

Irradiation of Red Meats

Ground Beef

Purpose: - Eliminate *E-Coli O157:H7* and other pathogens
- Extend shelf-life

Benefits: Low doses required to eliminate pathogens of concern and for shelf-life extension

Market Size: Large

Economical Advantage: Large volume, low cost, significant health benefit

Quality: Good

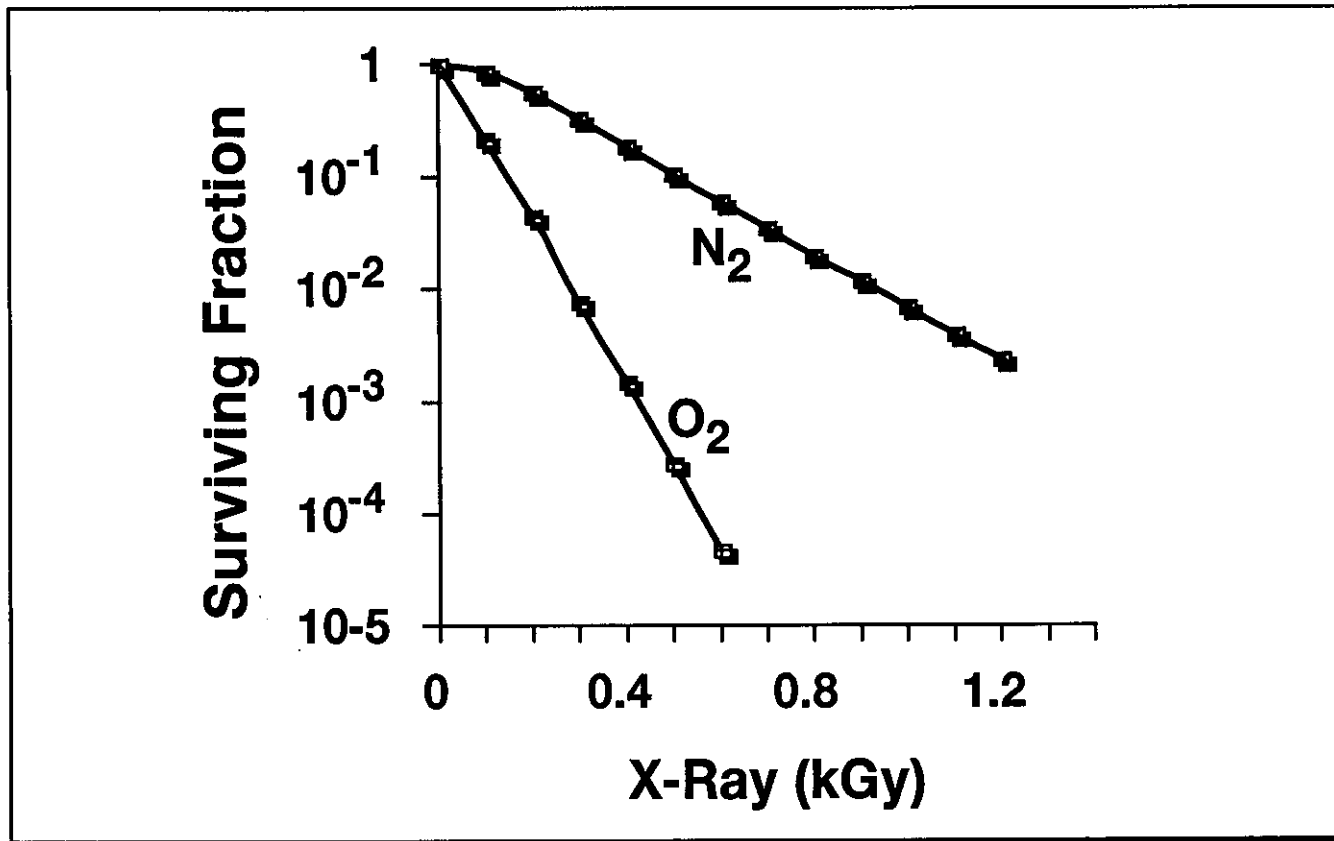
Industry: Appears very interested in North America

Customer Need: Accute awareness

Technical Advantage: Irradiation appears to be the best treatment

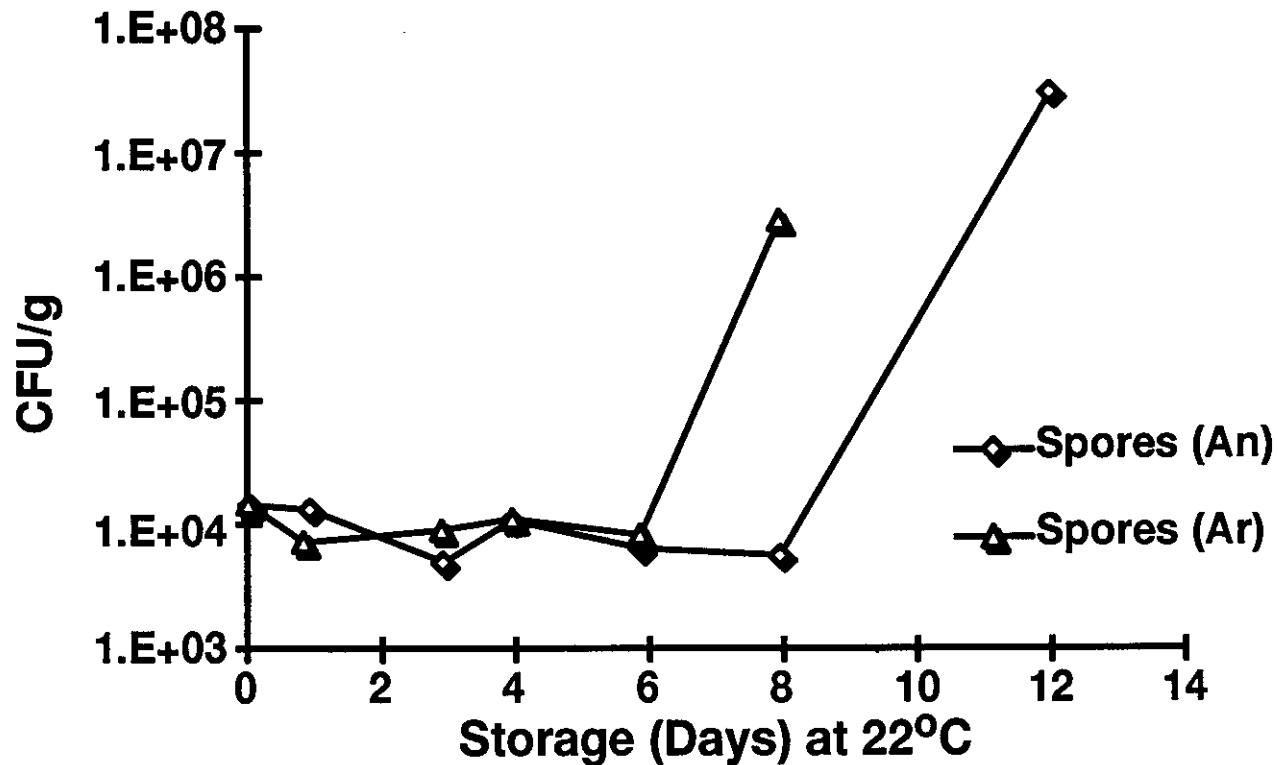
Regulatory Aspects: Clearance imminent in USA (3 kGy)

Radiation-Inactivation of *E. coli*



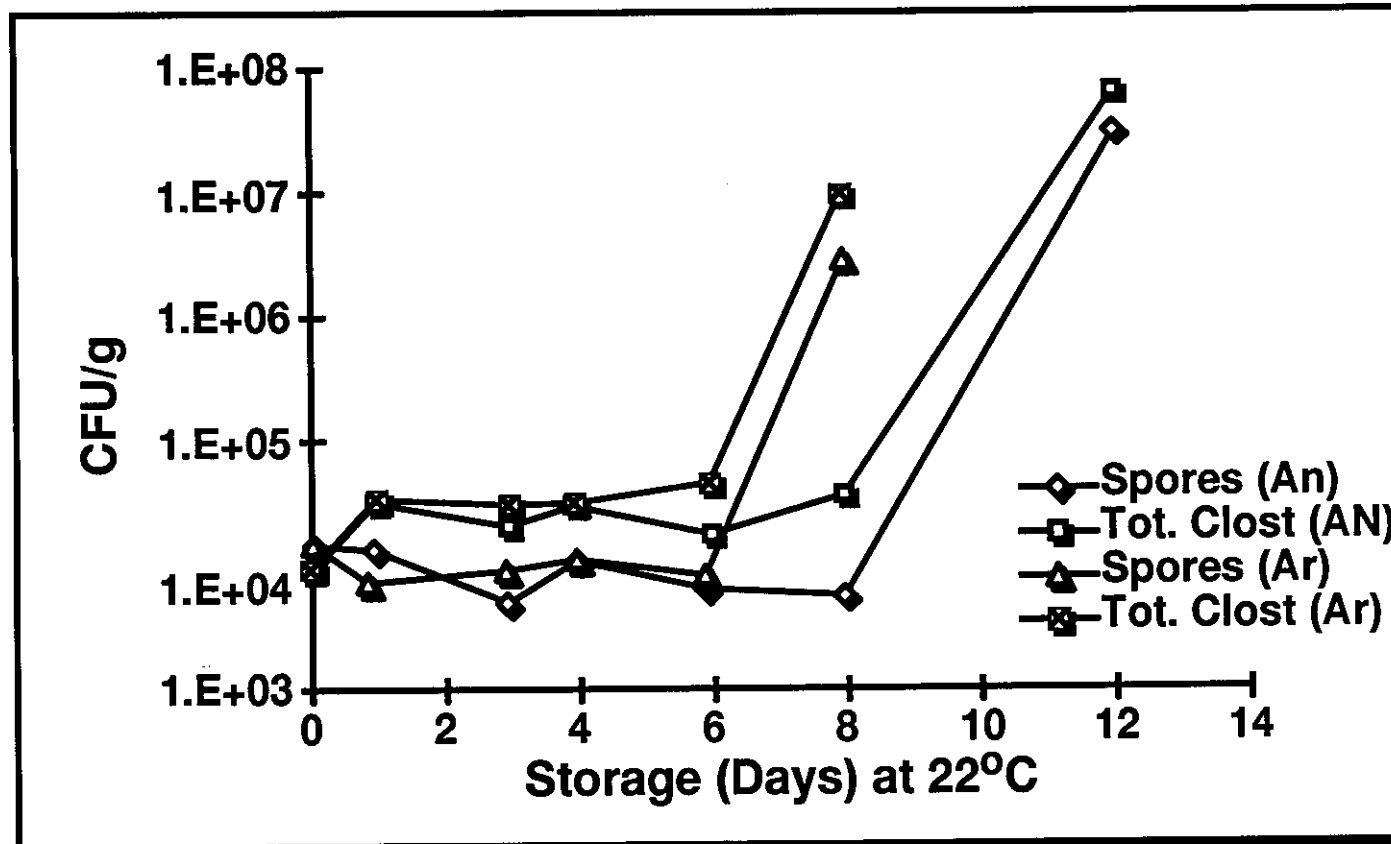
E. coli cultured aerobically in broth and irradiated in O₂-saturated or N₂-saturated buffer (Casarett, 1968)

Inoculation (*C. sporogenes*) Pack Study Ground Beef Patties



- Germination of *C. sporogenes* spores on storage at 22°C starts after day 6 in air, and after day 8 under vacuum
- Out growth follows the same pattern

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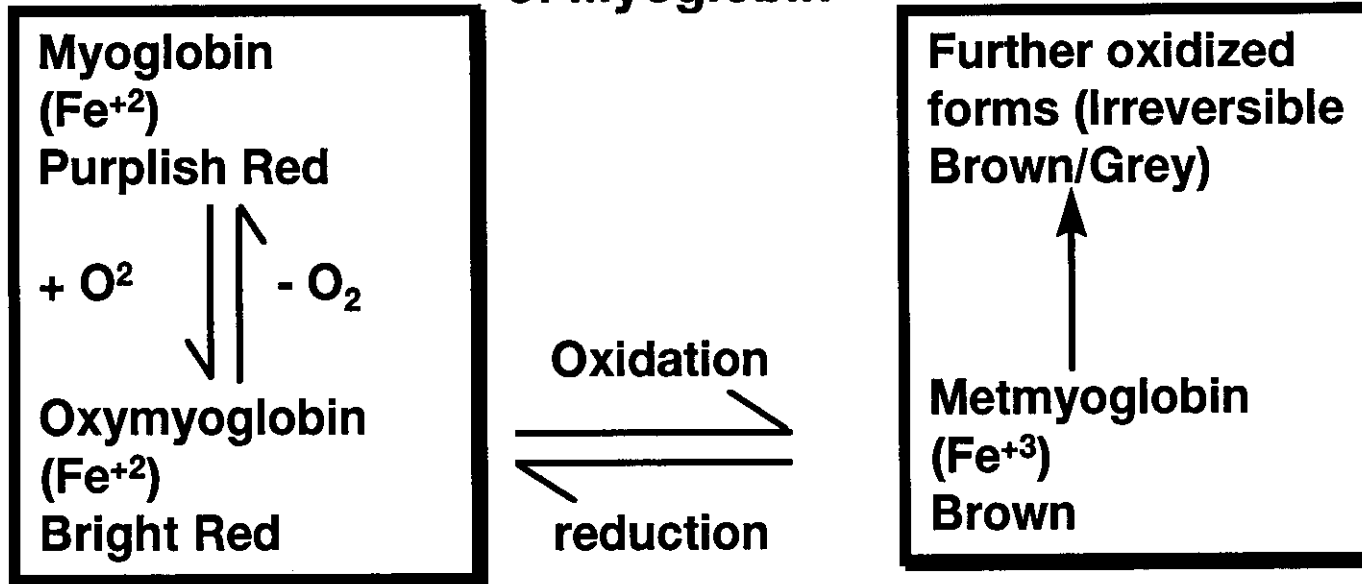


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Changes in Color

- Due to reversible chemical changes associated with oxidation of the meat pigment through
 - microbial oxidation
 - autoxidation
 - irradiation
 - myoglobin oxidation involved in color changes

Dynamic Equilibrium Between the Various Forms of Myoglobin



Microbial and Sensory Shelf-Life of Ground Beef Patties, Stored at 4°C

Dose (kGy)	Type of Packaging	Shelf-Life (Days)		
		Microbiological	Odour	Colour (0.1% Vit C) ^a
0	Anaerobic	24 (APC, 10 ⁷ /g)	<8	14
2.4	Anaerobic	>24 (APC, 10 ⁵ g)	19	14
0	Aerobic	<3	~3	2
2.4	Aerobic	16	14	10

a. In the presence of vitamin C, Singh (1993)

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Volatile Compounds (contd)

- **These volatiles are generally present at ppm to ppb (mg to ug/kg) levels**
- **Volatiles, such as aldehydes and ketones, impart particular flavors to foods, which increase with irradiation dose**
- **Some minor volatile products not detected in unirradiated but detected in irradiated samples have been suggested as markers of irradiated chicken e.g. 2-dodecyl cyclobutanone and hydrocarbons**

**Partial List of the Yields of the
Radiolysis Products in Beef as a Function
Of Dose^a**

Compound	Dose (kGy)			
	0	30	60	90
Group 1	µg/kg of Meat			
Pentane	5	103	288	306
Hexane	2	129	239	354
Heptane	3	186	343	537
Octane	8	126	298	412
Pentene	0	28	62	87
Hexene	0	38	86	122
Heptene	0	51	110	163
Octene	0	42	96	158
Group 2	µg/kg of Fat			
Pentadecane	0	23	27	58
Heptadecene	0	35	42	93
Heptadecadiene	0	5	7	13
Hexadecanal	0	70	110	240
Dihexadecanoyl propanedioldiester (1,2)	0	40	90	170
Hexadecanoyl octadecenoyl propanedioldiester (1,2)	0	40	90	150

^a Data taken from Merritt et al. (1985); results are average of duplicate determinations

CONCLUSIONS

- Refrigerated shelf-life of lean ground beef patties stored at 4°C can be extended by a dose of ~2.5 kGy to 14 days (aerobic) or to 19 days (anaerobic)
- The stability of the colour of irradiated ground beef was improved by the addition of 0.1% ascorbic acid
- The safety concern for the potential of botulism was eliminated (by inoculation with *C. sporogenes* spores as an indicator organism for *C. botulinum*) since no growth of *C. sporogenes* was observed in irradiated patties stored for 4 weeks, at 15°C
- The safety of irradiated patties stored at 22°C in both anaerobic and aerobic packaging conditions was demonstrated by the fact that detectable spoilage occurred prior to the growth of *C. sporogenes*

Shelf-Life of Irradiated and Unirradiated Pork Loin in 100% N₂

Irrad Dose (kGy)	Storage Temp (°C)	Shelf-Life (Days)			
		Microbial	Colour	Odour	Overall
0	5	14	9	16	9
1	5	21	35	26	21
0	25	2	<2	<2	<2
1	25	10	>14	2	2

Singh (1993)

Shelf-life of Irradiated and Unirradiated Bacon

Type	Dose (kGy)	Irrad Temp (°C)	Product Environ	Storage Temp (°C)	Shelf-Life (Days)	
					Unirrad	Irrad
Smoked	7.5		Vacuum, NO ₂ ⁻ } 0 ppm } 20 ppm } 120 ppm	5	After 14 d 14-42	>102 ^a >102} >102}
Smoked	7.5	4	Vacuum, NO ₂ ⁻ } 0 ppm } 20 ppm } 120 ppm		20-30	>90 ^{b,c}
	7.5				20-30	>90
					20-30	>90

a. Wierbicki and Heiligman (1980), b. Singh (1988b), c. Singh (1993)

Other Red Meats (e.g. Pork, Lamb, Bacon)

- **Very similar considerations as poultry and beef from the point of view of microbial contamination**
- **An absorbed dose of 0.3 kGy renders the pork parasite, *Trichinella spiralis*, inactive in fresh meat**
- **In general, most red meats require 2.5 kGy dose to control pathogens and to increase shelf-life from ~ 3 to 14 days (in air) at 4°C**