# **Irradiation of Red Meats**

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### **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  $O_2$ -saturated or  $N_2$ -saturated buffer (Casarett, 1968)



- 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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### **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	Type of	Shelf-Life (Days)			
(kGy)	Packaging	Microbiological	Odour	Colour (0.1% Vit C) <sup>a</sup>	
0	Anaerobic	24 (APC,10 <sup>7</sup> /g)	<8	14	
2.4	Anaerobic	>24 (APC, 10⁵g)	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<sup>a</sup>

		Dose	(kGy)	
Compound	0	30	60	90
Group 1		µg/kg	of Meat	
Pentane	G	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 ·		jug/kg	of Fat	
Pentadecane	0	23	27	58
Heptadecene	0	35	42	93
Heptadecadiene	0	თ	7	13
Hexadecanal	0	70	110	240
Dihexadecanoyl	0	40	06	170
propanedioldiester (1,2)				
Hexadecanoyl	0	40	06	150
octadecenoyi				
propanedioldiester (1,2)				

<sup>a</sup> 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% N<sub>2</sub>

Irrad	Storage Temp (°C)	Shelf-Life (Days)					
Dose (kGy)		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

Туре	Dose (kGy)	DoseIrradProductStorage(kGy)TempEnvironTemp(°C)(°C)(°C)		Storage	Shelf-Life (Days)	
	(NGJ)			(°C)	Unirrad	Irrad
Smoked	7.5		Vacuum, NO <sub>2</sub> <sup>-</sup> } 0 ppm } 20 ppm }120 ppm	5	After 14 d 14-42	>102} <sup>a</sup> >102} >102} >102}
Smoked	7.5	4	Vacuum, NO <sub>2</sub> <sup>-</sup> } 0 ppm		20-30	>90 <sup>b,c</sup>
	7.5		} 20 ppm }120 ppm		20-30 20-30	>90 >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