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Effect of gamma-irradiation and refrigerated storage on the improvement of quality and shelf life of pear (*Pyrus communis* L., Cv. Bartlett/William)

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ABSTRACT

Gamma-irradiation alone and in combination with refrigeration was tested consecutively for 3 years for extending the shelf life of pear. Matured green pears were irradiated in the dose range of 0.8–2.0 kGy and stored under ambient (temperature 25 ± 2 °C, RH 70%) and refrigerated (temperature 3 ± 1 °C, RH 80%) conditions. Dose range of 1.5–1.7 kGy extended the storage life of pear by 14 days under ambient conditions. Control unirradiated pears were almost fully ripe within 8 days, while as the pears irradiated in the dose range of 1.5–1.7 kGy were fully ripe within 22 days of ambient storage. Irradiation dose of 1.5–1.7 kGy significantly inhibited the decaying of pears upto 16 days of ambient storage. Irradiation in combination with refrigeration prevented the decaying of pears upto 45 days as against the 35% decay in unirradiated samples. Irradiation dose of 1.5–1.7 kGy also gave an extension of 8 and 4 days during additional ambient storage of the pears following 30 and 45 days of refrigeration, respectively.

1. Introduction

The state of Jammu and Kashmir, owing to its topography is famous for cultivation of number of temperate fruits. The main temperate fruits presently being grown in the state include apple, pear, plum, apricot, peach, cherry, strawberry and sea buckthorn. Pear occupies second leading position after apple both in terms of cultivation and production. There are about a dozen varieties of pear grown in Kashmir valley. The commercially exploited varieties are William pear, Kashmeri Nakh, Fertility and d'Anjou. William pear is highly perishable in nature and has a short shelf life due to its active metabolism, high respiration rate and rapid ripening behavior at optimal temperatures. The fast ripening behavior and senescence of the fruit are the major constraints in the marketing chain of the produce (Haggag, 1987). Due to inappropriate post-harvest management practices and lack of proper scientific storage and transportation facilities, huge post-harvest losses of the order of 20–40% are encountered during handling, packaging, and transportation of the produce. Microbial contamination of fresh produce also results in losses and pose potential health risks. Therefore, the post-harvest treatment of pear has become necessary to provide longer life to the fruit, which at the same time establishes price for the grower during the glut season.

Many studies have been carried out in order to develop preservation methods. Among the methods tested, gamma-irradiation has proved to be effective in reducing bacterial and mold contamination as well as delaying the ripening of climacteric fruits (Kader, 1986). Our earlier study (Wani et al., 2007) revealed that a gamma-ray dose of 1.5–1.7 kGy was effective in extending the shelf life by 2 weeks for ambient storage of the fruit. Combinatory treatments have also widely been investigated as they often result in synergistic effects. Gamma-irradiation in combination with other treatments (e.g., heat, washing, waxing) decreased the microbial contamination level leading thus to an improvement of the shelf life (Spalding and Reeder, 1986; Lacroix et al., 1991). Other reports revealed that pear could in general tolerate a dose of around 1 kGy. Bartlett pears irradiated within 1.0 and 2.0 kGy resulted in a delay in ripening by 2 days, while irradiation with 3 and 4 kGy resulted in abnormal ripening (Maxie et al., 1966). Sattar et al. (1971) reported that Leconte pear could be successfully irradiated when it is slightly unripe and with a dose of 2–3 kGy, ripening could be delayed by 2–3 days. In the present study, carried out consecutively for 3 years, the effect of gamma-irradiation alone and in combination with refrigerated storage was investigated with respect to shelf life extension of pear. The assessment of the treatments is based on the evaluation of physico-chemical parameters, overall acceptability, microbial load and decay percentage.

2. Materials and methods

The study was conducted consecutively for 3 years during 2004–2006. Fruit selection was done from same orchard and harvesting was carried out in the first week of August for all the 3

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years of study. The results showed similar behavior for all the 3 years; however, the data presented for each parameter is the average of the means of 3 years of study.

2.1. Raw material preparation

Pear (*Cv. Bartlett/William*) fruits of uniform shape and size, firm texture and proper maturity (120 days after full bloom) were procured from the pear orchards of Shalimar, Kashmir. Fruit was pre-cooled by keeping at 2 °C for 24 h in a cold storage chamber. The pre-cooled fruit was manually graded in order to have uniformity and packed in cardboard boxes. Four boxes each containing 75 fruits spaced uniformly on cardboard trays were taken for each treatment including control.

2.2. Gamma-irradiation treatment

The precooled and packaged fruit was subjected to gamma-irradiation in the dose range of 0.8–2.0 kGy using PANBIT irradiator having Co-60 as the gamma-ray source. The fruit was irradiated at minimum dose rate of 235, 215 and 195 Gy/h during year 2004, 2005 and 2006, respectively. To ensure uniformity of dose, boxes were turned by 180° half way through the irradiation time and the over dose ratio (D_{max}/D_{min}) was determined and found to be 1.6. The dose rate was determined by Fricke dosimetry. After irradiation separate batches of fruit were kept under ambient (temperature 25 ± 2 °C, RH 70%) and refrigerated (temperature 3 ± 1 °C, RH 80%) storage conditions for periodic evaluation of physico-chemical parameters namely firmness, titratable acidity, chlorophyll, physiological loss in weight (PLW), overall acceptability (OAA), percent full ripe fruits, decay percentage and microbial load as yeast and mold count.

2.3. Quality analysis

Firmness of fruits was determined by hand pentrometer model "FT-327" (EFFGI, Italy) provided with a 6 mm round plunger. Triplicate samples of 15 fruits were selected randomly and evaluated for firmness on three sides of each whole fruit and mean value was expressed in kg. The fruits initially used for firmness were subjected to juice extraction using an Omini mixer (Philips make). Ten milliliters of juice was used for determining the acidity (% malic acid) as per the method of Ranganna (1986). Chlorophyll was determined spectrophotometrically using the method of Witham et al. (1971). Loss in weight was determined by periodical weighing of samples. Overall acceptability based on color, texture and taste was done by a panel of five judges on round table basis using four-point scale where 4 = excellent, 3 = Good, 2 = fair and 1 = poor. Fifteen fruits were selected randomly, coded and served to judges for evaluation of color, texture and taste. Microbial load as yeast and mold count was determined by the serial dilution method using potato dextrose agar media (Aneja, 1996). Percentage of full ripe fruits and decay percentage was determined visually from known number of fruits. For each parameter, triplicate samples were used.

2.4. Statistical analysis

Completely randomized design experiment was used for statistical analysis as discussed by Cochran and Cox (1975) with $p \leqslant 0.05$.

3. Results and discussion

William pear at harvest had 78.2 ± 1.75 mm length, 61.2 ± 0.81 mm breadth, 166.4 ± 5.19 g average weight, 8.6 ± 0.45 kg firmness, $11.0 \pm 0.26°$ B total soluble solids, 0.28 ± 0.03% titratable acidity and 10.4 ± 0.55 mg/100 g chlorophyll. Results of the change in quality parameters of the fruit due to irradiation during storage are discussed as under.

3.1. Firmness

Firmness of pears decreased with storage. The decrease in firmness was significantly ($p \leqslant 0.05$) higher under ambient conditions than refrigerated conditions. Among the treatments, control unirradiated pears exhibited lower firmness throughout the storage under both the conditions. Firmness of control-unirradiated pears was 1.0 ± 0.03 kg after 14 days of ambient storage and 1.7 ± 0.01 kg after 45 days of refrigerated storage (Fig. 1). Dose range of 1.5–1.7 kGy recorded significantly ($p \leqslant 0.05$) higher firmness values after 14 days of ambient as well as 45 days of refrigerated storage. Decrease in firmness is associated with the conversion of insoluble pectic fraction to the soluble forms as a result of ripening. Also the activities of enzymes namely protopectinase and pectinmethyl esterase responsible for hydrolyzing and solubulization of pectic substances increase during ripening. Since irradiation is known to delay the ripening and senescence of climacteric fruits (Kader, 1986) and combination with low temperature gives a synergistic effect. Thus, slower decrease in firmness of irradiated samples during storage is related to the delayed enzymatic activities, thereby resulting in reduction in the rate of increase in soluble pectic fractions as a result of delayed ripening. Hence the normal conversion of insoluble to soluble pectins during storage appears to have been markedly retarded both by irradiation and low temperature (Massey et al., 1964; El Assi et al., 1997; d'Amour et al., 1993; Howard et al., 1995; Wills et al., 1996; Kovacs et al., 1997; Prakash et al., 2002). However, decrease in firmness values of samples irradiated at 2.0 kGy could be possibly due to radiation injury to the fruit, resulting in severe degradation of pectic substances.

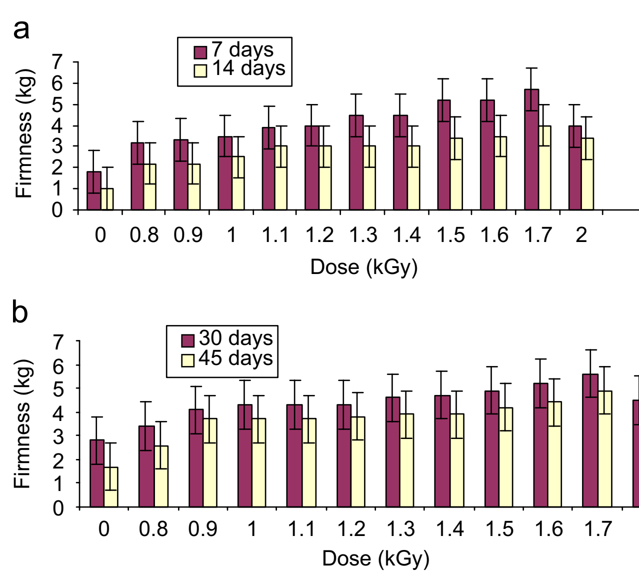

Fig. 1. Effect of gamma-irradiation doses on firmness of pear during storage under ambient (a) and refrigerated (b) conditions.