Irradiation of Fresh Fruits

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Purpose: Insect disinfestation

- Prevention of transfer of insects from one locality to another (quarantine treatment)
- Prevention of insect damage to the fruits
- Small gain in shelf-life of some fruits

Some Fruit Fly Species of Major International Concern[1]

Scientific Name	Common Name	Primary Hosts	Geographic Origin
Anastrepha ludens	Mexican fruit fly	Citrus, mango, soft fruits	Mexico, Central America, USA
Ceratitis capitata	Mediterranean fruit fly	Citrus, most fruits	Africa, Asia, Central and South America, Europe, USA, Belize
Dacus cucurbitae	Melon fly	Cucurbits, most fruits, legumes	Africa, SE Asia, Pacific Islands
Dacus dorsalis	Oriental fruit fly	Citrus, most fruits	SE Asia, Pacific Islands
Dacus passiflorae	Fiji fruit fly	Citrus, mango, guava, avocado,	Fiji, Indonesia, Malaysia, Japan, Philippines, Pakistan, Thailand

[1] ICGFI Document No.7 (1991)

Some Pests of Major International Concern[1]

Scientific Name	Common Name	Primary Economic Hosts	Geographic Origin
Anarsia lineatella	Peach twig borer	Peach	Europe, Asia, Africa, Canada, USA
Cydia molesta	Oriental fruit moth	Peach, deciduous fruit, mango, guava	Asia, Europe, South America, North America
Prays citri	Citrus flower moth	Citrus	Europe, Asia, Africa
Sternochetus mangiferae	Mango seed weevil	Avocado	Africa, Australia, Asia, Pacific Is. West Indies
Aleurocanthus woglumi	Citrus black fly	Citrus, ornamentals	Asia, Africa, West Indies South and Central America

1. International Consultative Group on Food Irradiation (ICGFI) Chiang Mai, Thailand, 1986 (ameded as ICGFI Document no. 91, 1991)

Pre-irradiation treatment

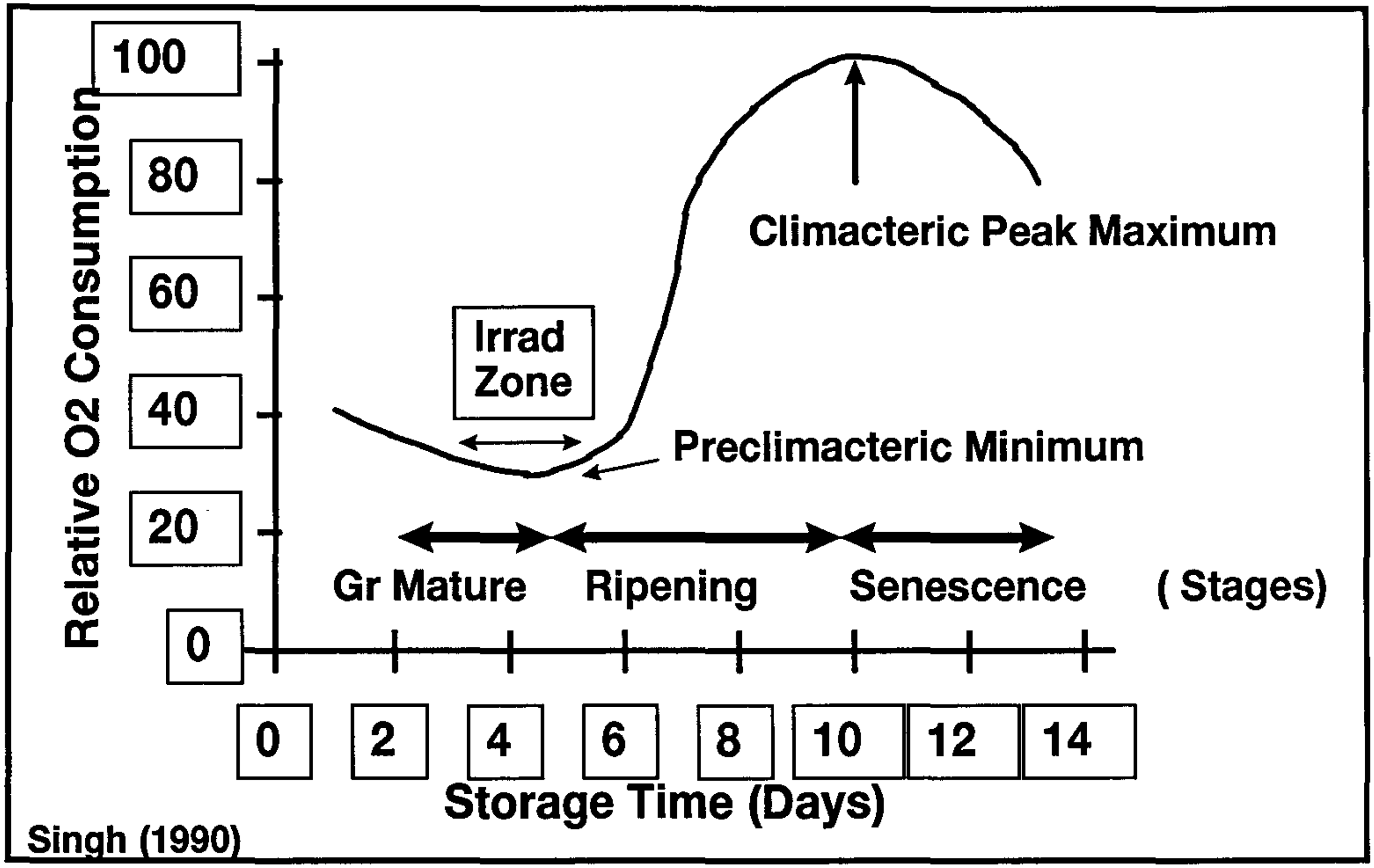
- Growers must use good agronomic practices to obtain good over-all quality fruits
- Crops should be aerated to remove heat absorbed in the fields, before irradiation treatment
- For some tropical fruits, a pre-irradiation heat treatment for fungal disease control could be useful (papayas: 20 min at 49°C or 10 min at 55°C; mangoes: 10 min at 50°C or 5 min at 55°C; bananas: 5 min at 50°C). Inclusion of an approved chemical fungicide in water may be beneficial

Stage of Development of Fruits

- Climacteric fruits and vegetables (mango, papaya, avocado, banana, tomato) are good candidates for radiation induced extension of shelf-life
- Growth, maturation (ripening) and senescence (the post-ripening decay of fruit) are the three important phases in the climacteric fruit cycle
- Radiation delays ripening and senescence

Therefore, fruits should be harvested just before the onset of the ripening process for radiation induced delay of ripening

Respiratory Pattern in Fruits After Harvest



- At the climacteric peak point, maximum ethylene production and eating ripeness stage is reached after which deterioration ensues

Selection of Dose Is Food And Target Specific

- The aim of irradiation is to give the minimum possible dose to the food item to achieve the desired technical effect
- Different varieties (e.g., mangoes) require different optimum doses for the same end point like shelf-life extension
- Same variety requires different doses for different end points

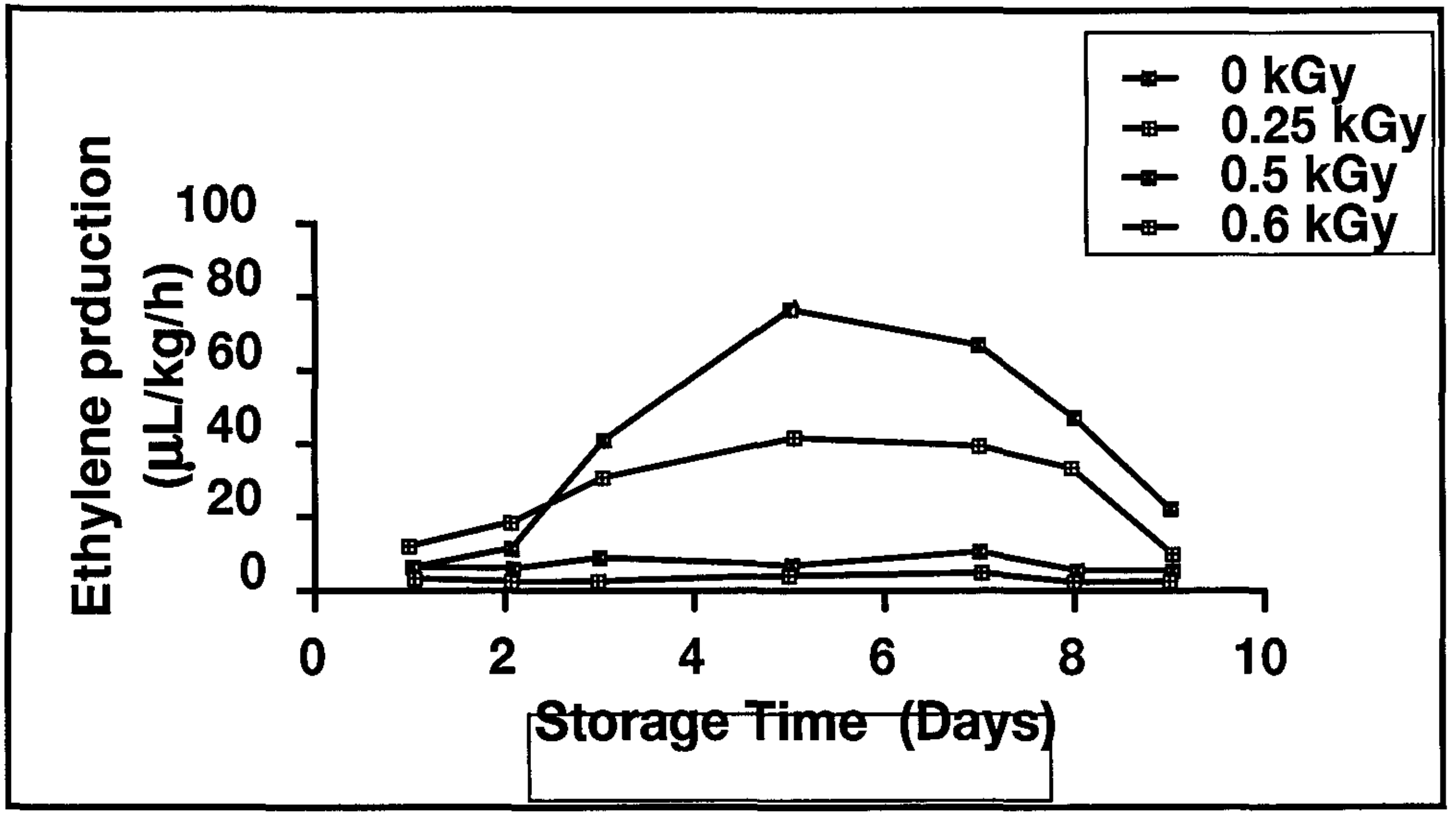
Radiation Dose Required for Shelf-Life Extension Disinfestation and Decay Control in Mangoes

Mango Variety	Purpose	Optimal Dose (kGy)	Max. Tolerance Dose (kGy)
Alphonso	Shelf-life	0.25	0.75
Haden	Disinfestation	0.33	1.00
Haden	Shelf-life	0.75	-
Okrong	Shelf-life	0.40	-
Pirie	Shelf-life	0.75	1.00
Zill	Shelf-life	0.75	-
Zill	Decay control	1.05-2.10	-

Singh, 1990; AECL-10187

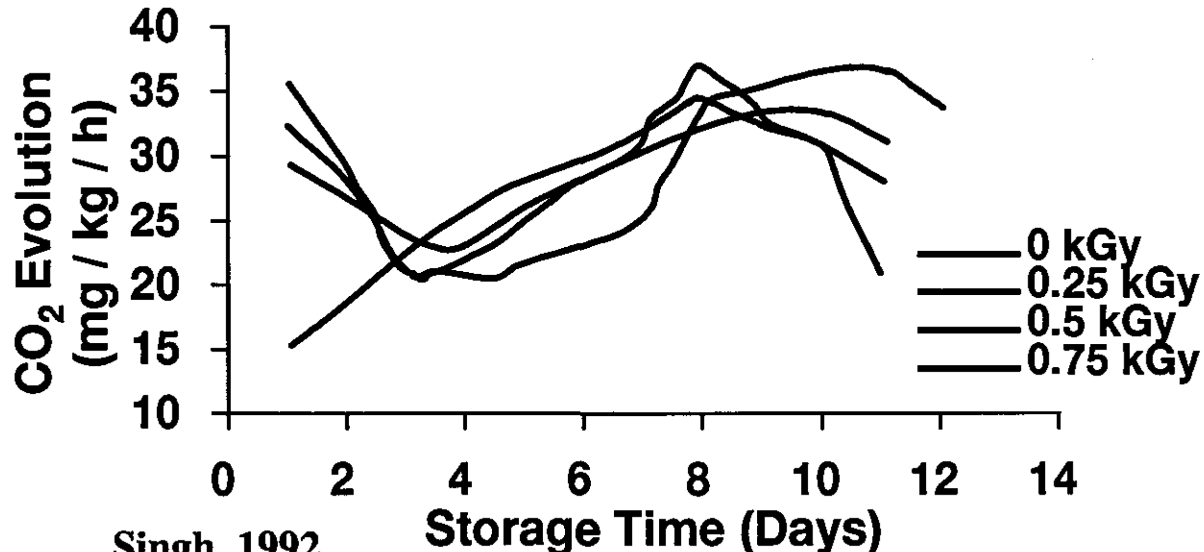
- Higher than the necessary dose may induce unfavourable side effects while lower dose will not achieve the specific end point. In some cases in fact a lower dose may also have an opposite effect, e.g., very small doses (<0.1 kGy) may stimulate sprouting of tubers

Evolution of Ethylene in Dusehri Mangoes



- Irradiation supresses ethylene production
- During ripening activities of many enzymes in mitochondria increase several fold (amylase, catalase, dehydrogenases, pectin esterases, peroxidases)

Respiration Pattern of 'Haden' Mangoes in Preclimacteric Stage at 21.7°C



Singh, 1992

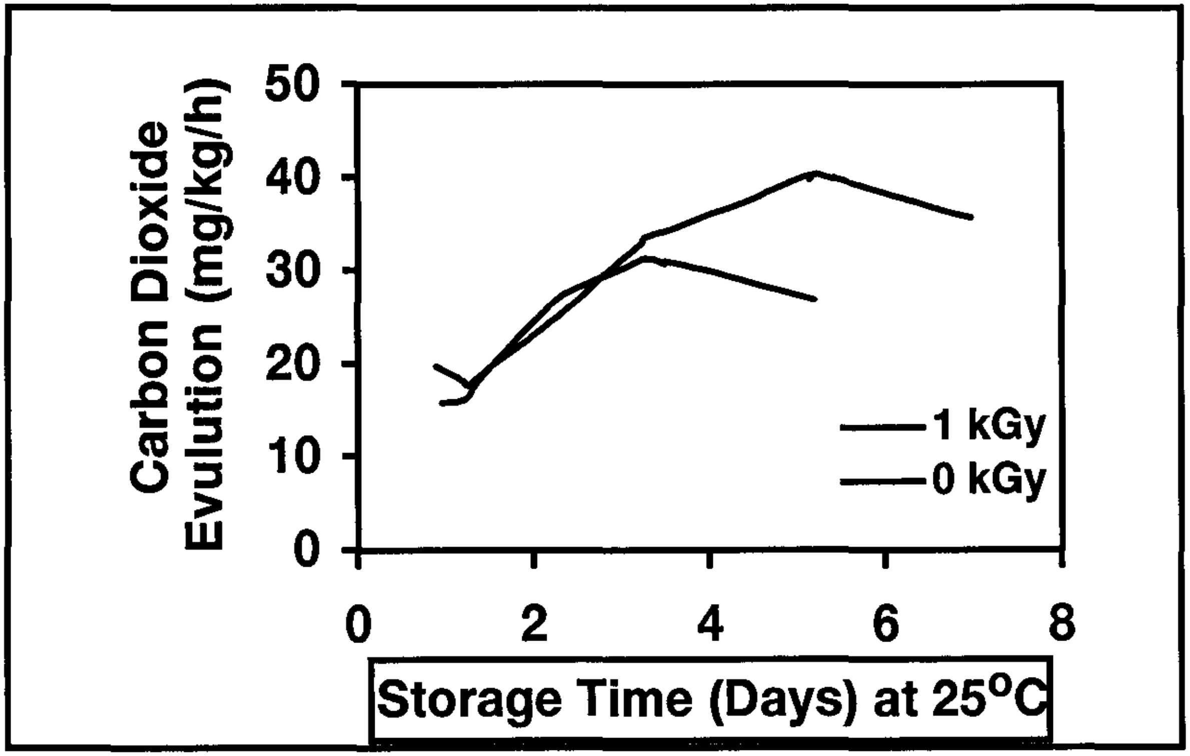
- Initial increase in respiration, followed by decrease in all irradiated samples
- Maximum delay in climacteric peak at 0.75 kGy, with extention of shelf-life of ~ 4 days

Radiation Dose Required for Shelf-Life Extension and Disinfestation in Papayas

Papaya Variety	Purpose	Optimal Dose (kGy)	Maximum Tolerance Dose (kGy)
Solo	disinfestation	0.26	1.00
Solo	shelf-life	0.75	1.00

Moy et al., (1977)

Respiration Pattern of Solo Papayas in Preclimactric Stage



- Small initial increase in respiration in irradiated sample
- A delay of ~2 days in the climacteric peak on irradiation

Carbohydrate Content of the Irradiated and Unirradiated Papayas[1]

	Total Reducing Sugars		Total Soluble Solids	
	Percent of Control		Percent	
Dose (kGy)	Day 3	Day 6	Day 3	Day 6
0	100.0	119.5	12.0	12.0
0.5	94.4	110.0	11.5	11.7
1.0	111.3	107.0	11.5	12.3
1.5	96.8	115.2	11.5	11.7
2.0	103.5	105.9	11.1	11.7

[1] Data taken from Upadhya et al., 1967

Changes in Niacin, Riboflavin and Thiamin in Irradiated (0.75 kGy) and Unirradiated Papayas[1]

Vitamin	Papaya Variety			
	Hortus Gold		Papinos	
	Unirrad	Irrad	Unirrad	Irrad
	(mg/100 g pulp)			
Niacin	0.33	0.31	0.77	0.51
Riboflavin	0.031	0.034	0.02	0.03
Thiamin	0.03	0.02	0.04	0.03

[1] Data taken from Beyers et al., 1979. Fruits treated with warm water (50°C, 10 min) and waxing, before irradiation

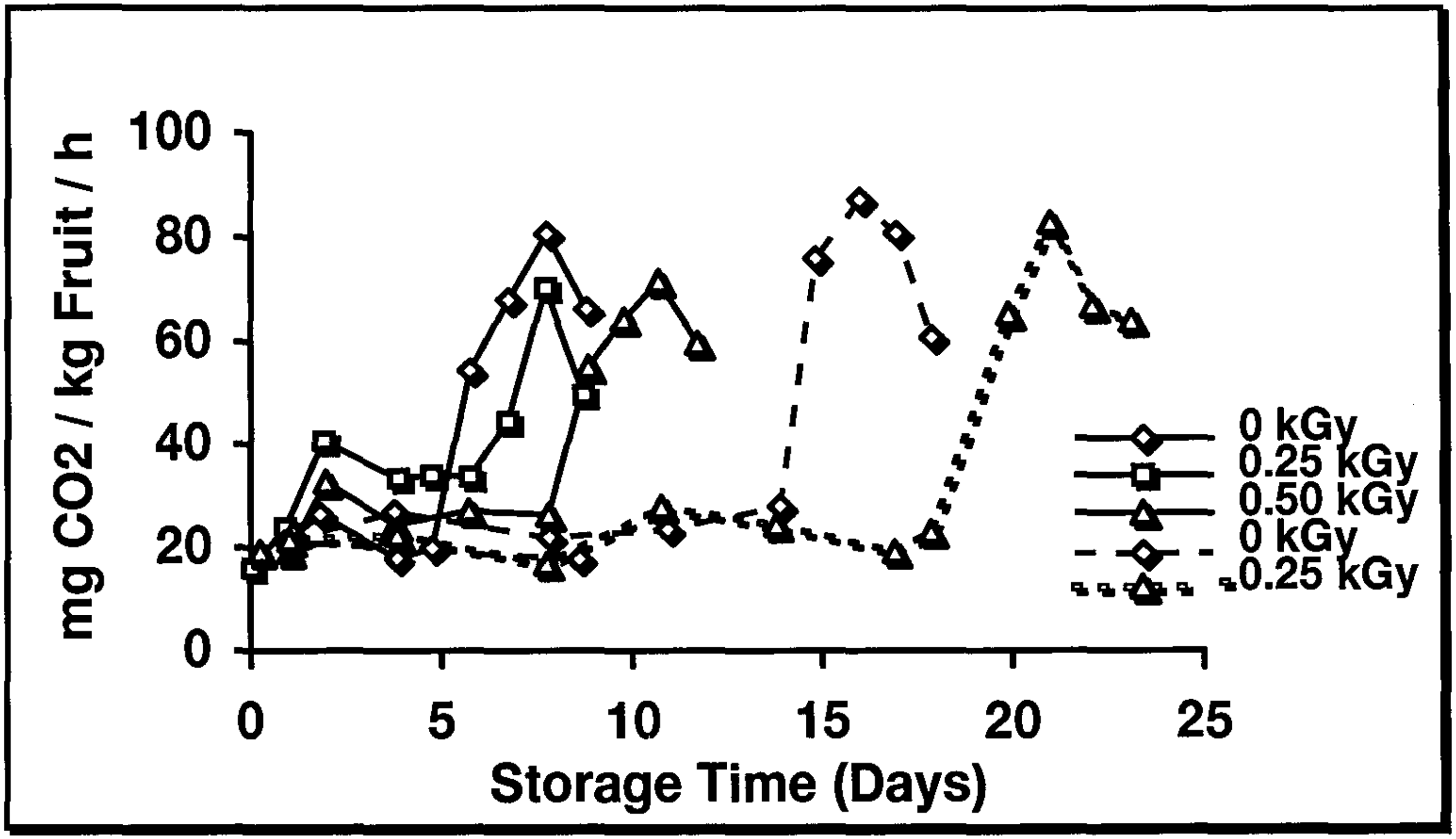
Sensory Analysis Data from Simulated Shipping Studies on Solo Papayas[1]

Type of Sample	Sensory Attribute[2]			
	Texture	Colour	Aroma	Flavour
Absolute Control	4.95 ± 0.24	5.78 ± 0.20	5.10 ± 0.21	5.26 ± 0.23
Fumigated	5.33 ± 0.15	5.84 ± 0.13	4.90 ± 0.15	5.18 ± 0.16
Vapour Heat Treated	5.51 ± 0.13	5.91 ± 0.11	4.50 ± 0.15	5.31 ± 0.14
Warm Water Treated	5.13 ± 0.28	5.92 ± 0.21	5.21 ± 0.34	5.67 ± 0.26
Irradiated				
0.25 kGy	5.57 ± 0.14	5.90 ± 0.12	5.39 ± 0.15	5.86 ± 0.13
0.50 kGy	5.91 ± 0.13	6.13 ± 0.11	5.62 ± 0.15	5.91 ± 0.14
0.75 kGy	5.50 ± 0.29	5.67 ± 0.24	4.73 ±0.32	5.73 ± 0.25
1.00 kGy	6.21 ± 0.13	5.96 ± 0.22	5.04 ± 0.36	5.36 ± 0.23
1.50 kGy	5.63 ± 0.29	6.38 ± 0.14	4.75 ± 0.35	5.88 ± 0.22

[1] Data taken from Dollar et al. (1970)

[2] The data is based on a hedonic scale of 1 to 7 (7 = like very much; 1 = dislike very much)

Respiratory Patterns of 'Fill Basket' Bananas



CONCLUSIONS

- Irradiation very effective in control of insects
- Shelf-life of climacteric fruits is increased on irradiation due to delay in ripening and senescence
  - Papayas 1 to 8 days
  - Mangoes 2 to 4 days
- At the required doses (~1 kGy), no adverse effect on nutritional quality or wholesomeness

Nutritional Loss Concerns (contd)

Altered Palatability (Sensory/Organoleptic Qualities)

- The leading attributes of processed foods, usually examined by expert and/or consumer panels during sensory analysis, are odour, taste (flavour), colour and texture
- Sensory analysis data have been reported for many irradiated foods including beef, bacon, ham, chicken, fish and fruit
- Under properly controlled coditions no significant changes in palatability have been observed for irradiated foods

Preference Scores of Irradiated and Unirradiated Chicken Carcasses Stored at 1.6°C (roasted at 177°C)[a]

Storage (days)	Unirrad W	Unirrad D	Irrad, 2.5 kGy W	Irrad, 2.5 kGy D	Irrad, 5 kGy W	Irrad, 5 kGy D
0	7.2	7.2	-	-	-	-
4	7.0	6.6	6.6	6.4	6.4	6.6
8	6.2	5.9	7.0	6.2	6.6	5.1
11	6.9	6.4	6.9	6.2	6.1	5.9
15	S	S	6.9	6.7	7.1	6.2
18	S	S	6.5	6.4	6.7	6.3
22	S	S	6.7	6.1	6.3	6.1
31	S	S	6.4	6.5	6.0	6.0

[a] Singh (1988); W-White Meat; D-Dark Meat; S-spoiled

- Increased shelf life of irradiated product (31 days)

Acceptance of Radappertized Meats

Product	kGy at -30°C	Recipe	Number Raters	Number Tests Rating[a]	Average Acceptance
Beef	33-47	Onion gravy	33	2	6.4
Beef Steak[b]	37-43	Fried	64	2	7.0
Ham[b]	37-44	Baked	79	3	7.7
Turkey Slices[b]	37-43	Roasted	64	2	6.4
Pork Sausage	27-43	Fried	91	4	7.7
Chicken	45-54	Breaded, Fried	79	2	7.0
Shrimp	38-49	Cocktail	115	4	7.2

a. 9-point hedonic scale where 9 is "like extremely"; 5 is "neither like or dislike"; 1 is "extremely dislike"; b. Apollo-Soyuz Test Program; c. Apollo 17

- The ratings for all products are from very acceptable to highly acceptable