Gamma Radiation Influences Postharvest Disease Incidence of Pineapple Fruits

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Additional index words. *Ananas comosus*, *Ceratocystis paradoxa*, *Penicillium purpurogenum*, gamma irradiation

Abstract. The application of gamma radiation for improving the storage of pineapple fruits [*Ananas comosus* (L.) Merr. cv. Queen] has been studied in an attempt to reduce decay caused by fungal pathogens such as *Ceratocystis paradoxa* (Dade)-Moreau and *Penicillium purpurogenum* Stoll. Gamma radiation at 50, 75, 100, 150, and 250 Gy improved shelf life. The maximum tolerable dose was ≈ 250 Gy. Fruits irradiated with up to 150 Gy and then stored at 25 to 28C maintained their texture better than did the controls. Radiation, particularly at doses >250 Gy, caused browning of the skin and softening of tissues. Browning increased with increasing radiation dose and storage duration. Excessively high doses promoted spoilage. Doses in the range of 50 to 250 Gy, in combination with storage at 11 to 13C, can be used to reduce postharvest losses in pineapple due to fungal diseases and senescence, thereby extending shelf life.

A huge quantity of pineapples are lost due to attacks by pathogenic microorganisms during storage. Without some preservative measures the ripe pineapple fruits do not keep well beyond 10 to 12 days.

Gamma radiation can extend the shelf life of many perishable fruits, including pineapple (Urbain, 1986; Zuleta, 1989), by controlling decay caused by pathogenic microorganisms and delaying ripening and senescence. However, a major hindrance to the practical use of radiation for disease control in fresh fruits appears to be that the dose required for effective control of the spoilage pathogens invariably results in damage to the fruit. Doses higher than the maximum tolerable dose cause skin blackening or browning and softening of tissue in oranges [*Citrus sinensis* (L.) Osb.] and grapefruit [*Citrus paradisi* Macfad.] (Dennison et al., 1966; Grierson and Dennison, 1965). Shelf life of many fruits is prolonged considerably by the combination of refrigeration and relatively low doses of radiation (i.e., those that do not alter flavor or texture (Thomas, 1987a, 1987b). Information regarding the effect of gamma radiation on the extension of shelf life in pineapple is meager (Urbain, 1986;

Zuleta, 1989). We investigated the effect of gamma radiation on postharvest diseases of pineapple fruits harvested during several seasons and determined the optimum dose for extending shelf life during storage.

Healthy, uniformly sized pineapple fruits, weighing 600 to 650 g each, were harvested 75% ripe. Extension of shelf life (in days) was determined from this maturity stage until the fruits became dry or infected. About 2 to 3 cm of the fruit stalk and crown were retained. Fruits were irradiated at 0, 50, 75, 100, 150, 250, 500, 750, or 1000 Gy using a 5100-Ci ⁶⁰Co-Gamma Irradiator from the Isotopes Division, Bhabha Atomic Research Centre, Bombay, at room temperature within 24 h of harvest. The racks and storage room had been fumigated with 3% formaldehyde solution before irradiation of the fruit.

The pathogens causing the postharvest diseases of pineapple fruits were isolated from diseased fruits and grown in potato dextrose

agar (PDA) culture medium. Pathogens from these pure cultures were then inoculated on healthy fruits to see whether the same symptoms of disease appeared and to compare the characteristic features of the pathogens isolated from diseased fruits and from the culture medium.

After irradiation, the control and irradiated fruits (three replicates each of 100 fruits per treatment) were stored at room temperature (25 to 28C) at 80% to 85% relative humidity (RH) in the June-July experiments. Similarly, equal numbers of fruits in each treatment were stored at room temperature (11 to 13C) at 70% to 83% RH in December-January.

To check whether infection was due primarily to postirradiation infection, nonirradiated and irradiated fruits (50, 75, 100, 150, and 250 Gy) were inoculated with agar disks (0.5 cm in diameter) of *Ceratocystis paradoxa* or *Penicillium purpurogenum*. These lots were divided into two replicates; one was stored at 25 ± 1 C and the other at 12 ± 1 C.

Ceratocystis paradoxa and *P. purpurogenum* were identified as the causal organisms responsible for the postharvest diseases of pineapples, *C. paradoxa* being predominant. *Ceratocystis paradoxa* caused water-soaked areas, and fruit flesh became dark yellow. Affected fruit became soft and it disintegrated under the slightest pressure; juice oozed through the surface. The rot spread rapidly throughout the area round the wound. Badly affected fruits turned black and emitted a characteristic sweetish, ether-like odor. These pathogens have been reported not only in Manipur, but also in other parts of the world (Py et al., 1987; Rangaswami, 1984; Singh, 1982).

Fruits irradiated with doses of 50, 75, 100, or 150 Gy and then stored at 25 to 28C (80% to 85% RH) maintained their texture (determined as a measure of crushing load) better than the nonirradiated fruits. The maximum tolerable dose was ≈ 250 Gy. Doses exceeding 250 Gy invariably cause phytotoxicity as

Table 1. Effect of gamma radiation on shelf life in irradiated pineapple fruits (mean value in days).

Season and temp (°C)	Dose (Gy)						
	0	50	75	100	150	250	500
Summer (25–28)	14	24	26	27	29	25	13
Winter (11–14)	16	30	32	34	38	42	24
Sources of variation	d.f.	Sum of squares		Mean squares		F ratio	
Level of radiation	6	635.06		105.84		9.38*	
Temperature	1	240.70		240.70		21.34*	
Error	6	67.71		11.28			

*F ratio significant at $P = 0.01$. Means for each dose and season based on 100 fruits.

Received for publication 3 June 1991. Accepted for publication 13 Jan. 1992. This work is supported by grants from the Dept. of Science and Technology, Government of India, New Delhi (Project no. WS/OO7/86). We thank M.S. Singh for identifying *Penicillium purpurogenum* and L. Ladu Singh for statistical calculation.

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Fig. 1. Effect of gamma radiation on the rate of visible natural infection of pineapple during storage at 25 to 28C and 80% to 85% relative humidity.

manifest by browning; at higher doses, i.e., 750 to 1000 Gy, the extreme browning of the skin and discoloration of crowns made the fruits undesirable. Such fruits also had soft pulp that collapsed on mild application of pressure. The browning and softening were not immediately noticeable after irradiation, but began to appear several days thereafter. This radiation-induced damage to the skin was more severe with increasing radiation dose and time in storage. As the dose was increased beyond 250 Gy, spoilage due to pathogenic microorganisms increased. For fruit harvested in December-January, storage at 11 to 13C and 70% to 83% RH resulted in a longer shelf life of irradiated and nonirradiated-pineapple than that obtained in summer (Table 1). We realize that the effects of harvest season and temperature were not separated in our experiments; thus, the contribution of each factor to the relative lengthening of shelf life cannot be determined from

our data. No infection was observed in either irradiated or nonirradiated fruits stored at 11 to 13C for 30 days. With the increase of radiation dosage up to the maximum tolerable dose (i.e., 250 Gy), color change (as observed visually) was slower and freshness was extended.

The number of naturally infected fruits during storage at 25 to 28C decreased as the dose was increased from 50 to 250 Gy (Fig. 1). The radiation doses required for effective control of the fungi (*C. paradoxa* and *P. purpurogenum*) were above 1000 Gy, which was invariably much higher than could be tolerated by the host tissues, i.e., 250 Gy (Damayanti et al., 1990).

With pineapple fruits artificially inoculated with *C. paradoxa* after irradiation, infection in control fruits was visible within 5 days and the fruit were completely rotten after another 4 to 5 days; fruit irradiated at 50, 75, 100, or 150 Gy showed no infection up

to 5 days and up to 7 days for fruit irradiated with 250 Gy and held at 25 ± 1 C. With fruits inoculated with *P. purpurogenum*, infection was visible by 7 days at 25 ± 1 C in nonirradiated fruits, by 8 days in those irradiated at 50 and 75 Gy, and by 9 days in those treated at 100, 150, or 250 Gy. In both pathogens, mycelial growth was completely inhibited with irradiation followed by cold storage (11 to 13C) and 70% to 83% RH. The inoculum had dried up within 3 days after inoculation without infecting the fruits.

We conclude that gamma radiation at doses of 50, 75, 100, 150, or 250 Gy in combination with storage at 11 to 13C and 70% to 83% RH can be used to reduce postharvest losses in pineapples due to fungal diseases caused predominantly by *Ceratocystis paradoxa*, thereby extending the shelf life of pineapple fruit.

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