

Irradiation of Meat Food Products

AGENCY: Food Safety and Inspection Service

ACTION: Final rule.

Food Irradiation

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

USDA Final Approval

December 2000

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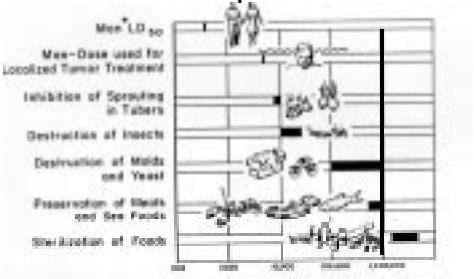
Special Food Uses

- 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

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
  - Iowa State Univ. & SureBeam
- X-rays 5-10 MeV
- 1 kGy dose ~ 1 bonds broken per 1 MM similar to cooking but are radicals
- 1 kGy = 10 million chest X-rays

Dose response



dose in rads 1 kGy = 100,000 rad

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D values for pathogens

dose needed for 90% destruction

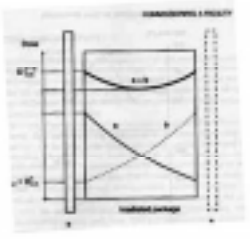
Salmonella	Ground beef	20 C	0.55 kGy
campylobacter	Ground Turkey	5 C	0.27
Listeria monotcytogenes	Chicken	4 C	0.77
	Ground beef	12 C	0.49
E. Coli O157:H7	Ground beef	-17 C	0.31
		5 C	0.24
Yersinia	Ground beef	-30 C	0.39
		25 C	0.2

Food Irradiation R. Molins Wiley 2001

Total Dose = #D_{risk} x D_{value}

- **Salmonellae on beef**
  - **Dose = 6 x 0.57 = 3.42 kGy**
- **E. coli in hamburger assume 10^6/g risk**
  - **Dose = 6 x 0.31 = 1.86 kGy**
    Note dose must be at slowest point in geometry

Effect of one sided vs. two sided



Question of overdose on surface

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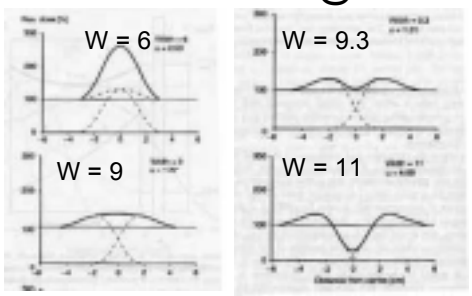
Effect of thickness @ 10 MeV



D values for viruses vs anthrax

dose needed for 90% destruction (1 D)

polio	fish	0 C	3 kGy
Echo virus	MEM	5 C	4.3- 5.5
Hepatitus A	oysters		2
Rotavirus SA11			2.4
Anthrax (NFPA)	Dry goat hair	20 C	2.5

3 to 10 x more resistant than vegetative

Risk analysis for envelopes

- 1 gram powder ~ 10^{12} spores
- Assume no effect of thickness
- Dose = 12 x 2.5 = 30 kGy
- Similar to dry spices
- Postal Service is suggesting 45 kGy or 18 log cycles

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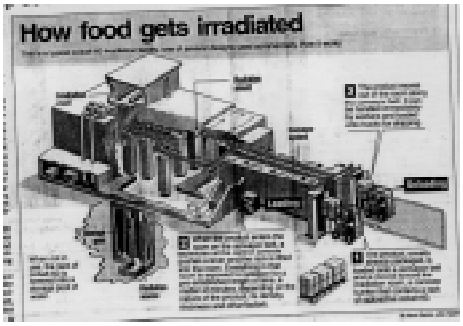
Gamma Process



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

preservation mechanism

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

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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

Gamma Irradiation costs

- average plant $7 to $12 MM
- handle 250,000 lb per day
- need isolated facility
- need radiation safety officer for dosimetry (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
- but leaves radioactive rods in plant - terrorism risk

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Transportation safety

Dropping metal casks

NIMBY

2/14/00

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Current gamma 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

And Then 9-11

SureBeam

Cost to install

~$2-3 MM

No radioactivity

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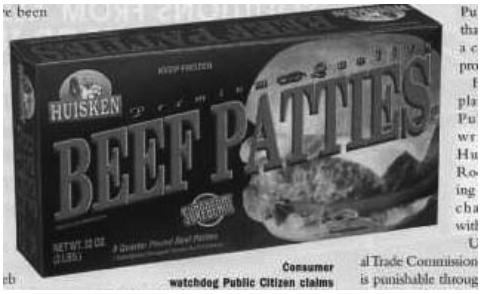
E-Beam Process

Excell - ConAgra IBP Solution

- Use electron beam (Titan SureBeam)
- Built large plant in Midwest

- < 1% of all ground beef
- Huiskens



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Informed consent

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

"Treated by irradiation"

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

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Questions

- Changes in practice - ie 10 lb chubs
- Change of shelf life
  - Oxidation
  - Nutrients
  - Lack of competitors
  - Induced resistance

Change of shelf life

- No competing organisms
- No flavor difference immediately after irradiation
- Flavor changes in storage especially if frozen
- Nutrient losses similar to heating

1997 FMI Study

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

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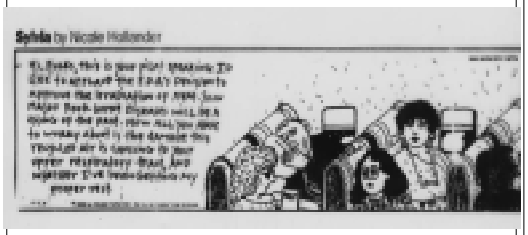
CMF&Z Public Relations Survey Oct 1997

- 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

Positive Outlook



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%

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Consumer Concerns

Questions

- Terrorism
- Dirty food
- Induced radioactivity
- free radical stability -> URLs
- mutation of organisms
- Difficulty of feeding studi

The Safety Issue
Chicken Chernobyl
Three Mile Island
Post 9-11

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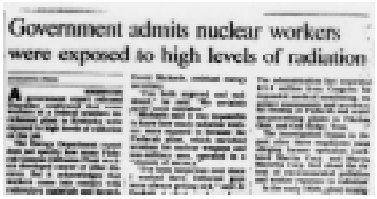
Trust Us


Government admits nuclear workers were exposed to high levels of radiation

2/14/00

Food and Water Campaign

Food & Water Ad

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City Pages MPLS 2/25/98

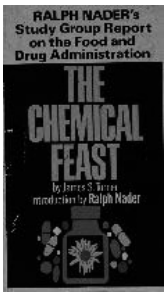

NEWS

Let Them Eat Shit

City Pages Response 3/18/98


CITY PAGES

Safety



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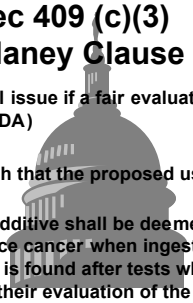
Sec 409 (c)(3) Delaney Clause



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 it 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

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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 cl
- Due diligence
- duty of consumer to cook

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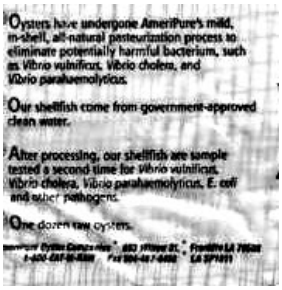
MIT Tech Review 12/97

Other Technologies

- Low temperature - long time
- Microwaves
- Pulsed Electric Field
- Pulsed Light
- High Pressure

Need 6 to 7 log kill

50 °C for 22 min


Oysters have undergone AmeriPure's mild, in-shell, all-natural pasteurization process to eliminate potentially harmful bacterium, such as *Vibrio vulnificus*, *Vibrio cholera*, and *Vibrio parahaemolyticus*.

Our shellfish come from government-approved clean water.

After processing, our shellfish are sample tested a second time for *Vibrio vulnificus*, *Vibrio cholera*, *Vibrio parahaemolyticus*, *E. coli* and other pathogens.

One dozen raw oysters.

General Review

Other references

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  - http://www.cdc.gov/ncidod/EID/vol3no4/osterhol.htm

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My websites

- **This presentation**
  - http://fscn.che.umn.edu/ted_Labuza/tpl-papers-Talks.html
- **Irradiation of Foods website**
  - http://courses.che.umn.edu/01fscn1102-1s/general_food_safety/Irradiation_Folder/Irradiation.html